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Open Science

Open Science Philosophy

Open science encompasses unrestricted access to scientific research articles, access to data from public research, and collaborative research enabled by information and communication technology tools, models, and incentives. Broadening access to scientific research publications and data is at the heart of open science. The objective of open science is to make research outputs and its potential benefits available to the entire world and in the hands of as many as possible:

- Open science promotes a more accurate verification of scientific research results. Scientific inquiry and discovery can be sped up by combining the tools of science and information technologies. Open science will benefit society and researchers by providing faster, easier, and more efficient availability of research outputs.
- Open science reduces duplication in collecting, creating, transferring, and re-using scientific material.
- Open science increases productivity in an era of tight budgets.
- Open science results in great innovation potential and increased consumer choice from public research.
- Open science promotes public trust in science. Greater citizen engagement leads to active participation in scientific experiments and data collection.

Open Science Index

The Open Science Index (OSI) currently provides access to over thirty thousand full-text journal articles and is working with member and non-member organizations to review policies to promote and assess open science. As part of the open science philosophy, and by making open science a reality; OSI is conducting an assessment of the impact of open science principles and restructuring the guidelines for access to scientific research. As digitalization continues to accelerate science, Open science and big data hold enormous promise and present new challenges for policymakers, scientific institutions, and individual researchers.

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Open Society

An open society allows individuals to change their roles and to benefit from corresponding changes in status. Open science depends to a greater or lesser extent on digital technologies and innovations in structural processes by an open society. When realized, open science research and innovation can create investment opportunities for new and better products and services and therefore increase competitiveness and employment. Open science research and innovation is a key component of thematic open science priorities. Central to the open science digital infrastructure is enabling industry to benefit from digital technology and to underpin scientific advances through the development of an open society. Open science research and innovation can also contribute to society as a global actor because scientific relations can flourish even where global relations are strained. Open science has a critical role across many areas of decision making in providing evidence that helps understand the risks and benefits of different open science choices. Digital technology is making the conduct of open science and innovation more collaborative, more global, and more open to global citizens. Open society must embrace these changes and reinforce its position as the leading power for science, for new ideas, and for investing sustainably in the future.

It is apparent in open society that the way science works is fundamentally changing, and an equally significant transformation is taking place in how organizations and societies innovate. The advent of digital technology is making research and innovation more open, collaborative, and global. These exchanges are leading open society to develop open science and to set goals for research and innovation priority. Open science goals are materializing in the development of scientific research and innovation platforms and greater acceptance of scientific data generated by open science research. Open science research and innovation do not need help from open society to come up with great ideas, but the level of success ideas ultimately reach is undoubtedly influenced by regulation, financing, public support, and market access. Open society is playing a crucial role in improving all these success factors.

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Open science represents a new approach to the scientific process based on cooperative work and new ways of diffusing knowledge by using digital technologies and collaborative tools. These innovations capture a systemic change to the way science and research have been carried out for the last fifty years. Science is shifting from the standard practice of publishing research results in scientific publications after the research and reviews are completed. The shift is towards sharing and using all available knowledge at an earlier stage in the research process. Open science is to science what digital technology is to social and economic transactions: allowing end users to be producers of ideas, relations, and services and in doing so, enabling new working models, new social relationships and leading to a new modus operandi for science. Open science is as important and disruptive as e-commerce has been for the retail industry. Just like e-commerce, the open science research paradigm shift affects the whole business cycle of doing science and research. From the selection of research subjects to the carrying out of research, to its use and re-use, to the role of universities, and that of publishers are all dramatically changed. Just as the internet and globalization have profoundly changed the way we do business, interact socially, consume culture, and buy goods, these changes are now profoundly impacting how one does research and science.

The discussion on broadening the footprint of science and on novel ways to produce and spread knowledge gradually evolved from two global trends: Open Access and Open Source. The former refers to online, peer-reviewed scholarly outputs, which are free to read, with limited or no copyright and licensing restrictions, while open source refers to software created without any proprietary restriction and which can be accessed and freely used. Although open access became primarily associated with a particular publishing

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or scientific dissemination practice, open access already sought to induce a broader practice that includes the general re-use of all kinds of research products, not just publications or data. It is only more recently that open science has coalesced into the concept of a transformed scientific practice, shifting the focus of researchers' activity from publishing as fast as possible to sharing knowledge as early as possible. Open science is defined as the idea that scientific knowledge of all kinds should be openly shared as early as is practical in the discovery process. As a result, the way science is done in the future will look significantly different from the way it is done now. Open science is the ongoing evolution in the modus operandi of doing research and organizing science. This evolution is enabled by digital technology and is driven by both the globalization of the scientific community and increasing public demand to address the societal challenges of our times. Open science entails the ongoing transitions in the way research is performed, researchers collaborate, knowledge is shared, and science is organized.

Open science impacts the entire research cycle, from the inception of research to its publication, and on how this cycle is organized. The outer circle reflects the new interconnected nature of open science, while the inner circle shows the entire scientific process, from the conceptualization of research ideas to publishing. Each step in the scientific process is linked to ongoing changes brought about by open science, including the emergence of alternative systems to establish a scientific reputation; changes in the way quality and impact of research are evaluated; the growing use of scientific blogs; open annotation; and open access to data and publications. All institutions involved in science are affected, including research organizations, research councils, and funding bodies. The trends are irreversible, and they have already grown well beyond individual projects. These changes predominantly result from a bottom-up process driven by a growing number of researchers who increasingly employ social media in their research and initiate globally coordinated research projects while sharing results at an early stage in the research process.

Open science is encompassed in five schools of thought:

- the infrastructure school, concerned with technological architecture
- the public school, concerned with the accessibility of knowledge creation
- the measurement school, concerned with alternative impact assessment
- the democratic school, concerned with access to knowledge
- the pragmatic school, concerned with collaborative research

According to the measurement school, the reputation and evaluation of individual researchers are still mainly based on citation-based metrics. The h-index is an author-level metric that attempts to measure both the productivity and citation impact of the publications of a scientist or scholar. The impact factor is a measure reflecting the average number of citations to articles published in an academic journal and is used as a proxy for the relative importance of a journal.

Numerous criticisms have been made of citation-based metrics, primarily when used, and often misused, to assess the performance of individual researchers. These metrics:

- are often not applicable at the individual level
- do not take into account the broader social and economic function of scientific research
- are not adapted to the increased scale of research
- cannot recognize new types of work that researchers are performing

Web-based metrics for measuring research output, popularized as altmetrics, have recently received much attention: some measure the impact at the article level, others make it possible to assess the many outcomes of research in addition to the number of scientific articles and references. The current reputation and evaluation system has to adapt to the new dynamics of open science and acknowledge and incentivize

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engagement in open science. Researchers engaging in open science have growing expectations that their work, including intermediate products such as research data, will be better rewarded or taken into account in their career development. Vice-versa, the use, and reuse of open data will require appropriate codes of conduct requiring, for example, the proper acknowledgment of the original creator of the data.

These ongoing changes are progressively transforming scientific practices with innovative tools to facilitate communication, collaboration, and data analysis. Researchers that increasingly work together to create knowledge can employ online tools and create a shared space where creative conversation and collaboration can occur. As a result, the problem-solving process can be faster, and the range of problems that can be solved can be expanded. The ecosystem underpinning open science is evolving very rapidly. Social network platforms for researchers already attract millions of users and are being used to begin and validate more research projects.

Furthermore, the trends towards open access are redefining the framework conditions for science and thus have an impact on how open innovation is produced by encouraging a more dynamic circulation of knowledge. It can enable more science-based startups to emerge thanks to the exploitation of openly accessible research results. Open science, however, does not mean free science. It is essential to ensure that intellectual property is protected before making knowledge publicly available in order to subsequently attract investments that can help translate research results into innovation. If this is taken into account, fuller and broader access to scientific publications and research data can help to accelerate innovation. Investments that boost research and innovation in open science would benefit society with fewer barriers to knowledge transfer, open access to scientific research, and greater mobility of researchers. In this context, open access can help overcome the barriers that innovative organizations face in accessing the results of research funded by the public.

Open innovation

An open society is the largest producer of knowledge, but the phenomenon of open science is changing every aspect of the scientific method by becoming more open, inclusive, and interdisciplinary. Ensuring open society is at the forefront of open science means promoting open access to scientific data and publications alongside the highest standards of research integrity. There are few forces in this globe as engaging and unifying as science. The universal language of science maintains open channels of communication globally. Open society can maximize its gains through maintaining its presence at the highest level of scientific endeavor, and by promoting a competitive edge in the knowledge society of the information age. The ideas and initiatives described in this publication can stimulate anyone interested in open science research and innovation. It is designed to encourage debate and lead to new ideas on what and open society should do, should not do, or do differently.

An open society can lead to a research powerhouse; however, open society rarely succeeds in turning research into innovation and in getting research results to the global market. Open society must improve at making the most of its innovation talent, and that is where open innovation comes into play. The basic premise of open innovation is to open up the innovation process to all active players so that knowledge can circulate more freely and be transformed into products and services that create new markets while fostering a stronger culture of entrepreneurship. Open innovation is defined as the use of purposive inflows and outflows of knowledge to accelerate internal innovation. This original notion of open innovation was primarily based on transferring knowledge, expertise, and even resources from one company or research institution to another. This notion assumes that firms can and should use external ideas as well as internal ideas, and internal and external paths to market, as they seek to improve their performance. The concept of open innovation is continually evolving and is moving from linear, bilateral transactions and collaborations

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towards dynamic, networked, multi-collaborative innovation ecosystems. This means that a specific innovation can no longer be seen as the result of predefined and isolated innovation activities but rather as the outcome of a complex co-creation process involving knowledge flows across the entire economic and social environment. This co-creation takes place in different parts of the innovation ecosystem and requires knowledge exchange and absorptive capacities from all the actors involved, whether businesses, academia, financial institutions, public authorities, or citizens.

Open innovation is a broad term, which encompasses several different nuances and approaches. Two main elements underpin the most recent conceptions of open innovation: the users are in the spotlight and invention becomes an innovation only if users become a part of the value creation process. Notions such as user innovation emphasize the role of citizens and users in the innovation processes as distributed sources of knowledge. This kind of public engagement is one of the aims of open science research and innovation. The term 'open' in these contexts has also been used as a synonym for 'user-centric'; creating a well-functioning ecosystem that allows co-creation and becomes essential for open innovation. In this ecosystem, relevant stakeholders are collaborating along and across industry and sector-specific value chains to co-create solutions for socio-economic and business challenges. One important element to keep in mind when discussing open innovation is that it cannot be defined in absolutely precise terms. It may be better to think of it as a point on a continuum where there is a range of context-dependent innovation activities at different stages, from research to development through to commercialization, and where some activities are more open than others. Open innovation is gaining momentum thanks to new large-scale trends such as digitalization and the mass participation and collaboration in innovation that it enables. The speed and scale of digitalization are accelerating and transforming the way one designs, develops, and manufactures products, the way one delivers services, and the products and services themselves. It is enabling innovative processes and new ways of doing business, introducing new cross-sector value chains and infrastructures.

Open society must ensure that it capitalizes on the benefits that these developments promise for citizens in terms of tackling societal challenges and boosting business and industry. Drawing on these trends, and with the aim of helping build an open innovation ecosystem in open society, the open society's concept of open innovation is characterized by:

- combining the power of ideas and knowledge from different actors to co-create new products and find solutions to societal needs
- creating shared economic and social value, including a citizen and user-centric approach
- capitalizing on the implications of trends such as digitalization, mass participation, and collaboration

In order to encourage the transition from linear knowledge transfer towards more dynamic knowledge circulation, experts agree that it is essential to create and support an open innovation ecosystem that facilitates the translation of knowledge into socio-economic value. In addition to the formal supply-side elements such as research skills, excellent science, funding and intellectual property management, there is also a need to concentrate on the demand side aspects of knowledge circulation, making sure that scientific work corresponds to the needs of the users and that knowledge is findable, accessible, interpretable and reusable. Open access to research results aims to make science more reliable, efficient, and responsive and is the springboard for increased innovation opportunities, e.g. by enabling more science-based startups to emerge. Prioritizing open science does not, however, automatically ensure that research results and scientific knowledge are commercialized or transformed into socio-economic value. In order for this to happen, open innovation must help to connect and exploit the results of open science and facilitate the faster translation of discoveries into societal use and economic value.

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Collaborations with global partners represent important sources of knowledge circulation. The globalization of research and innovation is not a new phenomenon, but it has intensified in the last decade, particularly in terms of collaborative research, international technology production, and worldwide mobility of researchers and innovative entrepreneurs. Global collaboration plays a significant role both in improving the competitiveness of open innovation ecosystems and in fostering new knowledge production worldwide. It ensures access to a broader set of competencies, resources, and skills wherever they are located, and it yields positive impacts in terms of scientific quality and research results. Collaboration enables global standard-setting, allows global challenges to be tackled more effectively, and facilitates participation in global value chains and new and emerging markets.

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The scholarly research review is a multidimensional evaluation procedure in which standard peer review models can be adapted in line with the ethos of scientific research, including accessible identities between reviewer and author, publishing review reports and enabling greater participation in the peer review process. Scholarly research review methods are employed to maintain standards of quality, improve performance, provide credibility, and determine suitability for publication. *Responsible Peer Review Procedure:* Responsible peer review ensures that scholarly research meets accepted disciplinary standards and ensures the dissemination of only relevant findings, free from bias, unwarranted claims, and unacceptable interpretations. Principles of responsible peer review:

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Progressive Damage Analysis of Mechanically Connected Composites

Şeyma Saliha Fidan, Ozgur Serin, Ata Mugan

Abstract— While performing verification analyses under static and dynamic loads that composite structures used in aviation are exposed to, it is necessary to obtain the bearing strength limit value for mechanically connected composite structures. For this purpose, various tests are carried out in accordance with aviation standards. There are many companies in the world that perform these tests in accordance with aviation standards, but the test costs are very high. In addition, due to the necessity of producing coupons, the high cost of coupon materials, and the long test times, it is necessary to simulate these tests on the computer. For this purpose, various test coupons were produced by using reinforcement and alignment angles of the composite radomes, which were integrated into the aircraft. Glass fiber reinforced and Quartz prepreg is used in the production of the coupons. The simulations of the tests performed according to the American Society for Testing and Materials (ASTM) D5961 Procedure C standard were performed on the computer. The analysis model was created in three dimensions for the purpose of modeling the bolt-hole contact surface realistically and obtaining the exact bearing strength value. The finite element model was carried out with the Analysis System (ANSYS). Since a physical break cannot be made in the analysis studies carried out in the virtual environment, a hypothetical break is realized by reducing the material properties. The material properties reduction coefficient was determined as 10%, which is stated to give the most realistic approach in the literature. There are various theories in this method, which is called progressive failure analysis. Because the hashin theory does not match our experimental results, the puck progressive damage method was used in all coupon analyses. When the experimental and numerical results are compared, the initial damage and the resulting force drop points, the maximum damage load values, and the bearing strength value are very close. Furthermore, low error rates and similar damage patterns were obtained in both test and simulation models. In addition, the effects of various parameters such as pre-stress, use of bushing, the ratio of the distance between the bolt hole center and the plate edge to the hole diameter (E/D), the ratio of plate width to hole diameter (W/D), hot-wet environment conditions were investigated on the bearing strength of the composite structure.

Keywords— puck, finite element, bolted joint, composite.

Connected Care Medical Module: Transforming Healthcare on Earth and in Space

Annie Martin, Tristan Richmond, Charlotte Pearce

Abstract— The Canadian Space Agency's (CSA) Health Beyond Initiative aims to collaboratively identify and develop innovative and sustainable medical solutions in order to improve the healthcare delivery model currently used in low-Earth orbit and address the additional and heightened healthcare challenges to be faced by astronauts traveling to farther destinations. The transformative approach proposed with the Connected Care Medical Module (C²M²) is one that is predictive, proactive, and that increases on-site medical capacity and autonomy. The C²M² will include a core computer-based system to facilitate the incorporation, interconnection, and utilization of the latest medical technologies. The system's plug and play architecture will enable the C²M² to operate in multiple configurations and adapt to the end users' needs. These cutting-edge medical technology incorporated in the C²M² will increase the user's capacity to independently detect, diagnose, treat, and/or monitor health conditions on-site. This aims to improve the timeliness, quality, and continuity of care; to refine clinical decision-making, and to reduce the occurrence of risky and expensive medical evacuations. The objective is to equip and empower crews to manage their health throughout long duration missions to distant destinations. With strategic national and international actors, the co-creation, co-operation, and co-iteration of such a novel healthcare approach will primarily occur on Earth to prepare for eventual implementation in deep space missions. This will dually serve to address today's inequalities in healthcare access across Canada and demonstrate capabilities to international space partners. This paper focuses on the flexible framework approach of the C²M²; the first prototypes delivered to the CSA in 2023, and how CSA is envisioning the development of a deep space healthcare system.

Keywords— human spaceflight, integrated medical system, medical autonomy, exploration.

Machine Learning Algorithms for Rocket Propulsion

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Abstract— In recent years, there has been a surge in interest in applying artificial intelligence techniques, particularly machine learning algorithms. Machine learning is a data-analysis technique that automates the creation of analytical models, making it especially useful for designing complex situations. As a result, this technology aids in reducing human intervention while producing accurate results. This methodology is also extensively used in aerospace engineering since this is a field that encompasses several high-complexity operations, such as rocket propulsion. Rocket propulsion is a high-risk operation in which engine failure could result in the loss of life. As a result, it is critical to use computational methods capable of precisely representing the spacecraft's analytical model to guarantee its security and operation. Thus, this paper describes the use of machine learning algorithms for rocket propulsion to aid the realization that this technique is an efficient way to deal with challenging and restrictive aerospace engineering activities. The paper focuses on three machine-learning-aided rocket propulsion applications: set-point control of an expander-bleed rocket engine, supersonic retro-propulsion of a small-scale rocket, and leak detection and isolation on rocket engine data. This paper describes the data-driven methods used for each implementation in depth and presents the obtained results.

Keywords— *data analysis, modeling, machine learning, aerospace, rocket propulsion*

List of Abbreviations and Acronyms

- *AI—Artificial Intelligence*
- *BPV—Bypass Valve*
- *CFD—Computational Fluid Dynamics*
- *DRTM—Detailed Real-Time Model*
- *FCV—Fuel Control Valve*
- *FEM—Finite Element Method*
- *HPDD—Hierarchical Physics Data-Driven*
- *INJ—Injection*
- *LNG—Liquefied Natural Gas*
- *LOX—Liquid Oxygen*
- *LPRE—Liquid Propellant Rocket Engine*
- *LUMEN—Liquid Upper Stage Demonstrator Engine*
- *MCC—Main Combustion Chamber*
- *MFV—Main Fuel Valve*
- *ML—Machine Learning*
- *MOV—Main Oxidizer Valve*
- *NASA—National Aeronautics and Space Administration*

- *NEM—Nozzle Extension*
- *NN—Neural Network*
- *OCR—Optical Character Recognition*
- *OCV—Oxidizer Control Valve*
- *OL—Open-Loop*
- *PCA—Principal Component Analysis*
- *RF—Random Forest*
- *RL—Reinforcement Learning*
- *SRP—Supersonic Retro-Propulsion*
- *TFV—Turbine Fuel Valve*
- *TOV—Turbine Oxidizer Valve*
- *VfR—Verein für Raumschiffahrt (Society of Space Travel)*

I. INTRODUCTION

Science and technology have shown expeditious development in recent years, mainly due to the increasing application of artificial intelligence (AI) in new development opportunities. AI is a science frequently studied and applied by many researchers, especially when the objective is to make computers automatically extract information from data with minimum human intervention. This extraction is possible through a data-analysis method known as machine learning [1], [2].

Machine learning (ML) techniques employ algorithms that can learn from data and make data-driven predictions and decisions. This method helps develop models that detect anomalies directly from data rather than relying on human expertise. It is also a branch of artificial intelligence that combines theoretical knowledge from various disciplines, such as statistics and algorithm complexity [1], [3], [4].

ML is also extensively used for applications in aerospace engineering, mainly for the propulsion of complex engineering systems, such as spacecraft. Rocket propulsion is a high-risk operation in which engine failure could result in the loss of life [3], [5]. Therefore, it is critical to use computational methods that accurately represent the spacecraft's analytical model to guarantee its security and operation.

This data-driven method can effectively execute numerous aerospace engineering activities. One prominent example is the detection of leaks (anomalies) in sensor data of rockets. ML helps automate this detection; this fact is crucial for at least three reasons. First, detecting leaks in near-real-time during launch can help make pivotal choices, such as choosing

whether to halt the launch of a rocket before reaching the expected altitude. Second, in the case of reusable spacecraft (e.g., Space Shuttle), discerning leaks in registered sensor data can help ascertain what maintenance to apply or not before the next departure. Third, detecting constant leaks in historical data covering a sequence of flights can create engineering knowledge that can result in design improvements [3], [6], [7].

Furthermore, ML is also useful for performing other restrictive activities in aerospace engineering, such as the control of expander-bleed rocket engines [8] or the operation of a rocket's supersonic retro-propulsion [5].

Thus, the objective of this paper is to describe the usage of machine learning algorithms for rocket propulsion, to facilitate the realization that this technology is an effective tool for dealing with challenging and restrictive activities related to aerospace engineering.

The remainder of this article divides itself into the following sections. Sec. II describes the history of the development of apparatus based on rocket propulsion. Section III discusses machine learning, covering some of its main tasks, scenarios, and algorithms. Sec. IV defines existing ML activities for rocket propulsion; the section also shows the obtained results. At last, Section V provides a few concluding remarks and future directions for this work.

II. HISTORY OF ROCKET PROPULSION

The third law of motion, which states that "for every action, there is an equal and opposite reaction" is the basis for the rocket's reaction mechanism. Although not all reaction devices are rockets, a missile is a type of reaction device. In contrast to conventional jet propulsion systems, which require atmospheric air to function, a rocket engine carries all the required components, including fuel and oxygen. Because of these features, rockets function effectively in space travel, enabling humans to complete important interplanetary missions like visiting the Moon or launching robotic spacecraft around the solar system [9], [10].

Much earlier than Newton's period, however, the rocket theory has been understood for a very long time. Hero of Alexandria (sometime around 67 AD), an Egyptian mathematician and inventor who created numerous devices involving water, air pressure, and steam, made the initial discovery of this theory. He created the *aeolipile* (Fig. 1), a device that consisted of a metal boiler that produced steam, a pipe connected to a radial steam turbine with two opposing nozzles, and a spinning joint. Two opposed jets are produced by the steam that exits via each nozzle, spinning the device. Although it is unclear whether Hero realized the reason for the rotation, the *aeolipile* is the first device to demonstrate the basis of reactive thrust, which is the foundation of rocket propulsion [11]–[13].

However, actual rockets were created by the Chinese around the tenth century AD, during gunpowder and bamboo experiments. Gunpowder was discovered in the ninth century AD by a Taoist alchemist. Following that, Feng Jishen (sometime around 970 AD) shot a rocket using gunpowder and bamboo, becoming the first rocket propulsion system to leave the terrain. This rocket came in two varieties. The first was a bamboo pipe filled with gunpowder with a small gap on the back end, as shown in Fig. 2(a). When the gunpowder caught fire, high-pressure hot gas was expelled from the small gap erratically. The second was also a gunpowder-weighted

bamboo rocket, but like modern fireworks, it had a bamboo stick attached for stability, as seen in Fig. 2(b) [12], [13].



Fig. 1. Hero's *Aeolipile* [11].

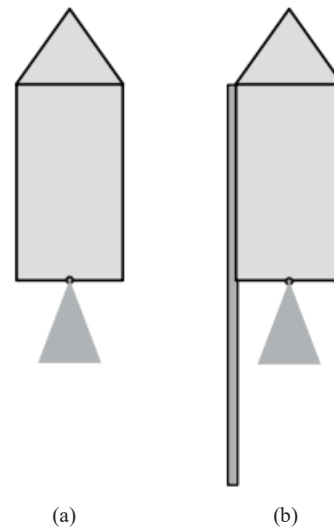


Fig. 2. Depiction of (a) a bamboo rocket and (b) a bamboo rocket with a stick [13].

It is also believed that during this time, a Chinese mandarin named Wan Hu invented a bamboo sleigh with 47 rockets attached to the seat. His goal was to see the moon rise and then ascend into heaven. To be more specific, he had directed his servants to transport him, seated on his throne, to a mountain ridge where he could observe the ascending Moon. His retainers then strung kites and strings of many gunpowder-loaded rockets to the bamboo sled. After receiving the order from Wan Hu, his servants lit the fuse and fled to safety. Unfortunately, this procedure resulted in his death due to a rocket explosion [12]–[14].

Later, these initial rockets developed further, used as lethal weapons in eastern wars. Kublai Khan used gunpowder artillery to win the battle against Japan in 1275. Around the thirteenth century, these rockets were bombardment weapons used in western countries such as Spain, usually brought by Arab and Mongol hordes [12], [13].

Eventually, similar metal equipment was used throughout wars in India, predominantly by the Mughals and Marathas [13].

In the seventeenth century, the kings of Mysore, Tipu Sultan and his father, Hyder Ali, used military rockets against the British army in India. They were the first to develop such missiles. The battalion of Tipu Sultan had 5000 rocketeers, accounting for roughly one-seventh of the overall strength of

this army. His rockets came in a wide range of sizes, the most common being a pipe made of soft hammered iron 20 cm long and 3.8 to 7.6 cm wide, closed at one edge, and strapped to a bamboo shaft 120 cm long. The gunpowder was tightly packed inside the iron pipe, which acted as a combustion chamber. A rocket could reach a height of 910 m with 0.45 kg (1 lb) of this ammunition. These early rockets had swords, a variety of pointy things, and a tall peak, allowing them to travel long distances and climb several meters into the atmosphere before crashing down on their enemies. The attacks of Tipu Sultan against the British army were very effective due to the sheer strength of this rocket arsenal [10], [12], [13], [15].

Following the battle against Tipu Sultan, the British army seized the rockets used in the Mysore war and reverse-engineered them. The army, led by Sir William Congreve, gained battle experience, and began developing several military missiles, using them in the twentieth century. The weight of these missiles ranged from 8 to 136 kg. Throughout the Napoleonic Wars, these rockets hit the French coast in 1812. By the nineteenth century, the Royal Navy of the United Kingdom had a fleet of battleships armed with rocket artillery. During the War of 1812 (Second War of American Independence), one of these warships bombarded the siege of Fort McHenry in America; the rockets used by these ships appear in the song "the rocket's red glare.". Rockets became popular as signals around the same time, being helpful in various tasks, including carrying lines between ships and rescuing shipwrecked people, the latter being a role in which the rockets still are used [10], [12]–[14].

Several researchers worked on developing the technology behind solid-propellant rockets up to the twentieth century. During World War I, many countries accelerated the development of these rocket engines, intending to win the battle. For the first time, aircraft fired rockets to bring down gas-filled hydrogen balloons used to transport armies. It has been discovered around this time that solid fuels are difficult to control. Hence, researchers all over the world began serious experiments devoted to the development of liquid fuel-fired rocket engines [13].

A Russian mathematics professor named Konstantin Tsiolkovsky (1857-1935) was the first to introduce the concept of a liquid propellant rocket engine (LPRE) and several other aspects of space travel. Tsiolkovsky may have begun to consider the physics of rocket-powered space navigation as early as the 1870s. He began publishing his discoveries in obscure Russian journals before the end of the nineteenth century. In his articles, Tsiolkovsky discussed the capabilities of various rocket fuels, the foundation of the multi-stage rocket (which allows the spacecraft to discard excess weight as it rises), and the concept of an orbiting space station. He also developed the rocket equation and described how rocket propulsion works in spaceflight. Thus, his writings had a mathematical approach. Tsiolkovsky, on the other hand, never experimented with rockets; his work was almost entirely theoretical. He discovered that exhaust velocity was the most significant parameter. More specifically, he found that higher temperatures and lower molecular weights produced by liquid fuels are essential in obtaining high exhaust velocity; he identified liquid oxygen and hydrogen as appropriate spacecraft fuels [12]–[14].

The research performed by Tsiolkovsky influenced many scientists and engineers around the world. Hermann Oberth

(1894-1992), a Romanian of German ancestry, was one of them. In 1923, he published *The Rocket into Interplanetary Space*, his (rejected) doctoral dissertation. In his thesis, he investigated the use of rockets for space navigation, also covering the design of liquid-propellant engines that used alcohol and liquid oxygen. Oberth, like Tsiolkovsky, used a mathematical approach in his analysis and never conducted rocket tests at the time. The book was a best-seller and inspired many newcomers to rocketry in Germany; they established several amateur rocket corporations. The *Verein für Raumschiffahrt* (VfR), to which Oberth donated the award money he received for a later book, was the most significant of these. Werner von Braun discovered the book published by Oberth, which sparked his interest in rocket propulsion in 1925. Von Braun later became a VfR representative and assisted Oberth in his research [12]–[14].

During World War II, Russia and Germany were more advanced in rocketry than other countries, particularly Germany. As a result, the German army began noticing several amateur rocket corporations around 1932; they quickly came under pressure and began applying their expertise to the military scope. Von Braun was among the enthusiastic researchers who decided to join the military research station at Peenemuende. In December 1934, he invented an A-2 rocket powered by ethanol and liquid oxygen, which became his first rocket achievement. Von Braun and his research team conducted numerous tests on new rocket configurations between 1934 and 1941, with incremental progress. After several trials and errors, they created the first rocket capable of flying above the atmosphere and into space, the A-4 rocket engine, also known as the V-2 (vengeance weapon number two). It was the first practical and reproducible liquid-fueled rocket, with liquid oxygen and ethyl alcohol in water as the primary fuel. The V-2 launched from Peenemuende on October 3, 1942. With a fueled mass of 14000 kg and a height of 15 m, the rocket could travel 400 m and reach an altitude of 100 m. The missile successfully followed its trajectory, landing at a destination 193 km away from its initial point. This rocket reached its target at a supersonic speed of around 5000 km/h. Due to WWII, Von Braun and his team did not launch the V-2 for interplanetary missions but for military purposes. More specifically, the first V-2s (Fig. 3) crashed into London, causing extensive property damage and casualties [9], [12]–[14].

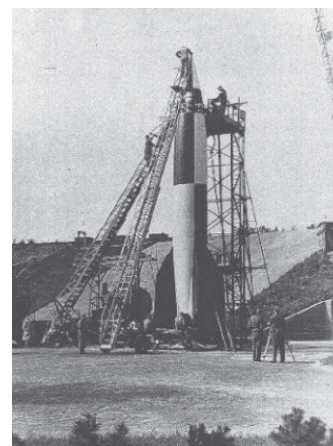


Fig. 3. German V-2 on rocket platform [14].

A-10, an enlarged version of the V-2, was being designed near the end of WWII. The A-10 would propel a hypersonic

bomber above the upper atmosphere. It could bombard Manhattan as early as 1946 or 1947, more than five decades before the September 11, 2001, terrorist attacks [14].

However, the US had a rocketeer who could oppose the A-10. Robert Goddard (1882-1945) was a physics professor at Clark University in Massachusetts who began experimenting with rockets soon after World War I. Goddard began his research in 1909, focusing on the theory of multi-stage rockets. Starting in 1914, he received numerous patents on the design of liquid-fueled rocket combustion chambers and nozzles, eventually receiving 214 patents on rocket apparatus. However, Goddard is best known for his empirical work. In 1919, he published an essay titled *A Method of Reaching Extreme Altitudes*, which covered the theory of rockets plus the detailed designs and experimental data from his testing. He also discusses the feasibility of launching an unpowered spacecraft to the Moon at the end of this essay. His rocket apparatus covered many aspects critical for modern spacecraft, such as gyroscope-aided navigation, engine activation or deactivation by controlling valves in the propellant lines, fuel delivery to the combustion chamber via turbo-pumps, and exhaust nozzle cooling via liquid oxygen. Goddard launched his first liquid-propellant rocket from Auburn, Massachusetts, on March 16, 1926. It weighed 5 kg, was propelled by liquid oxygen and gasoline, and reached an altitude of 12.5 m. He was later thrown out of Massachusetts by a firefighter due to his rocket experiments. However, he continued his work in New Mexico, establishing a launch facility funded by the Guggenheim Foundation. Throughout the 1920s and 1940s, he conducted increasingly refined liquid-propellant rocket experiments. During those tests, Goddard built a rocket that reached an unprecedented altitude of 3000 m. The US government paid two million dollars for his patents in 1960. Even though he could not fully implement his ideas before his death in 1945, his practical work contributed significantly to American rocketry advancement [12]–[14].

Following WWII, the rivalry between the United States and the Soviet Union intensified. More specifically, Russians and Americans stole the V-2 technology, which developed their space program at the time. There were two main experiments involving V-2 technology in the United States. The first was the attachment of a top stage to a captured German V-2 (Fig. 4). It soared to 400 km in altitude. The second was the development of the Viking (Fig. 5), a V-2 derivative that served as a prototype for the rockets that eventually carried American satellites into space [13], [14].

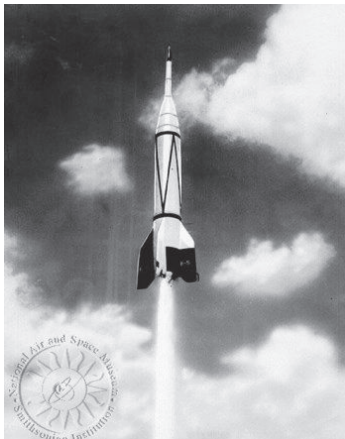


Fig. 4. A two-stage V-2, sent by the United States after WWII [14].

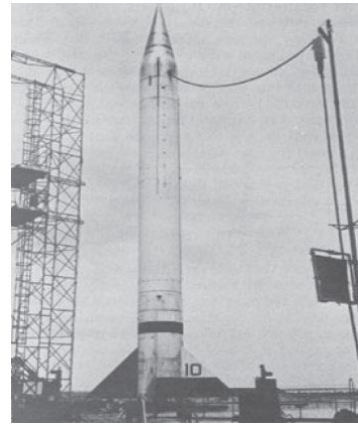


Fig. 5. A American V-2 derivative: the Viking [14].

However, the Americans and Russians later ignored the German V-2 rocket technology to develop their design for the next generation of spacecraft. The Russians launched their first satellite, Sputnik 1, into orbit in 1957 and the first man, Yuri Gagarin, into space on April 12, 1961. Following that, on July 20, 1969, American engineers and scientists landed on the moon as part of the NASA Apollo 11 mission, making space travel history. Later, other nations and corporations (e.g., European Space Agency, Japan, France, China, India, and Israel) advanced their space programs, developing more extensive and more advanced chemical spacecraft [13], [14].

III. PRINCIPLES OF MACHINE LEARNING

Machine learning (ML) is a broad term for computational techniques that use the experience to improve performance and predict outcomes. In this case, *experience* represents the prior knowledge of the learner (learning algorithm), typically converted into acquired data and made available for analysis. The information gathered could assume the structure of human-labeled training sets or other types of data obtained through interaction with the environment. In all scenarios, the quality and quantity of data are important factors that influence the prediction accuracy of the learner. This data-driven method makes it easier to solve problems by generating a model that accurately represents a given dataset. As a result, many disciplines (e.g., information technology, statistics, probability, artificial intelligence, psychology, and neurobiology) began to use this science to facilitate the solving of problems [16], [17].

Additionally, the dataset of a typical ML model usually divides itself into two subsets: training and testing data [17]. Training data trains an ML model, whereas testing data assess its precision, i.e., testing data certifies if the model works properly with previously unseen data.

Furthermore, ML entails developing algorithms that enable computer learning, which involves discovering mathematical regularities or other data arrangements. These algorithms represent the human approach to learning tasks. They can also provide insight into the relative difficulty of learning in various environments [17]. It is possible to select an algorithm by considering some factors, such as the type of data on the dataset (which can have labeled data, unlabeled data, or both); the quantity and quality of data; the learning task; among others.

The following subsections will describe the most relevant topics related to machine learning. These subsections will cover the most significant ML tasks, scenarios, and algorithms.

A. Basic Machine Learning Tasks

The following topics covers some fundamental machine learning tasks that have been extensively studied [16]:

1) *Classification*: this is the problem of assigning a group per item. There are various classification tasks, such as document classification (designating a group like politics, business, sports, or weather for each document) or image classification (selecting a group like a car, train, or plane for each image). The number of groups in these tasks is typically less than a few hundred, excluding some complex classification tasks (e.g., OCR, text classification, or speech recognition), where the number can be much higher, if not limitless.

2) *Regression*: this is the problem of predicting an actual value per item. The prediction of stock prices or changes in economic variables can be considered an example of a regression task. In these tasks, the absolute value of the difference between the true and predicted values represents the penalty for an incorrect prediction. This situation differs from the classification problem, in which there is usually no concept of proximity between numerous groups.

3) *Ranking*: this is the problem of learning to order items by following some principles. One prominent example of a ranking task is an online search, which returns web pages significant to a search query. Several other analogous ranking problems appear in the background of the design of information extraction or natural language processing systems.

4) *Clustering*: this problem is the process of dividing groups of items into homogeneous subgroups. This task helps examine large data sets, such as those used in social network analysis, where clustering algorithms try to determine natural communities in large populations.

5) *Dimensionality Reduction or Manifold Learning*: this problem entails reconstructing an initial depiction of items into a lower-dimensional one, albeit retaining a few attributes of the original one. In the background of computer vision, the preprocessing of digital images is a typical example of a dimensionality reduction task.

B. Standard Machine Learning Scenarios

The field of machine learning is comprised by various scenarios, which differ in the types of training data accessible to the learner; the order and manner through which training data is obtained; and the testing data utilized to assess the learner [16].

The subsequent topics describes some standard scenarios in machine learning.

1) *Supervised Learning*: This machine learning scenario involves learning a function that maps inputs to outputs based on input-output couples. Supervised learning depends on external assistance. Furthermore, this scenario divides into two steps: training and testing. During training, the learner infers (approaches the behavior of) the function after receiving labeled training data consisting of several training

samples (input-output couples). During testing, the learner admits testing data as input and executes the studied function to generate the expected label. It is possible to apply this scenario to regression, classification, or ranking tasks. Regression labels are continuous, and the model (also known as a *regression model*) maps the input space into a real-value domain. Classification labels are discrete, and the model (also known as a *classification model* or *classifier*) maps the input space (which takes the form of a feature vector) into previously defined groups [16]–[18].

2) *Unsupervised Learning*: This machine learning scenario entails predicting unseen points using only unlabeled data. As a result, there is no outside assistance involved. It diverges from the supervised learning scenario, in which a task, like classification or regression, is learned using a set of human-prepared examples. Because there is usually no labeled example accessible to the learner, assessing its operation can be challenging. Examples of unsupervised learning problems include clustering and dimensionality reduction [16], [19].

3) *Reinforcement Learning*: The training and testing stages merge in Reinforcement Learning (RL). This scenario entails the interaction of two schematic blocks: the agent and the environment. The agent attempts to solve its assigned task through interactions with the environment. More specifically, the agent, after receiving the present state of the system, learns a decision rule (policy) that generates an action. The action changes the system state, and the agent receives a reward depending on the quality of the pre-executed action. When this scenario uses a deep neural network algorithm (discussed in subsection C) as the agent, it is known as Deep Reinforcement Learning [8], [16].

C. Analysis of Commonly Used Algorithms in Machine Learning

The machine learning field encompasses various types of algorithms. They could be parametric or non-parametric. A parametric algorithm simplifies the function to a known structure, whereas a non-parametric algorithm makes no significant suppositions about its form. Examples of parametric algorithms include Linear Regression and Logistic Regression, whereas Support Vector Machines, Decision Trees, and Neural Networks are examples of non-parametric algorithms [20].

To describe, in greater detail, the actions performed by some of these algorithms, the following topics will cover a few commonly used algorithms in machine learning:

1) *Decision Tree*: This is a non-parametric supervised ML algorithm for classification and regression. It presents a model as a recurring division of the instance space. A Decision Tree is a rooted tree comprised of the following: a root node (a node with outgoing edges but no ingoing edges), internal or test nodes (nodes with both ingoing and outgoing edges), and leaf nodes (nodes with ingoing edges, but no outgoing edges). Each internal node divides the instance space into two or more sub-spaces. Each test node examines an individual attribute, so the instance space is divided based on its value (in classification) or range of values (in regression). The Decision Tree is a top-down algorithm, i.e., classifying instances is possible by navigating them from the

root node to the leaf nodes; based on the results of the test nodes along the path. Thus, this method helps process data calculation [1], [17], [20].

2) *Random Forest*: This is a supervised ML algorithm composed of several decision trees. It is part of a class of ML methods known as ensemble methods, which employ multiple ML algorithms to enhance processing and predictive precision. If every tree is an individual subset a_i ($i = 1, 2, 3, \dots, n$), the Random Forest is the entire set $A = a_1, a_2, a_3, \dots, a_n$, where $a = 1, 2, 3, \dots, n$. This algorithm is applicable for both regression and classification, which means that every one of its trees can produce either a continuous or a discrete response (class). Two methods for obtaining the final prediction are: averaging and voting. For the averaging process, the responses are continuous; it involves unweighted averaging of these to produce the final prediction. For the voting process, the responses are discrete; it involves unweighted voting of these to select the final result (i.e., the most frequently predicted class) [1], [21].

3) *Principal Component Analysis*: This ML algorithm uses an orthogonal transformation to transform a group of presumably correlated variables into a group of linearly uncorrelated variables. These uncorrelated variables are known as principal components. The Principal Component Analysis (PCA) is applicable for the dimensionality reduction task, which lessens the data dimension to allow for simpler and faster computations. It is employed to analyze the variance-covariance form of a group of variables by using linear combinations [18].

4) *Neural Network*: A Neural Network (NN) is an ML algorithm influenced by the operation of organic brains, consisting of several organic neurons that control human and animal behavior. The model divides into three layers: the input layer, the hidden layer, and the output layer. Each layer contains a grouping of artificial neurons, which are the primary units of a NN. Furthermore, artificial neurons entail nonlinear functions acting on the weighted sum of the inputs. After receiving enough parameters, the model can accurately express any continuous expression. The use of multiple hidden layers improves the model's performance. Each layer aids in obtaining progressively abstract attributes and, as a result, more appropriate depictions of the input data. A deep NN has more than one hidden layer, possessing algorithms called deep learning algorithms. Furthermore, Deep Reinforcement Learning combines deep NNs (also known as *deep learning*) and RL [1], [4].

IV. MACHINE LEARNING ACTIVITIES FOR ROCKET PROPULSION

Algorithms for machine learning are also crucial in aerospace engineering, where they aid in the control of multiple complex engineering systems, including a spacecraft. Thereby, ML techniques avert potential mistakes in the rocket engine (e.g., engine component destruction or thermoacoustic instabilities), which ensures the safety and performance of the spacecraft [3], [8].

Moreover, machine learning methods are less taxing than other computational methods, including elevated computational fluid dynamics (CFD) or the finite element method (FEM), which require much higher calculation effort.

The work needed to build a model significantly reduces when applying ML algorithms [4].

To provide additional clarity on the machine learning applications for rocketry, the subsequent subsections will encompass a few linked ML activities that occurred in recent years.

A. Set-Point Control of an Expander-Bleed Rocket Engine Using Deep Reinforcement Learning

The authors K. Dresia, G. Waxenegger-Wilfing, R. Hahn, J. Deeken and M. Oschwald [8] simulated the performance of an expander-bleed rocket engine by using a deep reinforcement learning method. In this case, the agent is a deep NN computed by the simulation environment EcosimPro/ESPSS. The test case in question is the LUMEN (Liquid Upper Stage Demonstrator Engine) engine demonstrator, a breadboard engine with an expander-bleed cycle in the 25 kN thrust class. It uses liquid oxygen (LOX) as an oxidizer and liquefied natural gas (LNG) as fuel. The engine is at the P8.3 test stand in Lampoldshausen.

The main objective is to control the chamber pressure and mixture ratio. The intention is to steer the engine to several set points without overshooting and, afterward, to retain the set point with a minimum steady-state error. Furthermore, it is crucial to establish limits to various mechanical and thermodynamic parameters. These constraints help avoid ruining components or causing thermoacoustic instabilities.

Fig. 6 shows a schematic representation of the LUMEN engine, which combusts LOX and LNG during an expander-bleed loop. The nominal combustion chamber pressure of the engine is 60 bar, whereas its nominal mixture ratio is 3.4.

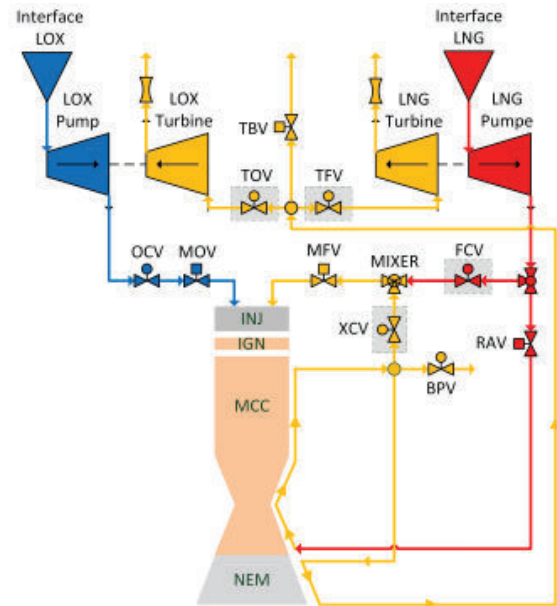


Fig. 6. LUMEN engine schematic [8].

The LNG pump begins the cycle by pumping the fuel through cooling tunnels. The LNG is then divided, with a fraction cooling the combustion chamber wall (in the opposite fuel-flow direction). Following that, the heated cooling mass flow partially merges with the main mass flow (via the mixer) to regulate the temperature of the LNG injection (INJ). Subsequently, the remaining mass flow enters the nozzle

extension (NEM), heating further. After that, the mass flow divides between the LNG and LOX turbines. Finally, without passing through the main combustion chamber (MCC), the turbine exhausts are ventilated.

Instead of having fixed apertures at various positions, the LUMEN engine demonstrator has electrically activated valves. When compared with other similar rocket engines, this engine offers a higher number of engine control options.

The main fuel and oxidizer valves (MFV and MOV) remain open during the simulation. The turbine fuel and oxidizer valves (TFV and TOV) split the liquefied natural gas between the LNG and LOX turbines. FCV and OCV are fuel and oxidizer control valves, respectively. The MFV and XCV (positioned near the mixer) regulate the temperature and stress in the cooling passageways. The BPV is a bypass valve that ejects LNG after wall cooling (something that lessens mass flow), and it is only needed if the necessary quantity of mass flow is higher than the current amount of mixed flow. As a result, BPV successfully controls the quantity of LNG inside the nozzle extension per the necessities of the turbines. TBV is a safety valve only used in the event of an emergency closure; it vents the warmed methane and rapidly reduces turbine power. Because of these characteristics, the LUMEN configuration can withstand high-stakes conditions in the cooling tunnels.

Concerning the NN controller results, the authors compared these with simple open-loop (OL) sequence results. The OL sequence linearly operates the valves through 0.5 s between steady-state valve positions. When compared to the OL sequence, Fig. 7 shows that the NN controller is considerably quicker at reaching the points of reference. For instance, whenever the main pressure points alter from 60 bar to 80 bar and from 80 bar to 40 bar, the NN controller takes less than 2 seconds to reach a steady-state combustion chamber pressure. On the other hand, the OL sequence moves at a much slower pace. For example, when the pressure changes from 80 bar to 40 bar, the sequence requires more than 10 seconds to adjust the chamber pressure and mixture ratio until they are nearly steady state.

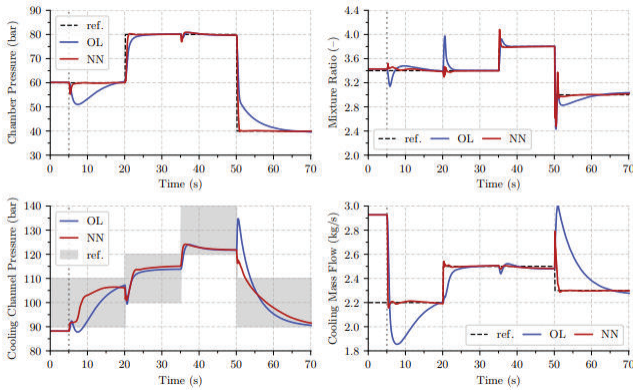


Fig. 7. Comparison of results obtained in the neural network controller and in the open-loop sequence [8].

B. Supersonic Retro-Propulsion of a Rocket Using a Physics-Embedded Neural Network

The authors D. Wu, W. Chung, and M. Ihme [5] reproduced the supersonic retro-propulsion (SRP) of a small-scale rocket engine, which is a category of motorized descent that utilizes rocket propulsion against free-stream flow, in

order to brake the spacecraft. The ML method used involves a physics-embedded NN regression model. This model is comprised of a data-driven model (NN feed-forward residual model, which enables less calculations by jumping over some layers) and a physics-embedded reduced-order model. The test case utilized was an engine from the NASA Langley Unitary Plan Wind Tunnel, possessing a dataset of 2500 points. The data consisted of 168 features θ (67 independent features plus 101 engineered features), and 125 measurements.

The flight-relevant parameters considered in [5] were the following: Mach number M , total thrust coefficient of rocket jet C_{TJ} , nozzle configuration $c_{\phi qe}$, angle of attack α , side-slip angle β , free-stream stagnation pressure $P_{T\infty}$, free-stream static pressure P_{∞} , free-stream static temperature T_{∞} , free-stream post-normal shock stagnation pressure P_{T2} , and free-stream Reynolds number Re_{∞} .

The main objective is to determine the quantity C (coefficient of aerodynamic axial force), which entails plume physics, plume-aerodynamics interaction, and sensitivities. To accurately predict this quantity, the sole application of an NN model might not be sufficient, due to certain limitations, such as small interpretation capacity or difficulty in generalizing challenges that are outside the offered data space. Therefore, a hierarchical physics-embedded data-driven (HPDD) frame is introduced. The frame blends ML with physics concepts, and can be represented in the following manner:

$$F(\theta_p, \theta_c, \theta_u) = \mathcal{P}(\theta_p) * \mathcal{C}(\theta_c) * \mathcal{U}(\theta_u) \quad (1)$$

where \mathcal{P} is a physics-embedded reduced-order model which defines plume-interaction and coalescence, \mathcal{C} is a coupling function that utilizes a NN to model non-linear phenomena and is comprised of ML algorithms, and \mathcal{U} is an uncertainty model that enhances the interpretation capacity of F . Concerning the inputs, the task is to discover the most likely parameters that belong to θ_p and to θ_c , in such a way that $\theta_p \subset \theta_c \subset \theta$. It is not necessary to determine the parameters associated with θ_u , because the intention is for these to be used in forthcoming (and possibly more advanced) wind tunnel experiments, that will reduce uncertainties present in the current frame F .

The next step is to analyze situations in which the rocket is on or off. This can be done by transforming (1) into an additive HPDD model for C :

$$C = \frac{C_0 + C_{SRP}}{\mathcal{P}(\theta_p)} + \frac{C_{NN}}{\mathcal{C}(\theta_c)} \quad (2)$$

where C is the summation of a zero thrust vehicle model C_0 (rocket off), a SRP model C_{SRP} (rocket on), and a NN residual regression model C_{NN} . The structure of (2) helps analyze the assistance of each model and enables gaining comprehension into how turning the rocket alters C .

As mentioned previously, one step to determining C entails determining the parameters likely to correspond to θ_p and to θ_c . This enables the characterization of \mathcal{P} and \mathcal{C} . To identify θ_p , it was used three algorithms: Principal Component Analysis (PCA) with 3 principal components to recognize correlations in the input space, correlation heatmap to measure the connection strength between inputs and outputs, and Random Forest (RF) with 200 trees to measure input significance. It was then determined that $\theta_p = \{M, C_{TJ}, c_{\phi qe}, \alpha\}$. For θ_c , [5] states that physical knowledge

from literature helps conclude that $\theta_c = \{M, C_{TJ}, c_{\phi_{qe}}, \alpha, \beta, P_{T\infty}, P_{\infty}, T_{\infty}, P_{T2}, Re_{\infty}\}$. Thus, it is now possible to express the HPDD model in terms of these parameters:

$$C = \underbrace{\frac{4 \tan(\delta)}{\gamma M^2} \left(\frac{2\gamma M^2 - (\gamma - 1)}{\gamma + 1} - 1 \right) \cos^{1.3}(\alpha)}_{\text{Zero thrust vehicle model } C_0} \quad (3)$$

$$+ \underbrace{\frac{L}{1 + e^{-k(C_{TJ} - x_0)}}}_{\text{Model with SRP } C_{SRP}} + \underbrace{C_{NN}(\theta_c)}_{\text{NN residual}}$$

Concerning the expressions of C_0 and C_{SRP} , the former revolves around practical structures from literature, whereas the latter uses concepts of plume structure transition physics, which indicates the logistic function as the adequate function for fitting. Regarding C_{NN} , its values were estimated by using Keras (an open-source NN library); it trained a feed-forward NN residual model after receiving θ_c as input.

The event of curved shocks is considered, by using data to fit $\delta = \phi_r^\circ + 0.372M^2 - 3.467M - 38.422$, in which ϕ_r is the half-angle of rocket forebody. γ is the ratio of specific heats, with a constant value of 1.4. The Mach responses are also covered, through fitting $L = -0.0124M^2 + 0.1186M - 1.663$. The modeling of the physical responses entails multiple quantities of nozzles, through fitting $k = e^{-3(c_{\phi_{qe}} - 1.6)} + 6$ and $x_0 = -e^{-1.05c_{\phi_{qe}}} + 0.6$. Subsequently, C_{NN} is added in accordance with (2).

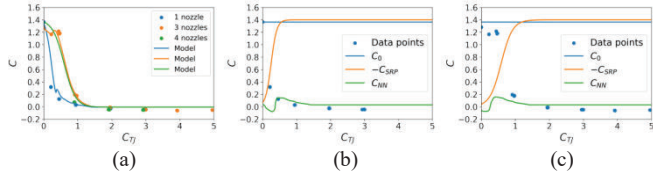


Fig. 8. Model plotted against test data points related to (a) several rocket nozzles, (b) 1 nozzle, and (c) 3 nozzles. The inputs were $M = 3.5$, $\alpha = 0^\circ$, and $\beta = 0^\circ$ [5].

Fig. 8 presents the predictions made by the HPDD model after receiving test points. It can be noted that the zero thrust vehicle model precisely fits the test points when $C_{TJ} = 0$, as shown in Figs. 8(b) and 8(c). Furthermore, the SRP model diminishes C while C_{TJ} raises due to obstruction of the expanding plume. Additionally, the NN residual regression model executes small adjustments (non-linear coupling) during low thrust, i.e., when $C_{TJ} < 3$. Fig. 8(b) presents acceptable estimations when $C_{TJ} > 3$, which are coherent with physics concepts. Thus, the NN model possesses high precision and interpretation capacity, since it regularly provides very low magnitude adjustments during the flight-significant regime (high thrust); the model deactivates if high thrust inputs are implanted.

C. Detection and Isolation of Simulated Leaks on Rocket Engine Data Using a Decision Tree

M. Schwabacher, R. Aguilar, and F. Figueroa [7] used ML techniques to detect and isolate simulated data leaks of a rocket engine. The engine in question is the J-2X, which was under progress at Pratt & Whitney Rocketdyne at the time of the test (the development of this engine halted). The decision was to use decision trees for applying these data-driven techniques because they are typically easier to understand than

other data-driven approaches. The decision tree algorithm used was the C4.5, and the simulator was the Detailed Real-Time Model (DRTM), also developed by Pratt & Whitney Rocketdyne. The DRTM fed the decision tree simulated J-2X data, which trained and tested this ML model.

Concerning the characteristics of the J-2X engine, the plan was to use liquid hydrogen and liquid oxygen as propellants. It would serve as the second and third stages of the Ares I cargo launch rocket and the Ares V manning launch rocket (both rockets from NASA). It originated from the J-2 engine, which powered the Saturn V launch rocket's second and third stages. The J-2X engine has a total vacuum thrust of 1307777.15 kg (294000 lb) and a specific impulse of 448 s. It would also stand 4.572 m (15 ft) tall and weigh 2468.85 kg (5450 lbs). Fig. 9 depicts the J-2X engine.



Fig. 9. The J-2X rocket engine [7].

Regarding the experiment, 56 DRTM simulations trained and tested the decision tree. The test included five distinct leak locations; eleven simulations per leak location, each with a different size leak; one reproduction without a leak; and a time duration of 500 seconds for each simulation, with the time for a leak to begin varying from 50 to 400 seconds. To create realistic simulations, these included simulated sensor noise and progressive degradation in fuel and oxidizer turbine efficiency. Eleven of these simulations trained the decision tree (two per leak plus one without leak). The remaining 45 simulations conducted the testing.

During the training stage, the C4.5 algorithm received labeled data samples from each leak location. These samples included nominal data and leaked data. Afterward, the algorithm learned a decision tree that classifies previously unseen data. As a result, the algorithm categorized the newly introduced data as having a leak or not having a leak at one of the five leak locations. The acquired decision tree had 12289 nodes, far too many for human comprehension. There are two possible explanations for this large number of nodes. The first is that C4.5 is overfitting, and the second is that it is implausible to convey the extrapolated function by a symmetric decision tree (this same model instead relies on a "stairstep" function with several nodes).

The test stage encompassed several activities that would assess the model's accuracy. The initial of these activities was to examine false alarm rates. Table I depicts the percentage of non-leaked time steps for which the decision tree incorrectly indicates a leak for each location. It demonstrates that the model has an overall false alarm rate of 0.0072%, which is exceedingly satisfactory.

Following that, the next step was to examine the missed detection rates of the decision tree. Table II shows the percentage of leaked time steps for which the decision tree fails to identify the leak for each location (with a given leak area). The tree performs well at leak locations 3 and 4 for leaks of 0.19 cm² (or larger). The tree performs well at location 7 for leaks of 0.32 cm² (or larger). The tree behaves well for leaks of size 0.65 cm² or larger in location 9. However, for leaks in location 8, the tree does not perform well in detecting the leak until its size reaches 1.42 cm². This fact means that leak location 8 generates the lowest leak rates.

TABLE I. FALSE ALARM RATES [7].

| | Leak location | | | | | |
|------------------|---------------|----------|----------|----------|----------|----------|
| | 3 | 4 | 7 | 8 | 9 | total |
| False alarm rate | 0.0032 % | 0.0011 % | 0.0000 % | 0.0029 % | 0.0000 % | 0.0072 % |

TABLE II. MISSED DETECTION RATES [7].

| Missed detection rate | Leak location | | | | | |
|------------------------------|---------------|--------|--------|--------|--------|--------|
| | 3 | 4 | 7 | 8 | 9 | |
| Leak area (cm ²) | 0.06 | 17.92% | 18.69% | 25.05% | 49.71% | 30.03% |
| | 0.19 | 0.02% | 0.19% | 23.74% | 54.73% | 29.09% |
| | 0.32 | 0.02% | 0.12% | 0.06% | 40.90% | 18.35% |
| | 0.45 | 0.00% | 0.01% | 0.05% | 5.77% | 6.94% |
| | 0.65 | 0.00% | 0.01% | 0.04% | 16.91% | 0.22% |
| | 0.77 | 0.01% | 0.02% | 0.06% | 12.06% | 0.04% |
| | 0.97 | 0.01% | 0.02% | 0.05% | 6.57% | 0.01% |
| | 1.1 | 0.00% | 0.02% | 0.02% | 2.96% | 0.00% |
| | 1.29 | 0.00% | 0.03% | 0.00% | 1.92% | 0.00% |
| | 1.42 | 0.00% | 0.02% | 0.00% | 0.05% | 0.00% |
| 1.61 | 0.01% | 0.01% | 0.02% | 0.62% | 0.00% | |

Later, the next activity involved investigating the misisolation rate for the same tree. Table III displays, for each leak location (with a given leak area), the percentage of leaked time steps misidentified as being at a different position. The tree behaves well in isolating leaks of size 0.65 cm² or greater at locations 3, 4, and 7; but not at locations 8 and 9. This misisolation will be further explained in Table IV.

Finally, the last activity involved a confusion matrix, as illustrated in Table IV. This matrix represents the number of times the decision tree states that there is a leak at a specific location (the correct or incorrect location) after receiving a leak (or no leak) at that location. The first row displays false alarms, whereas the first column displays missed detections.

The remaining rows and columns present misidentifications (excluding the diagonal). It is worth mentioning that the calculation of the matrices in Tables I and IV solely used test data. However, the computation of the matrices in Tables II and III utilized both training and test data (to add every leak area in the dataset). Considering these contrasts, the first column of Table IV does not match the total number of missed detections in Table II. The confusion matrix shows that locations 8 and 9 are frequently confused with each other, which contributes to the high misisolation rates for such places. One possible explanation for this event is that a small leak at location 8 may resemble a high leak at location 9.

TABLE III. MISISOLATION RATES [7].

| Misisolation rate | Leak location | | | | | |
|------------------------------|---------------|--------|--------|--------|--------|--------|
| | 3 | 4 | 7 | 8 | 9 | |
| Leak area (cm ²) | 0.06 | 82.02% | 23.15% | 9.23% | 0.50% | 18.89% |
| | 0.19 | 99.97% | 0.90% | 2.68% | 2.17% | 63.99% |
| | 0.32 | 99.91% | 0.55% | 0.05% | 2.39% | 61.17% |
| | 0.45 | 64.24% | 0.35% | 0.19% | 1.49% | 47.77% |
| | 0.65 | 0.73% | 0.43% | 0.40% | 16.02% | 2.57% |
| | 0.77 | 0.83% | 0.54% | 0.51% | 19.66% | 8.74% |
| | 0.97 | 0.00% | 0.33% | 0.30% | 34.85% | 2.48% |
| | 1.1 | 0.00% | 0.00% | 0.36% | 26.11% | 2.64% |
| | 1.29 | 0.22% | 0.19% | 0.00% | 46.41% | 0.67% |
| | 1.42 | 1.13% | 1.11% | 0.57% | 5.05% | 1.13% |
| 1.61 | 0.49% | 1.64% | 0.36% | 58.48% | 0.38% | |

TABLE IV. CONFUSION MATRIX [7].

| No leak | 3 | 4 | 7 | 8 | 9 | ← classified as |
|---------|-------|--------|-------|-------|-------|-----------------|
| 474581 | 15 | 5 | 0 | 14 | 0 | No leak |
| 4 | 51745 | 67796 | 413 | 17 | 136 | 3 |
| 2243 | 1800 | 109719 | 164 | 2815 | 322 | 4 |
| 6210 | 1995 | 100 | 97651 | 1258 | 61 | 7 |
| 29748 | 2788 | 1444 | 13 | 61028 | 23797 | 8 |
| 14564 | 1141 | 1123 | 127 | 34542 | 54756 | 9 |

V. CONCLUSION AND OUTLOOK

This paper demonstrates that machine learning algorithms are helpful tools for a variety of challenging and constrained applications within the field of aerospace, as they automatically generate models required for the execution of various rocket propulsion activities. The activities covered in this article included Deep RL for the LUMEN engine demonstrator's set-point control, HPDDs for a small-scale rocket's SRP, and Decision Trees for isolation and detection of leakages on the J-2X engine. These activities have shown that it is possible to obtain precise results without manually creating a framework of a spacecraft, making achieving these results less arduous. Furthermore, this paper shows that the combination of ML algorithms with specific scenarios (e.g., deep RL for rocket set-point control) or physics notions (e.g., HPDDs for supersonic retro-propulsion) allows for better rocket performance. As a result, ML algorithms are critical for ensuring the safety-critical factor of spacecraft propulsion.

Despite all the advantages ML methods provide for the investigated rocket engine operations, there remains room for improvement. For future work, it would be beneficial to employ uncertainty measurement (ML outcomes are not constantly impeccable) [4] to allow insight into how precise the spacecraft ML model is. It would also be advantageous to create frameworks that foresee thermoacoustic instabilities [22] to minimize engine damage. At last, it would be favorable to use a famous computational method that combines ML with CFD [4]; this mixture enables obtaining high-accurate results through CFD while still generating data models in a less arduous manner (through ML). In the case of spacecraft, the expectation is for the ML-aided CFD to boost the modeling of thermodynamic and aerodynamic events, such as turbulence flows and combustion occurrences.

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Numerical Modal Analysis of a Multi-Material 3D-Printed Composite Bushing and its Application

Paweł Żur, Alicja Żur, Andrzej Baier

Abstract—Modal analysis is a crucial tool in the field of engineering for understanding the dynamic behavior of structures. In this study, numerical modal analysis was conducted on a multi-material 3D-printed composite bushing, which comprised a polylactic acid (PLA) outer shell and a thermoplastic polyurethane (TPU) flexible filling. The objective was to investigate the modal characteristics of the bushing and assess its potential for practical applications.

The analysis involved the development of a finite element model of the bushing, which was subsequently subjected to modal analysis techniques. Natural frequencies, mode shapes, and damping ratios were determined to identify the dominant vibration modes and their corresponding responses. The numerical modal analysis provided valuable insights into the dynamic behavior of the bushing, enabling a comprehensive understanding of its structural integrity and performance. Furthermore, the study expanded its scope by investigating the entire shaft mounting of a small electric car, incorporating the 3D-printed composite bushing. The shaft mounting system was subjected to numerical modal analysis to evaluate its dynamic characteristics and potential vibrational issues.

The results of the modal analysis highlighted the effectiveness of the 3D-printed composite bushing in minimizing vibrations and optimizing the performance of the shaft mounting system. The findings contribute to the broader field of composite material applications in automotive engineering and provide valuable insights for the design and optimization of similar components.

Keywords—3D printing, composite bushing, modal analysis, multi-material.

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Personal Perception of The Acoustic Properties of Three Different Rooms for Music Lessons

Natalia B. Ivanova¹ and Konstantin Adamov²

Abstract – The importance of acoustics in music classes made us analyse three music rooms in a Bulgarian school. The same music piece was performed in every one of the classrooms. The recording was played to 2 groups of students. A survey was then taken among those students in order to determine their personal preferences and impressions of the acoustic. The results show differences in the preferences of older students compared to younger ones. Results of the survey show a correlation between older students' preferences and the standard requirements. However, we discover that younger students' classrooms should be further analysed and adapted to their needs and preferences.

Keywords – Sound quality, school acoustic, building acoustics, Acoustic layout of music classrooms.

I. INTRODUCTION

The acoustic treatment of music rooms is essential for both perception and health of the students. From the author's observations, as well as from impressions in various publications, it has been established that there is a lack of comprehensive rating and a treatment of the music training facilities in accordance with the students' needs.

The national standard gives very generalized requirements, sometimes with only one reverberation time value, which was considered insufficient to establish a quality music experience.

The present study poses more detailed evaluation questions regarding personal perception as well as the specific impact of the rooms on the students and their learning ability depending on the different acoustic treatment of the rooms, emphasizing on the initial impact of sound perception.

II. METHOD

A. Location




The analysis was made in three music classrooms of different sizes and different acoustic treatments.

- A room for individual music lessons
- A standard classroom
- A music studio

The sizes and the special configuration of the premises are shown in Table 1.

The three rooms are part of a standard school, but with very different indicators. Our aim is to examine the way the students perceive the different acoustic processing and how the dimensions and the sound affect them.

Table 1 : Evaluated music rooms dimensions and appearances

| | L [m] | W [m] | H [m] | Picture |
|-------------------------------------------------|----------|----------|----------|--------------------------------------------------------------------------------------|
| Room 1 individual music lessons | 6 | 4 | 3,35 |  |
| Room 2 Classroom | 8,5 | 6 | 3,35 |  |
| Room 3 Music Studio | 5,8 | 3,8 | 3,35 |  |

According to the standard guidelines for music rooms, the requirement for reverberation time for rooms with that volume is 0.6 seconds. [1].

In some Standards as the American National Standard

Acoustical Performance [2] is given the Minimum surface area of acoustical treatment for different sound absorption coefficients, ceiling heights, and reverberation times.

Some national Standards contain Recommended Reverberation Times for Small Music Rooms for different Music Activity Space [3].

The requirement according to DIN 18041 [4] of Reverberation time for music rehearsal room with this volume would be: Room 1 – 0,56 s, Room 2 – 0,69 s and Room 3 – 0,55 s.

Usually, studies evaluate the acoustical performance, regarding its Reverberation Time, Background Noise Level and Airborne Sound Insulation between rooms [5]. In the current premises, only the third one is close to these requirements (*cf. Fig 1*). This was due to its shape and characteristics but also enhanced by multiple performance acoustic panels and elements that were installed.

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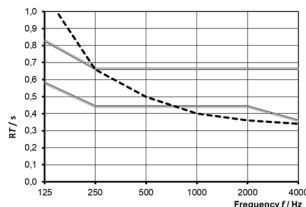


Figure 1: Range of reverberation time as a function of frequency according to DIN 18041 – Room 3

B. Participants

We chose to run the survey among 2 different age groups: 42 older students (about 18 years old) and 27 younger ones (about 13 years old). Younger participants are pupils at the music school used for this survey when the older ones are first year students from the University of Architecture, Civil Engineering and Geodesy, Physics Department.

C. Procedure

The same musical piece is played on a violin in each room from a professional musician and then recorded. The sound of the violin in the three rooms can be demonstrated in Fig.2.

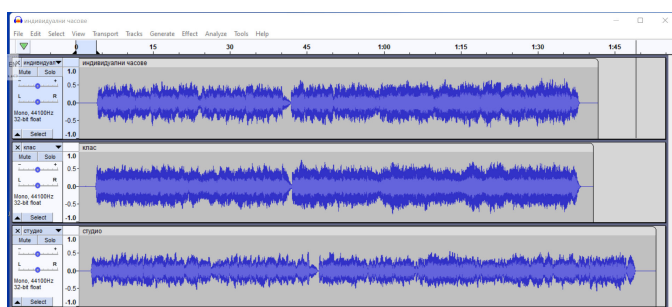


Figure 2: The sound of the violin in rooms 1, 2 and 3

The figure shows the effect of acoustic processing on loudness

The recording was played separately in front of the two groups of students and they were given a questionnaire for each recording.

The prepared questionnaire consisted of 3 questions on the acoustics of the rooms, overall preferences of the room and an opened question on the effect the recording had on them. The numerical responses were in the form of a 6-point scale, in which 1 indicated low rating of the acoustics and perception and 6 indicated a high rating.

An analysis of the three rooms on the point system was made, as well as a spontaneous description of the impact.

III. RESULTS

The results of the survey analysis are shown in Fig 3 and Fig 4. An analysis of the questionnaire was according to the point system. In addition, information was collected on the spontaneous description of the impact.

Differences depending on both age and gender are observed. For the purpose of this study we decided to analyse

only the differences in age and later – expose and analyse the differences in age and sex with the help of a specialist.

The personal sensations of the students generally show a higher preference for the third room, which has enhanced sound absorption. But younger students show more varied preferences.

Students described used the following to describe the sound and acoustics in the first classroom: excitement, tension, highest density of sound, piercing, intrusive sound, more effort, sharp, superimposed, truncated, squeaky, clean and well-directed sound when listening, uncleaned, resounding, muffled.

Perceptions about the third room were: voluminous, clear, clean and soft sound, muted, mystery, calm, pleasant feeling, harmonious, the sound is purest, balance at different frequencies, balanced but strong, pleasant dense, good acoustics, purest tone, emotionally pleasant, relaxing, mystery, tranquillity.

Fig 3 : Comparative study of the sound conditions of the room with ratings from students from upper grades.

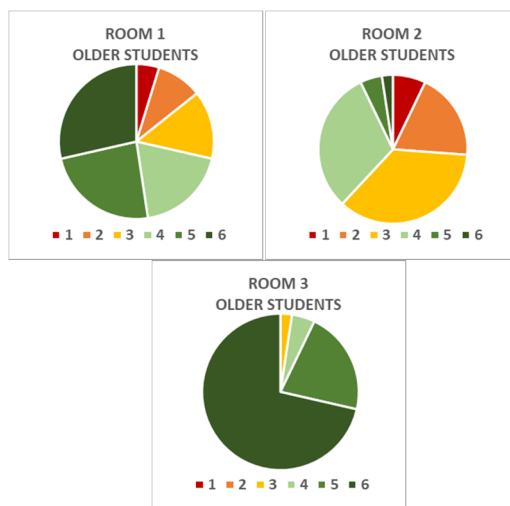
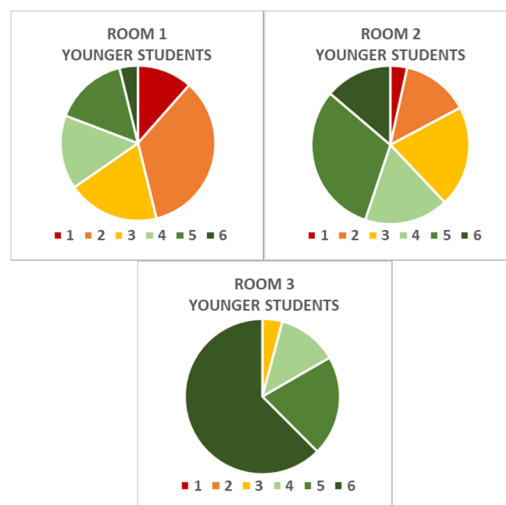


Fig 4 : Comparative study of the sound conditions of the room with ratings from students from upper grades.



These results show not only the different perception of the students and the requirement for appropriate processing of the premises, but also the need to find a more flexible approach that connects human sensations with the standard requirements for the premises. Further study can be led in order to find the optimal studying conditions taking in consideration changes in age characteristics and needs.

It is often thought that more acoustical absorption is better, especially in music spaces. This is not always true. If there is too much absorption, the music will seem distant to audiences, and performers will suffer from a lack of feedback.[6]

Sound is much more than a vibration. It is an emotion, it is well-being, a sensation, it gives information about feelings, preferences, attitudes, about the state of person. It is something alive and changing with a person and a person's life and development. Acoustics can contribute not only to a more effective music education but also – to a better perception of the world.

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Silica Sulfuric Acid as an Efficient Catalyst One-Pot Three-Component Aza-Friedel-Crafts Reactions of 2-(thiophen-2-yl)-1H-Indole, Aldehydes, and N-Substituted Anilines

Nagwa Mourad Abdelazeem, Marwa El-hussieny

Abstract— Multicomponent reactions (MCRs), one-pot reactions form products from more than two different starting compounds. (MCRs) are ideal reaction systems leading to high structural diversity and molecular complexity through a single transformation. (MCRs) have a lot of advantage such as higher yield, less waste generation, use of readily available starting materials and high atom. (MCRs) provide a rapid process for efficient synthesis of key structures in discovery of drug on the other hand silica sulfuric acid (SSA) has been used as an efficient heterogeneous catalyst for many organic transformations. (SSA) is low cost, ease of preparation, catalyst recycling, and ease of handling, so in this article we used 2-(thiophen-2-yl)-1H-indole, N-substituted anilines and aldehyde in the presence of silica sulfuric acid (SSA) as a catalyst in water as solvent at room temperature to prepare 3,3'-(phenylmethylene)bis(2-(thiophen-2-yl)-1H-indole) and N-methyl-4-(phenyl(2-(thiophen-2-yl)-1H-indol-3-yl)methyl)aniline derivatives Via one-pot reaction. Compound 2-(thiophen-2-yl)-1H-indole belongs to the ubiquitous class of indoles which enjoy broad synthetic, biological and industrial applications]. Cancer is considered the first or second most common reason of death all through the world. So the synthesized compounds will be tested as anticancer. We expected the synthesized compounds will give good results comparison to the reference drug.

Keywords— aldehydes, aza-friedel-crafts reaction, indole, multicomponent reaction.

Analysis of Moving Loads on Bridges Using Surrogate Models

Susmita Panda, Arnab Banerjee, Ajinkya Baxy, Bappaditya Manna

Abstract— The design of short to medium-span high-speed bridges in critical locations is an essential aspect of vehicle-bridge interaction. Due to dynamic interaction between moving load and bridge, mathematical models or finite element modeling computations become time-consuming. Thus, to reduce the computational effort, a universal approximator using an artificial neural network (ANN) has been used to evaluate the dynamic response of the bridge. The data set generation and training of surrogate models have been conducted over the results obtained from mathematical modeling. Further, the robustness of the surrogate model has been investigated, which showed an error percentage of less than 10% with conventional methods. Additionally, the dependency of the dynamic response of the bridge on various load and bridge parameters has been highlighted through a parametric study.

Keywords— Artificial neural network, Mode superposition method, Moving load analysis, Surrogate models.

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LCP Based Approach for Unilateral Frictional Contact between Wheel and Beam

Muskaan Sethi, Arnab Banerjee, Bappaditya Manna

Abstract— The present paper aims for investigation of a suitable contact between a wheel rolling over a flexible beam. A Linear Complementary (LCP) based approach has been adopted to simulate the contact dynamics for a rigid wheel traversing over a flexible Euler Bernoulli simply supported beam. The adopted methodology is suitable to incorporate the effect of frictional force acting at the wheel-beam interface. Moreover, the possibility of generation of a gap between the two bodies has also been considered. The present method is based on a unilateral contact assumption which assumes that no penetration would occur when the two bodies come in contact. This assumption helps to predict the contact between wheels and beam in a more practical sense. The proposed methodology is validated with the previously published results and are found to be in good agreement. Further, this method is applied to simulate the contact between wheels and beams for various railway configurations. Moreover, different parametric studies are conducted to study the contact dynamics between wheel and beam more thoroughly.

Keywords— Contact Dynamics, Linear Complementary problem, Railway Dynamics, Unilateral contact.

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Vibration Control of Bridges using MetaModels

Arnab Banerjee, Susmita Panda, Bappaditya Manna

Abstract— With the emergence of high-speed railways, the dynamic interaction between a moving load and the bridge has progressed and become more intense. The vibration of bridges under such circumstances questionnaires the safety and stability of the supporting structures. This topic in structural dynamics has sought attention of many researchers and engineers. Concerning this problem, metamodels can serve the best to control the vibration of bridge structures. It essentially consists of series of spring-mass-impregnated units attached to the bridge's deck, which is idealized as an Euler-Bernoulli beam. The concept of transfer matrix has been conceptualized to solve the defined problem. The efficiency of the proposed metamodels has been investigated, and essential parameters has been identified affecting the response of the supporting bridge structure.

Keywords—Euler-Bernoulli Beam, Metamodels, Transfer matrix, Vibration Control.

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Prediction of Embankment Fires at Railway Infrastructure Using Machine Learning, Geospatial Data and VIIRS Remote Sensing Imagery

Jan-Peter Mund, Christian Kind

Abstract— In view of the ongoing climate change and global warming, fires along railways in Germany are occurring more frequently, with sometimes massive consequences for railway operations and affected railroad infrastructure. In the absence of systematic studies within the infrastructure network of German Rail, little is known about the causes of such embankment fires. Since a further increase in these hazards is to be expected in the near future, there is a need for a sound knowledge of triggers and drivers for embankment fires as well as methodical knowledge of prediction tools. Two predictable future trends speak for the increasing relevance of the topic: through the intensification of the use of rail for passenger and freight transport (e.g.: doubling of annual passenger numbers by 2030, compared to 2019), there will be more rail traffic and also more maintenance and construction work on the railways. This research project approach uses satellite data to identify historical embankment fires along rail network infrastructure. The team links data from these fires with infrastructure and weather data and trains a machine-learning model with the aim of predicting fire hazards on sections of the track. Companies reflect on the results and use them on a pilot basis in precautionary measures.

Keywords— embankment fires, railway maintenance, machine learning, remote sensing, VIIRS data.

ICT Diagnosis Technology of the Electrical Equipment Using Magnetic Energy Harvesting (MEH)

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Abstract - The MEH wireless earth leakage overhear alarm was developed to prevent electric shock and fire accidents in a switchgear. First, the MEH induction coil was designed based on the theoretical background and the output characteristics of the MEH induction coil were analysed using COMSOL Multiphysics. Also, a prototype MEH wireless earth leakage overhear alarm was fabricated and the minimum operating current and the accuracy of wireless leakage current measurements were confirmed through test. The MEH wireless earth leakage overhear alarm developed from this study can be utilized for preventive diagnosis of electrical safety in power facilities.

Keywords: MEH, earth leakage, overheating, induction coil, electrical safety

1. Introduction

According to data from the National Fire Administration, among the fires that occurred in Korea over the past five years (2016-2020), electrical fires accounted for 47,492 cases (23%), with 246 deaths and 1,654 injuries, respectively, and property damage of KRW 668 billion. According to the Electricity Business Act, an inspector personally visits and inspects electrical equipment every 1 to 3 years, but it is difficult to predict the precursor of an accident because the electrical equipment cannot maintain its state at the time of inspection. For this reason, the development of IoT diagnostic technology that diagnoses the internal state of power facilities in real time and promptly alerts managers when abnormal symptoms occur is actively being developed [1]. However, existing IoT diagnostic technology has problems such as disturbance of the power system and periodic battery replacement because it needs to use a nearby power source or battery to drive sensors and wireless communication [2]. In order to solve this problem, Germany and the United States have succeeded in commercializing energy harvesting wireless temperature sensors that collect wasted energy around current-carrying conductors and supply power to sensors and communications through self-generation. However, since it operates only when a current of at least 5 A or more flows, development is underway to lower the operation start current [3].

In this paper, the conductor temperature and leakage current are measured through self-generation at a current of less than 1 A, and the internal state of the power facility is monitored in real time using radio frequency (RF) communication. Also, a MEH wireless earth leakage and overheating alarm that can quickly send out a warning sound when the sensor exceeds the setting value was developed.

2.1 MEH induction coil

In order to transmit the leakage current and temperature values inside the switchboard in real time, constant power of 6.6 mW or more is required. Such power can be easily operated by using a battery, but due to its short lifespan, replacement is required every 1.5 years, and replacement is impossible due to the risk of electric shock in an energized state. Therefore, in order to apply the wireless leakage and overheat diagnosis sensor to a switchboard, a self-generating system that supplies necessary power by itself is required. Self-generated electricity collects energy such as heat, vibration, and magnetic field from the surroundings, and supplies necessary power to the load through power conversion.

In this study, since the conductor always transmits current during switchboard operation, the induction coil collects the magnetic energy induced around the wire according to Ampere's law, the adjustable power is supplied for the ZCT, temperature sensor and communication module.

2.1.1. Theoretical background of MEH induction coil

The MEH induction coil is a toroidal shape in which an enamel-insulated copper wire with a diameter of 1 mm is wound around a low-loss, high-permeability cylindrical core in tens to hundreds of turns. As shown in Fig. 1, a toroidal-shaped induction coil is inserted into a cable or bus bar of one of the three phases without contact. When an alternating current is applied to a power cable or bus bar, an induced electromotive force is generated in the MEH induction coil on the secondary side in proportion to the change in the primary side current. When a load is connected to both ends of the induction coil, the secondary side current flows to the load and power is delivered.

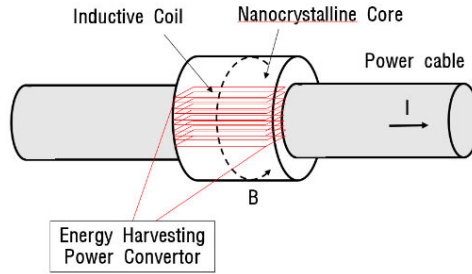


Fig. 1: MEH induction coil coupled to power cable

According to Faraday's law of electromagnetic induction, when a time-varying current flows through a wire, it creates an alternating magnetic field around the wire and induces an AC voltage in a coil with N turns. When the supply voltage (V_1) is applied to the primary side coil (power cable), the amount of magnetic flux (Φ_1) generated in the nanocrystalline core is expressed as follows.

$$V_1 = V_{1m} \sin(\omega t) = \sqrt{2} V_{1rms} \sin(\omega t) \quad (1)$$

$$\Phi_1 = \frac{N_1 i_1}{R_m} = -\frac{N_1}{R_m} i_{1m} \cos(\omega t) \quad (2)$$

Here, N_1 , i_1 , and R_m are the total flux linkage, the number of windings, the current, and the magnetic resistance in the primary side coil, respectively. ω is the angular frequency.

Ignoring the iron loss and leakage flux of the core and considering the saturation characteristics of the core, The magnetic flux density inside the core at r_0 away from the center of the wire where the sinusoidal alternating current with an angular frequency ω and amplitude of I_{1m} flows is expressed by Eqs. (3).

$$B(t) = B_{SAT} \frac{2}{\pi} \operatorname{atan}(H(t)) = k_1 B_{SAT} \frac{2}{\pi} \operatorname{atan} \left(k_2 \frac{I_{1m} \sin(\omega t)}{2 \pi r_0} \right) \quad (3)$$

Here, B_{sat} is the saturation magnetic flux density of the core, $\frac{2}{\pi}$ is used to normalize the arctangent function to 1 during magnetic saturation, and k_1 and k_2 are correction coefficients for fitting the BH curve provided by the manufacturer. The slope of the unsaturated shaded region of the core, that is, the magnetic permeability μ is obtained by Eqs. (4) by differentiating Eqs. (3).

$$\mu_r(BH) = \frac{\partial B}{\partial H} = k_1 \frac{2 B_{SAT}}{\pi} \frac{(2 \pi r_0)^2}{(2 \pi r_0)^2 + k_2^2 (I_{1m} \sin(\omega t))^2} \quad (4)$$

Also, the voltage V_{coil} induced in the MEH coil without load is as follows.

$$V_{coil}(t) = N_2 A \frac{dB(t)}{dt} = \frac{N_2 A B_{SAT} 4 \pi^2 r_0 \omega I_{1m} \cos(\omega t)}{(I_{1m}^2 \sin^2(\omega t) + 2 \pi r_0)^2} \quad (5)$$

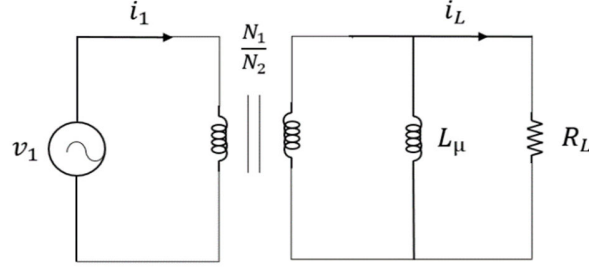


Fig. 2: Equivalent circuit of MEH coil with load

Fig. 2 shows the equivalent circuit when the load resistance R_L is connected to the MEH coil magnetically coupled to the AC current carrying wire. The magnetizing inductance L_μ is obtained as follows.

$$L_\mu = \mu N_2 \frac{A}{l} = \frac{2 N_2^2 A \mu_0 B_{SAT}}{\pi l} = \frac{2\pi r_0}{(2\pi r_0)^2 + I_{1m}^2 \sin^2(\omega t)} \quad (6)$$

Here, l is the magnetic path length, N_2 is the number of windings in the MEH coil, A is the cross-sectional area of the core, μ_0 is the vacuum permeability, μ_r is the core specific permeability, and μ is the core permeability, $\mu_0 \mu_r$. The equivalent impedance of the circuit and the current flowing in the load resistance are given by Eqs. (7) and Eqs. (8), respectively.

$$Z_T = \frac{(\omega L_\mu) R_L}{\sqrt{R_L^2 + (\omega L_\mu)^2}} \quad (7)$$

$$i_L = \frac{I_{1m}}{N_2} \frac{(\omega L_\mu)}{R_L \sqrt{R_L^2 + (\omega L_\mu)^2}} \quad (8)$$

The power delivered to the load resistance is given by Eqs. (9).

$$P_L = i_L^2 R_L = \left(\frac{I_{1m}}{N_2} \right)^2 \left(\frac{R_L (\omega L_\mu)^2}{\sqrt{R_L^2 + (\omega L_\mu)^2}} \right) \quad (9)$$

In Eqs. (9), when $\omega L_\mu = R_L$, the power delivered to the load resistance is maximized.

$$\frac{dP_L}{dR_L} = \frac{I_{1m}^2 (\omega L_\mu)^4 - (I_{1m} \omega L_\mu R_L)^2}{N_2^2 (\omega L_\mu)^4 + 2(N_2 \omega L_\mu R_L)^2 + N_2^2 (R_L)^4} = 0 \quad (10)$$

Fig. 3 is the output power delivered to the MEH coil according to the load resistance. in case of $I_{1m} = 1$ A, $N = 100$, and frequency 60 Hz using $\mu_r = 80,000$. When the load resistance is small, the output power increases, but the output power decreases exponentially when the load resistance exceeds the optimum value. From Eqs. (10), the load resistance when the delivered power is maximum was calculated as 200 Ω . Fig. 4 is the change in output power according to the current of the primary side coil when $N = 100$ and $R_L = 200$ Ω . It can be seen that the output power increases in the form of an exponential function as the current of the primary coil increases. Fig. 5 show the variation of the output voltage in the MEH coil according to the current in the primary coil when $I_{1m} = 1$ A, $N = 100$, and $R_L = 200$ Ω . In the linear region where the core is not saturated, the output voltage of the MEH coil maintains a sine wave, and the peak value of the output voltage increases in proportion to the primary side current. However, it can be seen that when the core is saturated, the output voltage waveform of the MEH coil is distorted due to the magnetic saturation effect, and the time for generating the output voltage is shortened. Since a minimum voltage of 1.8V or more is required to operate the semiconductor device through self-generation using the MEH coil, the transmitter may not operate while the output voltage is 0V. Therefore, a proper voltage regulator and LDO circuit should be reflected in the power conversion circuit so that the voltage supplied from the

MEH coil to the microcontroller unit (MCU) always maintains above 1.8V in consideration of the magnetic saturation characteristics.

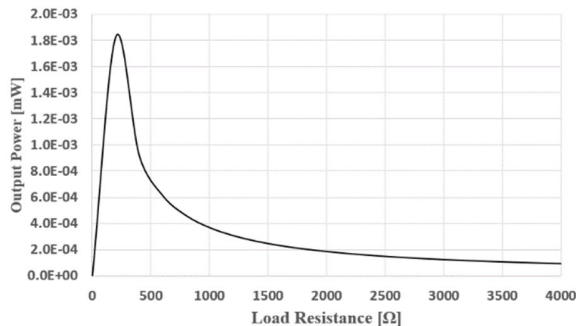


Fig. 3: The delivered power change in MEH coil as load resistance increases for $I_{Im}=1$ A, $N=100$, and $f=60$ Hz

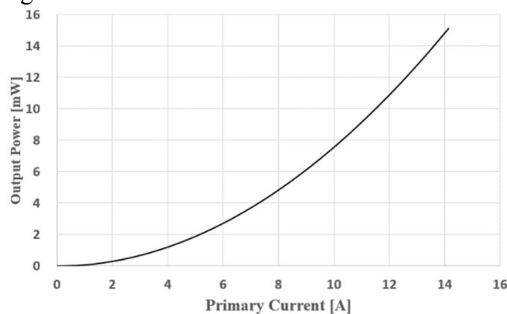


Fig. 4: The output power variation in the MEH coil according to primary coil current when $N=100$ and $R_L=200$ Ω

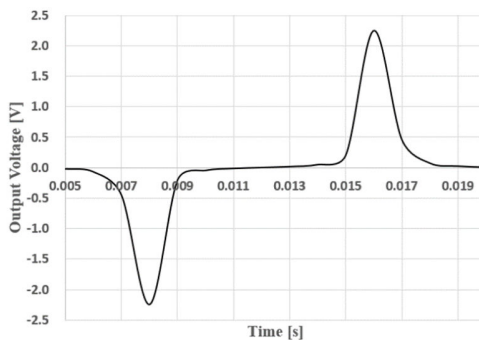


Fig. 5: The output voltage waveform of the MEH coil when $I_{Im}=100$ mA, $N=100$, $R_L=200$ Ω

2.1.2. MEH induction coil shape design and numerical analysis

Using the operating characteristics of the MEH induction coil, the MEH induction coil for the MEH wireless earth leakage and overheating alarm to prevent electric shock and fire accidents was designed using the electromagnetic module of COMSOL Multiphysics, and the output characteristics were confirmed through 3D transient analysis. The MEH coil is a toroidal shape wound around a cylindrical nanocrystal core with an inner diameter of 40 mm and a cross-sectional area of 100 mm². The voltage per turn, current per turn, power per turn, and magnetic flux distribution within the core induced in the MEH coil due to the change in the magnetic flux density inside the core as the primary coil current increase for $R_L=1$ kΩ and $f=60$ Hz were analyzed.

Fig. 6 shows the change in magnetic flux density inside the MEH coil core when the current of the primary coil is 0.5 A, 1.0 A, and 3.0 A. When the current of the primary coil is 0.5 A, the core is not saturated when the magnetic flux density is

below the saturation magnetic flux density of 1.24 T, so the voltage per turn and the current per turn of the MEH coil maintain a sine wave as shown in Fig. 7 and Fig. 8, but as the primary coil current is increased, the magnitude of the voltage per turn and the current per turn of the MEH coil increases in proportion to the increase in primary side current. While, when the magnetic flux density inside the core exceeds the saturation magnetic flux density, the distortion of the voltage waveform per turn and the current waveform per turn of the MEH coil becomes severe due to magnetic saturation characteristics of the core, and the phase difference of the voltage per turn with the primary current increases.

From Fig. 7 and Fig. 8, it can be seen that the phase difference of voltage per turn and current per turn is 180 degrees. Fig. 9 is the average power per turn generated in the MEH coil. It can be seen that the peak value of the generated power per turn increases significantly as the primary side current increases. Therefore, it was confirmed that the operation starting current of the semiconductor device can be reduced despite the waveform distortion of the voltage per turn and the current per turn due to magnetic saturation of the core.

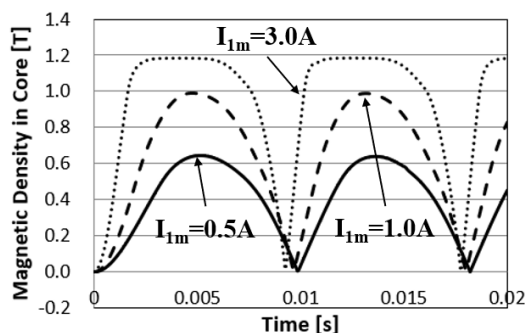


Fig. 6: Flux density change inside MEH coil core when $I_{1m} = 0.5$ A, 1.0 A, 3.0 A

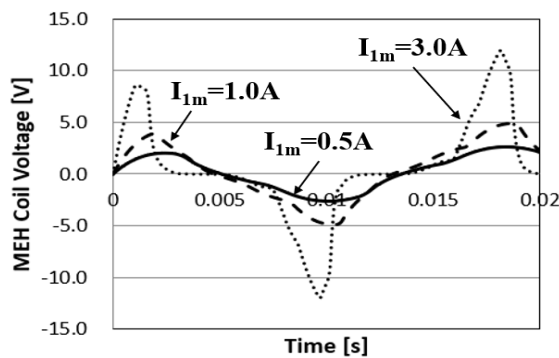


Fig. 7: Induced voltages of the MEH coil when $I_{1m} = 0.5$ A, 1.0 A, and 3.0 A

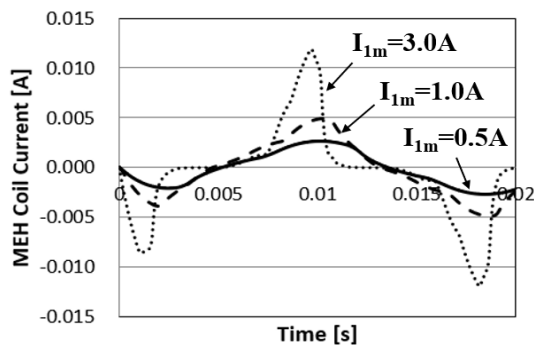


Fig. 8: Induced current in the MEH coil when $I_{lm} = 0.5$ A, 1.0 A, and 3.0 A

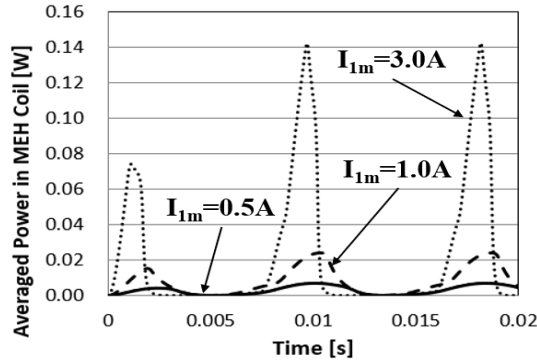


Fig. 9. Average power generated in the MEH coil when $I_{lm} = 0.5$ A, 1.0 A, and 3.0 A

2.2 Fabrication and test of the MEH wireless earth leakage and overheating alarm

Fig. 10 is a configuration diagram of the MEH wireless earth leakage overheating alarm. First, the MEH coil collects magnetic energy around current carrying wire and supplies stable and necessary power to the temperature sensor, MCU, and RF communication module after AC-DC and DC-DC power conversion. The voltage and current of the MEH coil enter the MEH power conversion circuit, and the AC voltage is converted into a stable DC voltage through the two-stage power conversion circuit. The first stage converts the AC voltage to a DC voltage, and the second stage converts the uncontrolled DC voltage to a controlled DC voltage through a DC converter conversion.

Fig. 11 is the output voltage of the AC-DC power conversion circuit when the AC voltage of the MEH coil is 1 V. Also, when an overvoltage comes from the MEH coil, a zener diode (ZD) for overvoltage protection is included to protect the circuit. Also, in order to lower the primary-side current required for MCU operation, DC-DC linear converter was applied to minimize current consumption in the circuit, noise, and PCB size. Fig. 12 is a transmitter module for the MEH wireless earth leakage overheating alarm. The microprocessor parts are on the left and low power wireless circuit parts are mounted on the right. When a 100mA leakage current is applied to the ZCT (zero phase current) sensor (DZR-030-200) and the current in the primary side coil increases using a variable AC automatic transformer, the minimum operating current to start the wireless communication between transmitter and receiver was measured at 2.8A. Also, the measured AC leakage current through the ZCT enters the AC-DC input terminal of the signal conversion amplifier circuit of the transmitter. The average value of the DC voltage measured by the MCU was calculated, and the relational expression between voltage and current was obtained. Also, the phase current of the earth leakage detector (DISIS DED-FD 16) (B) and the MEH wireless earth leakage overhear detector (C) is measured in increments of 50 mA from 50 mA to 1000 mA with the same ZCT. The error rate was calculated by comparing the measured zero-phase current values with the reference leakage current (A) directly measured with the tester. In Table 1, the maximum error between the reference leakage current and the existing leakage alarm was 9.1%, and it was measured as 2.4% with the MEH leakage. From Table 1, it was confirmed that the precision was greatly improved compared to the existing earth leakage alarm.

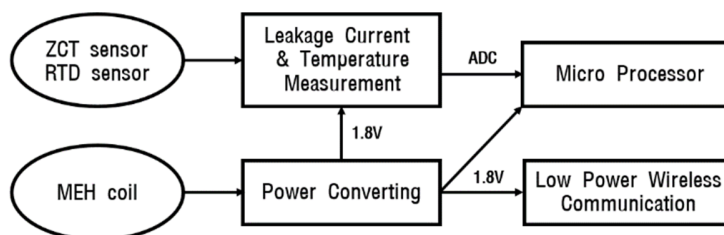


Fig. 10: Block diagram for configuring the MEH wireless earth leakage overhear alarm.

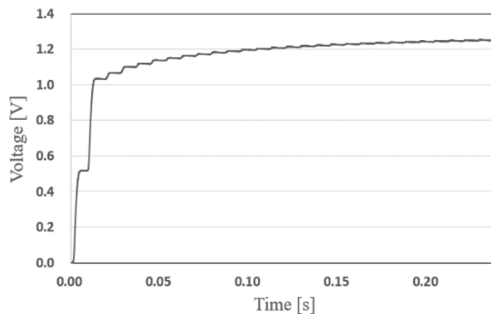


Fig. 11: Output voltage of AC-DC power conversion circuit when MEH coil voltage is AC 1 V

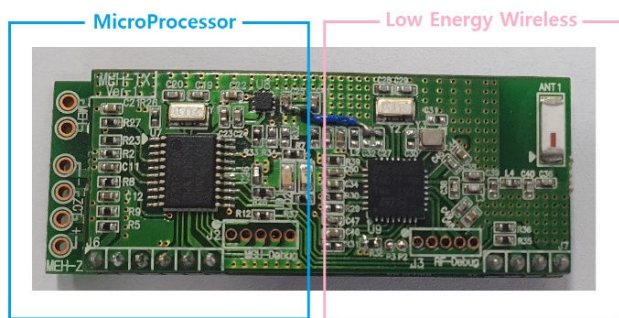


Fig. 12: a transmitter module for the MEH wireless earth leakage overheating alarm

Table 1: Comparison of error rates between existing earth leakage alarm and MEH wireless earth leakage and overheat alarm

| A [mA] | B [mA] | C [mA] | Error Rate ($\frac{B-A}{A} \times 100\%$) | Error Rate ($\frac{C-A}{A} \times 100\%$) |
|-----------|-----------|-----------|------------------------------------------------|------------------------------------------------|
| 50 | 50 | 50 | 0.0 % | 0.0 % |
| 90 | 100 | 88 | 11.1 % | 2.2 % |
| 230 | 250 | 226 | 8.7 % | 1.7 % |
| 330 | 360 | 328 | 9.1 % | 0.6 % |
| 410 | 440 | 408 | 7.3 % | 0.5 % |
| 510 | 550 | 510 | 7.8 % | 0.0 % |
| 650 | 700 | 648 | 7.7 % | 0.3 % |
| 750 | 810 | 751 | 8.0 % | 0.1 % |
| 1000 | 1084 | 1004 | 8.4 % | 0.4 % |

3. Conclusion

In order to prevent electric shock and fire accidents caused by short circuit and overheating of switchgear, MEH wireless short circuit overheating alarm was developed. First, the MEH induction coil was designed based on the theoretical background, and the output characteristics of the MEH induction coil were analyzed using COMSOL Multiphysics.

Also, the prototype MEH wireless leakage overheating alarm was manufactured and the minimum operating current and wireless leakage current precision were confirmed through tests. The results derived from this study are as follows.

1. In order to simplify the design of the MEH induction coil, a theoretical formula was derived. The output power of the MEH coil increases when the load resistance is small, but the output power of the MEH coil decreases exponentially when the load resistance exceeds the optimum value.
2. For a toroidal shaped MEH induction coil, the voltage per turn, the current per turn, the power per turn, and the magnetic flux distribution within the core in the MEH coil according to the change in primary coil current with resistive load were analyzed. When the current of the primary side coil is small, since the core is not saturated, the voltage per turn and the current per turn of the MEH coil maintain a sine wave. However, as the current of the primary coil increases, the magnitude of the voltage per turn and the current per turn increases in proportion to the increase in the current of the primary coil, but the distortion of the waveforms of voltage per turn and current per turn becomes severe due to magnetic saturation of the core and a phase difference of 180 degrees occurred between the voltage per turn and the current per turn.
3. As the current of the primary side coil increased, the peak value of the generated power per turn of the MEH coil increased significantly and despite the waveform distortion of the voltage per turn and the current per turn due to the magnetic saturation of the core, the operation start current of the semiconductor device can be lowered confirmed.
4. The zero-phase current of the existing earth leakage detector and the prototype MEH wireless earth leakage overheat detector were measured in 50 mA increments from 50 mA to 1 A using the same ZCT sensor, and the error rate was calculated by comparing the measured zero phase current values with the standard leakage current. The maximum error between the standard leakage current and the existing earth leakage alarm was 9.1%, and the maximum error between the existing earth leakage alarm and the MEH wireless earth leakage overheat detector was measured at 2.4%. It was confirmed that the precision was greatly improved compared to the existing earth leakage alarm.

Acknowledgements

A short acknowledgement section can be written between the conclusion and the references. Sponsorship and financial support acknowledgments should be included here. Acknowledging the contributions of other colleagues who are not included in the authorship of this paper is also added in this section. If no acknowledgement is necessary, this section should not appear in the paper.

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Development of CaO-based Sorbents Applied to Sorption Enhanced Steam Reforming Processes

P. Comendador, I. Garcia, S. Orozco, L. Santamaria, M. Amutio, G. Lopez, M. Olazar

Abstract—The in situ CO₂ capture in steam reforming processes has been studied in the last years as an alternative for increasing H₂ yields and H₂ purity in the product stream. For capturing the CO₂ at the reforming conditions, CaO-based sorbents are usually employed, due to their properties at high temperature, low cost and high availability.

However, the challenge is to develop high capacity ($g_{CO_2}/g_{sorbent}$) materials that retain their capacity over cycles of operation. Besides, since the objective is to capture the CO₂ generated in situ, another key aspect is the sorption dynamics, which means that, in order to efficiently use the sorbent, it has to capture the CO₂ at a rate equal or higher than the generation rate. In this work, different CaO-based materials have been prepared aiming at meeting these criteria.

First, and by using the wet mixing method, different inert materials (Mg, Ce and Al) were combined with CaO. Second, and with the inert material selected (Mg), the effect of its concentration in the final material was studied. Transversally, the calcination temperature was also evaluated.

It was determined that the wet mixing method is a simple procedure suitable for the preparation of CaO sorbents mixed with inert materials. The materials prepared by mixing the CaO with Mg have shown satisfactory anti-sintering properties and adequate sorption kinetics for their application in steam reforming processes. Regarding the concentration of Mg in the solid, it was concluded that high values contribute to the stability, but at the expense of losing sorption capacity. Finally, it was observed that high calcination temperatures negatively affected the sorption properties of the final materials, due to the decrease in the pore volume and the specific surface area.

Keywords—Calcination temperature effect, CO₂ capture, Mg-Ce-Al stabilizers, Mg varying concentration effect, sorbent stabilization.

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Energy Analysis and Integration of the H₂ Production from Biomass Fast Pyrolysis and in Line Sorption Enhanced Steam Reforming

P. Comendador, M. Suarez, L. Olazar, M. Cortazar, M. Artetxe, G. Lopez, M. Olazar

Abstract—H₂ production from biomass fast pyrolysis and in line Steam Reforming (SR) has been extensively studied in the last years. However, the Sorption Enhanced Steam Reforming (SESR) is gaining attention as an alternative to the conventional SR, since it allows obtaining higher H₂ yields, and a purity near to 100 % in the product stream.

In this work, both alternatives were compared through an energy analysis. The processes were modelled with PRO II v.2021 software.

First, general energy balances were carried out, in order to identify the total energy requirements in a wide range of operating conditions. At H₂ yield optimum conditions for both processes (steam to biomass ratio of 2 and temperature of 600 °C), the total energy requirement for the SR alternative is 936 kJ/kg_{H₂}, whereas for the SESR alternative is 1134 kJ/kg_{H₂}.

Then, the energy needs were grouped into operation stages, aiming at identifying the energy sinks and sources of the processes. It was determined that the SESR alternative is more energy intensive, due to the need of a calcination stage for regenerating the sorbent.

Finally, a configuration of the SESR alternative with energy integration was developed in order to compensate the energy demand.

Keywords—Biomass valorization, CO₂ capture, energy analysis, H₂ production.

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Neuronal Networks for The Study of the Effects of Cosmic Rays on Climate Variations

Jossitt Williams Vargas Cruz, Aura Jazmín Pérez Ríos.

Abstract—The variations of solar dynamics have become a relevant topic of study due to the effects of climate changes generated on the Earth. One of the most disconcerting aspects is the variability that the sun has on the climate is the role played by sunspots (extra-atmospheric variable) in the modulation of the Cosmic Rays CR (extra-atmospheric variable). CR's influence the earth's climate by affecting cloud formation (atmospheric variable), and solar cycles influence, are associated with the presence of solar storms and the magnetic activity is greater, resulting in less CR entering to the earth's atmosphere. The different methods of climate prediction in Colombia do not take into account the extra-atmospheric variables. Therefore, correlations between atmospheric and extra-atmospheric variables were studied in order to implement a Python code, based on neural networks, to make the prediction of the extra-atmospheric variable with the highest correlation.

Keywords— correlations, cosmic rays, Sun, sunspots and variations.

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Study of Atmospheric Cascades Generated by Primary Cosmic Rays, from Simulations in Corsika for the City of Tunja in Colombia

Tathiana Yesenia Coy Mondragón, Jossitt William Vargas Cruz, Cristian Leonardo Gutiérrez Gómez

Abstract— The study of cosmic rays is based on two fundamental pillars: the detection of secondary cosmic rays on the Earth's surface and the detection of the source and origin of the cascade. In addition, the constant flow of RC generates a lot of interest for study due to the incidence of various natural phenomena, which makes it relevant to characterize their incidence parameters to determine their effect not only at subsoil or terrestrial surface levels but also throughout the atmosphere. To determine the physical parameters of the primary cosmic ray, the implementation of robust algorithms capable of reconstructing the cascade from the measured values is required, with a high level of reliability. Therefore, it is proposed to build a machine learning system that will be fed from the cosmic ray simulations in CORSIKA at different energies that lie in a range $[10^9-10^{12}]$ eV. in order to generate a trained particle and pattern recognition system to obtain greater efficiency when inferring the nature of the origin of the cascade for EAS in the atmosphere considering atmospheric models.

Keywords— CORSIKA, cosmic rays, eas, Colombia.

Surviving a Storage Facility Fire

Paul E Calderwood

Abstract— This presentation is designed to assist upper level management in their responsibilities to provide a safe work place and the training for their team members to be able to respond to incidents no matter if they are accidental, natural disasters or terrorist attacks. The presentation will cover the planning requirements, the training and practice needed to respond and the aftermath activities; including the investigations.

Keywords— Fire, emergency, safety, planning.

Study Investigates the Applicability of Some Downhole Gas Liquid Separator Technologies

Eiman Al Munif, Hattan Banjar, Xiao Jinjiang, Luai Alhamad

Abstract— Liquid accumulation in deeper wells is a critical issue because it reduces the productivity index of a well. One of the lifting mechanisms for the accumulated liquid is the sucker rod pump system (SRP). There has been a challenge lifting large volumes of liquid and associated gas artificially to the surface, especially with rod pumps system since SRP doesn't handle a large quantity of gas and the difficulty of separating liquid from gas downhole. Several downhole gas-liquid separators have low efficiency and lack an acceptable guide for their optimum design. The objective of this paper is to perform an assessment of several conceptual downhole gas separators design. The assessment includes the effect of positioning and geometry of the separator, the effect of tubing diameter on flow characteristics, and an economic comparison between the assessed technologies. A downhole gas separator can be deployed below the pump intake to separate free gas from the produced liquid. The gas that is separated downhole can be produced through the tubing casing annulus while the liquid is artificially lifted through the tubing. In this study, eleven designs were investigated to determine the most optimum design applicable for 5-1/2-inch casing well and can handle high CGR up to 450 BBL/MMSCF/day. The first screening of the 11 technologies were based on the type of separator, simplicity, capability of being deployed in a well without packer in the annulus, and compatible with a SRP technology. The second screening involved calculations of pressure, temperature and density profile for each depth in the candidate well, then published equations were used to calculate the critical gas velocity for different tubing dimensions. The last screening step was to perform an economical study to compare the cost of the final four selected technologies. The results after calculating gas velocities showed liquid loading problem starts at the depth near the kickoff point. The study displayed that the installation of a separation device would help in the separation between gas and liquid if it was assembled with a tail pipe length of 1000 ft. This assessment can be utilized as a guide for the development of downhole gas liquid separation technologies in the industry. It also suggests which technology can be deployed with SRP to boost the SRP efficiency in wells that suffer liquid loading issues.

Keywords— artificial lift, gas liquid separator, liquid loading, sucker rod pump.

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Evaluation of Groundwater and Seawater Intrusion at Tajoura Area – NW-Libya

Abdalraheem Huwaysh, Yasmin El Ahmar

Abstract— Water quality is an important factor that determines its usage for domestic, agricultural and industrial uses. This study was carried out through the Tajoura Area, Jifarah Plain, Northwest Libya. Chemical and physical parameters were measured and analyzed for groundwater samples collected in 2021 from twenty-six wells distributed throughout the investigation area. Overexploitation of groundwater caused a considerable deterioration in the water quality especially at Tajoura Town (20 Km east of Tripoli). The aquifer shows an increase in salinization, which has reached an alarming level in many places during the past 25 years as a result of the sea water intrusion. The chemical composition of the water samples was compared with the drinking water standards of WHO and Libyan Standards. Groundwater from this area was not suitable to be source for direct drinking based on Total Dissolved Solids. The dominant cation is sodium while the dominant anion is chloride. Based on the Piper trilinear diagram, most of groundwater samples (90%) was identified as sodium chloride type. The best groundwater quality exists at the southern part of the study area. Serious degradation in the water quality, expressed in salinity increase, occurs as we go towards the coastline. The abundance of NaCl waters is a strong evidence to attribute the successive deterioration of the water quality to the seawater intrusion. Considering the values of Cl⁻ concentration and the ratio of Cl⁻/HCO₃⁻, about 70% of the groundwater samples were strongly affected by the saline water. Car wash stations in the study area as well as the unlined disposal pond used for the collection of untreated wastewater contribute significantly to the deterioration of water quality. The water quality in this area needs to be monitored regularly and it is crucial to treat the water before consumption.

Keywords— Tajoura, Groundwater, Overexploitation, Seawater Intrusion.

I. INTRODUCTION

In recent decades, groundwater became one of the most important natural resources because of increasing water demand and decreasing surface water supplies particularly at the arid and semi-arid regions. It became very necessary to find large quantities of groundwater, reachable, and has a good quality to use it in multi-purposes. Libya is a country that suffers from water scarcity. The situation has become more problematic due to continued population growth, low rainfall and higher water demand for Domestic, agricultural and industrial uses. Coastal aquifers serve as major sources for freshwater supply in many countries around the world, especially in the Mediterranean [1]. The fact that coastal zones contain some of the most densely populated areas in the world makes the need for freshwater even more acute [1]. The intensive extraction of groundwater from coastal aquifers reduces freshwater outflow to the sea and creates local water

table depression, causing seawater to migrate inland and rising toward the wells [1]-[2], resulting in deterioration in groundwater quality. This phenomenon, called seawater intrusion, has become one of the major constraints imposed on groundwater utilization in coastal areas. It is a significant issue that affects water resources in Libya.

Location of the Study Area

Libya, the third largest country in Africa, is located in the north of the continent. It lies between latitudes 33°10' N and 18°45' N and longitude 9°58' E and 25°E. It possesses a Mediterranean coastline of approximately 1820 km in length [3].

The Jifarah Plain at the northwestern part of the country, located between the Mediterranean coast and the Jabel Naffusah Mountain in the south. It comprises more than 60% of the country's population and produces 50% of the total agricultural outputs [4]. The targeted area lies in the Jifarah Plain and occupies about 156 km², extending for about 13 km from the coast line of the Mediterranean Sea southward (from 3630000 to 3643000 northing) with a width of about 12 km (from 338000 to 350000 easting), Zone 33 S, Fig. 1.

II. OBJECTIVES OF STUDY

This study aims to evaluate the causes, impacts and mitigation measures of seawater intrusion. A combination of previous works review, field and laboratory investigations have been used to evaluate the extent of seawater intrusion and its impacts on water resources in this part of Libya.

The main objectives of this study can be summarized as follows:

1. Assessment of the hydrogeochemical characteristics of groundwater in the targeted area.
2. Determination of groundwater facies and classification.
3. Assessment of the risk due to intrusion of salty marine water (Sea water intrusion) at Tajoura Area.

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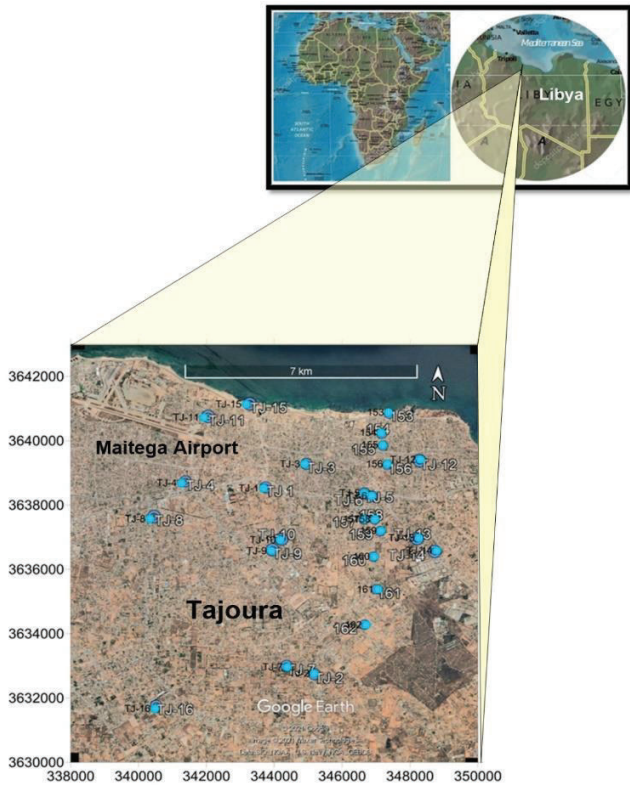


Fig. 1: Location map of the study area.

III. METHODOLOGY

A flowchart diagram representing research design is made to illustrate research stages, and because this study aims to evaluate the water chemistry types and water quality in Tajoura Town; the research will be designed to achieve the objectives set out by the researchers, as shown in the flowchart, Fig. 2.

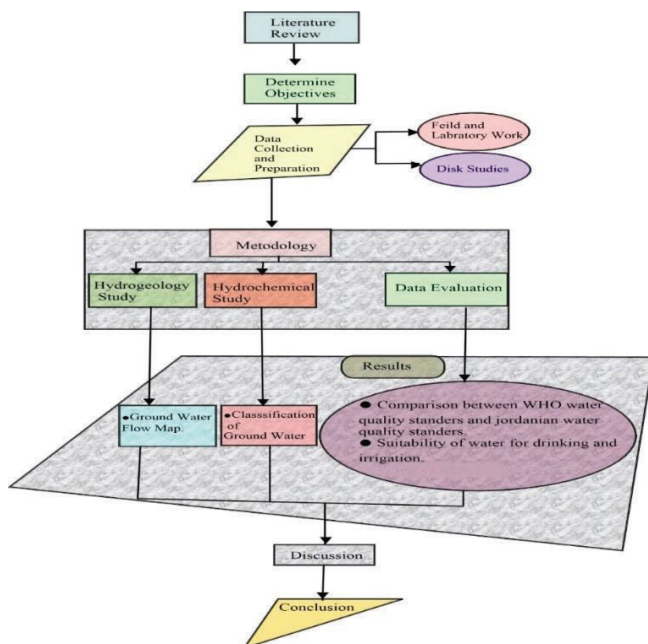


Fig. 2: Flowchart illustrating research stages

IV. DATA ACQUISITION AND COLLECTION

The first step was the collecting of necessary available data related to geological, hydrogeological, hydrological, hydrochemical features in the targeted area documented in technical reports, papers, internet websites and journals. Some data were collected from study area during the fieldwork stage, while others, especially hydrological information (Rainfall, Evaporation and static water level) and wells location in Tajoura Area were obtained from the General Water Authority (GWA).

Field work

Several field visits to collect 26 water samples from 26 boreholes, all of them are private wells have been carried out through two weeks. The coordinates of each sampling point (well) were recorded at the field by using the GARMIN GPS. Additionally, other data such as depth to water and ground surface elevation were recorded for each well, Fig. 3.

Water Sampling and rapid field-test

The 26 water samples were filled in plastic bottles of 1.5-liter size. Rapid field tests, including PH, TDS, T & EC have been also carried out for all the collected water samples by using portable water analysis device.

Laboratory and office work

The laboratory works included chemical analyses of water samples in order to determine the concentrations of the major elements have been carried out in the Laboratories of the *Advanced Laboratory for Chemical Analyses, Tajoura*. These analyses aimed to determine the concentration of cations such as Ca^{2+} , Mg^{2+} , Na^+ , K^+ and the anions such as HCO_3^- , SO_4^{2-} , Cl^- , NO_3^- , in addition to pH, TDS and EC.

Data interpretation

Different software packages were used in handling, drawing figures and diagrams, geochemistry modeling, graphical plots and data analysis, which are:

- Aquachem 2014.2
- Rochwork version 16.
- Surfer version 11.
- Google Earth pro 2014
- Microsoft office Excel 2010

V. HYDROGEOLOGY

In the past, the Jifarah Plain was the most important basin, providing water for domestic and agricultural uses in the populous Tripoli region. The aquifers of the Jifarah plain are estimated to be recharged by 200 $Mm^3/yr.$ of water from rainfall, wadi runoff, and return flows from the irrigation and water supply systems [4]. Water extraction was 1000 $Mm^3/yr.$ in 1993 (800 $Mm^3/yr.$ for irrigation and 200 $Mm^3/yr.$ for settlement water supply), thus producing an annual deficit of 800 $Mm^3/yr.$ The water resources of the basin were in natural balance up to the year 1950. There after groundwater extraction surpassed the annual recharge. Due to the increasing rate of extraction, there has been an ever-increasing annual deficit in the water balance [4].



Fig. 3: Field work (Collection of samples and water level measurements)

The average rainfall ranges between 221.7 mm/yr. in the Al-Ajilat region and increases gradually until it reaches about 301.2 mm/yr. in the Tripoli area and gradually decreases towards the east until it reaches about 241 mm/yr. in the Zliten region.

Jifarah Plain is characterized by the presence of some seasonal valleys whose water collects as a result of rain fall on the mountain slopes in the southern regions. The most important of which are Wadi Al-Majnin, Wadi Gan, Wadi Labda and Wadi Kaam, and dams have been constructed on them to collect their water instead of losing it in the sea [4].

Main Aquifers

The aquifers which play an important role in the groundwater flow and storage in the Jifarah plain are as follows:

The Quaternary–Pliocene–Upper Miocene aquifer consisting of sand, calcarenites and clay, has approximately the same extension as the Miocene formation. The saturated thickness of the aquifer varies from 10 to 150 m.

A thick series of sandstones forms another important aquifer in the central and eastern part of the plain. The age of the sandstones is uncertain but is generally attributed to lower

Cretaceous-upper Jurassic (Kiklah Formation). In some places, the sandstones probably belong to the upper Triassic (Abu Shaybah Formation).

Azizia dolomitic limestones (middle Triassic) form another aquifer which is well developed in the south–central part of the Jifarah. This formation shows interesting hydraulic properties mostly in it's out cropping area where Karstic channels and openings enable the groundwater to flow easily. In the western part of Al Jifarah , Azizia also seems to form a good aquifer (although with poor quality water) in the area where it's depth does not exceed 300 to 400 m [5].

Hydraulic Behavior of the Aquifers

Recharge

The spreading zones of the wadis have been identified and indicated on the map in order to understand the recharge by infiltration of runoff water from the wadis, Fig. 4. Assuming that all the infiltrated water will contribute to the recharge of the aquifers (which is not completely true between Bi'r al Ghanam and Qasr al Haj where the Jurassic evaporites subcrop) and assuming that 10 to 30% of the runoff infiltrates [5].

Groundwater flow

In the south-central part of the Jifarah Plain the ground water flows mainly in the Triassic sandstones and dolomitic limestones. The flow is likely to originate a few kilometers south of the jabal escarpment but this hypothesis still needs to be confirmed by some deep wells south of Gharyan because it is also possible that the flow, at least in Azizia limestone, comes from further south. To the north, most of the ground water flows into the Quaternary-Pliocene-Upper Miocene aquifers but part of the flow probably also recharges the Lower Miocene and Mesozoic sandstone aquifers confined by the clays of the Middle Miocene [4].

In the eastern part of the Jifarah Plain the groundwater flows mainly in the Mesozoic sandstone (mostly Kiklah Fm.). This groundwater flow is in continuity with the general south-north flow in the eastern Suf Ajjln basin. To the north, most of the groundwater flow remains in the Mesozoic sandstone (associated with the Lower Miocene aquifer). The shallow aquifer (mostly Quaternary and Upper Miocene) becomes independent and has its own direct recharge [4]. In the central and eastern parts of the Jifarah Plain, the groundwater flow is directed towards the sea which is the natural outlet of the aquifers. In the southwestern part of the Jifarah the groundwater flows northwards through Jurassic aquifers of limited intake (the groundwater divide is located a few kilometers to the south) and of limited extension to the north (Middle and Lower Jurassic evaporites outcrop a few kilometers north of jabal escarpment). The groundwater flow is discharged in small springs or in diffuses outlets.

The overexploitation of the Jifarah upper aquifer is characterized by the falling of piezometric head over a wide region, reducing the outflow rate to the sea, and the continuous degradation of the chemical quality of water. Depression cones in various places have dropped from 25 to 35 m below sea level, which testifies the inversion of the hydraulic gradient and the intrusion of seawater. This was mainly observed in Sabratah region and southern Tripoli [4].

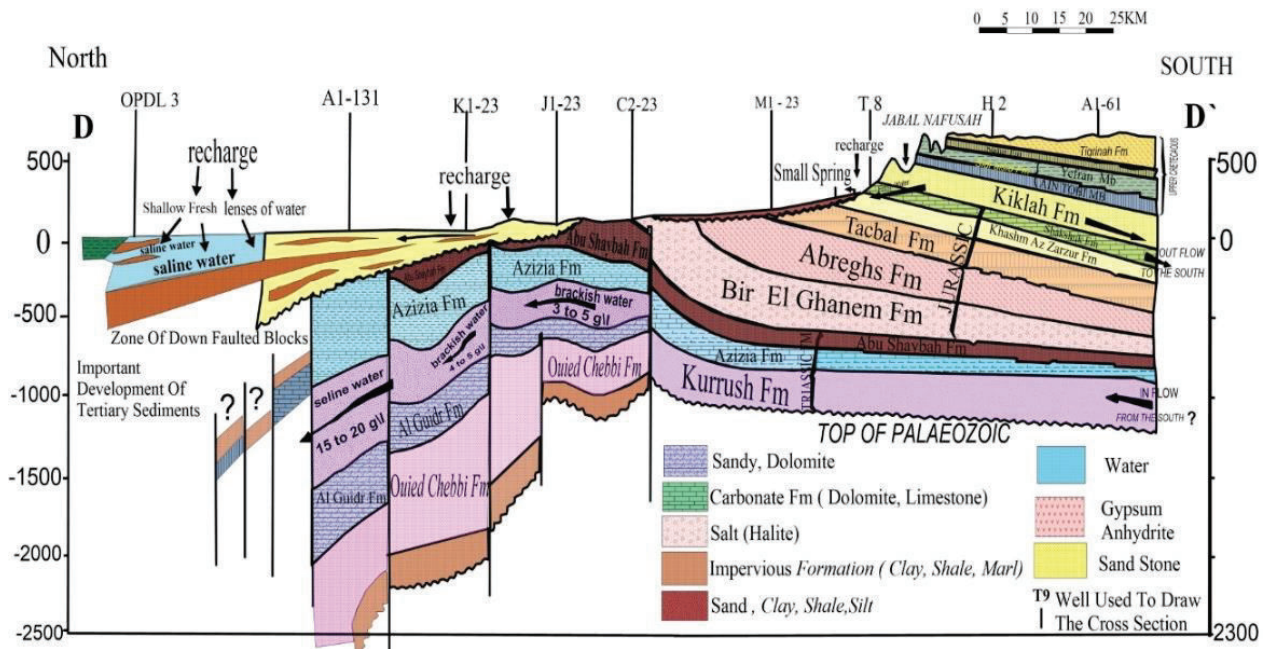


Fig. 4: Hydrogeological cross section of the Jifara Plain (after Pallas,1980)

Groundwater use

Despite the scarcity of water resources, consumption is on the rise as a result of improving economic conditions, urbanization, and improving standards of living.

Agricultural use

Agriculture is and will continue to be the major water consumer. It represents about 85% of the current water demand and despite the use of pressurized irrigation techniques in practically all farming areas, application rates are still among the highest in the world. This is mainly due to the unsuitable climatic and soil conditions. Two types of irrigated areas have been identified and correspond to [5]:

Permanently irrigated fields with heavy groundwater extraction estimated to range from 5000 to 9000 m³ /ha/year.

Partly irrigated fields with moderate groundwater extraction estimated to range from 1500 to 3000 m³ /ha/year. The groundwater extraction from the Jifarah Plain has been estimated by different authors and at different dates, Table I [6].

Domestic use

In Libya, 80% of the population live in urban centers, varying in size from 5000 to 1000000 inhabitants, The average water consumption per capita was found to range from 150 to 300 l/capita/day, depending on the size of the city, location, and age of the supply network [6]. In rural areas, people depend to a certain extent on private water supply sources, usually wells, rainwater reservoirs and springs. The average per capita consumption falls between 100 and 150 l/capita/day. Domestic water consumption rates are generally increasing with time as a function of income. In Jifarah Plain, estimates of annual domestic water use found to be 228.59 million cubic meters [6].

VI. HYDROCHEMISTRY

The hydrogeochemistry of groundwater vary spatially and temporally, depending on the geology and chemical characteristics of the aquifer and the groundwater quality is nearly of equal importance to the quantity [7].

Water Quality in Jifara Plain

Quaternary-Pliocene-Miocene aquifer: Water of this aquifer is generally of good quality with TDS of less than 1000 ppm. However, in the western part of the plain (mainly west of Sabratah), the water quality deteriorates rapidly and becomes saline with TDS higher than 5000 ppm. Along the coast and mostly between Sabratah and Az Zawiyah and in the immediate surroundings of Tripoli, higher salinity resulting from seawater intrusion can be observed .

Mesozoic sandstone aquifer: The water quality is generally good with TDS ranging from 1000 to 2000 ppm [1].

Azizia aquifer: Water is usually of medium to poor quality with TDS ranging from 2000 to 4000 ppm. This hydrochemical study of groundwater in the targeted area includes interpretation of the chemical properties and the concentration of the major cations Ca²⁺, Mg²⁺, Na⁺ and K⁺ and the major anions CO₃²⁻, HCO₃⁻, SO₄²⁻, Cl⁻ and NO₃⁻ as well as the total dissolved solids (TDS) [2].

Data Reliability –Error balance equation

Charge Balance Error (CBE) has been used to judge the reliability of water analyses according to the following equation:

$$CBE = \frac{\sum cations - \sum anions}{(\sum cations + \sum anions)} * 100 = Error\% \quad (1)$$

The error % for the twenty six wells were calculated, and therefore the analyses results of these water samples are reliable and can be used in this study, Table II.

Table I: The water balance of Jifara Plain area

| Region | Available (Million cubic meters per year) | | | | | | Total | Consumption (Million cubic meters per year) | | | Total | Water balance |
|--------------|----------------------------------------------|--------------|---------------|-----------------|----------------|-------------|--------|------------------------------------------------|----------|------------|---------|---------------|
| | conventional | | | nonconventional | | | | Agricultural | Domestic | Industrial | | |
| | Renewable | Nonrenewable | Surface water | Desalination | Treated sewage | Transported | | | | | | |
| Jifara Plain | 300 | 50 | 25.5 | 19.70 | 11.10 | 215.6 | 621.94 | 995.2 | 228.59 | 12.3 | 1236.09 | -614.15 |

Table II: Calculations of the charge-balance error (CBE) in percent

| No | Ca (meq/l) | Mg (meq/l) | Na (meq/l) | K (meq/l) | HCO ₃ (meq/L) | Cl (meq/l) | NO ₃ (meq/l) | SO ₄ (meq/l) | TDS | Total Cations + | Total Anions- | Ionic Balance |
|-------|------------|------------|------------|-----------|--------------------------|------------|-------------------------|-------------------------|-------|-----------------|---------------|---------------|
| 153 | 6.74 | 4.34 | 142.01 | 0.28 | 6.39 | 148.08 | 0.85 | 13.33 | 9840 | 153.37 | 168.65 | -4.7% |
| 154 | 2.58 | 2.47 | 63.16 | 0.81 | 8.80 | 50.07 | 1.70 | 8.33 | 4230 | 69.01 | 68.90 | 0.1% |
| 155 | 3.32 | 11.51 | 138.10 | 1.36 | 8.00 | 127.18 | 0.10 | 14.57 | 7480 | 154.28 | 149.85 | 1.5% |
| 156 | 2.52 | 4.52 | 42.36 | 0.15 | 13.19 | 20.03 | 1.42 | 11.45 | 3730 | 49.56 | 46.09 | 3.6% |
| 157 | 3.07 | 1.64 | 25.49 | 0.05 | 4.39 | 20.03 | 1.35 | 4.37 | 1788 | 30.25 | 30.14 | 0.2% |
| 158 | 4.40 | 0.00 | 45.67 | 0.10 | 4.00 | 40.05 | 0.74 | 8.54 | 3710 | 50.17 | 53.33 | -3.1% |
| 159 | 8.62 | 5.75 | 43.71 | 0.14 | 8.39 | 40.05 | 2.41 | 7.08 | 3530 | 58.23 | 57.93 | 0.3% |
| 160 | 3.05 | 4.11 | 31.58 | 0.10 | 4.39 | 23.02 | 1.98 | 6.66 | 2210 | 38.84 | 36.06 | 3.7% |
| 161 | 2.24 | 3.04 | 32.06 | 0.14 | 2.79 | 27.05 | 0.92 | 6.04 | 2220 | 37.47 | 36.80 | 0.9% |
| 162 | 0.12 | 2.63 | 3.82 | 0.05 | 5.20 | 1.00 | 0.25 | 0.83 | 338 | 6.62 | 7.28 | -4.7% |
| tj-2 | 0.06 | 2.47 | 3.20 | 0.03 | 3.11 | 2.20 | 0.40 | 0.62 | 329 | 5.75 | 6.34 | -4.8% |
| tj-16 | 0.75 | 0.49 | 3.49 | 0.03 | 0.51 | 1.00 | 1.28 | 1.87 | 486 | 4.77 | 4.66 | 1.2% |
| tj-7 | 3.03 | 5.75 | 32.45 | 0.11 | 1.20 | 31.06 | 0.57 | 4.79 | 2520 | 41.35 | 37.61 | 4.7% |
| tj-8 | 10.48 | 0.41 | 68.42 | 0.12 | 5.20 | 70.09 | 0.34 | 8.12 | 5500 | 79.43 | 83.75 | -2.6% |
| tj-9 | 4.94 | 8.22 | 81.12 | 0.22 | 6.00 | 80.11 | 0.58 | 5.41 | 5750 | 94.50 | 92.10 | 1.3% |
| tj-10 | 8.32 | 1.64 | 27.84 | 0.07 | 7.59 | 28.04 | 1.35 | 2.71 | 2280 | 37.87 | 39.68 | -2.3% |
| tj-11 | 7.24 | 0.82 | 78.29 | 0.12 | 7.60 | 66.43 | 1.49 | 18.11 | 5470 | 86.47 | 93.63 | -4.0% |
| tj-12 | 1.02 | 6.08 | 6.32 | 0.04 | 6.39 | 2.93 | 2.19 | 3.33 | 1686 | 13.46 | 14.85 | -4.9% |
| tj-13 | 2.61 | 2.88 | 13.27 | 0.03 | 1.97 | 10.30 | 1.28 | 3.96 | 2360 | 18.79 | 17.49 | 3.6% |
| tj-14 | 1.56 | 6.99 | 3.83 | 0.05 | 5.57 | 5.98 | 0.69 | 1.46 | 729 | 12.43 | 13.70 | -4.9% |
| tj-15 | 4.64 | 2.71 | 261.84 | 1.20 | 12.39 | 213.97 | 0.34 | 17.70 | 11030 | 270.40 | 244.40 | 5.0% |
| TJ-1 | 4.28 | 4.11 | 18.70 | 0.04 | 1.79 | 20.05 | 1.35 | 2.08 | 1535 | 27.13 | 25.27 | 3.5% |
| TJ-3 | 1.74 | 2.05 | 23.18 | 0.16 | 10.33 | 10.01 | 2.41 | 7.08 | 3530 | 27.14 | 29.83 | -4.7% |
| TJ-4 | 1.49 | 0.41 | 27.62 | 0.06 | 3.70 | 18.62 | 1.77 | 7.91 | 2040 | 29.59 | 32.00 | -3.9% |
| TJ-5 | 1.38 | 1.64 | 14.16 | 0.09 | 1.79 | 9.59 | 0.03 | 5.83 | 9840 | 17.27 | 17.23 | 0.1% |
| TJ-6 | 2.09 | 0.41 | 30.36 | 0.09 | 4.00 | 23.78 | 0.85 | 3.75 | 1883 | 32.96 | 32.38 | 0.9% |

Physical properties

Temperature (C°)

All groundwater samples taken from the wells measured to have temperature ranges from 25 to 27 degrees Celsius, Fig. 5.

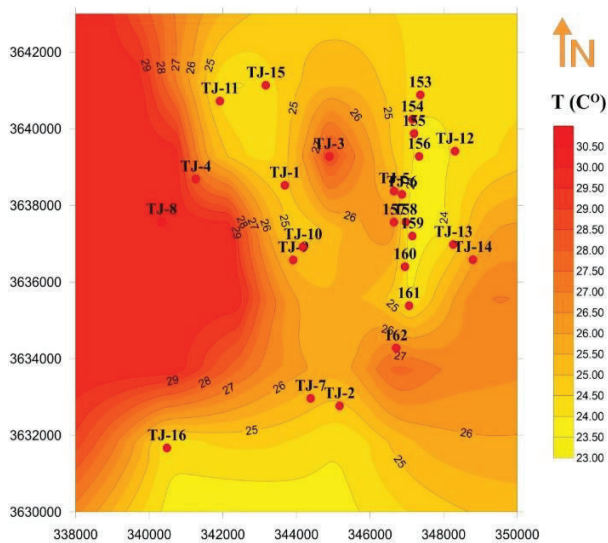


Fig. 5: Contour map of groundwater temperature (°C)

Hydrogen number (pH value)

The pH of a solution is defined as the negative logarithm of its hydrogen ion activity [8].

$$pH = - \log [H^+] \quad (2)$$

PH is one of the most important operational water quality parameters with the optimum pH required often being in the range of 7.0–8.5. The maximum permissible limit for pH in drinking water as given by the WHO is 8.5 [8]. The values of pH in the groundwater samples in this study varied from 6.8 to 7.27 with an average value of 6.9, Fig. 6.

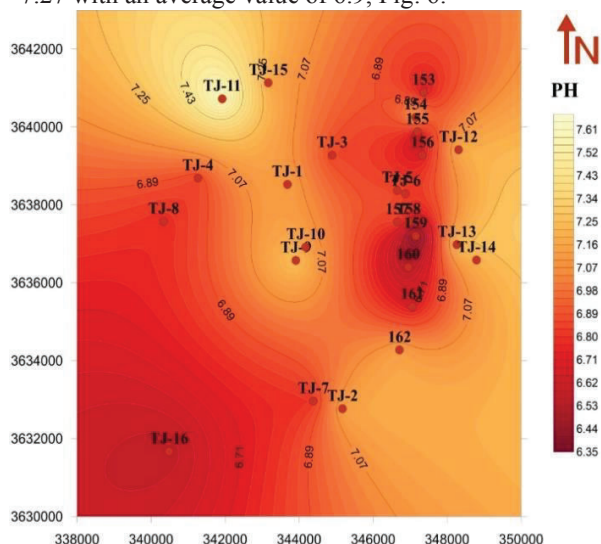


Fig. 6: Contour map of PH values.

Electrical Conductivity (EC)

Electrical Conductivity (EC) is the ability of (1cm³) of water to conduct electrical current, at temperature of 25C°, when

measured by micro Siemens per centimeter (µs/cm). It depends on the concentration of soluble salts and the temperature of the water [8]. The EC depends on water temperature, where an increase in water temperature of one degree Celsius causes an increase in electrical conductivity by 2% [9]. Also, the EC increases with the increase of the total dissolved salts [10]. The EC values of the groundwater samples in the study area are shown in Fig 7

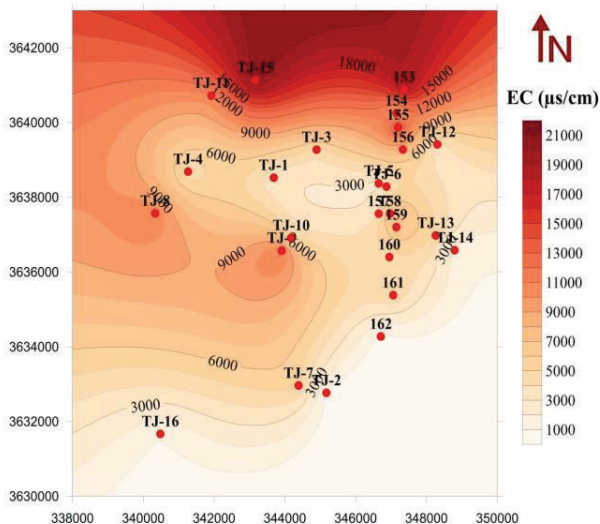


Fig. 7: Contour map of electrical conductivity (EC) values

Total Dissolved Solids (TDS)

Total dissolved solids (TDS) comprise inorganic salts; principally calcium, magnesium, potassium, sodium, bicarbonate, chlorides, and sulphates and some small amount of organic matter that are dissolved in water[11]. TDS values of the collected groundwater samples measured as (ppm) or (mg/l) units are represented as a contour map, shown in Fig. 8. It is clear that the northern part of the study area has the highest TDS values (11030 ppm) compared to the southern part where the minimum value is recorded to be 329 ppm, with an average value of 3694 ppm. Fig. 8.

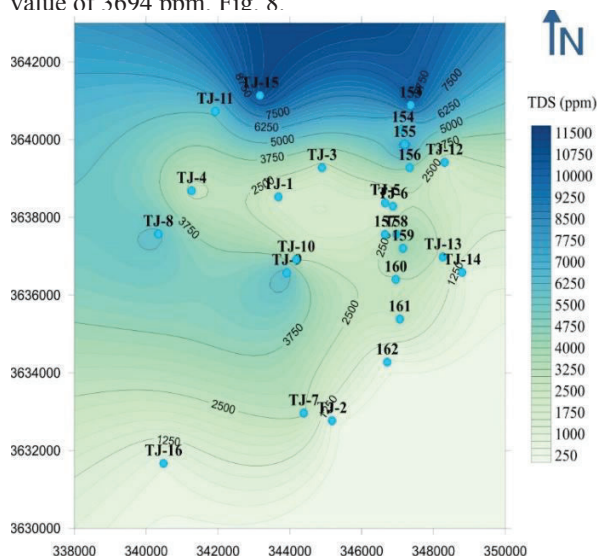


Fig. 8: Contour map showing the TDS concentration

North- south profile was selected to determine the spatial variation of the concentration of the total Dissolved Solids (TDS). It is very clear that this concentration is inversely proportional to the distance from the coastline, that is to say, it decreases as we go southward, Fig. 9.

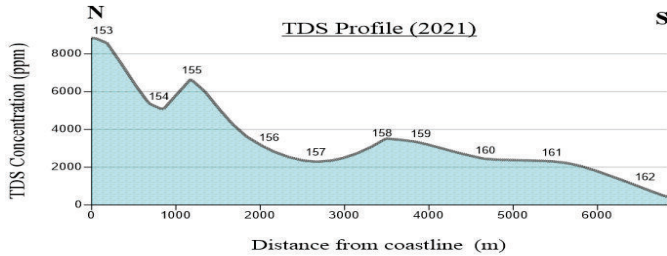


Fig. 9: North- south profile showing the spatial variation of TDS concentrations in the study area.

Major Ions

Groundwater always contains variable amounts of dissolved salts. These are derived from the interaction between the water and various solids, liquids and gases as the groundwater makes its way from its recharge area to discharge area. More than 90% of the dissolved solids in groundwater can be attributed to eight ions: Na^+ , Ca^{2+} , K^+ , Mg^{2+} , SO_4^{2-} , Cl^- , HCO_3^- and CO_3^{2-} [12].

Major Cations

Calcium (Ca^{2+})

Calcium ion concentration in the groundwater samples collected from the study area are shown in Table II. The limit of Ca^{2+} for drinking water is specified as maximum permissible limit about 75 mg/l [13]. In the study area, calcium reached a maximum value of 210 mg/l for the sample that taken from well No. TJ-8 whereas it reached only 1.3 mg/l for the sample collected from the well No. TJ-2. The average was calculated to be 71.1 mg/l, Fig. 10.

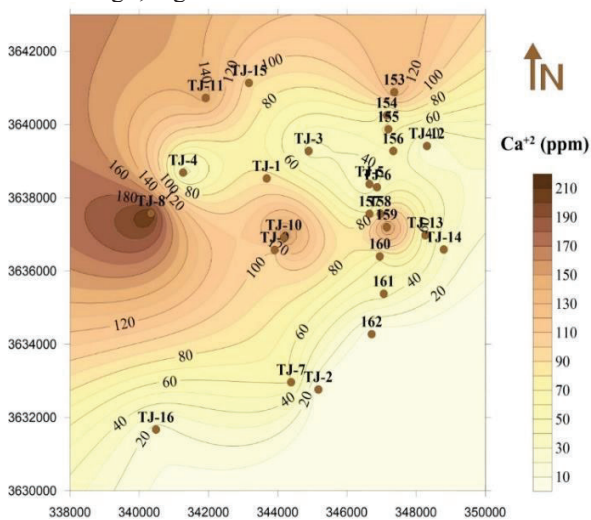


Fig. 10: Contour map showing the spatial variation of calcium concentration (mg/l)

Magnesium (Mg^{2+})

This cation is mainly less abundant than calcium in the groundwater, a fact that can be explained by the low abundance

of dolomitic rocks spread of Mg^{2+} ions in the water. The maximum acceptable limit of Mg^{2+} for drinking water is 50 mg/l [13]. In the study area, the minimum Mg^{2+} concentration observed in Well No. TJ-8 (5 mg/l) at the western part, and reached the maximum value in the well No. 155 (140 mg/l) with an average value of 42.8 mg/l, Fig. 11.

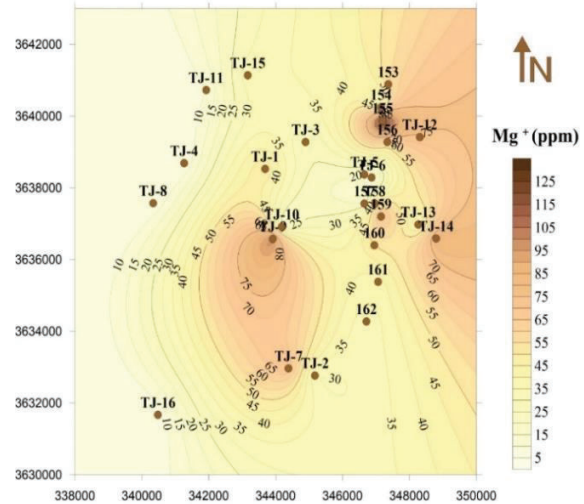


Fig. 11: Contour map showing the spatial variation of magnesium concentration (mg/l).

Sodium (Na^+)

Sodium is the most abundant member of the alkali-metal group in nature. This cation is found in brines and hard water and percolated easily into the groundwater through the municipal dumping of industries wastes and effluent plants infiltration, so it spreads very fast and well dissolved in groundwater and generally increases with the increasing of TDS.

The limit of Na^+ for drinking water is specified as 200 mg/l as desirable limit [13]. In the study area the sodium concentration reached its maximum value of 6020 mg/l; exceeding permissible limit, at the well No. TJ-15 and minimum value of 73.5 mg/l at well No. TJ-2 with an average value of 1116 mg/l, Fig. 12.

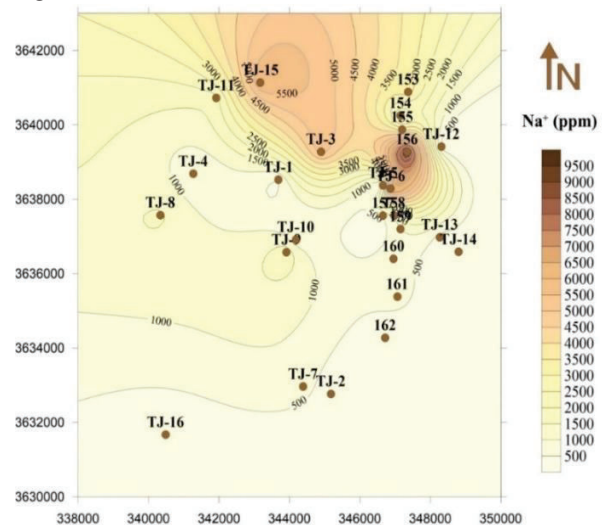


Fig. 12: Contour map showing the spatial variation of sodium concentration (mg/l).

Potassium (K⁺)

The potassium content in natural waters is usually less than that of sodium, magnesium and calcium. Potassium infiltrated into the groundwater through leaching of some salty rocks from industry and municipal sewage treatment plants, as well as from potassium salts that used as fertilizers. The potassium is substantially larger than sodium ion and it would normally be expected to be adsorbed less strongly than sodium in Ion-exchange reactions [9]. The potassium ion (K⁺) concentrations of groundwater samples are given in Table 2. In the study area the highest Potassium concentration found to be of 53 mg/l at well No.155 whereas the lowest value found to be 1 mg/l at well No.TJ-2 with an average value of 8.49 mg/l, Fig. 13.

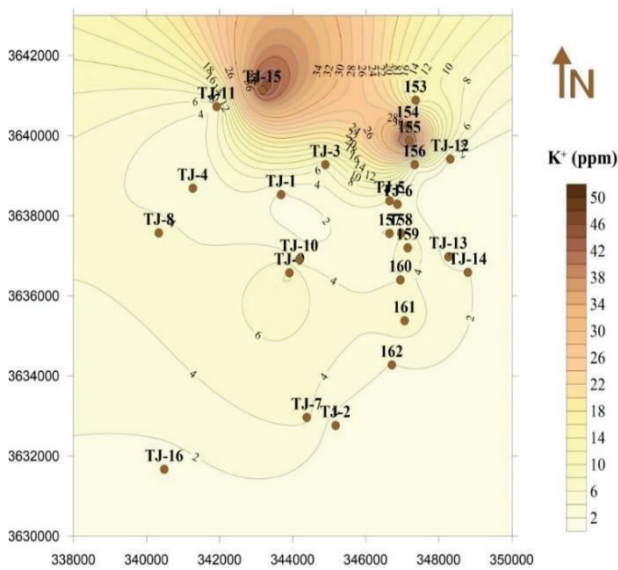


Fig. 13: Contour map showing the spatial variation of potassium concentration (mg/l).

Major Anions

Bicarbonates (HCO₃⁻)

Carbonates and bicarbonates are considered to be the most important anions in natural water. They considered as a source of alkalinity (Carbonate Alkalinity), while total alkalinity is a measure of carbonates, bicarbonates and hydroxyl dissolved in groundwater, and responsible of PH. The results of HCO₃⁻ concentrations of groundwater samples are shown in Table 2. The maximum acceptable limit of HCO₃⁻ for drinking water is 500 mg/l [13]. In the study area, the minimum bicarbonate concentration was observed to be of 31 mg/l at well No.TJ-16 and maximum of 805 mg/l at well No. 157 with an average of 339.5 mg/l, Fig. 14.

Sulfates (SO₄²⁻)

Sulfates are abundant in most groundwater species, their occurrence can be attributed to the chemical weathering of some of the sedimentary rocks such as gypsum and anhydrite, oxidation of barite minerals. The human activities (agricultural and industrial activities) can be also considered as a significant sources for sulfates [14]. The sulfate concentrations of groundwater samples are shown in Table II.

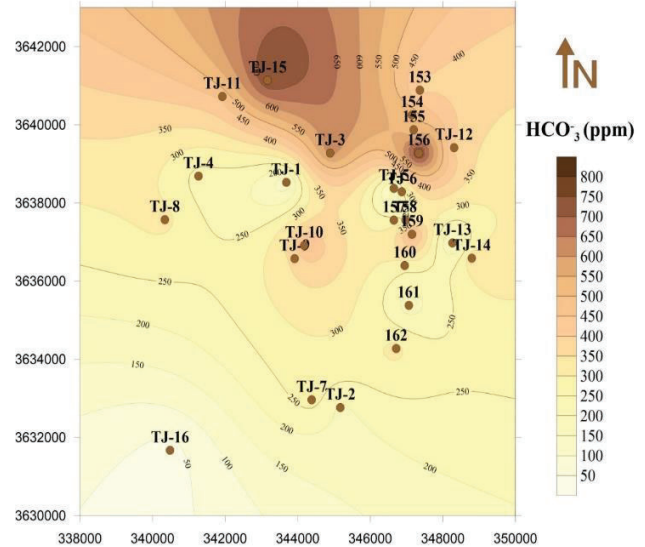


Fig.14: Contour map showing the spatial variation of bicarbonates concentration (mg/l).

High levels of sulphate in drinking water can cause Diarrhea [13]. The WHO standards for sulphate in 2011 for drinking water is 400 mg/l. Maximum Sulphate concentration was observed to be 870 mg/l; exceeding permissible limit at well No.TJ-11 whereas the minimum value was 30 mg/l at well No.TJ-2 in the study area with an average value of 325 mg/l, Fig. 15.

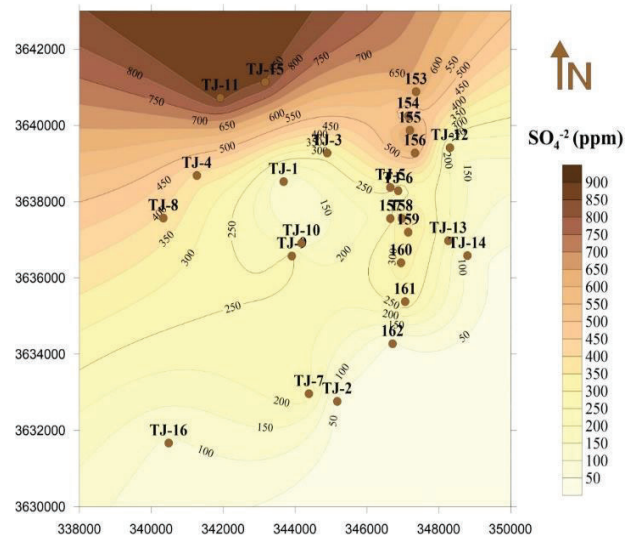


Fig. 15: Contour map showing the spatial variation of sulphates concentration (mg/l).

Chloride (Cl⁻)

Chloride concentrations of groundwater samples are shown in Table 2. The maximum acceptable limit of chloride for drinking water is 250 mg/l [13]. The maximum chloride concentration was observed to be of 7586 mg/l; exceeding the potable limit at well No.TJ-15 and the minimum value was found to be of 35.5 mg/l at well No.162 in the study area, with an average value of 1487mg/l, Fig. 16.

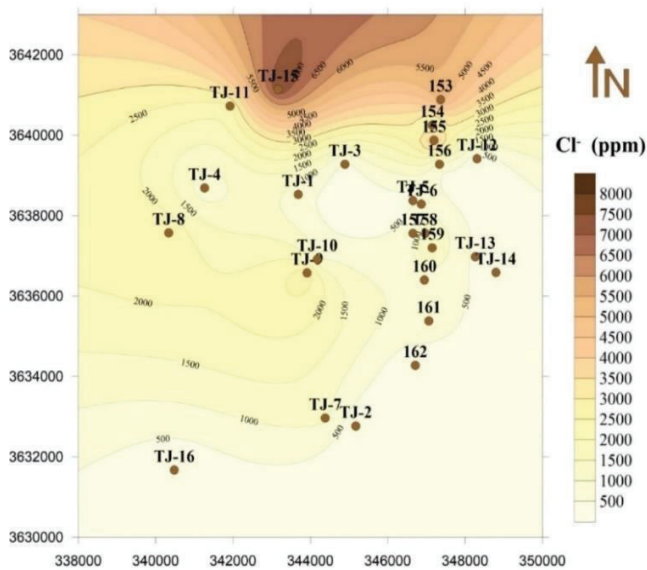


Fig. 16: Contour map showing the spatial variation of chloride concentrations (mg/l).

Nitrate (NO₃-)

Nitrate is the most available indicator for pollution and it is well-dissolved in groundwater and easily leached from soils. Nitrogen occurs in water as nitrate or nitrite anions. Nitrate concentrations in the study area are given in Table II. They range from 1.8 mg/l at the well No. TJ-5 to 150 mg/l at the well No. 159, with an average value of 68.8 mg/l, Fig. 17. This high concentration of nitrates might be attributed to the disposal of untreated sewage water either from septic tanks or from the sewage water treatment station.

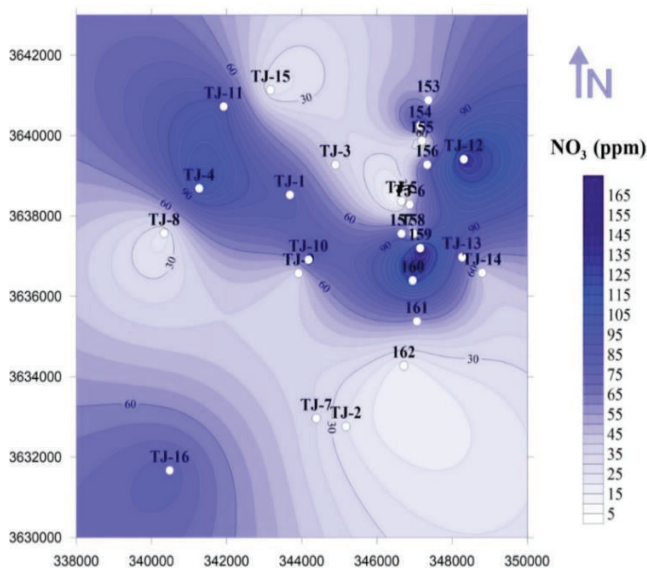


Fig. 17: Contour map showing the spatial variation of nitrates concentrations (mg/l).

VII. RESULTS AND DISCUSSION

Field measurements of water levels and the results of chemical analyses of samples collected from twenty-six water points (wells) distributed throughout the targeted area have been plotted and interpreted in order to evaluate the changes in the groundwater levels and quality during a period of 25 years.

Groundwater Levels (hydraulic head)

A contour map of the hydraulic head was constructed to represent the configuration of the potentiometric surface and flow direction within the targeted area in July 2021. It was noticed that there is a significant cone of depression at the southern part of the study area with a maximum head value of about 10 m below the sea water level, Fig. 18. It has been also noticed that there is a buildup (or Upconing) in the hydraulic head at two locations; one of them located at cars washing station and the other one is very close to the disposal pond of the sewage water station. This confirms that there is a possible recharge of the shallow aquifer by this contaminated water.

Groundwater Classification

The interpretation of analytical results was performed mainly based on the water-type classification according to the Aquachem version 3.7 programme and the graphical illustration method Piper diagram.

Piper Classification

The well-known piper diagram is extensively used by plotting the concentrations of major cations and anions in the Piper trilinear diagram [15]. Based on the chemical analyses, groundwater is divided into three distinct fields; two triangular fields and one diamond-shaped field.

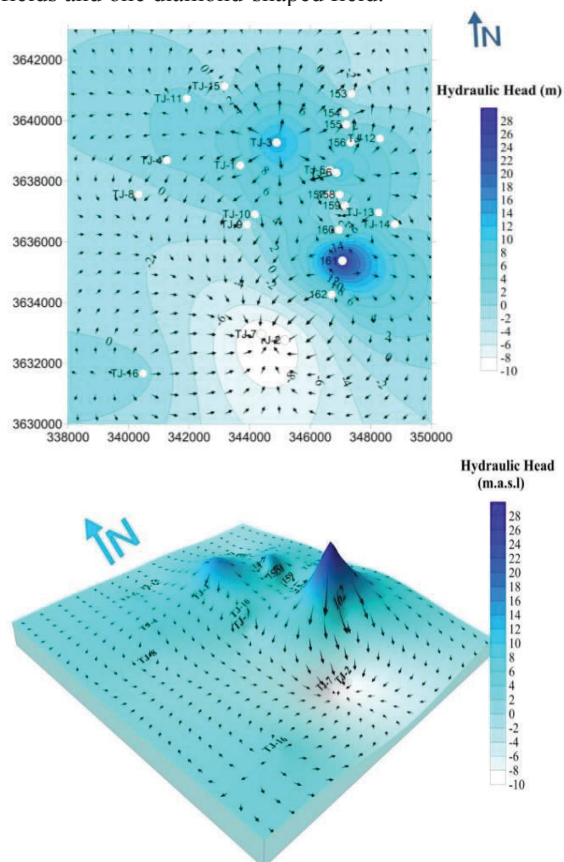


Fig. 18: Contour map of hydraulic head in the study area in 2021.

Groundwater Facies in the Study Area

The Rockware software version 17.2 has been used for plotting the Piper Diagram to display the relative concentrations of different ions in twenty six samples collected from the targeted area. Classification of hydrochemical facies for groundwater according to Piper diagram is shown in Fig. 19.

Generally, the predominant anions and cations are chloride and sodium respectively. Based on the contents of major cations and anions, most of the samples fall within sodium chloride type.

Simpson Ratio (Ionic Ratio)

The Simpson Ratio, first described by Todd [7] is the ratio of $Cl/(HCO_3^-)$. Five classes were created to evaluate the level of contamination;

- Good quality (<0.5),
- Slightly contaminated (0.5-1.3),
- Moderately contaminated (1.3-2.8),
- Injuriously contaminated (2.8-6.6), and
- Highly contaminated (6.6-15.5).

Based on the Simpson Ratio of the water samples, the evaluation of the quality of such samples are shown in table III: 2 samples are of good quality, 3 samples are slightly contaminated, 2 samples are moderately contaminated, 8 samples are injuriously contaminated, and 10 samples are highly contaminated

Comparison of water quality with the Libyan and (WHO) Standards:

During this study, the average values of chemical analyses for the collected water samples were matched with the Libyan specifications as well as the specifications of the World Health Organization for drinking water, Table IV.

Only calcium, magnesium, potassium and PH fall within the permissible limits, whereas the rest of the parameters fall outside the acceptable range.

Temporal changes in TDS concentration (1994 –2021)

The results of chemical analyses of samples from 10 water wells obtained from the historical data by the General Water Authority (GWA) in 1994 have been compared with the results of water samples collected from the same locations in 2021, in order to evaluate the temporal changes in the groundwater quality during a period of 25 years, Fig. 20.

It is clear that the overexploitation of groundwater caused a considerable increase in salinization, which has reached an alarming level in many places during the past 25 years. This deterioration in groundwater quality can be attributed to the sea water intrusion.

In contrast with all water samples, it has been noticed that two locations (wells No 159 & 160) displayed anomalies, in which the TDS concentration in 2021 is lower than that in 1994. This decrease in the TDS concentration with time can be attributed to the presence of these two wells very close to the unlined disposal pond of a sewage treatment plant.

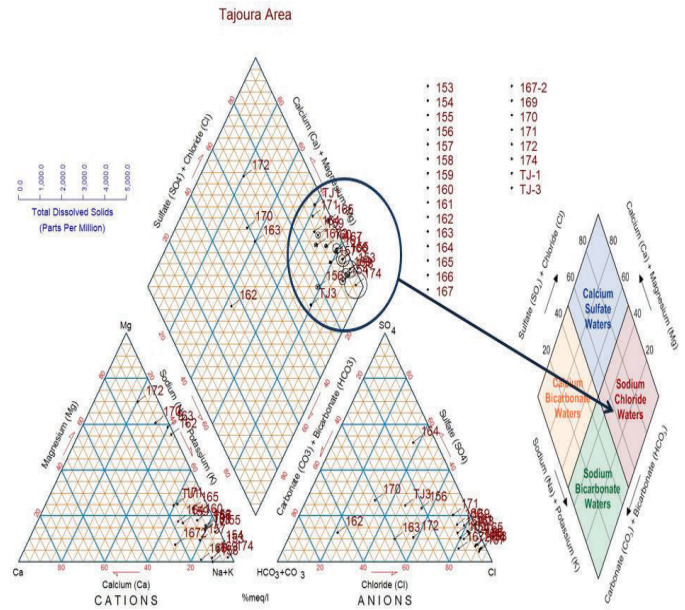


Fig. 19: Piper classification diagram illustrating the chemical composition of groundwater in the study area.

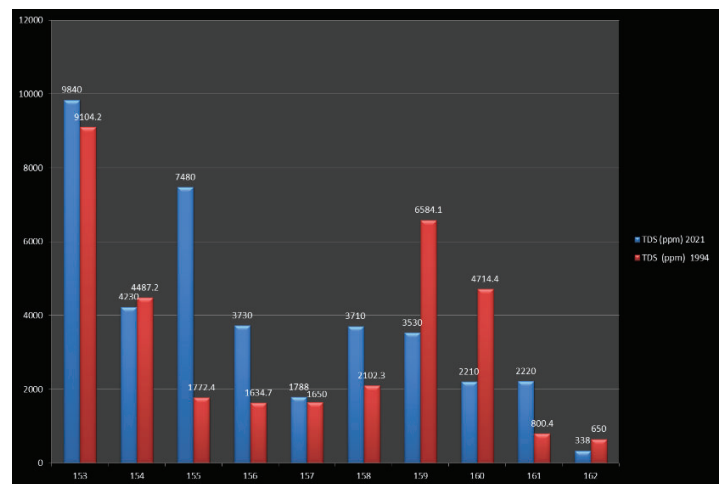


Fig. 20: Temporal changes in TDS concentration in the study area during the period 1994-2021

Table III: Contamination level based on the Simpson Ratio ($\text{Cl}^-/(\text{HCO}_3^-)$)

| Sample No | HCO_3^- (mg/l) | HCO_3^- (meq/l) | Cl^- (mg/l) | Cl^- (meq/l) | Simpson Ratio | Contamination Level |
|-----------|-------------------------|--------------------------|----------------------|-----------------------|---------------|--------------------------|
| 153 | 390 | 6.39 | 5250 | 148.08 | 23.17 | highly contaminated |
| 154 | 537 | 8.80 | 1775 | 50.07 | 5.69 | injuriously contaminated |
| 155 | 488 | 8.00 | 4509 | 127.18 | 15.90 | highly contaminated |
| 156 | 805 | 13.19 | 710 | 20.03 | 1.52 | moderately contaminated |
| 157 | 268 | 4.39 | 710 | 20.03 | 4.56 | injuriously contaminated |
| 158 | 244 | 4.00 | 1420 | 40.05 | 10.02 | highly contaminated |
| 159 | 512 | 8.39 | 1420 | 40.05 | 4.77 | injuriously contaminated |
| 160 | 268 | 4.39 | 816 | 23.02 | 5.24 | injuriously contaminated |
| 161 | 170 | 2.79 | 959 | 27.05 | 9.71 | highly contaminated |
| 162 | 317 | 5.20 | 35.5 | 1.00 | 0.19 | good quality |
| TJ-1 | 109 | 1.79 | 711 | 20.05 | 11.23 | highly contaminated |
| TJ-10 | 463 | 7.59 | 994 | 28.04 | 3.69 | injuriously contaminated |
| TJ-11 | 464 | 7.60 | 2355 | 66.43 | 8.73 | highly contaminated |
| TJ-12 | 390 | 6.39 | 104 | 2.93 | 0.46 | good quality |
| TJ-13 | 120 | 1.97 | 365 | 10.30 | 5.23 | injuriously contaminated |
| TJ-14 | 340 | 5.57 | 212 | 5.98 | 1.07 | slightly contaminated |
| TJ-15 | 756 | 12.39 | 7586 | 213.97 | 17.27 | highly contaminated |
| TJ-16 | 31 | 0.51 | 35.5 | 1.00 | 1.97 | moderately contaminated |
| TJ-2 | 190 | 3.11 | 78 | 2.20 | 0.71 | slightly contaminated |
| TJ-3 | 630 | 10.33 | 355 | 10.01 | 0.97 | slightly contaminated |
| TJ-4 | 226 | 3.70 | 660 | 18.62 | 5.03 | injuriously contaminated |
| TJ-5 | 109 | 1.79 | 340 | 9.59 | 5.37 | injuriously contaminated |
| TJ-6 | 244 | 4.00 | 843 | 23.78 | 5.95 | injuriously contaminated |
| TJ-7 | 73 | 1.20 | 1101 | 31.06 | 25.96 | highly contaminated |
| TJ-8 | 317 | 5.20 | 2485 | 70.09 | 13.49 | highly contaminated |
| TJ-9 | 366 | 6.00 | 2840 | 80.11 | 13.35 | highly contaminated |

Table IV: Comparison of water quality with the Libyan and (WHO) Standards

| Parameters | Minimum | Maximum | Average | WHO Standards (2011) | Libyan Standards |
|-------------------------|---------|---------|---------|----------------------|------------------|
| PH | 6.8 | 7.27 | 6.9 | 6.5-8.5 | 6.5-8.5 |
| EC (uS) | 727 | 20880 | 6647.9 | 1500 | 1200 |
| TDS (ppm) | 329 | 11030 | 3694 | 500 | 500-1000 |
| HCO_3^- (mg/l) | 31 | 805 | 339.5 | 500 | 500 |
| Cl^- (mg/l) | 35.5 | 7586 | 1487 | 250 | 250 |
| So_4^- (mg/l) | 30 | 870 | 325 | 250 | 400 |
| Ca^{+2} (mg/l) | 1.3 | 211 | 71.1 | 75 | 200 |
| Mg^{+2} (mg/l) | 5 | 140 | 42.8 | 50 | 150 |
| Na^+ (mg/l) | 73.5 | 6020 | 1116 | 200 | 200 |
| K^+ (mg/l) | 1 | 53 | 8.49 | 12 | 40 |
| NO_3^- (mg/l) | 1.8 | 150 | 68.8 | 45 | 45 |

VIII. CONCLUSION AND RECOMMENDATIONS

Water resources in Libya and their quality are affected by a wide range of natural and human influences. Most important of the natural influences are geological, hydrological and climatic, since these affect the quantity and the quality of available water. Their influence is generally greatest when available water quantities are low and maximum use must be made of the limited resource.

Conclusion

The area targeted by this research is a part of the Jifarah Plain basin and represented by different relevant rock formations, from the Cretaceous to the Quaternary deposits. Overexploitation of groundwater caused a considerable deterioration in the water quality especially at Tjura Town. The aquifers are showing an increase in salinization, which has reached an alarming level in many places during the past 25 years as a result of the sea water intrusion.

It can be concluded that:

- Dropping of water table has been recorded throughout the targeted area as a result of aquifer overexploitation.
- Based on the contents of major cations and anions, all (most of the) samples fall within NaCl type.
- The best groundwater quality exists at the southern part of the study area. Degradation in the water quality expressed in salinity increase, occurs as we go towards the coastline.
- The aquifer is showing an increase in salinization, which has reached an alarming level in many places.

The NaCl waters indicate a strong relationship with seawater, and the salinization process in the Tajoura coast is primarily due to seawater intrusion, which is mixed with the freshwater in the aquifer and reduces its quality.

Considering the values of Cl^- concentration and the ratio of $\text{Cl}^-/\text{HCO}_3^-$, about 70% of the groundwaters were strongly affected by the saline water.

There is possible contamination of the shallow aquifer by the surface water (from sewage water ponds and cars washing stations).

Recommendations

In order to mitigate the serious deterioration in the water quality at Tajoura area, the following points are recommended:

- Periodic monitoring of the groundwater quality and water levels should be carried out.
- Conducting an urgent biological and detailed hydrochemical studies in the targeted area in order to determine the bacteriologic and heavy metals pollution.
- To improve the quality of water, the Government and non-government organizations should provide the support to design the rain water harvesting infrastructures and artificial recharge methods for young generation especially hydrogeologists and budding civil engineers.
- More attention should be paid for the nonconventional water resources such seawater desalination and treatment of sewage water.

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Thermal Ageing of a 316 Nb Stainless Steel: From Mechanical and Microstructural Analyses to Thermal Ageing Models for Long Time Prediction

Julien Monnier, Isabelle Mouton, Francois Buy, Adrien Michel, Sylvain Ringeval, Joel Malaplate, Caroline Toffolon, Bernard Marini, Audrey Lechartier

Abstract— Chosen to design and assemble massive components for nuclear industry, the 316 Nb austenitic stainless steel (also called 316 Nb) suits well this function thanks to its mechanical, heat and corrosion handling properties. However, these properties might change during steel's life due to thermal ageing causing changes within its microstructure. Our main purpose is to determine if the 316 Nb will keep its mechanical properties after an exposition to industrial temperatures (around 300 °C) during a long period of time (< 10 years). The 316 Nb is composed by different phases, which are austenite as main phase, niobium-carbides, and ferrite remaining from the ferrite to austenite transformation during the process. Our purpose is to understand thermal ageing effects on the material microstructure and properties and to submit a model predicting the evolution of 316 Nb properties as a function of temperature and time. To do so, based on Fe-Cr and 316 Nb phase diagrams, we studied the thermal ageing of 316 Nb steel alloys (1%v of ferrite) and welds (10%v of ferrite) for various temperatures (350, 400, and 450 °C) and ageing time (from 1 to 10.000 hours). Higher temperatures have been chosen to reduce thermal treatment time by exploiting a kinetic effect of temperature on 316 Nb ageing without modifying reaction mechanisms. Our results from early times of ageing show no effect on steel's global properties linked to austenite stability, but an increase of ferrite hardness during thermal ageing has been observed. It has been shown that austenite's crystalline structure (fcc) grants it a thermal stability, however, ferrite crystalline structure (bcc) favours iron-chromium demixion and formation of iron-rich and chromium-rich phases within ferrite. Observations of thermal ageing effects on ferrite's microstructure were necessary to understand the changes caused by the thermal treatment. Analyses have been performed by using different techniques like Atomic Probe Tomography (APT) and Differential Scanning Calorimetry (DSC). A demixion of alloy's elements leading to formation of iron-rich (α phase, bcc structure), chromium-rich (α' phase, bcc structure), and nickel-rich (fcc structure) phases within the ferrite have been observed and associated to the increase of ferrite's hardness. APT results grant information about phases' volume fraction and composition, allowing to associate hardness measurements to the volume fractions of the different phases and to set up a way to calculate α' and nickel-rich particles' growth rate depending on temperature. The same methodology has been applied to DSC results, which allowed us to measure the enthalpy of α' phase dissolution between 500 and 600 °C. To resume, we started from mechanical and macroscopic measurements and explained the results through microstructural study. The data obtained has been match to CALPHAD models' prediction and used to improve these calculations and employ them to predict 316 Nb properties' change during the industrial process.

Keywords— stainless steel characterization, atom probe tomography APT, vickers hardness, differential scanning calorimetry DSC, thermal ageing.

Alternative Coating Compositions by Thermal Arc Spraying to Improve the Contact Heat Treatment in Press Hardening

Philipp Burger, Jonas Sommer, Haneen Daoud, Franz Hilmer, Uwe Glatzel

Abstract— Press-hardened structural components made of coated high-strength steel are an essential part of the automotive industry when it comes to weight reduction, safety, and durability. Alternative heat treatment processes, such as contact heating, have been developed to improve the efficiency of this process. However, contact heating of the steel sheets often results in cracking within the Al-Si-coated layer. Therefore, this paper will address the development of alternative coating compositions based on Al-Si-X, suitable for contact heating. For this purpose, robot-assisted thermal arc spray was applied to coat the high-strength steel sheets. This ensured high reproducibility as well as effectiveness. The influence of the coating parameters and the variation of the nozzle geometry on the microstructure of the developed coatings will be discussed. Finally, the surface and mechanical properties after contact heating and press hardening will be presented.

Keywords— press hardening, hot stamping, thermal spraying, arc spraying, coating compositions.

Numerical Approach to Boost an Internal Combustion Engine

M. A. El Hameur, L. Tarabet, M. Cerdoun, B. Zebiri, G. Ferrara

Abstract—Due to the drastic environmental and energy regulations regarding the reduction of exhaust emissions and fuel consumption, added to the increasing demand for powerful performance, several automotive manufacturers are constantly obliged to redesign their existing products and/or develop novel powertrain techniques to respond to the aforementioned restrictions. In this aspect, an implemented approach is proposed in the present work to boost a 1.5 L, three-cylinder diesel engine with a turbocharger, based on 1D preliminary design codes, 3D design, and numerical assessment of a suitable radial turbine followed by an accurate selection procedure of an adequate centrifugal compressor. Furthermore, to investigate the effect of the turbine's rotor position on the simulation convergence, stability, and calculation time; two combinations (rotor blade- volute) have been assessed. Consequently, significant results are obtained when comparing the original turbocharged engine and the developed one at the engine's full load and rated speed (@4500 rpm) conditions. Maximum improvements have been found in terms of Brake Specific Fuel Consumption (BSFC) of about 6.5% (corresponding to a decrease of 2.3 L/hr in fuel consumption), 7% in terms of thermal efficiency, 10.9% for the total-to-static turbine efficiency, and 19.9% in the total-to-total compressor efficiency

Keywords—CFD investigation, engine boosting, turbine design, turbocharger, rotor blade positioning.

I. INTRODUCTION

NOWADAYS the Internal Combustion Engine (ICE) is the most common thermal machine in the world, playing a key role in numerous application fields [1], where significant advancements are continuously performed on it to achieve clean and powerful mobility. An optimal design and/or selection of a suitable Turbocharger (TC) for ICE charging purposes is fundamental to guarantee an improvement in terms of the engine's brake power ' P_b ', BSFC and thermal efficiency ' η_{th} ', minimizing CO₂ production and toxic NO_x, CO, and HC emissions as well [2], [3]. Turbocharging technique is still the best option for the automotive constructors to respond to the growing users' demand for output performance, fuel consumption as economic constraints, and limitations relative to the ICE exhaust emissions. However, matching an ICE to TC consists principally to match between the ICE and a radial inflow turbine (RIT), between the ICE and a Centrifugal Compressor (CC), and between the CC and RIT [4]. Matching between these three systems is not an easy task to realize, due to hot exhaust gases, pulsatile flow, turbo-lag, CC's limited operating range (between the surge and choke lines), and the TC's weak efficiency at low engine speeds [5]. Therefore, a

suitable arrangement and design of the TC components need to be planned carefully to ensure a secure and performing operation, particularly, the RIT design, which needs to be judiciously assessed due to thermo-mechanic stresses (rotor blade erosion [6], deformation [7]).

In this aspect, modeling methods and simulation programs are fundamental in the design chain, ICE development, and/or the ICE-TC matching process. Numerical modelling approaches allow quickly testing the effect of different solutions on performances and emissions. During the last two decades, a significant research effort in the field of 1D/3D engine modeling has been carried out to help the ICE and turbo-machinery industries [8] due to the time-consuming and expensive cost needed for performing numerous experimental tests, which require complex facilities often not available at the industrial level. Several types of research are found about 1D and 3D thermo-fluid dynamic modeling of ICE-TC matching such as the matching regarding the CC stability [9] and design [10], on the RIT design stage [11], regarding the ICE components such as intercooler [12], after-treatment processes [13] and the RIT pulsating flow causing engine's backpressure [14], [15]. In addition, the size and the geometry of the volute tongue have significant effects on the turbine performance as reported by Gu et al. [16]. An important pressure gradient observed near the tongue can be a source of flow distortions, resulting in velocity, pressure, and flow angle variations on the rotor periphery. Cerdoun et al. [17], [18] analyzed numerically the flow structure through a twin-entry radial turbine at steady and unsteady conditions. They showed that the Fast Fourier Transform (FFT) analysis of the pressure fluctuation due to components' periodic interaction could be modelled by double Fourier decomposition.

Recently, Mosca et al. [15] investigated the capabilities of Neural Network (NN) models in predicting the unsteady performance of a RIT under pulsating flow conditions. The NN model shows excellent capacities in predicting the turbine performance for various amplitude and frequency pulses within and outside the range of the training data set, with a coefficient of determination reported larger than 0.98 for both cases. Therefore, the proposed model could be considered as a black box, hence, integrated into ICE-TC reduced-order models as a substitute for 0D-1D models for the TC turbines.

From the above-mentioned studies, it was concluded that the volute and rotor are key components in the RIT, and their design influences greatly both the turbine and TC performance, then the ICE operating area.

As the flow inside the volute is fully 3D and turbulent, a better understanding of flow mechanisms is essential to enable

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a perfect RIT design methodology.

This paper is a step forward to provide a boosting approach of a 1.5 L, three-cylinders, turbocharged (TCed) ICE with a new one based on implemented 1D codes for the RIT's stage sizing, 3D modeling, and CFD simulation in addition to a CC selection method.

II. MATERIALS AND METHODS

In the present section, a brief explanation is provided for three main developing steps of a TC for boosting aims.

A. Database Establishment

The constructed Database (DB) used in this paper contains several types of TCs, collected from six big TC manufacturers based on geometric and performance parameters, and covering large mass flow and pressure ratio ranges.

B. TC Selection Procedure

A careful TC selection procedure has been followed in this paper to match an ICE with a suitable TC from DB. It starts by turning the studied TCed engine into a Naturally Aspirated (NA) one. Then, two main propositions are made for the user depending on the RIT and CC maps' availability in the DB and/or the accuracy desired by the operator. Then, based on geometric and performance data, a selection algorithm estimates a minimum weighted function that ensures a compromise of 50% between the deviations of mass flow rates and pressure ratios of the TCs present in the DB, and the TC designed after following a mean-line preliminary design method. However, with the aim of clarity and simplicity, the design procedure and selection algorithm are fully detailed in [19]. The global TC-ICE matching procedure is depicted in Fig. 1.

C. RIT Design and Numerical Assessment

In the present work, only a small part of the developed global methodology for TC-ICE matching (for more details see [19]) is used in the actual paper. In addition to a selection of a suitable TC from a DB, the CC and RIT rotors and volutes are proposed to the user in the case of initiating a TC manufacturing process. Consequently, only the 1D preliminary design procedure, 3D geometry generation, and CFD inflow investigation in terms of aero-thermodynamic behavior and predicted performance of the RIT stage are performed in the actual subsection.

In addition, The ICE's input and output thermodynamic data are supplied by a combination of 1D and 0D-single zone algorithms (see [19] for more details), respectively. The output data of the latter codes are considered as initial conditions for the RIT's design. Indeed, the design starts by estimating the geometry of the RIT's rotor using a modified Aungier's equations [20], [21], followed by the design of the RIT's volute using output data of the RIT's rotor and the main sizing equations of Chen [22], [23]. The volute cross-sections and their centroids at each azimuthal angle are calculated by applying the numerical scheme discretized using the finite-difference method.

The data provided by the RIT's 1D designing algorithm are exported to ANSYS Vista RTD[®] software to define the geometric constraints and velocity triangles of the RIT rotor. Then, the created design is sent to ANSYS BladeGen[®] to generate the 3D geometry of the rotor, where the flow path and the blade profiles can be adjusted if it is required. The 3D geometry was then transferred to ANSYS TurboGrid[®] to create mesh grids.

Next, the mesh was exported to the ANSYS CFX[®] solver to fix the boundary conditions and start solving. Finally, the results obtained after calculation convergence are used to start the analysis of the RIT's rotor flow field and to predict its performance using post-treatment tools.

To assess the flow through the RIT components, CFD mesh creation tools specifically designed for turbomachinery; ANSYS TurboGrid[®] and Design Modeler software are used to create mesh grids of the rotor and volute, respectively. An unstructured mesh was generated for the volute. The mesh is refined in areas of high curvatures and flow gradients, particularly around the tongue and at the peripheral outlet cross-section (at rotor interface) (see Fig. 2). The volute inlet and outlet cross-sections were meshed applying inflation layers, with a total thickness sufficiently large to contain the aerodynamic boundary layer within it. The data used to generate suitable initial volute inflation layers are listed in Table I.

The commercial CFX software was used to solve the full 3D RANS equations for various working conditions. The solver was a 3D CFD code in which the governing equations are discretized using the finite-element-based finite volume method. Such a hybrid CFD method is advantageous because of its geometric flexibility.

For the rotor, an H-grid topology was adopted with an O-grid around the blade (see Fig. 2) to minimize the skew angles and to ensure the boundary layer resolution. In addition, high grid resolution was set on the hub and shroud with a growth ratio of 1.05 to model more precisely the flow near the blade wall. To guarantee boundary layer resolution, 8 layers were generated with a growth ratio of 1, and a tip clearance of about 2.5% of the blade span is imposed to capture the tip leakage flow. The minimum and maximum measured values of y^+ are between 0.013-49.23 and 0-70.68 for the volute and one blade of the rotor, respectively.

Finally, to minimize sensitive sources of inaccuracy, a mesh sensitivity analysis is performed to ensure the independence between the generated mesh and the monitored thermodynamic quantities. The followed analysis provides a gain in computational time and accuracy. The mesh sensitivity analysis applied to the volute showed that the monitored outlet static temperature as depicted in Figs. 3 become independent from the generated mesh, after applying more than 340,000 cells.

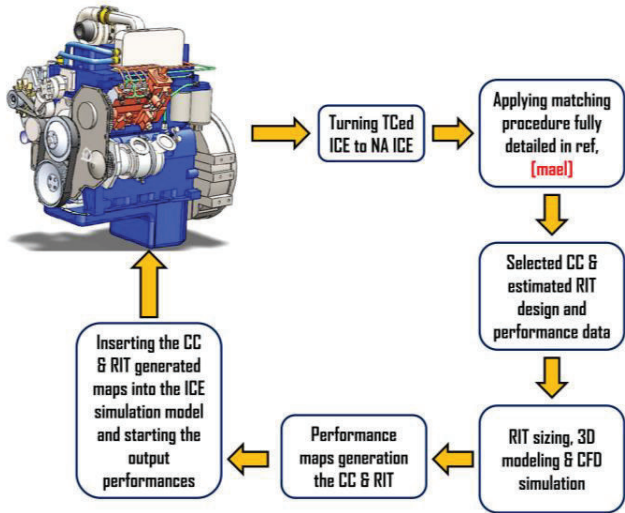


Fig. 1 TC-ICE matching flowchart

 TABLE I
 ROTOR AND VOLUTE MESHING DATA AND TURBINE DESIGN REQUIREMENTS

| Parameters | Value | | |
|------------------------------------------|-----------------------|-----------------------|-----------------------|
| | Volute inlet | Volute outlet | Rotor |
| Reynolds number 'Re' | 3.16×10^4 | 6.08×10^5 | 6.08×10^5 |
| High of the first cell ' y_{H1} ' [mm] | 8.45×10^{-5} | 1.80×10^{-6} | 1.80×10^{-6} |
| Number of layers 'N' | 23 | 23 | 8 |
| Growth ratio 'r' | 1.357 | 1.22 | 1.05 |

| Total layers high ' y_T ' [mm] | 0.0123 | 8×10^{-4} | 1.72×10^{-5} |
|------------------------------------------------------------------------|-----------------------|--------------------|-----------------------|
| Boundary layer thickness ' δ_{99} ' [mm] | 2.28×10^{-4} | 7×10^{-4} | 1.44×10^{-5} |
| Turbine requirements | | | |
| Parameters | Value | | |
| Expansion ratio ' Π_{Tis} ' provided by 1D preliminary design code | 1.1372 | | |
| Mass flow rate ' m_{gas} ' [kg/s] | 0.05185 | | |
| Inlet total pressure ' P_{04} ' [bar] | 3.3 | | |
| Inlet total temperature ' T_{04} ' [K] | 1094.17 | | |
| Turbine rotational speed 'N' [rpm] | 131,760 | | |
| Turbine isentropic efficiency ' η_{Tis} ' [%] | 60.78 | | |

III. RESULT AND DISCUSSIONS

In the present paper, a downsized 1.5 L, three-cylinder TCed diesel engine developing a P_b , T_b , and BSFC of about 130 kW, 310 N.m, and 218.7 g/kW/hr, respectively at full load and rated power conditions (@4000 rpm), is turned into a NA engine after applying the aforementioned implemented methodology. In this case, the selected CC and the designed RIT are matched to the NA engine via their respective performance maps (see Figs. 4 (a), (b) and (c) for the ICE model and CC and RIT maps, respectively). Following Chen's rules for the volute sizing and Aungier's method for rotor design, the 3D geometry of the RIT's components with their respective meshing are depicted in Fig. 2.

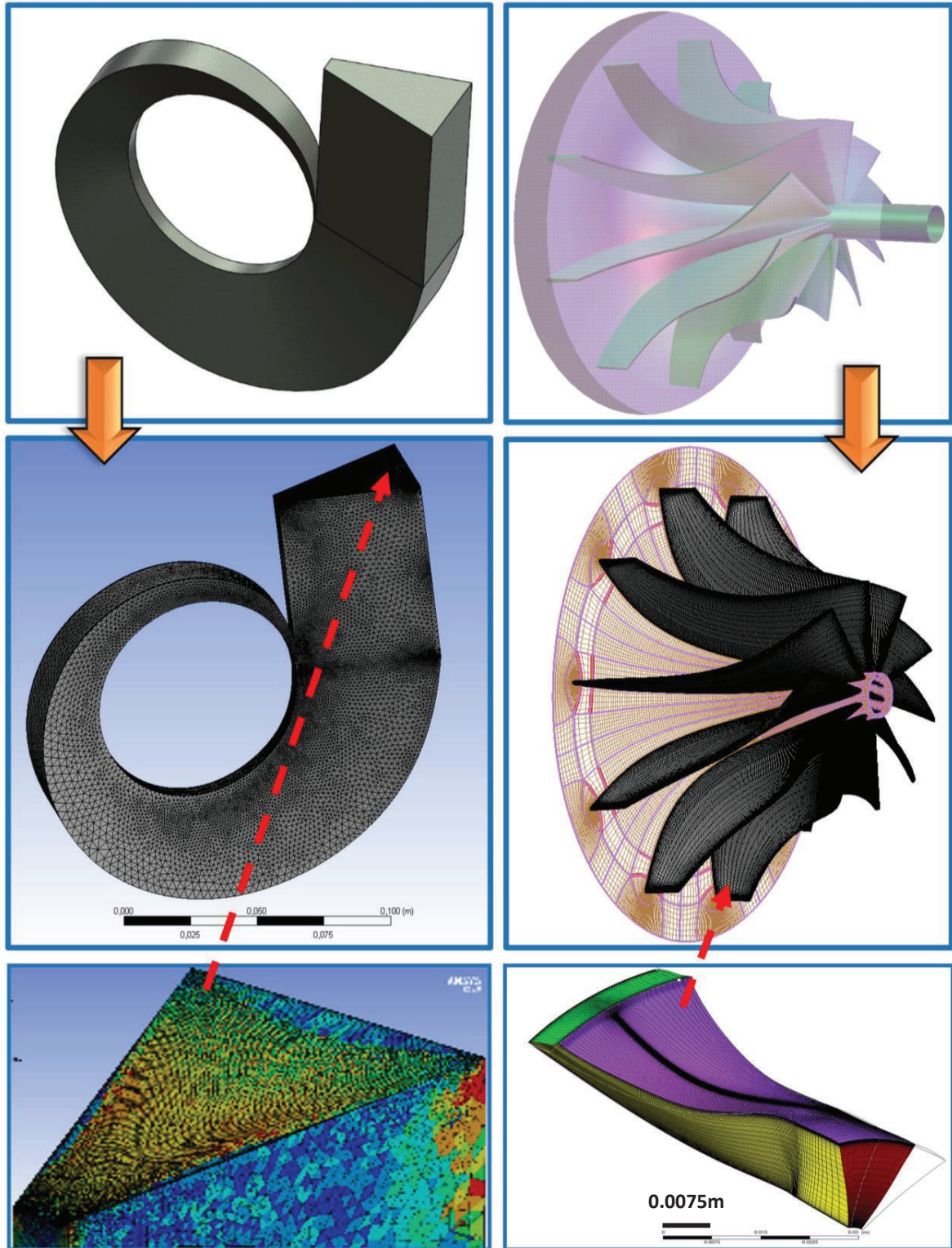


Fig. 2 Turbine components

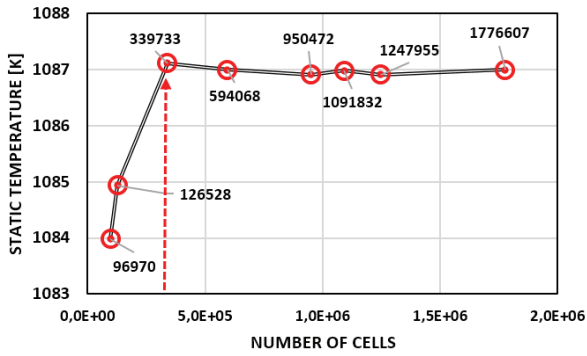
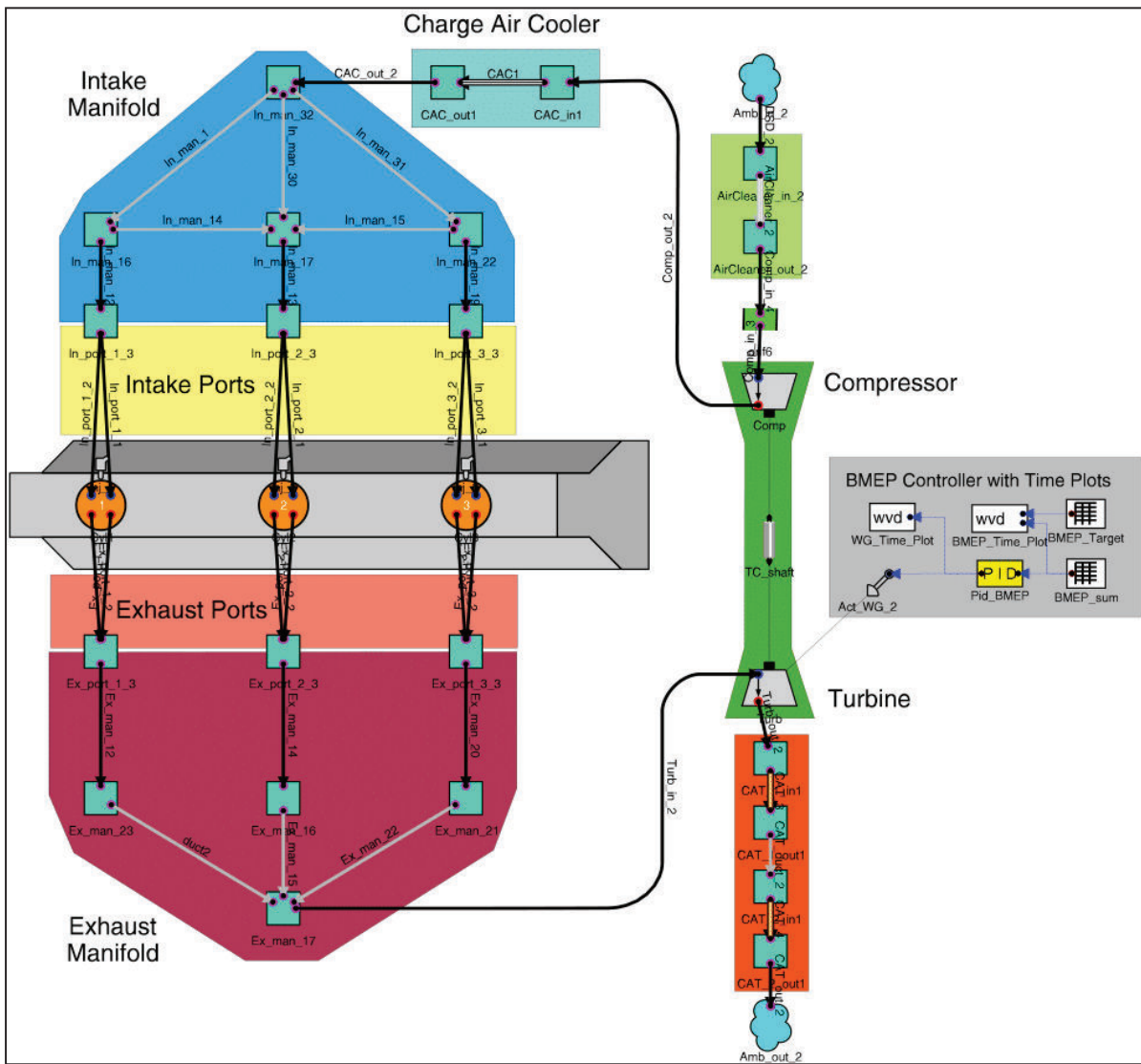
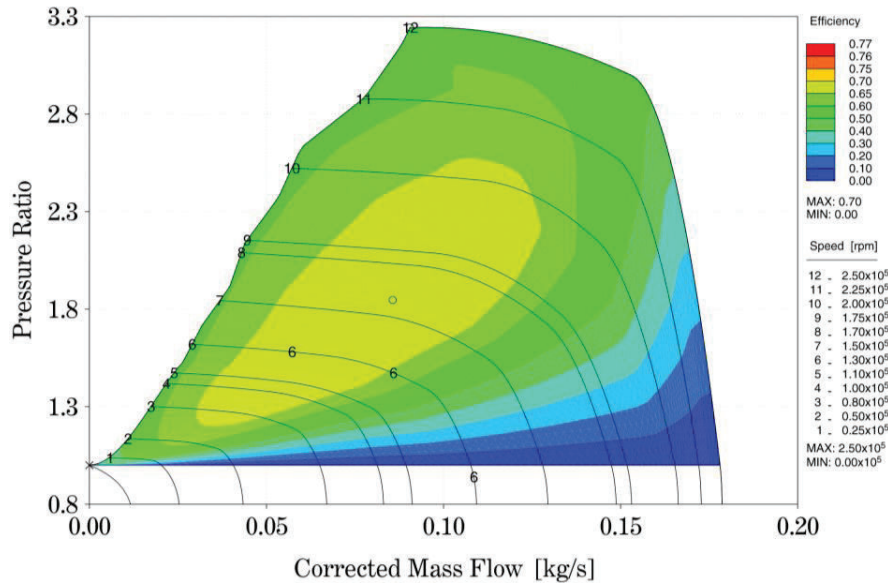


Fig. 3 Static temperature vs. cells' number

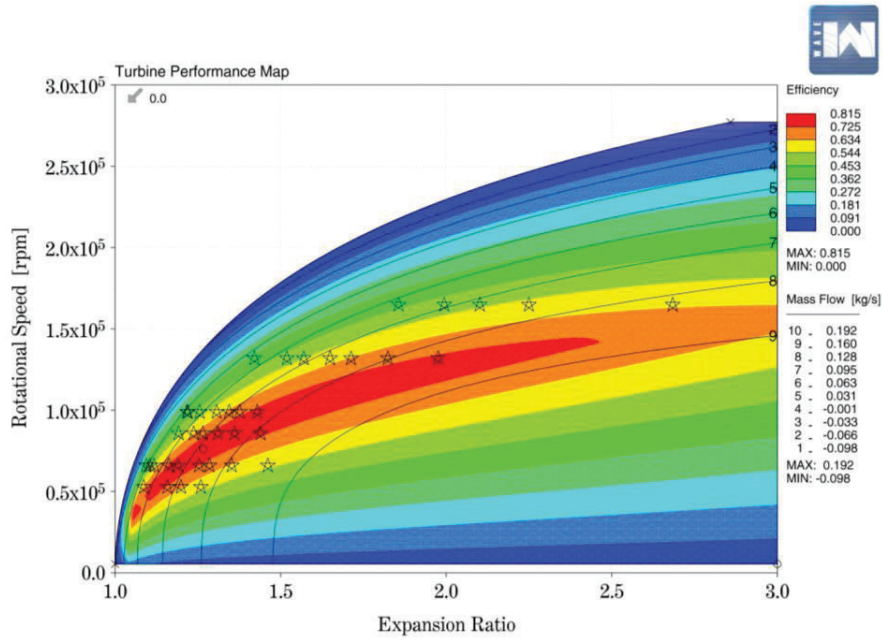
After analyzing the distribution of the Mach number and static temperature and pressure fields through the volute passage, an obvious flow distribution was perceived upstream and downstream of the volute tongue. To adjust the flow circulation through the volute passage, we imposed a small increase of 20% on the volute cross-sections' width and a decrease of 20 mm of the volute high at the inlet cone, which allows the flow to be distributed equitably around the peripheral outlet section, especially upstream and downstream of the tongue. The new Mach number and static pressure distributions after correcting the volute size are highlighted in Figs. 5 (a) and (b).



(a)



(b)



(c)

Fig. 4 (a) Engine model and the superimposition of the new engine operating area on; (b) CC map and (c) RIT map

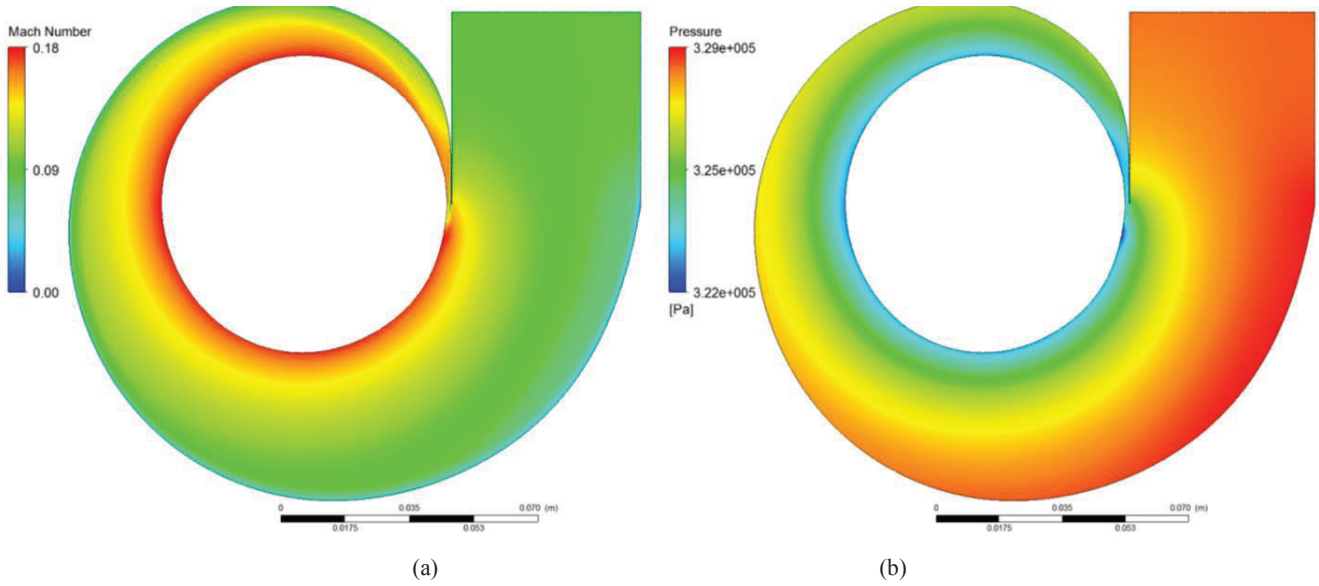


Fig. 5 Flow fields of the RIT: (a) Mach number, (b) static pressure

As seen in Fig. 5, the designed volute ensures a perfect distribution of the flow fields through it and also contributes to the pressure drop in static pressure by about 2.17% corresponding to 0.07×10^5 Pa.

The global number of nodes of the volute and one rotor blade equals 300,000 and 1,401,008, respectively while, the global number of elements used for the volute and one rotor blade equals 340,000 and 1,309,761, respectively.

In the present work, a numerical study is performed to investigate the effect of the turbine's blade rotor positioning on the simulation convergence, stability, and time calculation.

For this reason, two different configurations of the combined volute-rotor; Blade Near the Tongue (BNT) (see Fig. 6 (a)) and Blade Far from the Tongue (BFT) (see Fig. 6 (b)), are numerically assessed to observe their impact on the new TCed engine's output performances.

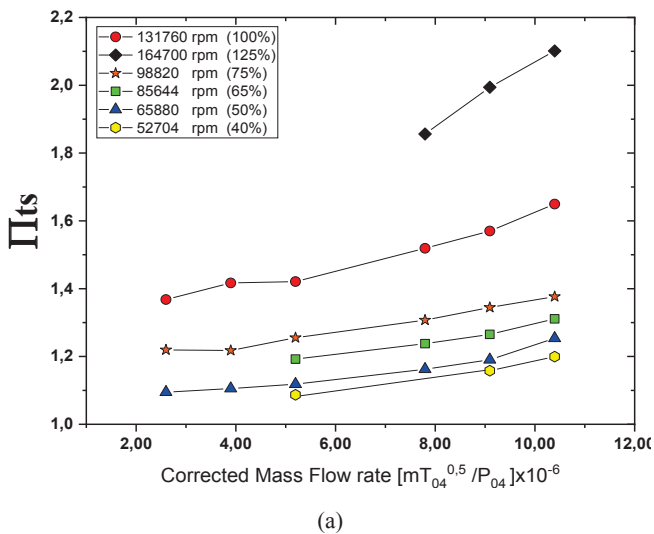


(a)

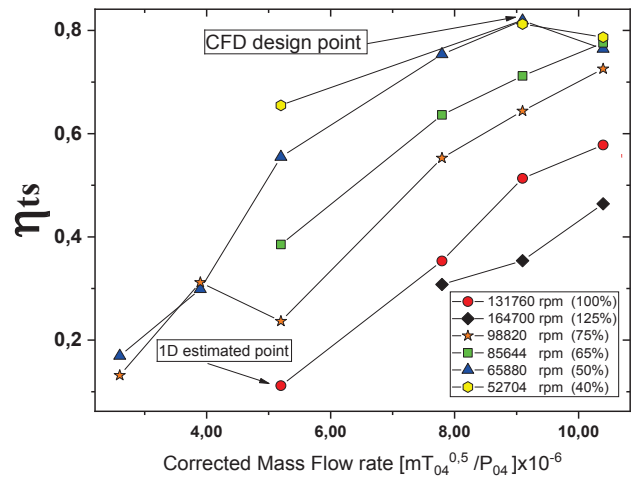


Fig. 6 Volute with one rotor blade: (a) near the tongue and (b) far from the tongue

Therefore, a CFD simulation of the RIT stage is performed using ANSYS CFX® software to capture the flow field and predict the turbine aerodynamic performance by applying turbo-machinery and fluid-dynamic equations. Indeed, an exploration procedure over a large operating field, using 41 points have been achieved, after using discretized values of mass flow (from 50% to 250%), and rotational speed (from 40% to 125%). Figs. 7 (a) and (b) depict the turbine expansion ratio ' Π_{Tts} ' and isentropic efficiency ' η_{Tts} ' versus reduced mass flow, respectively.



(a)



(b)

Fig. 7 CFD simulation results: (a) expansion ratio, (b) isentropic efficiency

Results of the designed RIT present a point of maximum performance (design point) at mass flow rate and rotational speed of 0.091 kg/s and 65,880 rpm, respectively. At this point, the η_{Tts} and Π_{Tts} equal 82% and 1.19, respectively (see Fig. 7).

Next, after executing the developed selection procedure, a multitude of TCs was proposed by the selection step, only one TC namely, Master Power R444, which has the best performance was chosen to be matched with the designed RIT. Then, the RIT map was generated using the data obtained by the CFD simulation. The RIT CFD data were injected into the Wave® software where an interpolating/extrapolating algorithm (originally installed on the software) allows for expanding the RIT's map over its entire operating range [24].

From the findings, the engine equipped with the TC R444 demonstrates an operating range sufficiently far from the CC surge and choke lines over the entire speed range, with a surge margin of 23.37%, the CC isentropic efficiency and pressure ratio of 65.85% and 3.07, respectively, all measured at the engine rated power (@4000 rpm).

As seen in Figs. 8 (a)-(f), a comparison between the original TCed and NA engines and the new TCed one is established in terms of predicted performances. Firstly, as highlighted in Figs. 8 (a)-(d) the proposed TC guarantees the improvement of the engine's performance (P_b , BSFC, η_{th} , η_{vol}) over the entire speed range, compared to the NA engine.

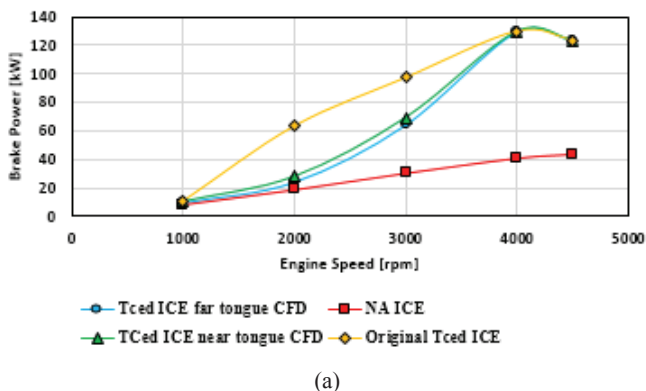
Secondly, as reported in Fig. 8 (a) the TCed ICE (with the two RIT configurations) provides equal P_b with the original TCed one at high engine speeds, with maximum deviations observed at 2000 rpm between the original TCed ICE and the BNT and BFT configurations of around 56.2% and 61.4%, respectively. In Fig. 8 (b), the developed TC exhibited an improvement in η_{th} at the mid-high engine's speed range, with a maximum improvement measured between the original TCed engine and the new one of around 7% (equal deviations for both RIT's configurations) at 4500 rpm. Furthermore, as

shown in Fig. 8 (c) a satisfying improvement in terms of BSFC is highlighted by the TCed engine at high engine speeds, where a maximum improvement of around 6.5% for BNT and 6.4% for BFT at full load and 4500 rpm, corresponding to a decrease in fuel consumption of 2.30 l/hr and 2.27 l/hr, respectively.

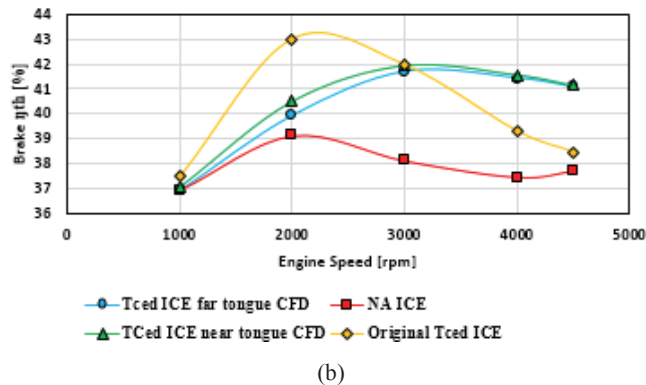
Finally, the volumetric efficiency ' η_{vol} ' measured on the TCed engine for both RIT configurations is lower than the original value at the entire engine's speeds, with maximum deviations estimated at 2000 rpm of about 53.8% for BNT and 58.7% for BFT (see Fig. 8 (d)). This can be interpreted by the fact that the original TC has a higher engine intake air density (higher engine intake airflow) than it is for the TC. The difference between the two TCs in the intake air density may be due to geometric and aerodynamic differences in their respective CC.

Concerning the output performances of the developed TC, remarkable improvement is observed for η_{Tts} at mid-high engine's speed range; equaling 14.6% for the BNT and 4 % for BFT configurations, at 4000 rpm (see Fig. 8 (e)). On the other hand, as depicted in Fig. 8 (f), the TC showed an improvement in η_{ctt} in the extreme engine high speed, where a value of 19.9% is measured for both turbine configurations.

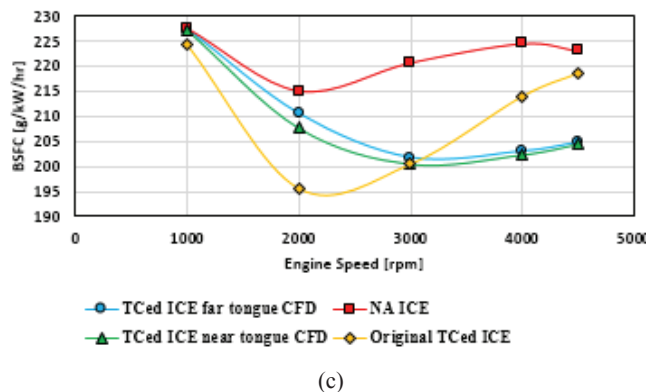
A global interpretation is provided concerning the highlighted deviations during the performance comparison of the TCed engine and the original one; the waste-gate control (closing and opening) was not performed during the ICE-RIT matching process. The latter will be performed in detail in future works by imposing a boost pressure value for the wastegate regulation. In addition, the original ICE was equipped with a twin-entry turbine; however, we only developed a RIT with only one big inlet area, which may cause the drop in the engine's performance at low-speed conditions due to the insufficient mass flow of the exhaust gas coming in.



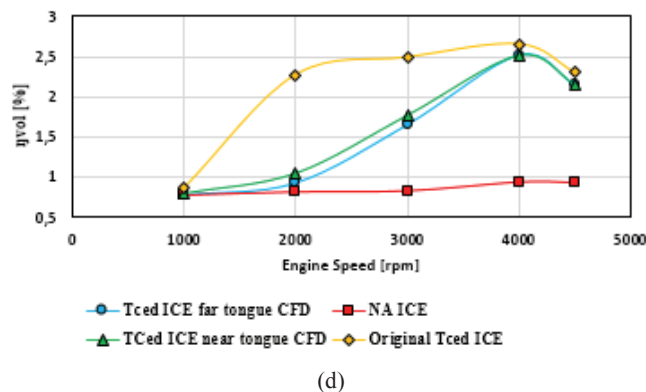
(a)



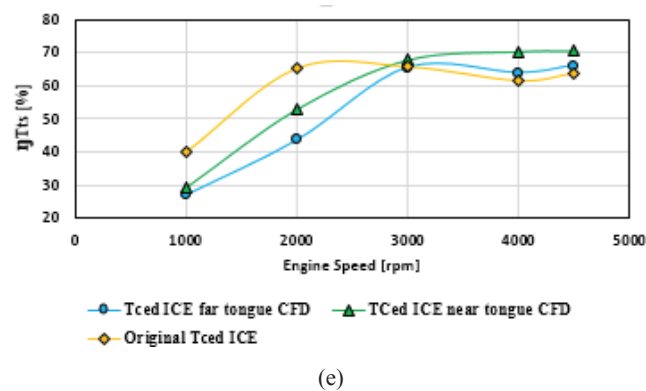
(b)



(c)



(d)



(e)

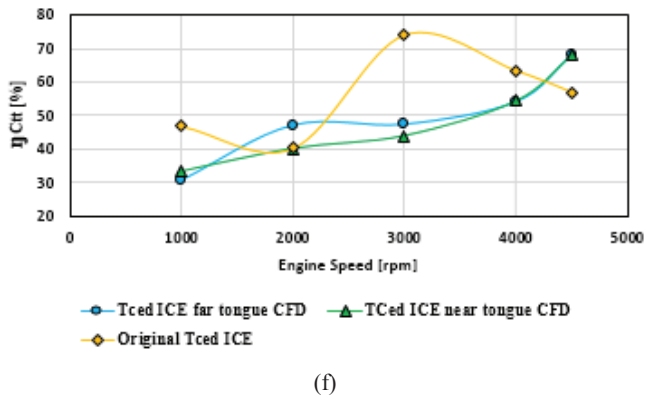


Fig. 8 Comparison between the developed TCed engine, original TCed engine and NA ICE in terms of: brake (a) power, (b) thermal efficiency, (c) specific fuel consumption, (d) volumetric efficiency, isentropic efficiency of the (e) RIT and (f) CC

IV. CONCLUSION

In the present work, a developed methodology for engine charging (boosting) has been applied based on compressor selection and aerodynamic turbine design to produce a TC. In this work, a small-downsized diesel engine was modified as a NA one to apply the implemented method for TC's performance maps generation. Then, after the CFD and 0D/1D simulations of the turbine components and the developed turbocharged engine, respectively have converged, satisfactory results have been obtained in terms of TC and ICE output performances, where considerable improvements in terms of brake thermal efficiency, fuel consumption and turbine isentropic efficiency are perceived at mid-high engine's speeds and full load conditions. However, insufficient performance is still noted particularly at low engine speeds. Consequently, several steps are still to do on the optimal turbine design, thermal strength, and vibration/acoustic studies, before initiating any manufacturing process.

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Detectability of Malfunction in Turboprop Engine

T. Vampola, M. Valášek

Abstract— On the basis of simulation-generated failure states of structural elements of a turboprop engine suitable for the busy-jet class of aircraft, an algorithm for early prediction of damage or reduction in functionality of structural elements of the engine is designed and verified with real data obtained at dynamometric testing facilities of aircraft engines. Based on an expanding database of experimentally determined data from temperature and pressure sensors during the operation of turboprop engines, this strategy is constantly modified with the aim of using the minimum number of sensors to detect an inadmissible or deteriorated operating mode of a specific structural elements of an aircraft engine. The assembled algorithm for the early prediction of reduced functionality of the aircraft engine significantly contributes to the safety of air traffic and to a large extent contributes to the economy of operation with positive effects on the reduction of the energy demand of operation and the elimination of adverse effects on the environment.

Keywords— detectability of malfunction, dynamometric testing, prediction of damage, turboprop engine.

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Radiation Dosimetry Using Sintered Pellets of Yellow Beryl (Heliodor) Crystals

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Abstract— Beryl is a silicate with chemical formula $\text{Be}_3\text{Al}_2(\text{SiO}_3)_6$ commonly found in Brazil. It has a few colored variations used as jewelry, like Aquamarine (blueish), Emerald (green) and Heliodor (yellow). The color of each variation depends on the dopant that is naturally present in the crystal lattice. In this work, Heliodor pellets of 5 mm diameter and 1 mm thickness have been produced and investigated using thermoluminescence (TL) to evaluate its potential for use as gamma ray's dosimeter. The results show that the pellets exhibited a prominent TL peak at 205 °C that grows linearly with dose when irradiated from 1 Gy to 1000 Gy. A comparison has been made between powdered and sintered dosimeters. The results show that sintered pellets have higher sensitivity than powder dosimeter. The TL response of this mineral is satisfactory for radiation dosimetry applications in the studied dose range.

Keywords— dosimetry, beryl, gamma rays, sintered pellets, new material.

Excitation of the 2^1S , 2^1P and $N = 3, 4, 5$ (n^1P) of Helium by Positron Impact

Jorge Luiz S. Lino

Abstract— We report cross sections for excitations of 2^1S , and 2^1P state of helium atom by positron impact using the scaled Born positron (SBP) approach [1]. Particular attention is paid to the n^1P ($n=3, 4, 5$) states which for the first time, integral cross sections are investigated using the SBP method. The possibility of using the SBP approach to estimate the contribution of open channels effects is discussed. A investigation on the determination of Z_{eff} classical ($Z_{\text{eff}} = Z$) in the context of SBP method illustrate the good convergence characteristics of the procedure.

Keywords— born, positron, scattering, cross sections, scaled.

Collapse by Entanglement Suppression

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We study a recently proposed modified Schrödinger equation having an added nonlinear term, which gives rise to disentanglement. The process of quantum measurement is explored for the case of a pair of coupled spins. We find that the deterministic time evolution generated by the modified Schrödinger equation mimics the process of wavefunction collapse. Added noise gives rise to stochasticity in the measurement process. Conflict with both principles of causality and separability can be avoided by postulating that the nonlinear term is active only during the time when subsystems interact. Moreover, in the absence of entanglement, all predictions of standard quantum mechanics are unaffected by the added nonlinear term.

Introduction - In standard quantum mechanics a measurement is described by a two-step process. The first step is governed by the standard Schrödinger equation. To avoid a possible paradoxical outcome of a description based only on the first step (undefined cat state [1]), a second step is postulated, in which the state vector collapses. However, it has remained unknown how such a second step can be self-consistently added [2–4]. This difficulty has become known as the problem of quantum measurement.

In this work we explore an alternative to the collapse postulate, which is based on a modified Schrödinger equation that has an added nonlinear term giving rise to disentanglement [5, 6]. The proposed equation can be constructed for any physical system whose Hilbert space has finite dimensionality, and it does not violate norm conservation of the time evolution. We explore the dynamics of a system made of two coupled spins, and find that disentanglement gives rise to a process similar to state vector collapse.

Other types of nonlinear extensions of quantum mechanics [7] have been previously proposed and studied [8–14]. Most previously proposed extensions give rise to a spontaneous collapse [15–19]. In some cases, however, the proposed nonlinear models are inconsistent with well-established physical principles. Moreover, many predictions of standard quantum mechanics, that have been experimentally verified to very high precision, are significantly altered by some of the proposed nonlinear extensions. Such difficulties are discussed below in the final part of this paper for the case of our proposed modified Schrödinger equation. We find that possible conflicts with the principles of causality and separability, and with many experimentally confirmed predictions of standard quantum mechanics, can be avoided by postulating that disentanglement is active only when subsystems interact.

Disentanglement - Consider a system composed of two subsystems labeled as '1' and '2', respectively. The dimensionality of the Hilbert spaces of both subsystems, which is denoted by N_1 and N_2 , respectively, is assumed

to be finite. The system is in a normalized pure state vector $|\psi\rangle$ given by

$$|\psi\rangle = \mathcal{K}_1 C \otimes \mathcal{K}_2^T, \quad (1)$$

where C is a $N_1 \times N_2$ matrix having entries C_{k_1, k_2} , matrix transposition is denoted by T , $\mathcal{K}_1 = (|k_1\rangle_1, |k_2\rangle_1, \dots, |k_{N_1}\rangle_1)$, $\mathcal{K}_2 = (|k_1\rangle_2, |k_2\rangle_2, \dots, |k_{N_2}\rangle_2)$, and $\{|k_1\rangle_1\}$ ($\{|k_2\rangle_2\}$) is an orthonormal basis spanning the Hilbert space of subsystem '1' ('2').

The purity P_1 (P_2) is defined by $P_1 = \text{Tr} \rho_1^2$ ($P_2 = \text{Tr} \rho_2^2$), where $\rho_1 = \text{Tr}_2 \rho$ ($\rho_2 = \text{Tr}_1 \rho$) is the reduced density operator of the first (second) subsystem. By employing the Schmidt decomposition one finds that $P_1 = P_2 \equiv P$, where $P = 1 - \langle \mathcal{Q} \rangle = 1 - \langle \psi | \mathcal{Q} | \psi \rangle$, the operator \mathcal{Q} is given by [see Eq. (A15) of appendix A, and Ref. [20]]

$$\mathcal{Q} = \frac{1}{2} \sum_{k'_1 < k''_1} \sum_{k'_2 < k''_2} |\Psi_{k'_1, k''_1, k'_2, k''_2}\rangle \langle \Psi_{k'_1, k''_1, k'_2, k''_2}|, \quad (2)$$

and the state $\langle \Psi_{k'_1, k''_1, k'_2, k''_2}|$, which depends on the matrix C corresponding to a given state $|\psi\rangle$, is given by (note that $\langle \Psi_{k'_1, k''_1, k'_2, k''_2}|$ is not normalized)

$$\langle \Psi_{k'_1, k''_1, k'_2, k''_2}| = C_d \langle a| + C_a \langle d| - C_c \langle b| - C_b \langle c|, \quad (3)$$

where $a = k'_1, k'_2$, $b = k'_1, k''_2$, $c = k''_1, k'_2$ and $d = k''_1, k''_2$. Note that $\langle \mathcal{Q} \rangle = 0$ for a product state. In standard quantum mechanics $\langle \mathcal{Q} \rangle$ is time independent when the subsystems are decoupled (i.e. their mutual interaction vanishes).

As an example, consider a two spin 1/2 system (i.e. $N_1 = N_2 = 2$) in a pure state $|\psi\rangle$ given by $|\psi\rangle = a |--\rangle + b |+-\rangle + c |-+\rangle + d |++\rangle$. For this case the sum in Eq. (2) contains a single term with $\langle \Psi| = d \langle --, -| - c \langle --, +| - b \langle +-, -| + a \langle +-, +|$, and thus $P = 1 - 2|ad - bc|^2$. Note that for this case $\langle \mathcal{Q} \rangle \leq 1/2$ (provided that $|\psi\rangle$ is normalized) [21].

Consider a modified Schrödinger equation for the ket vector $|\psi\rangle$ having the form

$$\frac{d}{dt} |\psi\rangle = [-i\hbar^{-1} \mathcal{H} - \gamma(\mathcal{Q} - \langle \mathcal{Q} \rangle)] |\psi\rangle, \quad (4)$$

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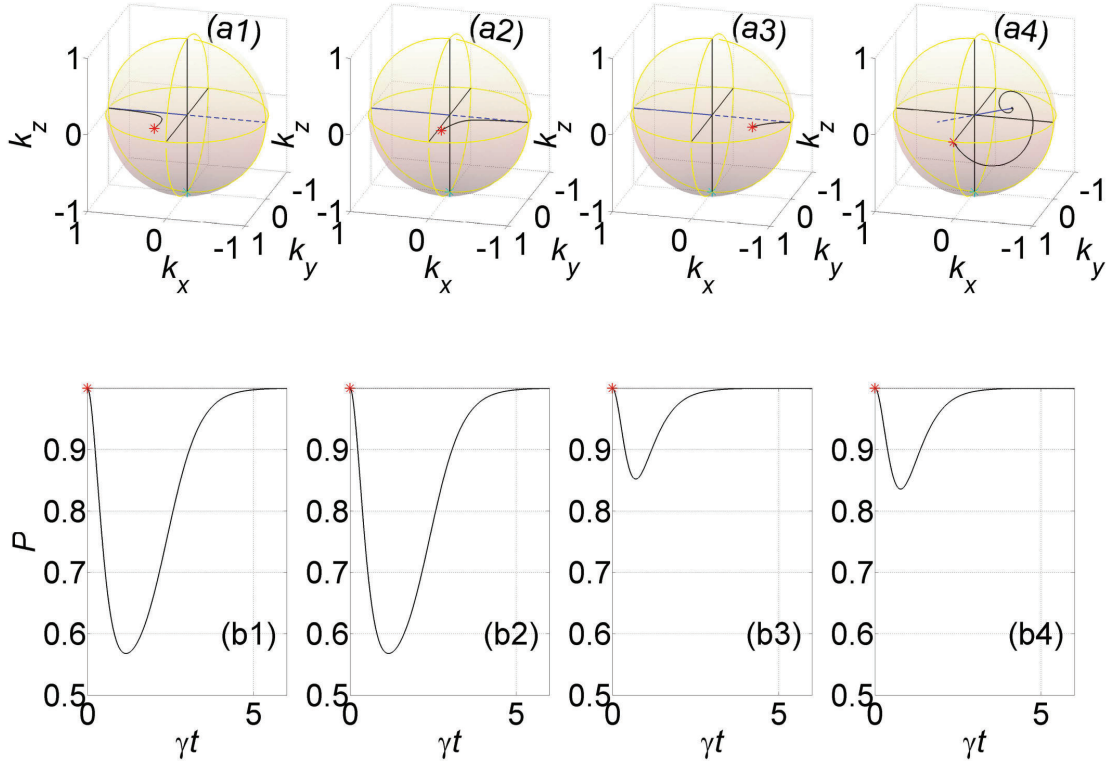


FIG. 1: Dipolar measurement. The spin numbers are $S_1 = 1/2$ and $S_2 = 21/2$, the rates are $\gamma = \omega_d = 1$, and $\hat{\mathbf{n}}_2 = -\hat{\mathbf{z}}$ (initial direction of the S_2 spin, which is labeled by a cyan star symbols). For the plots labeled by the numbers 1, 2 and 3 the dipolar unit vector $\hat{\mathbf{u}}_d$ is given by $\hat{\mathbf{u}}_d = \hat{\mathbf{x}}$ (i.e. $\hat{\mathbf{u}}_d$ is perpendicular to $\hat{\mathbf{n}}_2$), whereas $\hat{\mathbf{u}}_d = (\sin(3\pi/8)\cos(3\pi/4), \sin(3\pi/8)\sin(3\pi/4), \cos(3\pi/8))$ for the plots labeled by the number 4 (i.e. $\hat{\mathbf{n}}_2 \cdot \hat{\mathbf{u}}_d \neq 0$). At time $t = 0$ the spin $1/2$ is pointing in the direction $\hat{\mathbf{n}}_1 = (\sin\theta_1 \cos\varphi_1, \sin\theta_1 \sin\varphi_1, \cos\theta_1)$, where for (1) $\theta_1 = 0.55\pi$ and $\varphi_1 = 0.45\pi$, for (2) $\theta_1 = 0.55\pi$ and $\varphi_1 = 0.55\pi$, for (3) $\theta_1 = 0.55\pi$ and $\varphi_1 = 0.75\pi$, and for (4) $\theta_1 = 0.5\pi$, and $\varphi_1 = 0.5\pi$. Red star symbols label the initial points $\hat{\mathbf{n}}_1$, and the blue solid (dashed) lines connect the origin and the unit vectors $\hat{\mathbf{u}}_d$ ($-\hat{\mathbf{u}}_d$).

where \hbar is the Planck's constant, $\mathcal{H} = \mathcal{H}^\dagger$ is the Hamiltonian, the rate γ is positive, and the operator \mathcal{Q} is given by Eq. (2). The added nonlinear term proportional to γ gives rise to disentanglement, however, it has no effect when $|\psi\rangle$ represents a product state. Note that the norm conservation condition $0 = (d/dt)\langle\psi|\psi\rangle$ is satisfied by the modified Schrödinger equation (4).

Dipolar interaction - As an example, the dynamics generated by the modified Schrödinger equation (4) is explored for the case of dipolar interaction between two spins having spin quantum numbers S_1 and S_2 , respectively. The dipolar interaction is represented by the operator $V_d = \hbar^{-1}\omega_d(\mathbf{S}_1 \cdot \hat{\mathbf{u}}_d)(\mathbf{S}_2 \cdot \hat{\mathbf{u}}_d)$, where the rate ω_d is positive, \mathbf{S}_n is the spin angular momentum vector operator of the n 'th spin ($n \in \{1, 2\}$), and $\hat{\mathbf{u}}_d = (\sin\theta \cos\varphi, \sin\theta \sin\varphi, \cos\theta)$ is a unit vector.

Time evolution examples for the case $S_1 = 1/2$ and $S_2 = 21/2$ are shown by the plots in Fig. 1. The initial state at time $t = 0$ is a product state, for which the spin $1/2$ is pointing in the direction of the unit vector $\hat{\mathbf{n}}_1$ (labeled by a red star symbol), and the spin $21/2$

is pointing in the direction of the unit vector $\hat{\mathbf{n}}_2 = -\hat{\mathbf{z}}$ (labeled by a cyan star symbol). The overlaid blue solid (dashed) lines connect the origin and the dipolar coupling unit vectors $\hat{\mathbf{u}}_d$ ($-\hat{\mathbf{u}}_d$). The spin $1/2$ Bloch vector $\mathbf{k} = (\hbar/2)^{-1}\langle\mathbf{S}_1\rangle$ is numerically calculated by integrating the modified Schrödinger equation (4) for the case $\mathcal{H} = V_d$. The black solid lines in Fig. 1(a1), (a2), (a3) and (a4) represent the spin $1/2$ Bloch vector \mathbf{k} evolving from its initial value $\hat{\mathbf{n}}_1$ at time $t = 0$. The single-spin purity $P = 1 - \langle\mathcal{Q}\rangle$ as a function of time t is shown in Fig. 1(b1), (b2), (b3) and (b4).

For the plots in Fig. 1 labeled by the numbers 1, 2 and 3, the dipolar unit vector $\hat{\mathbf{u}}_d$ is given by $\hat{\mathbf{u}}_d = \hat{\mathbf{x}}$ (i.e. $\hat{\mathbf{u}}_d$ is perpendicular to $\hat{\mathbf{n}}_2 = -\hat{\mathbf{z}}$). These plots, which differ by the initial direction $\hat{\mathbf{n}}_1$ of the spin $1/2$ (labeled by red star symbols), demonstrate that the Bloch sphere is divided into two basins of attraction. The first (second) basin is the hemisphere $\hat{\mathbf{n}}_1 \cdot \hat{\mathbf{u}}_d > 0$ ($\hat{\mathbf{n}}_1 \cdot \hat{\mathbf{u}}_d < 0$), and the corresponding attractor is $\hat{\mathbf{u}}_d$ ($-\hat{\mathbf{u}}_d$).

While $\hat{\mathbf{n}}_2 \cdot \hat{\mathbf{u}}_d = 0$ for the plots in Fig. 1 labeled by the numbers 1, 2 and 3, the behavior when the initial spin S_2

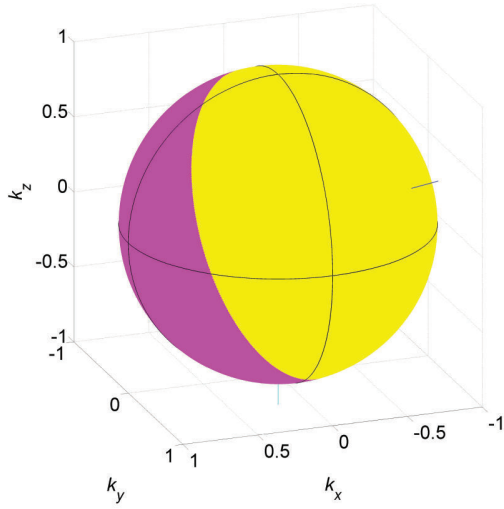


FIG. 2: Basins of attraction. All parameters are the same as those used to generate the plots of Fig. 1 labeled by the number 4. Initial direction of the S_2 spin $\hat{\mathbf{n}}_2 = -\hat{\mathbf{z}}$ is labeled by a cyan tick, and the dipolar unit vector $\hat{\mathbf{u}}_d = (\sin(3\pi/8)\cos(3\pi/4), \sin(3\pi/8)\sin(3\pi/4), \cos(3\pi/8))$ is labeled by a blue tick. At time $t = 0$ the spin 1/2 is pointing in the direction $\hat{\mathbf{n}}_1$. The yellow (purple) colored region is the basin of attraction lying in the hemisphere $\hat{\mathbf{n}}_1 \cdot \hat{\mathbf{u}}_d > 0$ ($\hat{\mathbf{n}}_1 \cdot \hat{\mathbf{u}}_d < 0$), and the corresponding attractor is $\hat{\mathbf{u}}_d$ ($-\hat{\mathbf{u}}_d$).

direction $\hat{\mathbf{n}}_2$ is not perpendicular to the dipolar coupling unit vector $\hat{\mathbf{u}}_d$ is demonstrated by the plots labeled by the number 4. The plot in Fig. 1(a4) shows that the Bloch vector trajectory, from the initial value $\hat{\mathbf{n}}_1$ (labeled by the red star symbol) towards the attractor at $\hat{\mathbf{u}}_d$ becomes spiral-like when $\hat{\mathbf{n}}_2 \cdot \hat{\mathbf{u}}_d \neq 0$. The basins of attraction for this case (i.e. plots in Fig. 1 labeled by the number 4) are shown in Fig. 2. This example demonstrates that the dipolar unit vector $\hat{\mathbf{u}}_d$ determines the spin 1/2 component that is being measured. The measurement process is deterministic however the outcome, which is either +1 (when $\hat{\mathbf{n}}_1 \cdot \hat{\mathbf{u}}_d > 0$) or -1 (when $\hat{\mathbf{n}}_1 \cdot \hat{\mathbf{u}}_d < 0$) is quantized. This behavior is demonstrated by the green dash-dotted line in Fig. 3, in which the probability p_+ that the measurement outcome is +1 is plotted as a function of the angle $\theta_1 = \cos^{-1}(\hat{\mathbf{n}}_1 \cdot \hat{\mathbf{u}}_d)$. For comparison, the red solid line represents the Born rule of standard quantum mechanics, for which $p_+(\theta_1) = \cos^2(\theta_1/2)$. A simplified model is employed below to explore noise-induced stochasticity.

Noise - The effect of external noise is taken into account by applying a random rotation to the initial spin 1/2 Bloch vector $\hat{\mathbf{n}}_1$. The random rotation is characterized by an axis normal to $\hat{\mathbf{n}}_1$, and by a rotation angle ϕ_r . As an example, consider the case where the rotation angle ϕ_r has a wrapped Cauchy probability distribution

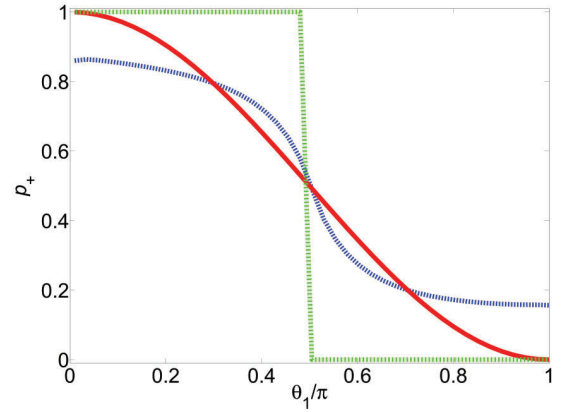


FIG. 3: Noise. The probability p_+ is plotted as a function of the angle $\theta_1 = \cos^{-1}(\hat{\mathbf{n}}_1 \cdot \hat{\mathbf{u}}_d)$ for the noiseless case (green dash-dotted line), the case $\phi_0 = 0.5$ (blue dashed line), and the Born rule (red solid line).

$f(\phi_r)$ given by

$$f(\phi_r) = \frac{1}{2\pi} \frac{\sinh \phi_0}{\cosh \phi_0 - \cos \phi_r}, \quad (5)$$

where $\phi_0 > 0$ is a scale factor. Consider a rotated frame, in which the dipolar unit vector $\hat{\mathbf{u}}_d$ is parallel to the unit vector $\hat{\mathbf{z}}$. The unit vector $\hat{\mathbf{n}}_1$ in this frame is denoted by $\hat{\mathbf{n}}_{1R}$. The probability p_+ that the measurement outcome is +1 is calculated by spherical integration over the hemisphere $z' \geq 0$

$$p_+ = \frac{1}{4\pi} \int_0^{\pi/2} d\theta' \sin \theta' \int_0^{2\pi} d\varphi' \frac{4f(\theta_{1R})}{\sin \theta_{1R}}, \quad (6)$$

where $\theta_{1R} = \cos^{-1}(\hat{\mathbf{n}}_{1R} \cdot \hat{\mathbf{n}}')$, and where $\hat{\mathbf{n}}' = (\sin \theta' \cos \varphi', \sin \theta' \sin \varphi', \cos \theta')$. As can be seen from the blue dashed line in Fig. 3, which is calculated using Eq. (6) with a scale factor of $\phi_0 = 0.5$, noise-induced stochasticity mimics the behavior predicted by the Born rule (red solid line).

The measurement time - For the examples shown in Fig. 1, initially at time $t = 0$, the ket vector $|\psi\rangle$ represents a product state having single-spin purity $P = 1$. The time dependency of P is shown in Fig. 1(b1), (b2), (b3) and (b4). In the short time limit of $\omega_d t \ll 1$ the effect of the disentanglement term in the modified Schrödinger equation (4) is relatively weak (since $\langle \mathcal{Q} \rangle$ is initially small), and consequently P rapidly drops due to entanglement generated by the dipolar interaction V_d . At latter times, when disentanglement becomes sufficiently efficient, the single-spin purity P starts increasing. Interaction-induced generation of entanglement becomes inefficient when the spin 1/2 becomes nearly parallel or nearly anti-parallel to the dipolar unit vector $\hat{\mathbf{u}}_d$, and consequently the single-spin purity P approaches unity in the long time limit.

For sufficiently short times after turning on the interaction (i.e. after $t = 0$), time evolution is dominated by the effect of the dipolar interaction. When the effect of the disentanglement term is disregarded, one finds that in the short time limit the following holds $d\langle \mathbf{S}_n \rangle / dt \simeq \omega_n \hat{\mathbf{u}}_d \times \langle \mathbf{S}_n \rangle$, where $n \in \{1, 2\}$, $\omega_1 = \omega_d \hbar^{-1} \langle \mathbf{S}_2 \cdot \hat{\mathbf{u}}_d \rangle$ and $\omega_2 = \omega_d \hbar^{-1} \langle \mathbf{S}_1 \cdot \hat{\mathbf{u}}_d \rangle$. Thus, in the short time limit, the purity P is roughly given by $P \simeq 1 - (2^{-3/2} S_2 |\hat{\mathbf{n}}_1 \times \hat{\mathbf{u}}_d| (\hat{\mathbf{n}}_2 \cdot \hat{\mathbf{u}}_d) \omega_d t)^2$ [see Eqs. (6.192) and (8.701) of Ref. [20], and note that it is assumed that in the short time limit the spin states are nearly spin coherent states [22]]. The above-derived expression for the purity time evolution $P(t)$ reveals the dependence of short-time dynamics on the macroscopicity of the measuring apparatus (i.e. the second spin), which is represented by the spin number S_2 .

Vanishing Hamiltonian - To gain further insight into the disentanglement process generated by the nonlinear term $-\gamma(\mathcal{Q} - \langle \mathcal{Q} \rangle)$ added to the Schrödinger equation (4), consider for simplicity the case where the Hamiltonian vanishes, i.e. $\mathcal{H} = 0$. The Schmidt decomposition of a general state vector $|\psi\rangle$ is expressed as

$$|\psi\rangle = \sum_{l=1}^{\min(N_1, N_2)} q_l |l, l\rangle, \quad (7)$$

where q_l are non-negative real numbers, the tensor product $|l\rangle_1 \otimes |l\rangle_2$ is denoted by $|l, l\rangle$, and $\{|l\rangle_1\}$ ($\{|l\rangle_2\}$) is an orthonormal basis spanning the Hilbert space of subsystem '1' ('2'). Note that for a product state $q_l = \delta_{l, l_0}$, where $l_0 \in \{1, 2, \dots, \min(N_1, N_2)\}$. The normalization condition reads $\langle \psi | \psi \rangle = L_2 = 1$, where the n 'th moment L_n is defined by

$$L_n = \sum_{l=1}^{\min(N_1, N_2)} q_l^n. \quad (8)$$

Note that for a product state $L_n = 1$ for any positive integer n (provided that $|\psi\rangle$ is normalized).

In the Schmidt basis, the following holds [see Eqs. (2) and (3)]

$$\mathcal{Q} |\psi\rangle = \sum_{l=1}^{\min(N_1, N_2)} q_l (1 - q_l^2) |l, l\rangle, \quad (9)$$

and $\langle \mathcal{Q} \rangle = 1 - L_4$, and thus [see Eq. (4)]

$$\frac{d \log q_l}{dt} = \gamma (q_l^2 - L_4). \quad (10)$$

An example solution of the set of equations (10) for the case $\min(N_1, N_2) = 10$ and $\gamma = 1$ is shown in Fig. 4.

The time evolution of the n 'th moment L_n is governed by [see Eqs. (8) and (10)]

$$\frac{dL_n}{dt} = n\gamma (L_{n+2} - L_n L_4). \quad (11)$$

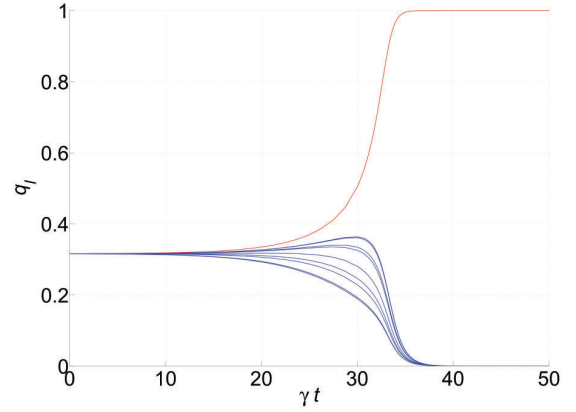


FIG. 4: Vanishing Hamiltonian. The plot shows an example solution of the set of equations (10) for the case $\min(N_1, N_2) = 10$ and $\gamma = 1$. The solution for $q_{l_0}(t)$ is represented by the red line, whereas the blue lines represent the solutions for $q_l(t)$ with $l \neq l_0$. For this example, $q_l(t=0) \simeq (\min(N_1, N_2))^{-1/2}$, i.e. the initial value of the purity P is close to its smallest possible value of $1/\min(N_1, N_2)$. The corresponding initial entropy σ is close to its largest possible value of $\log(\min(N_1, N_2))$. In the limit $t \rightarrow \infty$ the purity $P \rightarrow 1$ (largest possible value) and the entropy $\sigma \rightarrow 0$ (smallest possible value).

For the case of $n = 2$, Eq. (11) yields the norm conservation condition $0 = (d/dt) \langle \psi | \psi \rangle$, which is satisfied provided that $|\psi\rangle$ is normalized, i.e. $L_2 = 1$ [see Eq. (7)]. For the case $n = 4$ Eq. (11) yields an evolution equation for the purity $P = L_4$, which is given by $dL_4/dt = 4\gamma (L_6 - L_4^2)$. Using the Cauchy-Schwarz inequality one finds that $L_4^2 \leq L_2 L_6$ [see Eq. (8)], hence $dP/dt \geq 0$ (recall the normalization condition $L_2 = 1$), i.e. the purity P monotonically increases with time. The same conclusion can alternatively be drawn from Eq. (10), which can be expressed as $dq_l/dt = \partial H / \partial q_l$, where $H = (\gamma/4)(3 - 2L_2)L_4$ [see Eq. (8), and note that $H = (\gamma/4)L_4 = (\gamma/4)P$ when $L_2 = 1$].

For any two integers $l', l'' \in \{1, 2, \dots, \min(N_1, N_2)\}$ the following holds [see Eq. (10)]

$$\frac{d \log \frac{q_{l'}}{q_{l''}}}{dt} = \gamma (q_{l'}^2 - q_{l''}^2). \quad (12)$$

The above relation (12) implies that the ratio $q_{l'}/q_{l''}$ monotonically increases with time, provided that $q_{l'} > q_{l''}$ (recall that $\gamma > 0$). This behavior gives rise to disentanglement. Consider the case where initially, at time $t = 0$, $q_{l_0} = \max\{q_l\}$ for a unique positive integer $l_0 \in \{1, 2, \dots, \min(N_1, N_2)\}$. For this case, $|\psi\rangle$ evolves into the product state $|l_0, l_0\rangle$ in the long time limit, i.e. $q_l \rightarrow \delta_{l, l_0}$ in the limit $t \rightarrow \infty$ (see Fig. 4). Note, however, that in the long time limit the state can be strongly affected by noise when initially the set $\{q_l\}$ doesn't have a unique member significantly larger than all others.

Discussion - As was already mentioned above, several types of nonlinear extensions of quantum mechanics have been proposed and explored [15, 23–26]. However, it was found that for some cases, the proposed nonlinear extension gives rise to the violation of the causality principle by enabling superluminal signaling [27–30]. More recently, it was shown that when a condition called ‘convex quasilinearity’ is satisfied by a given nonlinear master equation, the violation of the causality principle becomes impossible [31, 32]. Some of the proposed nonlinear extensions are inconsistent with the principle of separability [28, 33, 34]. Moreover, any proposed extension must be ruled out if it alters predictions of standard quantum mechanics that have been experimentally confirmed.

The modified Schrödinger equation given by Eq. (4) has an important advantage compared to other proposals: the added nonlinear term $-\gamma(\mathcal{Q} - \langle \mathcal{Q} \rangle)$ has no effect on product states. This implies that in the absence of entanglement, the added term does not vary any prediction of standard quantum mechanics. Moreover, possible conflicts with both principles of causality and separability can be avoided by postulating that $\gamma \simeq \hbar^{-1} \langle \psi | V^\dagger V | \psi \rangle^{1/2}$, where V is the coupling term in the Hamiltonian giving rise to the interaction between subsystems [γ is the disentanglement rate in Eq. (4)]. This postulate implies that the added nonlinear term is active only when subsystems interact, and that time evolution is governed by the standard Schrödinger equation when subsystems are remote (i.e. decoupled). Note that for the examples shown in Fig. 1, the calculations are performed for the case $\gamma = \omega_d$. This demonstrates that a disentanglement rate γ having the order of $\hbar^{-1} \langle \psi | V^\dagger V | \psi \rangle^{1/2}$ is sufficiently large to allow full suppression of entanglement.

Summary - Further theoretical study is needed to check whether quantum mechanics can be self-consistently reformulated based on the proposed modified Schrödinger equation (4). We find that conflict with some well-established physical principles, as well as many experimental observations, can be avoided by postulating that $\gamma \simeq \hbar^{-1} \langle \psi | V^\dagger V | \psi \rangle^{1/2}$.

The expression given by Eq. (2) for the operator \mathcal{Q} is applicable for the bipartite case, for which the entire system is divided into two subsystems. The multipartite case, however, for which the entire system is divided into more than two subsystems, requires a generalization of Eq. (2). Such generalization is discussed in Ref. [35]. The generalization of the above discussed postulate (regarding the disentanglement rate γ) for the multipartite case states that disentanglement between two given subsystems is active only during the time when they interact.

Further insight can be gained from experimental study of entanglement in the region where environmental decoherence is negligible [36]. Upper bounds imposed upon the disentanglement rate γ in Eq. (4) can be derived from lifetime measurements of entangled states. Experimental observations of deviation from the Born rule may provide supporting evidence for nonlinearity (see Fig. 3).

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Appendix A: The Schmidt decomposition

The system’s normalized pure state vector $|\psi\rangle$ is given by $|\psi\rangle = \mathcal{K}_1 C \otimes \mathcal{K}_2^T$ [see Eq. (1) in the main text]. Consider the unitary transformations (the letter k is used to label the states of the original basis, whereas the transformed states are labeled by the letter l)

$$\mathcal{K}_1^T = u_1 \mathcal{L}_1^T = u_1 (|l_1\rangle_1, |l_2\rangle_1, \dots, |l_{N_1}\rangle_1)^T, \quad (\text{A1})$$

$$\mathcal{K}_2^T = u_2 \mathcal{L}_2^T = u_2 (|l_1\rangle_2, |l_2\rangle_2, \dots, |l_{N_2}\rangle_2)^T, \quad (\text{A2})$$

where u_1 (u_2) is a $N_1 \times N_1$ ($N_2 \times N_2$) unitary matrix (i.e. $u_1^\dagger u_1 = 1$ and $u_2^\dagger u_2 = 1$). The state vector $|\psi\rangle$ in the transformed basis is expressed as

$$\begin{aligned} |\psi\rangle &= \mathcal{L}_1 \hat{C} \otimes \mathcal{L}_2^T \\ &= \sum_{l_1, l_2} \hat{C}_{l_1, l_2} |l_1\rangle_1 \otimes |l_2\rangle_2, \end{aligned} \quad (\text{A3})$$

where the transformed matrix \hat{C} is given by

$$\hat{C} = u_1^T C u_2, \quad (\text{A4})$$

and the corresponding density operator $\rho = |\psi\rangle \langle \psi|$ is expressed as

$$\rho = \sum_{l'_1, l'_2, l''_1, l''_2} \hat{C}_{l'_1, l'_2} \hat{C}_{l''_1, l''_2}^* |l'_1, l'_2\rangle \langle l''_1, l''_2|. \quad (\text{A5})$$

The following holds

$$\begin{aligned} \text{Tr } \rho &= \sum_{l_1, l_2} |\hat{C}_{l_1, l_2}|^2 \\ &= \text{Tr } S_1 = \text{Tr } S_2 = \text{Tr } (C C^\dagger) = \text{Tr } (C^\dagger C), \end{aligned} \quad (\text{A6})$$

where the $N_1 \times N_1$ ($N_2 \times N_2$) matrix S_1 (S_2) is given by (recall that $u_1^\dagger u_1 = 1$ and $u_2^\dagger u_2 = 1$)

$$S_1 = \hat{C} \hat{C}^\dagger = u_1^T C u_2 u_2^\dagger C^\dagger u_1^{\text{T}\dagger} = u_1^T C C^\dagger u_1^{\text{T}\dagger}, \quad (\text{A7})$$

$$S_2 = \hat{C}^\dagger \hat{C} = u_2^\dagger C^\dagger u_1^{\text{T}\dagger} u_1^T C u_2 = u_2^\dagger C^\dagger C u_2, \quad (\text{A8})$$

hence $\text{Tr } \rho = 1$ provided that $|\psi\rangle$ is normalized. The matrix S_1 (S_2) is Hermitian and positive definite, hence the unitary matrix u_1 (u_2) can be chosen to diagonalize S_1 (S_2), and the eigenvalues, which are denoted by q_l , are non-negative. For this transformation, which is called the

Schmidt decomposition, the transformed matrix \hat{C} has a diagonal form

$$\hat{C}_{l_1, l_2} = q_l \delta_{l_1, l_2}. \quad (\text{A9})$$

The purity P_1 (P_2) is defined by $P_1 = \text{Tr} \rho_1^2$ ($P_2 = \text{Tr} \rho_2^2$), where $\rho_1 = \text{Tr}_2 \rho$ ($\rho_2 = \text{Tr}_1 \rho$) is the reduced density operator of the first (second) subsystem. With the help of the Schmidt decomposition (A9), one finds that $P_1 = P_2 \equiv P$, where

$$\begin{aligned} P &= \sum_l q_l^4 \\ &= \text{Tr} S_1^2 = \text{Tr} (CC^\dagger)^2 = \text{Tr} S_2^2 = \text{Tr} (C^\dagger C)^2. \end{aligned} \quad (\text{A10})$$

Note that $P = 1$ for a product state, and P obtains its minimum value of $1/\min(N_1, N_2)$ for a maximally entangled state. The purity P is independent on the local transformations u_1 and u_2 , hence it is a constant when the subsystems are decoupled (i.e. when the interaction between the subsystems vanishes). Using the relations

$$\text{Tr} (C^\dagger C) = \sum_{k'_1=1}^{N_1} \sum_{k'_2=1}^{N_2} C_{k'_1, k'_2}^* C_{k'_1, k'_2}, \quad (\text{A11})$$

and

$$\text{Tr} (C^\dagger C)^2 = \sum_{k'_1, k'_1'=1}^{N_1} \sum_{k'_2, k'_2'=1}^{N_2} C_{k'_1, k'_2}^* C_{k'_1, k'_2} C_{k'_1', k'_2'}^* C_{k'_1', k'_2'}, \quad (\text{A12})$$

one finds that the level of entanglement $1 - P$ is given by

$$\begin{aligned} 1 - P &= (\text{Tr} (C^\dagger C))^2 - \text{Tr} (C^\dagger C)^2 \\ &= \frac{1}{2} \sum_{k'_1, k'_1'=1}^{N_1} \sum_{k'_2, k'_2'=1}^{N_2} |\phi_{k'_1, k'_1', k'_2, k'_2'}|^2, \end{aligned} \quad (\text{A13})$$

where

$$\phi_{k'_1, k'_1', k'_2, k'_2'} = C_{k'_1, k'_2} C_{k'_1', k'_2'} - C_{k'_1', k'_2} C_{k'_1, k'_2'}. \quad (\text{A14})$$

Note that the term $\phi_{k'_1, k'_1', k'_2, k'_2'}$ vanishes unless $k'_1 \neq k'_1'$ and $k'_2 \neq k'_2'$, and the following holds $\phi_{k'_1, k'_1', k'_2, k'_2'} = \phi_{k'_1', k'_1, k'_2', k'_2}$, thus Eq. (A13) can be rewritten as

$$1 - P = 2 \sum_{k'_1 < k'_1'} \sum_{k'_2 < k'_2'} |\phi_{k'_1, k'_1', k'_2, k'_2'}|^2. \quad (\text{A15})$$

Note that for any product state $\phi_{k'_1, k'_1', k'_2, k'_2'} = 0$ [see Eq. (A14)]. The above result (A15) implies that $P = 1 - \langle Q \rangle$, where the operator Q is given by Eq. (2) in the main text.

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Measuring Human Perception and Negative Elements of Public Space Quality Using Deep Learning: A Case Study of Area within the Inner Road of Tianjin City

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Abstract—Due to lack of data sources and data processing techniques, it has always been difficult to quantify public space quality, which includes urban construction quality and how it is perceived by people, especially in large urban areas. This study proposes a quantitative research method based on the consideration of emotional health and physical health of the built environment. It highlights the low quality of public areas in Tianjin, China, where there are many negative elements. Deep learning technology is then used to measure how effectively people perceive urban areas. First, this work suggests a deep learning model that might simulate how people can perceive the quality of urban construction. Second, we perform semantic segmentation on street images to identify visual elements influencing scene perception. Finally, this study correlated the scene perception score with the proportion of visual elements to determine the surrounding environmental elements that influence scene perception. Using a small-scale labeled Tianjin street view data set based on transfer learning, this study trains five negative spatial discriminant models in order to explore the negative space distribution and quality improvement of urban streets. Then it uses all Tianjin street-level imagery to make predictions and calculate the proportion of negative space. Visualizing the spatial distribution of negative space along the Tianjin Inner Ring Road reveals that the negative elements are mainly found close to the five key districts. The map of Tianjin was combined with the experimental data to perform the visual analysis. Based on the emotional assessment, the distribution of negative materials, and the direction of street guidelines, we suggest guidance content and design strategy points of the negative phenomena in Tianjin street space in the two dimensions of perception and substance. This work demonstrates the utilization of deep learning techniques to understand how people appreciate high-quality urban construction, and it complements both theory and practice in urban planning. It illustrates the connection between human perception and the actual physical public space environment, allowing researchers to make urban interventions.

Keywords—Human perception, public space quality, deep learning, negative elements, street images.

I. INTRODUCTION

Spatial perception refers to the vague definition of a spatial perception situation by humans, and the study of human spatial perception can help enrich spatial semantics [1], [2], and further help researchers understand the underlying

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urban heterogeneity and reveal the impact of urban functions [3]-[5]. In recent years, how to collect visual information about the surrounding environment of urban buildings and affect the observation space attracted extensive attention in various fields [6], [7]. Early research methods mainly relied on traditional data collection methods, such as street interviews and questionnaires [8], [9]; these methods have high time and labor costs, and more importantly, the early research methods greatly limiting the size of the research field, urban-level spatial research is difficult to generalize. With the modernization of the country, the scale of the city is constantly expanding, and the appearance and structure of the city are undergoing dramatic changes. It is of great significance to develop a comprehensive building knowledge system based on streets, localities and even cities. It is also important for researchers and urban planners to understand how citizens perceive and evaluate the physical environment in large urban areas. Therefore, the development of a low-cost and efficient urban spatial method is particularly important.

Thanks to the rapid development of geographic information technology and volunteered geographic information (VGI) [10]-[12], the Internet has released a large number of street view images with rich geographic information, which contain detailed descriptions of each street and corner of the city [13]. Street view imagery is important to the research of building environment. Moreover, computer vision based on deep learning has also made great progress in the field of image recognition, its high accuracy and computing speed have been great successes in image feature extraction, image scene perception and image scene inference [14]-[16]. Therefore, many scholars use the massive data provided by the Internet and the deep learning technology to deal with series of emotional perception and behavior prediction problems

Objects

The surrounding environment of city streets affects the behavior and health of residents. In order to explore the humanistic perception of urban street scenes and the main factors that affect the perception results, we make a quantitatively analyzes scene perception elements, and divide this task into two sub-sections: scene perception based on image classification and scene element mining based on image semantic segmentation.

II. METHODS

Image classification and image semantic segmentation are

two mature technologies in the field of computer vision. In this paper we apply them to Tianjin streetscape images. First, the scene perception model is trained according to the public dataset of MIT Place Pulse. We divided the predict results into six categories: "safety score", "activity score", "boring score", "abundance score", "suppression score" and "beauty score", considering that there are many categories of tasks and classification is too difficult. Therefore, the scene perception task is divided into six binary classification tasks: whether it is safe and whether it is suppressed, etc., and the model output results are used as the final score. We take Tianjin as an example, the latitude and longitude coordinates of Tianjin

streets are obtained through ArcGIS, and obtain the corresponding pictures according to the latitude and longitude coordinates base on Baidu Map API, and then predict the crawled street view pictures using the trained scene perception model, and employ image semantic segmentation explores the factors affecting the scene perception semantically, and finally use the linear regression algorithm to calculate the specific relationship between the scene perception results and the influencing factors and visualization. We realize an urban scene perception experiment based on deep learning. The specific technical route is shown in Fig. 1.

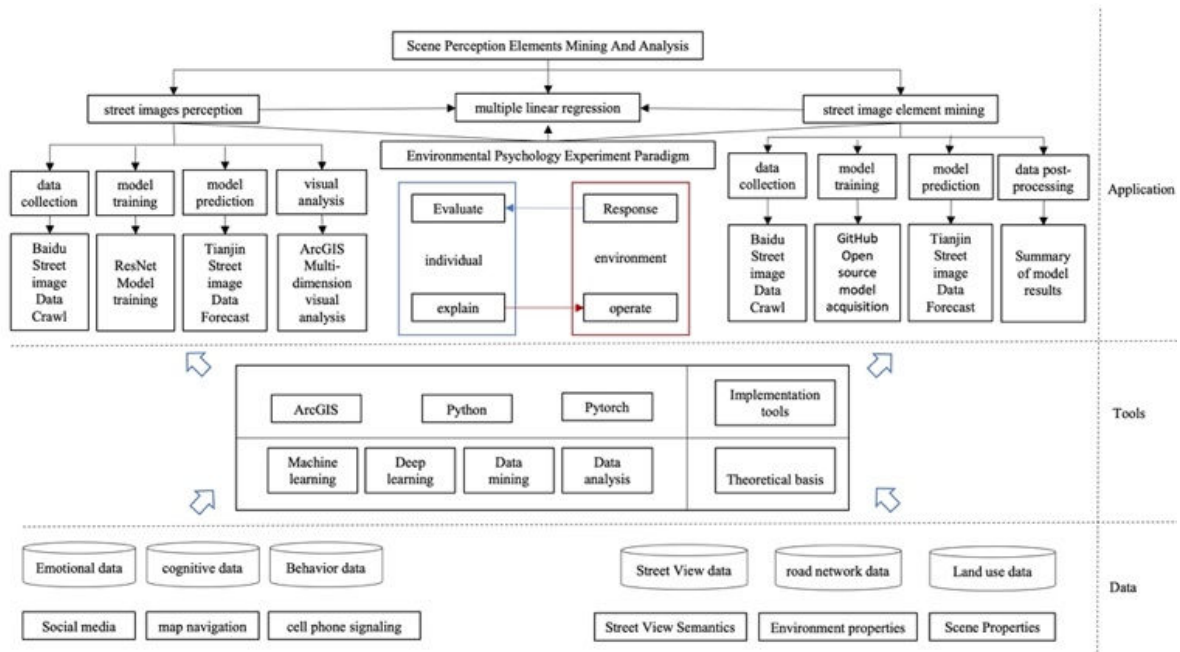


Fig. 1 Technology Roadmap

A. Acquisition of Tianjin Street View Data

In this paper we firstly complete Tianjin road network data visualization in ArcGIS, and then obtain WG1984 standard latitude and longitude coordinates through coordinate transformation in the software. Considering the geographical structure of Tianjin, the research site is selected within the bounding rectangle of Tianjin Outer Ring Road. In order to match the requirements of subsequent tasks, the conversion of WG1984 to BD09 coordinate system is completed by writing

relevant programs in Python programming language (BD09 coordinate system is a special encrypted coordinate system for Baidu Maps), and then we use Python to access Baidu Maps API for crawling the corresponding pictures, considering that Baidu Street View is a panorama, so we divide the panorama and finally each coordinate point gets four pictures of 0°, 90°, 180°, and 270° respectively, as shown in Fig. 2, the resolution of each image is 960×720, and total of 38024 street view images are crawled.

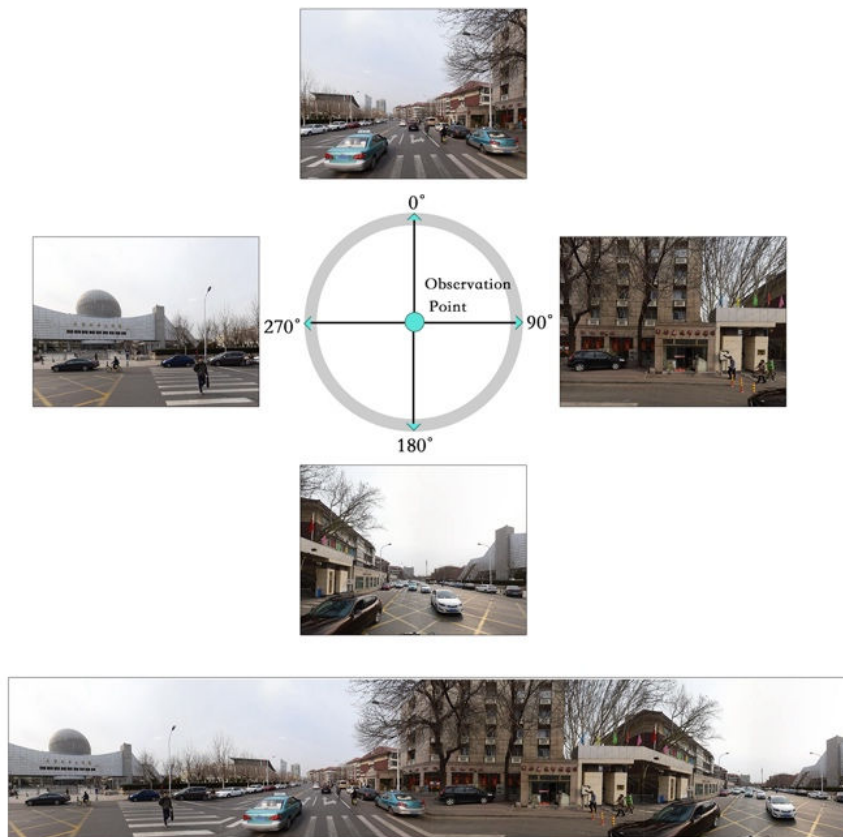


Fig.2 Tianjin Street View Data

B. MIT Place Pulse Data

In 2013, the MIT Media Lab launched the "Place Pulse 2.0" project, it is an online data collection platform for collecting public perceptions of the appearance of cities. On this data platform, two randomly selected street view images of a city will be displayed to the participants at a time, and then the participants will be asked to answer the following questions based on the displayed street view images: "Which picture looks more X?", where X can be one of six choices: "Safe", "Active", "Boring", "Affluent", "Depressed" and "Aesthetic", participants can choose from three options from the left, right or equal as an answer, and the answer results represent their scene-aware judgment. The Street View Imagery dataset contains 110,988 Street View images collected between 2007 and 2012, covering 56 cities in 28 countries on 6 continents.

C. Scene Perception Based on Convolutional Neural Network

Predict human scene perception requires training a deep learning model, and we divide the task into six scene perception scores of street view images, namely safety score, activity score, boredom score, opulence score, depression score, and beauty score. In this study, we convert the six scene-awareness metrics into six binary classification tasks. Each binary classification task was trained and predicted by the ResNet model. The training data of each binary classification task is MIT Place Pulse. 5W pieces of positive and negative data were

extracted from MIT Place Pulse, and the training set, validation set and test set were divided according to the ratio of 7:2:1, and finally we obtain 7W pieces of training set data, 2W pieces of validation set data, and 1W pieces of test set data. The experiments in this section use two NVIDIA Tesla V100 GPUs for model training. Part of the model training parameters are: {Batch size: 16, Learning rate: 0.0001, Dropout: 0.1, Epoch: 50}. The average accuracy of the final model on the test set is 83.2%. The input of the model is a complete picture, and the output is one of the six scene indicators, as shown in Fig. 3.

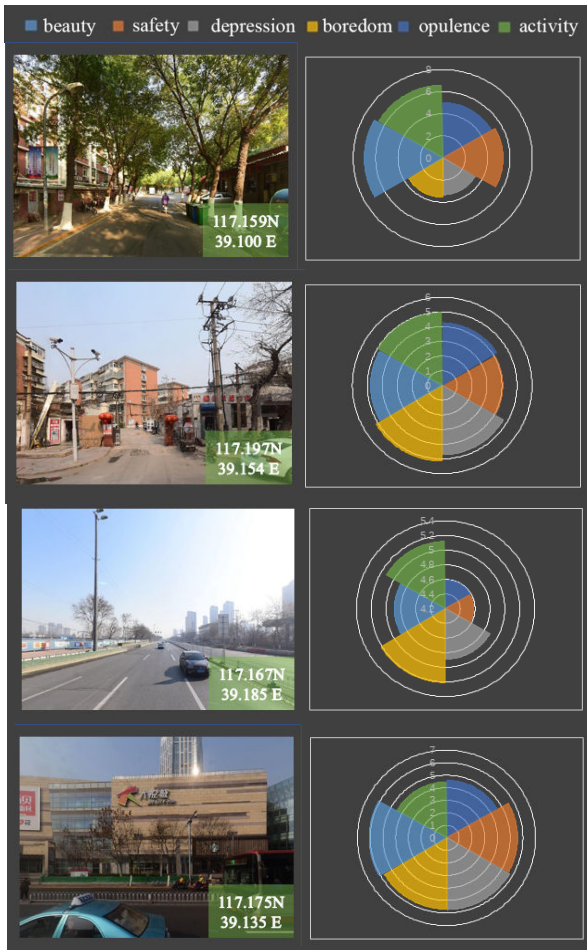


Fig. 3 Scene-aware output results

The trained model is used to predict the street view data in Tianjin, and ArcGIS is used to display the model prediction results. As shown in Fig. 4, the analysis results show that the roads with low safety score (safety score less than 4) account for 21.89%, and the visualization results show that they are mainly distributed in the boundary of the five districts in the

center of Tianjin (Nankai District, Heping District, Hongqiao District, Hebei District, Hedong District), the overall safety value in the northwest direction is relatively high; the proportion of roads with a low activity score (activity score less than 4) is 20.97%. The visualization results show that the activity score is higher in the urban area and lower in the suburbs. The overall distribution is relatively uniform, and there is no local concentration area; roads with a high boring score (boring score greater than 5) account for 39.05%, and the visualization results show that the boredom score in the peripheral edge of the four districts of the city center is higher, and the boredom score in the urban center is lower; the proportion of roads with a low affluence score (the affluence score is less than 4) is 24.35%, and the visualization results show that the affluence score is also higher in urban area and lower in suburbs, the affluent score in the northwest of the suburbs is the highest; roads with a high depression score (a depression score greater than 5) account for 56.20%, The visualization results show that the overall depression score in Tianjin is high, and the depression score in the southeast suburbs is low, which may be related to the small urban area of Tianjin and the compact building structure; the proportion of roads with a low aesthetic score (aesthetic score less than 4) is 25.73%, the visualization results show that the aesthetic score is also higher in urban areas and lower in suburbs, and the aesthetic score in the northwest direction in the suburbs is the highest; comprehensively analyzing the six scene perception results, the positive perception results are mainly distributed in the urban area, and the negative perception results are mainly distributed in the urban area. The results are mainly distributed in the suburbs. It is worth noting that the suburbs in the northwest also have a relatively high distribution of positive perception results. It may be related to the neighboring capital Beijing. Data analysis shows that a large number of employees working in Beijing choose to settle in the adjacent Wuqing District of Tianjin, which has driven the development of the local economy and changes in the urban structure.

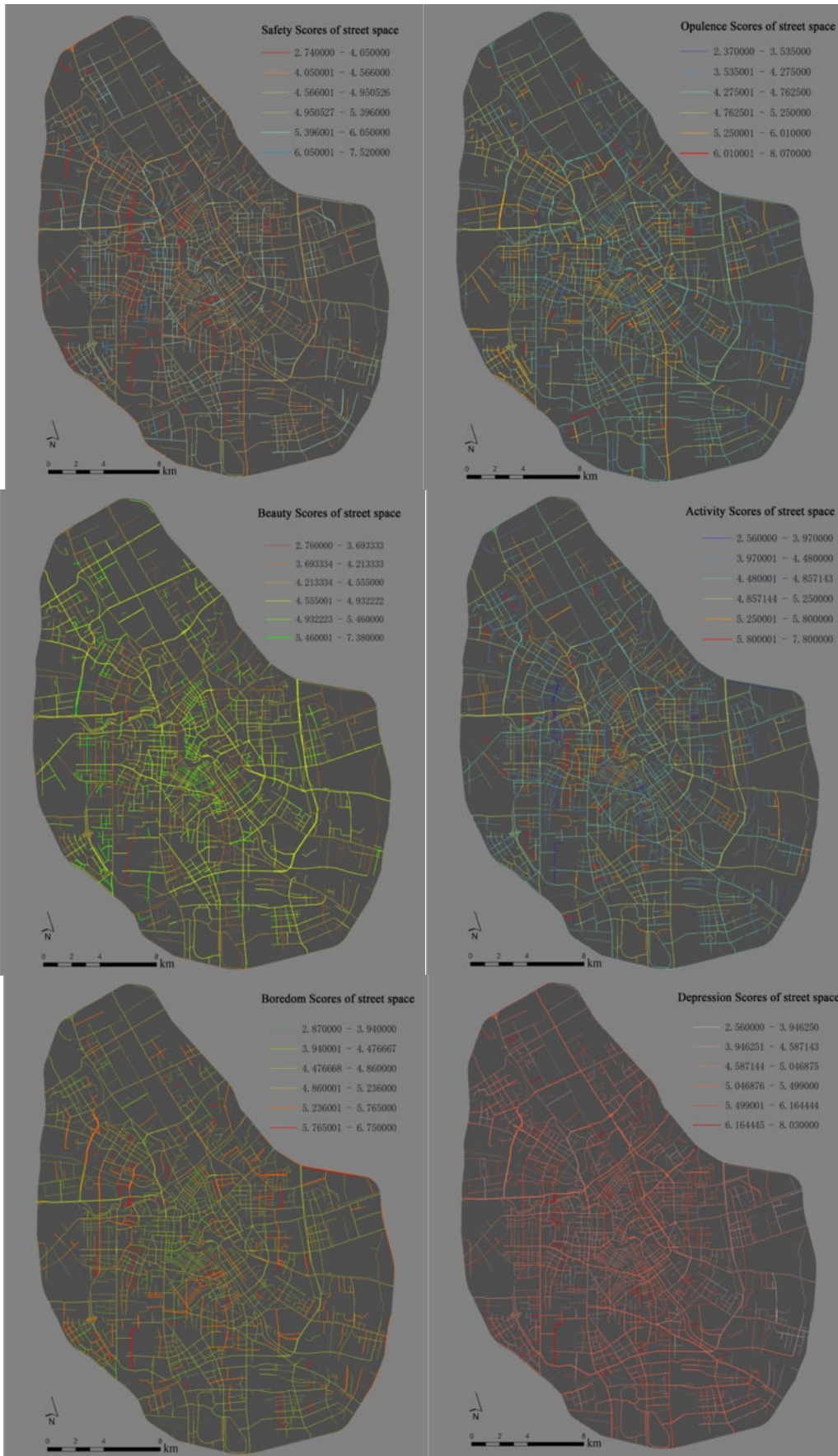


Fig.4 Road distribution map of perception score

D. Scene Perception Based on Convolutional Neural Network

To explore the visual factors that affect the scene perception results, we introduce a picture semantic segmentation-based method to identify visual elements related to the scene perception results. The experiment adopts the scene semantic segmentation technique [17] to calculate the area ratio of semantic objects in the scene. Semantic scene parsing is one of the key techniques for scene understanding, which aims to identify and segment object instances in a natural image. Giving an input image, the model is able to predict a class label for each label. This paper adopts the mature Unet model in the industry for scene semantic segmentation task.

The Unet model is a relatively mature model in the field of image semantic segmentation. We use an open source Unet model based on the Github, which is the largest technical exchange platform for programmers. The accuracy of this model on the training set is 97%, and it can be recognized the elements include the proportion of buildings, roads, sky and other areas in the picture, etc., which can better match the semantic segmentation task. Therefore, we use this Unet model to predict street view pictures.

The selected semantic segmentation extracts greening ratio, sky ratio, number of cars, number of shops, proportion of buildings, proportion of motor vehicle lanes, proportion of sidewalks, and number of pedestrians. The input of the model is a complete picture, and the output is the area ratio or quantity of corresponding 8 elements in the picture, The specific output results are shown in Fig. 5.



Fig. 5 Semantic segmentation output diagram

E. Correlation Analysis between Perception and Physical Elements

The scene perception score can obtain the perception score from the scene perception model, and calculate the area ratio of each visual element in the image through scene semantic segmentation. Finally, the scene perception score and the area ratio of each visual element are regressed through multi-dimensional analysis, and obtain the main visual elements that lead to the perception of the local scene.

The linear regression model is a classic multidimensional regression analysis that analyzes each of the six perception indicators separately. The principle is to use a polynomial to fit the target problem.

$$f(x) = w_0 + w_1x_1 + w_2x_2 + \dots + w_nx_n \quad (1)$$

Among them, x_i is called the weight of the polynomial, which is the final output result of the model, indicating the influence of each factor on the final result. The weight can be positive or negative, and the absolute value of the weight

indicates the size that the factor has a positive effect or negative effect on the final result. This paper uses a linear regression ALGORITHM TO EXPLORE THE IMPORTANCE OF FACTORS AFFECTING SCENE perception, and visualize the final weight.

Using Python to extract 5K pieces of scene perception and semantic segmentation data from Tianjin street view data, divide training set, validation set and test set according to the ratio of 7:2:1, and finally get 3.5K pieces of training set data and 1K validation set data There are 0.5K pieces of data in the test set. In this section, two NVIDIA Tesla V100 GPUs are used for model training. The training parameters of the model are {normalize: True, fit_intercept: True, copy_X: True}.

III. RESULTS

It can be seen from the regression coefficient diagram of the safety score (Fig. 6) that the places with more modern factors such as the area occupied by buildings and the number of cars in the street view pictures are mostly urban centers, where the facilities are complete, the streets are regular, and the safety score is high, and the place with a high proportion of sky area is relatively empty, and the risk factors will increase, which will reduce the safety score.

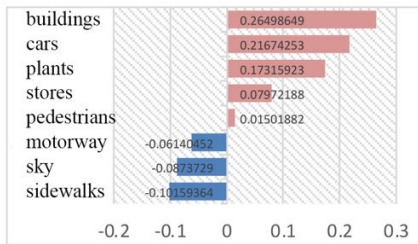


Fig.6 Regression diagram of safety score

From the regression coefficient graph of the activity score (Fig. 7), it can be seen that the places with a large number of cars and a high proportion of green vegetation in the street view pictures show the diversified characteristics of the street view, and more abundant and complex environmental factors are conducive to the increase of the activity score and the high proportion of the sky area will make the composition of the street view relatively simple, and the relatively monotonous factors will reduce the activity score.

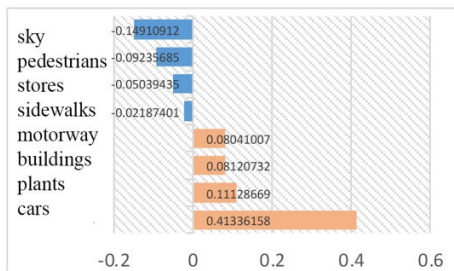


Fig.7 Regression diagram of activity score

From the regression coefficient graph of the boredom score (Fig. 8), it can be seen that the areas with high proportion of sidewalks or motor vehicle lanes in the street view images are usually suburban ring roads. Relatively monotonous, increase the boredom score, while a larger vegetation area will make the picture full of vigor and vitality, increase the ornamental value, and thus reduce the boredom score.

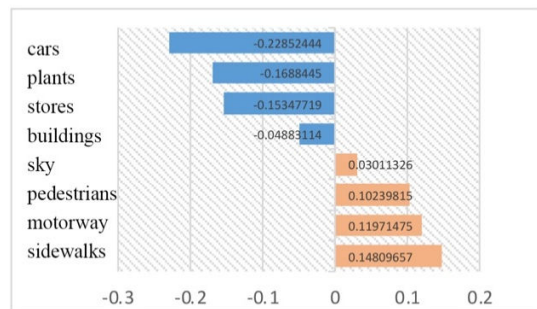


Fig.8 Regression diagram of boredom score

From the regression coefficient graph of the wealth score (Fig.9), it can be seen that the more vegetation area, the number of cars and shops in the street view picture will increase the wealth score, and the reason for the vegetation area is explained here, because the picture of the MIT Place Pulse dataset is large. Some of them are from abroad, and most of the pictures with a higher wealth score are villas of the wealthy and have a higher green area, so the model will give a higher weight to the vegetation area, while the open suburbs with a large proportion of motor vehicle lanes are It is considered sparsely populated and the affluence score is low.

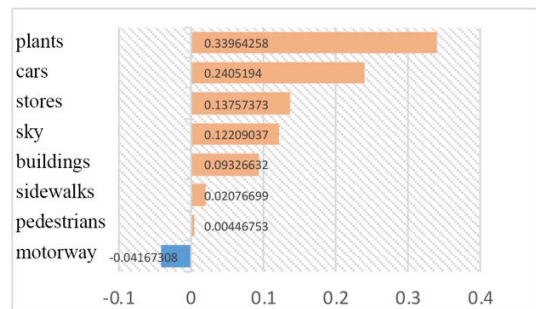


Fig.9 Regression graph of wealth score

It can be seen from the regression coefficient diagram of the depression score (Fig. 10) that the higher proportion of building area in the street view picture will increase the depression score. More places are considered to have a relatively large flow, and a higher proportion of greenery will bring people a sense of visual comfort, which is conducive to the reduction of the depression score.

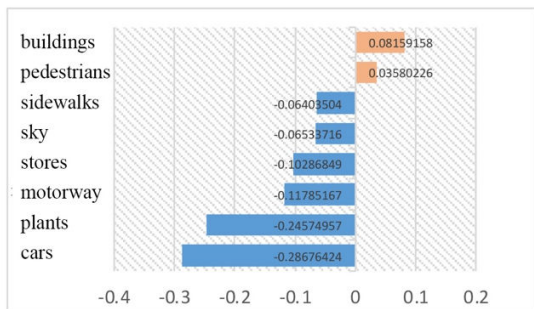


Fig.10 Regression graph of depression score

It can be seen from the regression coefficient diagram of the aesthetic score (Fig.11) that the high vegetation and sky proportions in the street view images are mostly in the suburbs, which are far away from the hustle and bustle of the urban area. while intersections with large traffic or suburban ring roads with a large proportion of roads are monotonous, lacking in viewing, and have a low aesthetic score.

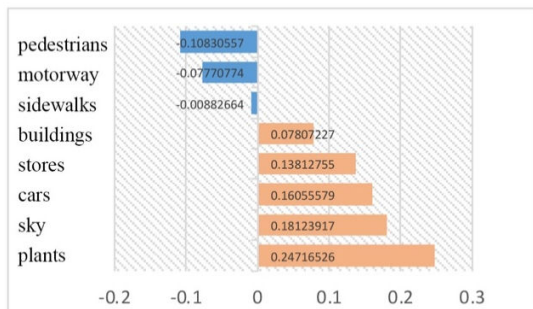


Fig.11 Regression diagram of aesthetic score

IV. DISCUSSION

A. Measures to improve the experimental process

The work conducts corresponding experiments on the mining and quantification of scene perception elements based on deep learning, and the efficiency has been greatly improved. However, review the entire experimental process, there are also points worth improving:

The scene perception evaluation model did not include Tianjin data in the training process, resulting in no learning experience of Tianjin street view pictures when the model landed in Tianjin City. Later, it was considered to add manually reviewed Tianjin street view pictures to the data set to improve scene perception and the model predict accuracy.

The scene element recognition model directly uses the open source model, which greatly shortens the experiment time. However, the scene elements which not involved in the open source model cannot be analyzed, which reduces the effect of the model. Later, the U-net model is considered to be used with a larger scale data sets which cover all elements of the street view, aiming to improve the actual predict effect of the semantic segmentation model.

B. Countermeasures to improve the six indexes

This paper makes a detailed analysis of the specific factors affecting the six score of scene perception, and the test results have almost equal effect in the fields of environmental psychology and ecological land-scape science [18-22]. For example, the green vegetation in the street scene, such as trees, potted plants, grass, etc., can significantly reduce the individual sense of depression.

The appearance of cars and green vegetation in the street view increases the sense of vitality in the scene and improves the activity score. On the other hand, too many buildings in the streetscape often make people feel depressed.

Rational construction of man-made features to reduce the impact of manmade features on individual emotional perception is an optimization strategy worthy of attention, and controlling the ratio of man-made features to natural landscapes in urban landscapes is a key element in building a healing environment. For example, the safety score can be improved by reasonably reducing the proportion of the sky area of the street view, and the wealth score can be improved by reasonably increasing the green vegetation area, the proportion of cars and shops in the scene, and so on.

V. CONCLUSION

The surrounding environment of city streets affects the behavior and health of residents. More than a century, various fields of urban planning have discussed the importance of a city's appearance and the exploitation of visual factors that may contribute to human perception. We first use a method that combines big data and deep learning of street view imagery to determine scene awareness in large urban areas. Second, this paper quantitatively studies the connection between scene perception and scene elements. Through the above experimental, we mine and quantify scene perception factors from the perspective base on deep learning in Tianjin. These technologies have great potential and will directly support the theory and practice of urban design. Moreover, the research content of us can also provide reference value for research in related fields.

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Synthesising Smart City and Smart Port Concepts: A Conceptualization for Small and Medium-Sized Port City Ecosystems

Christopher Meyer, Laima Gerlitz

Abstract— European Ports are about to take an important step towards their future economic development. Existing legislatives such as the European Green Deal are changing the perspective on ports as individual logistic institutions and demand a more holistic view on ports in their characteristic as ecosystem involving several different actors in an interdisciplinary and multilevel approach. A special role is taken by small and medium-sized ports facing the same political restriction and future goals - such as reducing environmental impacts with 2030 and 2050 as targets - while suffering from low financing capacity, outdated infrastructure, low innovation measures and missing political support. In contrast, they are playing a key role in regional economic development and cross-border logistics as well as facilitator for the regional hinterland. Also, in comparison to their big counterparts, small and medium-sized ports are often located within or close to city areas. This does not only bear more challenges especially when it comes to the environmental performance, but can also carry out growth potentials by putting the city as a key actor into the port ecosystem. For city development, the Smart City concept is one of the key strategies currently applied mostly on demonstration level in selected cities. Hence, the basic idea behind is par to the Smart Port concept. Thus, this paper is analysing potential synergetic effects resulting from the application of Smart City and Smart Port concepts for small and medium-sized ports' ecosystems closely located to cities with focus on innovation application, greening measurements and economic performances as well as strategic positioning of the ports in Smart City initiatives.

Keywords— port-city ecosystems, regional development, sustainability transition, innovation policy.

Application of a Hybrid Modified Blade Element Momentum Theory/Computational Fluid Dynamics Approach For Wind Turbine Aerodynamic Performances Prediction

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Abstract: In the field of wind turbine blades, it is complicated to evaluate the aerodynamic performances through experimental measurements as it requires a lot of computing time and resources. Therefore, in this paper a hybrid BEM-CFD numerical technique is developed to predict power and aerodynamic forces acting on the blades. CFD simulation was conducted to calculate the drag and lift forces through Ansys software using the K-w model. Then an enhanced BEM code was created to predict the power outputs generated by the wind turbine using the aerodynamic properties extracted from Computational fluid dynamics approach. The numerical approach was compared and validated with experimental data. The power curves calculated from this hybrid method were in good agreement with experimental measurements for all velocity ranges.

Keywords: Blade element momentum, Aerodynamic forces, Wind turbine blades, Computational fluid dynamics approach.

1. INTRODUCTION

The wind turbine is a mechanism which converts mechanical energy to electrical energy. The aerodynamic efficiency of the wind turbine is defined by the kinetic energy captured from the wind. To enhance this efficiency, it's necessary to determine the forces exerted on the rotor blades by analyzing the flow behavior around these blades. To analyze the aerodynamic performances including forces acting on the blades and power, it's relevant to study the velocity field around the airfoil. Numerous techniques are available in the scientific literature (Empirical expressions, experimental measurements and CFD simulation). However, in comparison with the experimental method, the simulation technique is more economical and efficient. CFD simulation is a very useful tool that allows solving complex fluid dynamics problems while providing reliable results. In addition to CFD simulation, the BEM theory is a widely used method in wind turbines design [1]. The implementation of the blade element momentum theory is simple and provides accurate results. It uses two approaches (Momentum technique and the Blade

Element technique) to calculate the rotor power from the aerodynamic coefficients. Several numerical

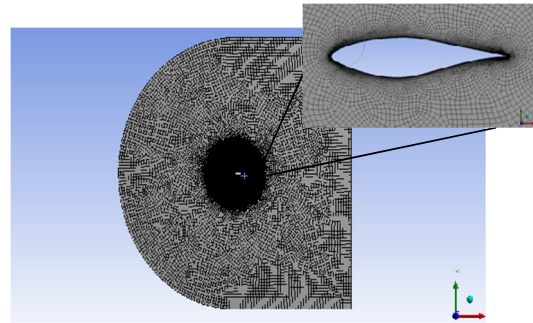
studies have been done in previous works using these approaches. H.Yilei and K.Ramesh [2], worked on the optimization of the airfoil shape using a genetic algorithm and Ansys Fluent. H.Yang [3], used the BEM technique and 3D CFD approach to evaluate the aerodynamic performances of the Mexico rotor. P.Margaris [4], used 3D CFD simulation to study and compare the aerodynamic characteristics of the NACA0012 and the S809 airfoil. M.Ajam [5], Analyzed the wind turbines energy under different conditions using the blade element momentum theory. A.Shayesteh [6], used the actuator disk method with the BEM theory to simulate the flow field around the Mexico wind turbine rotor. The aim of this research is to create a hybrid numerical code that combines the modified blade element method with computational fluid dynamics (CFD) to calculate the wind turbine aerodynamic performances. The objective of this hybrid method is to simplify the evaluation of the aerodynamic performances of wind turbines in a limited time, to obviate the use of experimental measurements that require significant time and

computational resources. This paper is structured as follows:

-Application of CFD methodology to simulate the flow field around the rotor blades and calculate the wind turbine aerodynamic performances.

-Implementation of a modified BEM method based on brake state and stall delay effect models to predict the wind turbine power using the aerodynamic characteristics extracted from CFD calculations.

-Validation of the numerical approach by comparing results with experimental data.



1. NUMERICAL TECHNIQUES

2.1. CFD CALCULATIONS

Compressive Turbulent flow over a wind turbine blade is simulated at 1M Reynolds number and various angles of attack. A two-dimensional domain around the S809 profile presented in figure was modeled and analyzed using ANSYS FLUENT. The flow field is simulated by K-w SST model, which solves the Navier Stokes equations provided by:

$$U_i \frac{\partial k}{\partial x_i} = P_k - \beta^* k \omega + \frac{\partial}{\partial x_i} \left[(v + \sigma_k v_T) \frac{\partial k}{\partial x_i} \right] \quad (1)$$

$$\frac{\partial \omega}{\partial t} + U_i \frac{\partial \omega}{\partial x_i} = \alpha S^2 - \beta \omega^2 + \frac{\partial}{\partial x_i} \left[(v + \sigma_\omega v_T) \frac{\partial \omega}{\partial x_i} \right] + 2(1 - F_1) \sigma_{\omega^2} \frac{1}{\omega} \frac{\partial k}{\partial x_i} \frac{\partial \omega}{\partial x_i}$$

Where k and ε are respectively the turbulent kinetic energy and the turbulent rate of turbulent dissipation. Equation (1) presents the transport equation of the turbulent kinetic energy and equation (2) presents the specific dissipation rate of turbulent kinetic energy.

Ansys meshing was used to create the right mesh topology which is a C-grid type, expressed as a structural mesh at which each node is followed by another node consecutively. The C mesh is used for CFD analysis of an airfoil to give better convergence of the flow over the airfoil, to control the wall plus function of the mesh to give good result and to match the leading-edge curvature for a good flow separation. Fig 1 presents the mesh topology used in this work.

Fig. 1. Mesh topology

FLUENT CFD ANALYSIS has been used to simulate the flow field around the turbine blade at different velocities and angles of attack. The boundary conditions on the fluid domain are as follow:

| Model | K-w |
|-----------------------|---------------------------------|
| Air Viscosity-Density | 1.7894e-05 Kg/m-s - 1.225 Kg/m3 |

| | |
|------------------------|-------------------------------|
| Spatial Discretization | Simple Scheme Second order |
| Angle of attack | 0° - 20° |

Table 1: Boundary Conditions

2.2. MODIFIED BEM METHOD

To calculate the wind turbine power, a modified BEM method was used through a numerical code. This method was developed by glauert [7] to evaluate performances of wind turbines. It combines two methods: momentum theory and blade element theory.

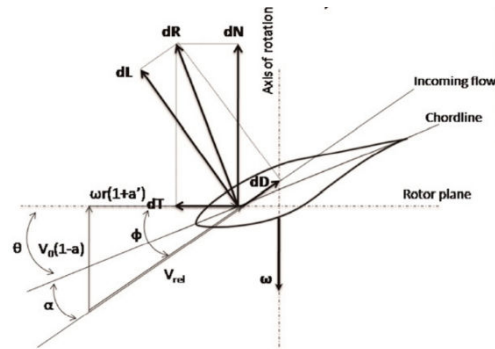


Fig.2. Forces applied on a blade element

This technique uses the drag and lift coefficients to calculate moments and forces acting on each section of the wind turbine blade. Fig 2 [8] represents the forces acting on an element of the blade.

The relative wind speed can be calculated from the tangential and axial induction factors, a and a',

$$W = \sqrt{V^2(1 - a)^2 + 2r^2(1 + a')^2} \quad (3)$$

Furthermore, to enhance the efficiency of the BEM technique several correction models were employed in this paper such as Prandtl tip losses [9], brake state model and 3D corrections [10] to take into account the stall delay effects.

Tip and Hub loss modifications: In the BEM method, numerous corrections are taken into account to improve its efficiency as the tip and hub corrections.

These corrections help to consider vortices at the wind turbine blade tip and hub.

The hub and tip loss factors were developed by Prandtl, and are expressed respectively as follow;

$$F_{Hub} = \frac{2}{\pi} \arccos e^{-p} \quad (4)$$

Where $p = \frac{N r - R_{hub}}{2 r \sin \phi}$

$$F_{Tip} = \frac{2}{\pi} \arccos e^{-p} \quad (5)$$

Where $p = \frac{N R - r}{2 r \sin \phi}$

These factors are used to calculate the axial factor as follow,

$$a = \frac{1}{\frac{4F \sin^2 \phi}{\sigma(C_L \cos \phi + C_d \sin \phi) + 1}} \quad (6)$$

Where F refers to the total loss factor.

Brake state model: In this paper the Jonkman Buhl brake state model was implemented with the BEM code to provide accurate results. Based on previous works, this model predicts better the power for wind speeds between 5m/s and 20m/s. It's a combination of the Buhl equation for $a > 0.4$, the axial induction factor equation (13) for $a < 0.4$ and Jonkman equation. In 1926, Glauert and Buhl [11], corrected the axial induction factor by creating a link between this factor and the thrust coefficient while using the tip loss factor.

$$a = \frac{18F - 20 - 3\sqrt{C_T(50 - 36F) + 12F(3F - 4)}}{36F - 50} \quad (7)$$

The thrust coefficient equation is expressed as follow;

$$C_T = \left[\frac{1 + \sigma(1-a)^2(C_L \cos \phi + C_d \sin \phi)}{\sin^2(\phi)} \right] \quad (8)$$

Stall delay effect: The aerodynamic coefficients extracted from 2D-CFD numerical simulation were corrected using different models to consider the stall delay effects to improve the modified BEM model accuracy. In this work two different models were used to correct the 2D parameters: DU Selig model [12] and Chaviaropoulos and Hansen model [13]. A comparison between both models and experimental results was conducted to detect.

The DU Selig stall delay model corrects the aerodynamic parameters as follow:

$$C_{l,3D} = C_{l,2D} + g_{cl} C_l \quad (9)$$

$$C_{d,3D} = C_{d,2D} + g_{cd} C_d \quad (10)$$

$$g_{cl} = \frac{1}{2\pi} \left[\frac{1.6 \left(\frac{C}{R}\right) a - \left(\frac{C}{R}\right)^{\frac{dR}{\lambda r}}}{0.1267 b + \left(\frac{C}{R}\right)^{\frac{dR}{\lambda r}}} - 1 \right] \quad (11)$$

$$g_{cd} = \frac{1}{2\pi} \left[\frac{1.6 \left(\frac{C}{R}\right) a - \left(\frac{C}{R}\right)^{\frac{dR}{\lambda r}}}{0.1267 b + \left(\frac{C}{R}\right)^{\frac{dR}{\lambda r}}} - 1 \right] \quad (12)$$

Where the constants a, b and d are taken as 1 and λ is the tip speed ratio expressed as follow;

$$\lambda = \frac{R}{\sqrt{V^2 + (R\Omega)^2}} \quad (13)$$

V and Ω refers respectively to the wind speed and the rotational velocity.

The Chaviaropoulos and Hansen model consider the three-dimensional effects as follow;

$$C_{l,3D} = C_{l,2D} + f_{cl} C_l \quad (14)$$

$$C_{d,3D} = C_{d,2D} + f_{cd} C_d \quad (15)$$

$$f_{cl,cd} = a \left(\frac{C}{R}\right)^h \cos^n \quad (16)$$

Where ΔC_l and ΔC_d are the differences between the C_l and C_d and f_{cl}, C_d is a specific function to this model. The constant parameters are given as: $n=4$, $a=2.2$ and $h=1$ [13].

2.3. HYBRID BEM-CFD TECHNIQUE

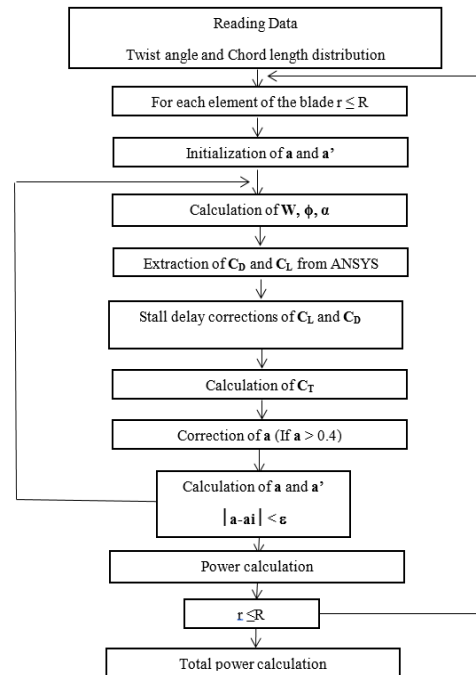


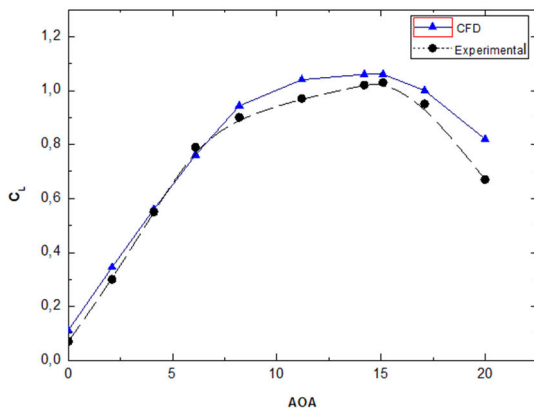
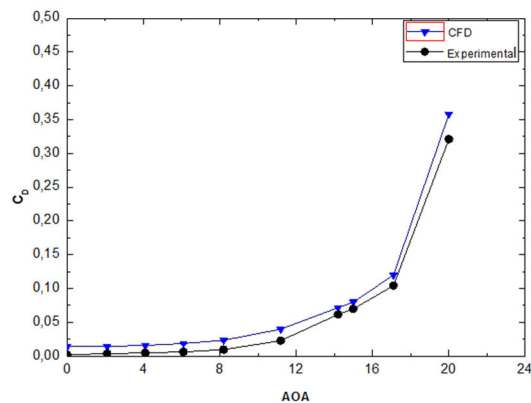
Fig. 3. BEM/CFD Algorithm

In the present work, a BEM/CFD linking program has been developed to calculate forces acting on the rotor blade and evaluate power. The steps of this iterative solving method presented in Figure 3 are as follows:

- First, the BEM program calculates the wind relative velocity for each section of the blade to compute the angle of attack,
- This angle of attack is used by the CFD solver through a coupling interface between Matlab and Ansys to calculate the drag and lift coefficients,
- The two-dimensional aerodynamic parameters extracted from CFD simulation are inserted then into the modified BEM program based on brake state and stall delay effect models,
- The axial induction factor is computed at the last iteration and compared to its previous value. Once the right precision is attained the total power is calculated.

1. RESULTS AND DISCUSSION

3.1. CFD SIMULATION RESULTS



In this part, a comparison between the aerodynamic coefficients obtained from the two-dimensional CFD simulation and experimental data was conducted to validate the numerical results. It can be seen from figure 4 that at high angles of attack greater than 8°, the drag increased considerably. However, the drag remained constant at small angles of attack. As the angle of incidence increased, the lift coefficient increased linearly and became unstable once it reached the stall point (15°) due to the boundary layers separation from the blade surface.

The aerodynamic coefficients computed from the CFD simulation presented in this work and experimental measurements are nearly identical for small angles of incidence (0°-8°). At higher angles of attack above 8° the drag and lift coefficients are slightly overpredicted due to the instability of the flow: the stall behavior of the airfoil is not considered by the turbulence model. For this reason, 3D corrections were applied in the second section of this work to enhance the results.

3.2. MODIFIED BEM METHOD RESULTS

To validate the hybrid modified BEM-CFD approach, the power curves obtained numerically for various ranges of wind speed were compared to experimental data as presented in figure 5. In addition, a comparison between both stall delay effect models (Chaviaropoulos and Hansen model and Du and Selig model) was performed to determine the more efficient one. The results obtained from figure lead to the following analysis:

- The rotor power is exponentially related to the wind speed: At low wind velocities (6m/s-10m/s) the power generated from the wind turbine is less important compared to the power generated at higher velocities from 10 m/s to 12 m/s. The power output continuously decreases after the peak point (12 m/s).

- The experimental power curve shape is nearly close to the one obtained numerically for both stall delay models at different velocity ranges.

- With an error rate between 2% and 17%, the Du and Selig power curve is underpredicted at low wind velocities less than 10 m/s and overpredicted at higher wind velocities from 10m/s to 12 m/s.

- With an error rate between 2% and 9%, the modified BEM/CFD code results with Chaviaropoulos and Hansen model are nearly close experimental measurements.

- Compared to the DU and Selig model, the power curve calculated from the Chaviaropoulos and Hansen model is more consistent with the experimental data for all velocity ranges.

- Implementing the modified BEM-CFD linking approach based on brake state and stall delay models to predict the wind turbine power yielded good results.

CONCLUSIONS

In this paper a hybrid BEM/CFD technique based on brake state and stall delay models was developed to predict the wind turbine performances. This new approach saves computational time and resources, making it particularly useful for engineering applications.

Based on the numerical code results presented in this work, the modified BEM technique used with Chaviaropoulos and Hansen stall delay model predict better the wind turbine power compared to other models. The results obtained from the coupling method developed by the authors, are in good agreement with experimental measurements.

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Systems Lens: Towards Sustainable Management of Maintenance and Renewal of Wire-based Infrastructure: The Case of Water Network in the City of Linköping, Sweden

Hegazy E., Anderberg S., Krook J.

Abstract— The city's wire-based infrastructure systems (WBIS) are responsible for the delivery of electricity, telecommunications, sanitation, drainage, and district heating, and are a necessity for sustainable modern urban life. Maintaining the functionality of these structures involves high costs and brings disturbance to the local community and effects on the environment. One key reason for this is that the cables and pipes are placed under streets, making system parts easily worn and their service lifetime reduced, and all maintenance and renewal rely on recurrent needs for excavation. In Sweden, a significant part of wire-based infrastructure is already outdated and will need to be replaced in the coming decades. The replacement of these systems will entail massive costs as well as important traffic disruption and environmental disturbance. However, this challenge may also open a unique opportunity to introduce new, more sustainable technologies and management practices. The transformation of WBIS management for long-term sustainability and meeting maintenance and renewal needs does not have a comprehensive approach. However, a systemic approach may inform WBIS management. This approach considers both technical and non-technical aspects, as well as time-related factors. Nevertheless, there is limited systemic knowledge of how different factors influence current management practices. The aim of this study is to address this knowledge gap and contribute to understanding of what factors influence the current practice of WBIS management. A case study approach is used to identify current management practices and underlying factors that influence them, and their implications for sustainability outcomes. The case study is based on both quantitative data on the local system, and data from interviews and workshops with local practitioners and other stakeholders. Linköping was selected as a case since it provided good accessibility to the water administration and relevant data for analyzing water infrastructure management strategies. It is a sufficiently important city in Sweden to be able to identify challenges, which to some extents are common to all Swedish cities. By uncovering current practices and what is influencing in Linköping, knowledge gaps and uncertainties related to sustainability consequences were highlighted. The findings show that goals, priorities, and policies controlling management are short-termed, and decisions on maintenance and renewal are often restricted to finding solutions to the most urgent issues. Sustainability transformation in the infrastructure area will not be possible through individual efforts without coordinated technical, organizational, business, and regulatory changes.

Keywords— Case study, infrastructure, management, practice, Sweden

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I. INTRODUCTION

CITIES play a crucial role for global sustainable development. Although their growth often leads to increased resource consumption and greenhouse gas emissions, cities hold the potential to offer solutions to various sustainability challenges [1]. Wire-based infrastructure systems (WBIS), including electricity, telecommunication, district heating, water, and sewage networks, form the technological backbone of cities and are essential for the well-being of their inhabitants [2]. However, increasingly frequent breakdowns arise as the systems age, making it increasingly difficult to secure efficient long-term supply [3].

Moreover, fast-growing cities require infrastructure adaptations to meet rising utility demands [4]. The current practice of locating WBIS cables and pipes under the streets has some challenging consequences [2]. Excavation operations for renewal and maintenance entail large costs and cause significant interference and disturbance to living areas, restrict other activities, and are connected to environmental impacts related to the use of equipment, transportation, treatment of excavated dirt, and reconstruction and asphaltting. Due to the complexity and cost of excavation, maintenance and renewal operations are often neglected, resulting in abandoned network lines [5].

Sustainability challenges related to WBIS extend beyond physical structures and subsurface positioning and are also influenced by financial, policy, and management practices [5]. The maintenance and renewal of urban subsurface infrastructure systems are particularly challenging and complex since many different actors and activities are affected [6]. Currently, management approaches are predominantly reactive, prioritizing immediate problem-solving over long-term network functionality [2]. Despite the fact that all of these networks are situated in close proximity to one another in urban environments, management of each utility system is often handled separately. Potential benefits in terms of cost savings and decreased environmental effects, from coordinating the maintenance and renewal operations are seldom exploited. System owners tend to focus on short-term gains from delivered utilities, and neglect maintenance and renewal needs, taking the functionality of the existing infrastructure for granted [5].

Consequently, most urban wire-based service networks have an underlying debt due to decades of insufficient repair and renewal. A large share of these systems is already outdated and will have to be renewed in the coming years. Replacing currently outdated WBIS represents a major challenge for network owners

[7], as it will entail massive costs and significant increases in sustainability consequences related to excavation work, among other factors [5]. However, this challenge may also present opportunities to change current management practices to become more sustainable.

There is no comprehensive approach to transforming WBIS management for long-term sustainability and meeting maintenance and renewal needs [3]. Several recent studies (e.g., [8], [9]) have proposed the use of a systemic approach for managing WBIS. This approach should not only consider technical aspects, but also non-technical aspects and time-related factors such as agents, procedures, and regulations when analyzing subsurface infrastructure systems to incorporate various societal and technological factors [10] and address different management challenges [11]. However, there is limited systemic knowledge on how different factors influence current management practices [8]. The aim of this study is to address this lack of systemic knowledge and contribute to understanding of what influences the current practice of WBIS management.

The investigation is based on a case study of the water network management in the city of Linköping, Sweden, which is approached via four research questions:

1. How do system owners plan, prioritize, finance, and execute maintenance and renewal of water networks in practice?
2. What are the policy and organizational factors that influence management practices of water networks?
3. What are the challenges system owners face in managing maintenance and renewal, and how do they cope with them?
4. What are the factors and barriers that limit the adoption of higher rates of renewal and more proactive maintenance in systems?

The case study utilizes both data from interviews and workshops with local practitioners and other stakeholders, as well as quantitative data on the local system. The paper starts off with a presentation of the theoretical approach of the study followed by a presentation of the case, and how the study has been performed. Subsequently, the existing management practices are analyzed, encompassing organizational and management strategies, and their implementation. Finally, the discussion synthesizes the findings and evaluates the relationship between current management practices, the factors influencing them, and implications for sustainability outcomes.

II. THEORETICAL APPROACH

The transformation toward more sustainable infrastructure management cannot be achieved by individual measures [12], but must rely on a comprehensive approach that includes coordinated and collaborative measures and changes that collectively improve the long-term durability of the systems and facilitate their joint maintenance and renewal [4], [8]. This is commonly described as the "holism principle," which recognizes that the sum of the parts of a system or sub-system interact on different levels, and an outcome or function will

emerge that cannot be merely explained through an individual systems element [10]. The use of a systems perspective in this study acknowledges the importance of considering the interdependencies between different elements of WBIS management.

Due to the lack of knowledge on how various factors influence current management practices, the management of WBIS can be considered a complex and challenging process [10]. To understand the current conditions of WBIS management and how to change general practices to be more sustainable, this study uses systems perspective [12], [13]. The systems perspective facilitates a comprehensive and interdisciplinary approach to gain a better understanding of the sustainability challenges and to develop a more sustainable infrastructure management for maintenance and renewal [8], [9], [11]. It does not only consider technical elements, but also non-technical and time-dependent elements like people, processes, and policies. Applying systems perspective enables the examination of interconnections, relationships, and dependencies between different components within the water network system [14], [15]. This includes technical, social, economic, and environmental aspects, ensuring a comprehensive analysis that captures the multifaceted nature of system management, revealing the intertwined interplay of system components, stakeholder dynamics, and management elements – encompassing priorities, processes, and coordination – that collectively shape practices of urban water infrastructure management.

The systems framework in Fig. 1 serves as an overarching approach guiding data collection, analysis, and discussion. Data collection is executed through a combination of qualitative and quantitative methods, including interviews, workshops, and document analysis. This comprehensive approach transcends isolated data points, encapsulating the holistic interplay of stakeholders, policies, and operational dynamics.

During analysis, the system's framework morphs into an interpretive lens, unveiling connections, dependencies, and intricate patterns. Spanning from qualitative to quantitative analysis, the analysis spans from a quantitative examination of the network, renewal prerequisites, and financial considerations, to a qualitative analysis of managerial processes and policies. This inquiry reveals challenges and lays the groundwork for proposing strategies that bridge the gap between different challenges and factors, and infrastructure resilience.

Subsequently, the systems framework synchronizes the synthesis of empirical insights and theoretical foundations, shedding light on the interplay between organizational policies, and infrastructure challenges. endeavor culminates in a narrative that extends beyond empirical observations, resonating with the profound rhythms of systemic dynamics that govern the intricate fabric of the water network.

III. MATERIALS AND METHODS

In this study, the management of the water network in Linköping city is investigated. The utilization of a case study approach provides concrete and in-depth knowledge for exploring complex phenomena [16], [17]. It is appropriate for this type of explorative investigation of context-dependent processes based on "what", "how", and "why" questions [18].

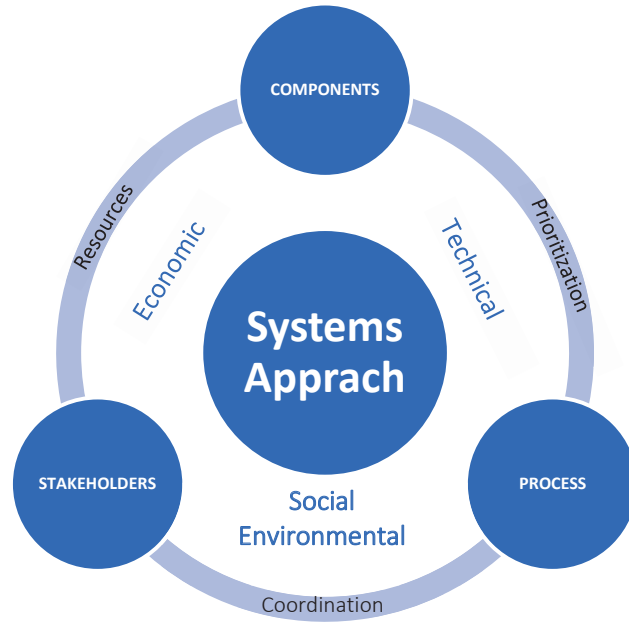


Fig. 1 Applied Systems Framework for Analyzing the Different Management Elements

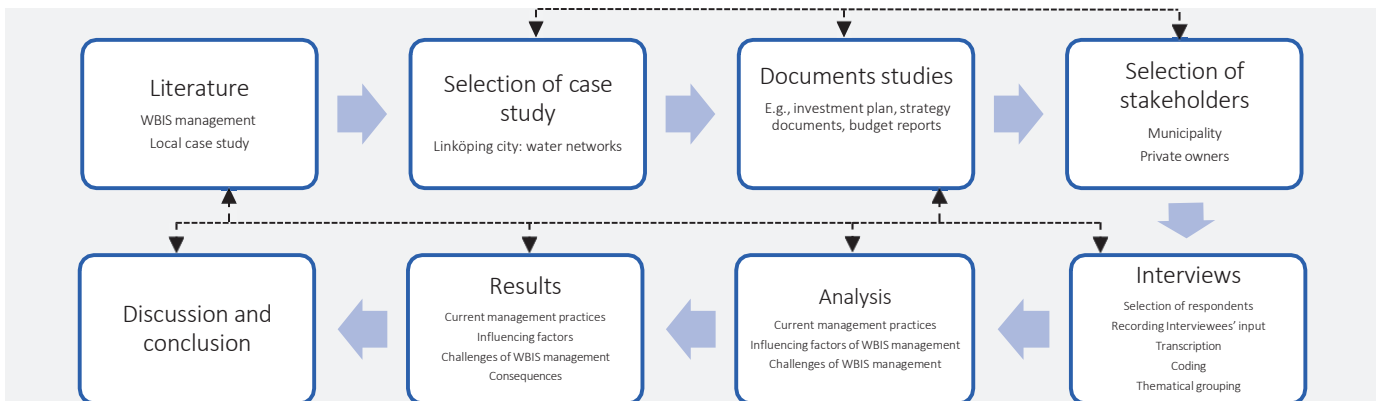


Fig. 2 The Structure of the Study

Utilizing a case study approach proves beneficial as it allows understanding and interpreting subjective data, opinions, experiences, and perceptions. Stakeholders are enabled to effectively articulate, comprehend, and elucidate their perspectives and experiences. By giving a platform for stakeholders to share their viewpoints, the case study approach ensures that perspectives are acknowledged and integrated into the research findings [19].

The present study is based on analysis of data on the networks and their management, local strategic documents, and stakeholder interviews. The process of the study is presented in Fig. 2.

A. The Case: Linköping City in Sweden

The city of Linköping with 166,000 inhabitants (2022), the 5th largest municipality in Sweden [20], was selected as a suitable case since it has a relatively large population and a combination of old and new urban water infrastructure networks. Furthermore, unlike several other major cities in

Sweden, where the infrastructure is partly owned and managed by private companies, all urban wire-based infrastructure in Linköping is managed by a single municipality-owned company, Tekniska verken AB (TV).

TV is fully owned by the city and is responsible for all utilities in the city and provides water, electricity, district heating as well as waste services to the inhabitants.

Centralized management facilitated the data collection of this project. According to Swedish law, the Municipal Council (Kommunfullmäktige, KF) is responsible for the municipal water services such as water and wastewater management. In Linköping, KF has delegated the management of the water services and the water infrastructure to TV, but it oversees its activities and controls the budget, and sets the user tariffs [21].

B. Data Collection

The data collection processes involved inventory of documents and statistics, interviews, and workshops, where a combination of primary and secondary data were gathered to gain insights in

the current management of water infrastructure systems. The interviews and workshops involved stakeholders from TV. The initial findings from the interviews and workshops guided the selection of additional participants using a respondent-driven sampling method, commonly known as snowballing [22].

1. Interviews

The main stakeholders targeted were municipalities and network owners and managers. Respondent stakeholders were selected based on their position and area of expertise. Preliminary interviews with representatives from other cities and infrastructure companies were conducted to refine interview questions, and potential participants were identified through snowball sampling. Table I presents the respondents and their positions.

TABLE I
Overview of Interviews and Workshops

| INT/WS | Respondents' positions | Date | Time-min |
|--------|----------------------------------------------------------------------------|------------|-----------|
| Int.1 | Group leader project, water and sewage networks AB, Malmö | 06/10/2020 | 60 |
| Int.2 | Group Manager project, Nordvästra Skånes Water and Sewage AB, Helsingborg | 07/10/2020 | 60 |
| Int.3 | Head of Planning & Projects, water, and sewage, Tekniska verken, Linköping | 26/10/2020 | 60 |
| Int.4 | Head of Planning & Projects, water, and sewage, Tekniska verken, Linköping | 26/10/2020 | 60 |
| Int.5 | Business Unit Manager Management Network, Tekniska verken, Linköping | 06/11/2020 | 60 |
| Int.6 | Deputy CEO, water network, Tekniska verken, Linköping | 17/11/2020 | 60 |
| Int.7 | Representative of the board of Tekniska verken, and for the municipality | 13/01/2023 | 60 |
| WO.1 | Head of department, water management network, Operation, and investigation | 24/08/2022 | 120 |
| WO.2 | Water management network- database and Trimble support | 04/10/2022 | 120 + 240 |
| WO.3 | Water management network- budget and finance | 22/09/2022 | 120 + 240 |
| WO.4 | Database and Trimble support | 30/09/2022 | 240 |
| WO.5 | Water management network- budget and finance | 14/11/2022 | 120 + 240 |
| WO.6 | Database and Trimble support | 24/11/2022 | 240 |

Semi-structured interviews were utilized, based on an interview guide comprising open-ended questions that can be tailored to each interviewee. This approach allows for adapting questions to different interviewees while also providing flexibility to ask additional questions based on the answers given. Interviews were conducted both through video calls and in person. Interviewers introduced themselves, explained the process, and asked open-ended questions to encourage free discussion. Follow-up questions were used for expansion and clarification, to learn more and ensure that the responses were correctly understood. Appendix 1 contains the interview questions, which focus on exploring organizational management processes, regulations and strategies, challenges, maintenance and renewal, and measures and changes related to infrastructure networks.

Interviews were recorded and transcribed. Transcription of the interviews was performed both manually, and automatically using Trint software.

2. Workshops

The participants were members from water network management at TV. Table I displays the number of workshops and participants' positions. The meetings were held in person at the office of TV.

During the workshops, different questions were addressed, and participants engaged in presentations and discussions. The first workshop aimed to introduce the study objectives and the purpose of the workshops, which was to collect and complete data on the water networks, and to validate previous findings and hypotheses in relation to the management based on the analysis of the literature and interviews. The following workshops facilitated continuous interaction with the TV staff, enabling the continuation of data collection and the extension of discussions, providing an opportunity to ask further questions or clarifications.

The data needs included information about water and sewerage networks such as the length, age distribution, and material composition of the entire network and by district. It also included information and data on water leakage and pipelines in damage. Additionally, the major causes of these damages, leaks, interruptions were addressed, as well as how maintenance and renewal work has changed over time. Furthermore, questions concerned how the management handled the budget, and particularly the distribution between emergency measures, new construction, renewal, and preventive measures.

The workshops also involved discussions on how a sustainable pace of renewal can be developed and key challenges were identified. They also focused on the budget and planning processes, and how these processes affect the work of TV and its room for maneuver. The workshops' discussions were facilitated to allow participants to share their perspectives, identify challenges and opportunities, and generate valuable recommendations and ideas.

The collected data was subsequently transcribed and summarized manually for analysis.

3. Network and Management Data

After the workshops, TV staff provided data on the urban water infrastructure (UWI) networks, including state of leakage and interruptions, and budget plans for different operation, maintenance, repair, and renewal projects. Data on the networks including installation and renewal dates, pipe materials, dimensions, and location, were accessible via particular database, Trimble.

C. Data Analysis

The first step of the analysis involved organizing and analyzing the quantitative and qualitative data to provide an adequate account of the current state of water networks and their management. The analysis included the collected data in interviews, workshops, and network management data in relation to management practices and challenges for the renewal of Linköping's water and wastewater network. This included understanding the rate of renewal, how it has changed over time, the actual need for renewal now and in the future, and the factors that influence the planning, budgeting, and implementation of different types of projects.

The quantitative analysis included validating management

data in terms of assessing the physical conditions of different networks, e.g., age, material, type, and location, were analyzed to assess the current state of the networks, including the development of leakage and interruptions and needs for renewal. The development of renewal debt was estimated based on the estimated length of lines that would be over 80 years or more at a certain point in time and would thus require renewal, their replacement cost, assumed inflation rates, and discount rates [25]. The details of the calculation are provided in Appendix (5).

The outcomes of the analysis were communicated and presented between members of the research group allowing for further discussions of key insights, and provided an opportunity to consider further questions or clarifications to be addressed in the following-up workshops. After these workshops, additional observations and insights were incorporated for further integration into the discussion section.

NVivo 12 software was utilized for the analysis of the interviews data. Main themes and sub-themes were identified in the interviews data with the help of NVivo 12 software, which allowed coding of relevant statements, and the identification of relevant themes. Coding and theme generation were performed manually, enabling the rapid extraction of key assertions, and revealing linkages and interactions between stakeholders. Examples of the coding, the theme categorization, and the illustrations can be found in Appendixes 2 and 3.

The main themes reflected the main topics or categories of interest, including management practices, actors' responsibilities, legalization, challenges, and measures and changes, while the sub- themes provided a more detailed breakdown of the specific aspects discussed within each theme, including management processes, priorities, strategies, applied policies and regulations, resources and organizational capacity, and technical methods. These main and sub-themes helped to analyze and understand the different dimensions and components of WBIS management. They were further refined and developed throughout the research process, reflecting relationships between them, and highlighting common influencing factors. The statements were summarized, grouped in tables, and illustrated for further analysis, facilitating the identification of current management practices, challenges, and factors influencing them.

Connections and relations between analysis results and the research questions were established. The identified management practices and their influencing factors were further analyzed based on the phases of the management process, including planning, funding, and implementation. The most important identified influencing factors were either connected to organizational capacity or regulations, but the emerging concern for climate change was identified as an additional factor of increasing importance. An illustration of the flow from data collection to connection between analysis results and research questions, leading to the discussion section is presented in Fig. 3.

IV. RESULTS

A. Management of Water Network in Linköping

The municipality is responsible for providing water and sewerage services in line with four main national laws for the water sector [21], Fig. 4. The Act of Public Water Services, Plan and Building Act, Construction Act, and Environmental Code.

LAV (2006:412) regulates public water supply expansion and availability, and assesses the municipality's water responsibility based on Environmental Quality Criteria.

PBL promotes fair living conditions and sustainable environments for present and future generations. It regulates planning and building procedures.

Construction Act (Anläggningslagen AL, 1973:1149) establishes guidelines for property interaction, management, and distribution of construction costs, including shared sewage treatment facilities, benefiting rural communities.

The Environmental Code (Miljöbalken MB, SFS 1998:808) promotes sustainable development and safeguards human health and the environment from pollution. It particularly regulates the handling of wastewater.

In connection with water management, these laws primarily come in via that national authorities require permits at various stages of different processes [21], [23]. The municipality has delegated water utility management and ownership to TV, while retaining control over activities through deciding the budget, tariff levels, and controlling the board of TV, which consists of municipal settlements and utility networks.

TV operates public water plants, purifies politicians (Interview 7). Through its local planning monopoly, the municipality also regulates land use and the expansion of water, provides water and sewerage services, and conducts maintenance and renewal operations in accordance with LAV regulations. The company operates several facilities, including two waterworks, a wastewater treatment plant, and the networks that connect them [24].

B. Current Status of the System

The city of Linköping has networks for drinking water, wastewater, and stormwater spanning approximately 1982 km [25]. The smooth operation of this network is ensured through the presence of sewage pumping stations, overflowing locations, overflow pumping stations, and sewage storage tanks located throughout the city.

A significant portion of the water networks are between 50 and 80 years old. The stormwater and wastewater networks mainly consist of concrete pipes, but some plastic pipes have been introduced in connection with renewals. The drinking water network consists of mostly plastic materials and iron pipes, where the latter are being replaced with plastic pipes renewals. Detailed information on materials used can be found in Appendix (4).

1. Interruptions and Leaking Pipes

Leaking lines pose a significant challenge for water supply systems, resulting in water loss, reduced water pressure, and potential contamination of the drinking water supply. In 2020, the water leakage rate was estimated at 5.5%, which increased to 6.7% in 2021. From the year 2000 onward, the frequency of interruptions has exhibited significant variation between different years,

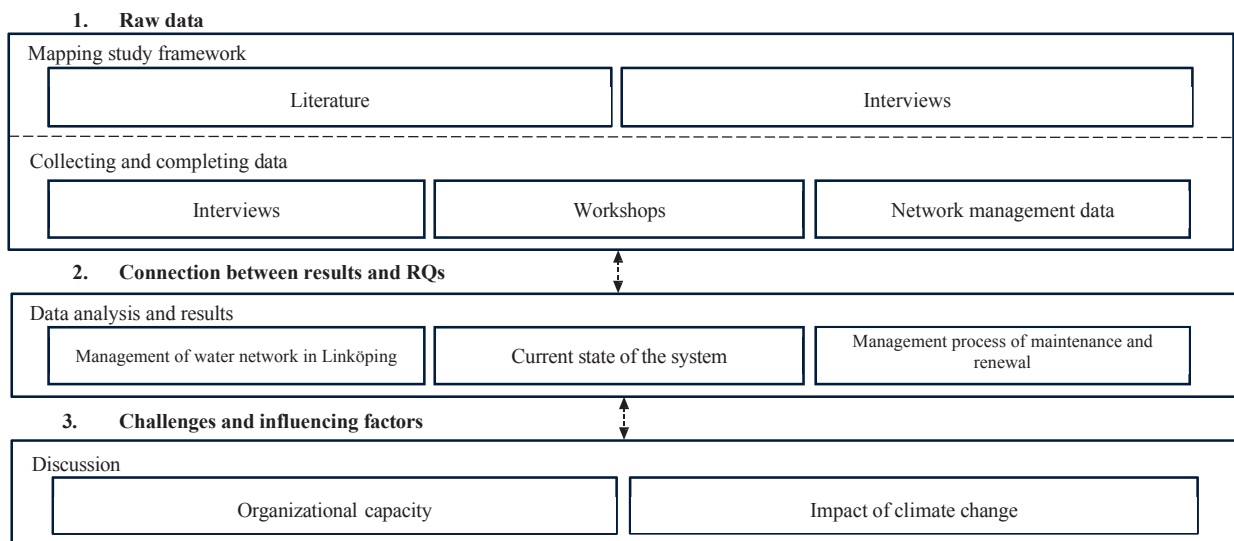


Fig. 3 Data Collection and Analysis Process



Fig. 4 The Municipality's Responsibility is to Plan for, and Implement the Legal Requirements Imposed by LAV, PBL, AL, and MB

displaying an overall trend of escalating interruptions. Notably, six out of the seven years with the highest recorded number of interruptions occurred after 2013 [25], Fig. 5.

Interruptions in the municipal water system are most prevalent during the winter and spring months, Fig. 5. This suggests that seasonal weather patterns, such as freezing temperatures, can contribute to interruptions as water pipes may freeze and break. However, it is plausible that inadequate maintenance, aging infrastructure, and insufficient rejuvenation of water networks are the primary contributing factors. The documented instances of interruptions primarily comprise water leakage, supply cuts, and pipe breakages, with water leakage emerging as the most prevalent form.

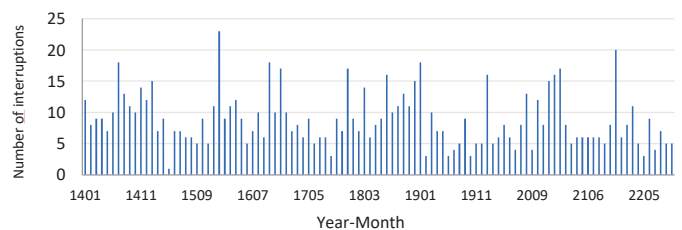


Fig. 5 Number of Interruptions per Month 2014-2022

The central areas of the city, which encompass the oldest sections of the networks, report the highest frequency of interruptions. This tendency is evident in Fig. 6 that shows interruptions due to leaking in pipes of different ages. Water lines established during the 1950s to the 1970s dominate. The

materials predominantly employed during this period, notably cast iron, may exhibit greater susceptibility to damage and leaks in comparison to more contemporary materials like plastic.

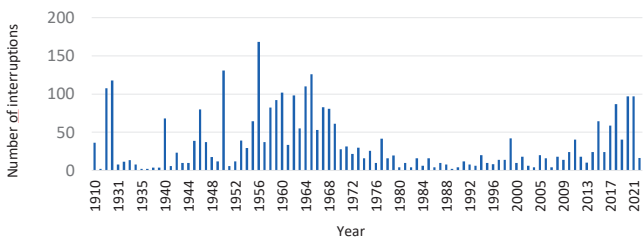


Fig. 6 Number of Interruptions Due to Leaking in Pipes of Different Ages 1910-2021

2. Renewal

Documentation for the drinking water network dates back to as early as 1900, while records for the wastewater network's inception can be traced to the mid-1970s. The stormwater network's documentation, on the other hand, commenced in 1984 [25], Figures 7, 8 and 9.

Renewal efforts have gained momentum in recent decades. Plastic materials, particularly since the 2000s, have been the predominant choice for renewing all types of water networks. Notably, post 2005, the renewal of the wastewater network has shown an upward trajectory, averaging around 200 km annually. Of these renewals, 89% have been executed using Polyethylene (POLY), with Polyethene material (PEH) constituting 8%, replacing Concrete (BTG) (Fig. 7), due to the durability and cost-effectiveness of plastics [26].

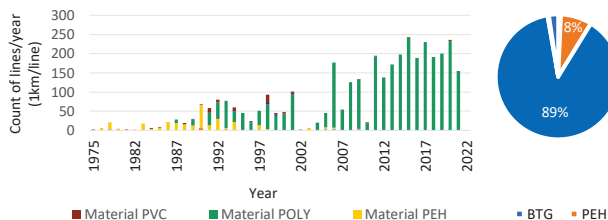


Fig. 7 Renewals in the Wastewater Network 1975-2021

Conversely, the stormwater network's renewal has been sporadic and less significant. Only a few years after 2000 witnessed the renewal of 50 km on average, whereas the wastewater and drinking water networks often saw over 100 km renewed annually. In the stormwater network, Polyethene material (POLY) dominated at 94%, alongside some utilization of Polyethene material (PEH) at 5%, Fig. 8.

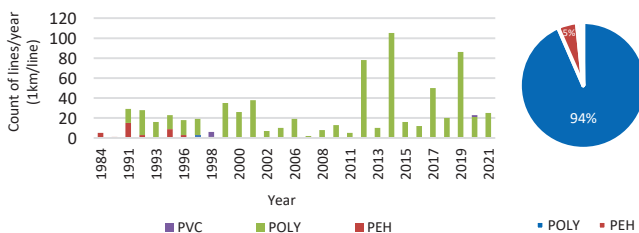


Fig. 8 Renewals of Stormwater Network 1984-2021

Drinking water line renewals have gained prominence over the last two decades, potentially due to aging pipes or the drive to adopt more advanced materials. Approximately 70% of renewed portions were initially made of Cast Iron (GJJ), while 14% were Polyvinyl Chloride (PVCT) and 11% Galvanized Iron (GALV). Renewal predominantly employed plastic materials, with Polyethene (PEM) accounting for 54% and Polyethene (PE) for 42% (Fig. 9), driven by their corrosion resistance, easy installation, and low maintenance cost [27].

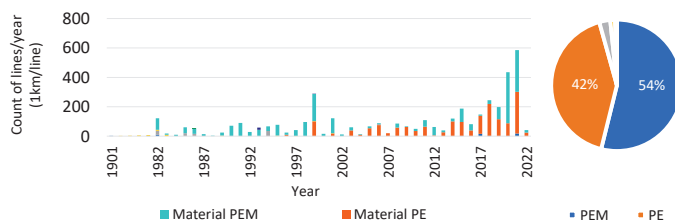


Fig. 9 Renewals in the Drinking Water Network 1982-2021

Since 2000, roughly 25% of networks have undergone renewal. However, a substantial number of pipes that are 80 years old or older remain in service (Drinking water: 40%, Wastewater: 43%, Stormwater: 48%). TV staff underlined that exceeding an 80-year network pipe age is undesirable (Workshop 1).

C. Management Process of Maintenance and Renewal

The management for Linköping's water networks is structured into two phases: planning and implementation (Fig. 10), which involve both the Municipal Council KF and TV, (Interviews 3, 4, 5).

The water management at TV is divided into three departments. The customer department takes charge of customer-related matters, including maintenance tasks and new water and sewerage service connections. The planning and projects department is responsible for monitoring the network, overseeing construction projects, and managing operational activities related to urban development. The operation and business unit handles the maintenance and renewal responsibilities, as well as creating investment plans based on identified requirements.

1. Planning and Network Expansion

Over an adjustable time period, the KF grants approval to the Water Plan. The water plan also includes the Water Expansion Plan, which outlines the anticipated expansion of water and sewerage systems over a planning horizon of approximately 15 years, but also encompasses other documents such as the Rural Water Policy, which has received approval from the city council and serves as a guiding framework for water management in rural regions, and the Guidelines for Water and Sewerage Planning endorsed by the Board of TV, to provide directions for planning water and sewerage infrastructure.

The plan specifies the areas for which the municipality assumes responsibility in terms of water supply and sewerage provision, accompanied by a timeline for future expansions. The Water Expansion Plan can be periodically updated to adapt to changing needs. These comprehensive plans underscore the significance of effective water and sewerage management, with a

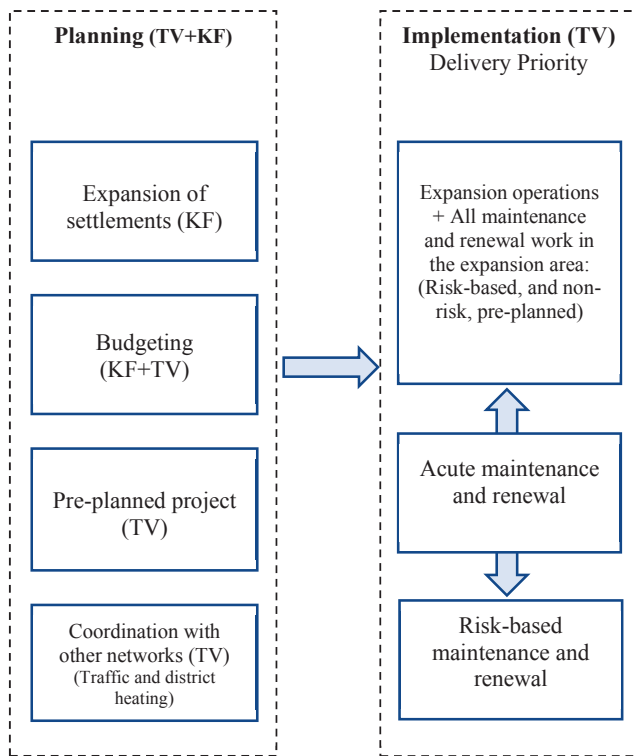


Fig. 10 The Management Process for Water Networks in Linköping

strong emphasis on supervision, the improvement of existing small sewage plants, and the overall well-being of rural areas [21].

Settlement expansion is connected to the regular planning process with a new master plan every 10-15 years. For properties located outside current activity areas, contract customers (or UVO customers) may be connected to the public water supply network, depending on the availability of space and capacity in the wiring network. Decisions are made by KF in consultation with TV.

If a new area is introduced due to the city's expansion, proposals for new activity zones are first accepted by the TV Board, and the Municipal Planning Committee is informed. The KF makes the final decision on new activity areas. Once a new expansion area is approved by KF, a detailed plan is legally required to specify how the water supply will be organized. Every year, TV compiles details of action plans for new expansion areas. After detailed plans have been developed, TV is then commissioned to carry out implementation and expansion operations of water services in the activity areas. All activity areas are located in LinGIS and accessible to KF and TV [21].

2. Budgeting of Maintenance and Renewal

Water and sewerage services are funded through user fees. The level of these fees is decided by KF. Generally, the fees are intended solely for covering the operational and maintenance costs of the water and wastewater systems and are the same for all customers. However, in situations where costs are unusually high due to specific conditions in an area, "special tariffs" may be introduced [21].

The KF is responsible for approving the water plan, which

encompasses various activities in the water and wastewater sectors, including major investments and new areas of focus within a specific timeframe. The water budget sets the frame for these activities. It is categorized into three parts: expansion, acute repairs, renewal, and preventive operations, and planned renewal/maintenance (workshops 3,5).

The current long-term budget for the network of Linköping's water systems for the years 2023 to 2027 is 95 million on average per year. The year 2022 had notably lower expenditures of only 49 million, due to the particular circumstances during the Covid-19 pandemic in 2022, which decreased the activities connected to preventive operations. Between 2022 and 2027, expansion operations constitute approximately 42% of the total investment budget for the network. These expansion projects receive additional financing from KF and are allocated in a separate category in the budget. Currently, planned proactive maintenance and renewal operations make up roughly 18% of the total investment budget, while renewal emergency and preventive operations account for about 40% of the total investment budget. The findings suggest that acute operations may compete with other priorities for resources (Workshops 3,5).

3. Implementation

In line with the Public Water Services Act, TV is primarily focused on ensuring reliable delivery of services [21]. To achieve this, the maintenance and renewal strategy is based on risk assessment, giving priority to urgent operations in the event of malfunctions. When a malfunction occurs, swift action is taken to address the situation through immediate maintenance and renewal operations to restore functionality. Second priority is for network expansion projects, where all maintenance and renewal within the expansion area should also be performed. Third priority is for risk and consequential pipelines, followed by planned proactive maintenance and renewal operations, and finally, planned strategic and tactical operations aimed at long-term network efficiency [25].

Proactive maintenance and renewal operations are prioritized based on factors such as pipeline importance, age, and material, with special emphasis on high-risk pipelines that pose significant malfunction risks. The objective of proactive maintenance is to restore or renew the network, ensuring efficient performance and minimizing the potential for malfunctions with severe consequences. It should take the risks and potential impacts associated with climate change into account. (Interviews 3, 4, 5).

Planned strategic and tactical operations aim to enhance long-term network performance. TV primarily focuses on improving plant, maintenance, and renewal activities at a tactical level within a timeframe of 3 to 5 years. Tactical-level maintenance and renewal activities are established based on a comprehensive list of issues and challenges. Decisions are made on this list, outlining how plant, maintenance, and renewal activities will be improved over the next few years. (Interviews 3, 4, 5).

TV is actively working on enhancing its strategic-level maintenance and renewal activities. Although the longer-term planning is still in its early stages, the goal is to establish a regular strategic assessment process. This process would continuously evaluate significant changes related to water plant maintenance and planning, ensuring effective long-term

management (Interviews 3, 4, 5).

4. Technical and Operational Methods of Maintenance and Renewal

Since 2012, TV has implemented online monitoring systems that utilize real-time information. This data is processed and analyzed using tools provided by Svenskt Vatten. The Supervisory Control and Data Acquisition (SCADA) system, integrated into the Swedish Water and Wastewater Association's (Vattentjänst branschens Statistik System, VASS) framework, is utilized by TV [28].

To ensure efficient management of the network, TV has set a requirement that the age of network pipes should not exceed 80 years (Workshop 1). TV employs its self-produced application called Trimble. It offers a user-friendly interface along with a comprehensive set of tools and features that simplify documentation and planning. This application has lots of benefits, including time savings in renewal planning, improved quality by minimizing interference, significant cost reductions by avoiding unnecessary maintenance expenses, and substantial financial gains through optimal utilization of the renewal rate (Workshops 1, 2, 4).

One notable advantage of the Trimble application is its ability to assist in prioritizing pipes that require immediate action by evaluating the combination of probability and consequence associated with each pipe. For example, it can identify pipes with a high probability of experiencing multiple water leaks, coupled with a significant cost per leak (Workshops 1, 2, 4).

In recent decades, TV has increasingly utilized materials with plastic bases such as Poly material, PEH, PVC, and PE in connection with maintenance and renewal. The selection of poly material is due to its durability and resistance to harsh environmental conditions, while also being cost-effective and providing excellent hydraulic performance [26]. Additionally, TV has used trenchless technology, which makes it possible to replace pipes without excavating the ground, by inserting the new plastic material into the old pipe, which minimizes disruption to traffic and reduces costs.

The drinking water network is divided into 18 flow zones, each equipped with designated flow meter regions to monitor flow and pressure. To ensure accuracy, the system is calibrated using data from approximately 200 real-time pressure sensors [28].

V. DISCUSSION

Water suppliers such as TV are legally obligated to provide safe and high-quality water to its customers (Interviews 3, 4, 5). As a result, the primary focus of the water management at TV is on limiting water supply disruptions and maintaining water quality through a risk-based strategy. As a consequence, acute operations and improving high-risk pipelines are prioritized. This means that disruptions that require immediate attention and greater needs for connecting new customers can disrupt the original plan of operations, and lead to less maintenance and renewal than what has been planned and budgeted for.

Normally, most of the budget is allocated to expansion operations, followed by acute maintenance and renewal of aging pipelines. (Workshops 1, 2, 4). Since priority is given

to emergencies and the prevalence of such cases is difficult to predict, there is often competition for resources in terms of time and capacity with planned maintenance and renewal. Therefore, it seems impossible to substantially increase the renewal rate within the current frames of the budget and the capacity of the water management.

The current renewal rate in Linköping is insufficient. Additionally, the number of leaking cases is increasing. Currently, TV prioritizes the maintenance and renewal of pipelines based on their age, which should not exceed 80 years. The result of this strategy is rather that the consequences of water leaks are reduced than that the overall number of leaks decrease. The ambition of TV is, however, to work more systematically with renewal plans that result in increases the rate of renewal.

For renewal, the choice of pipeline material is based on past experience and the performance history of pipes (Interviews 3, 4, 5). This approach takes into account the durability, reliability, and maintenance requirements of different materials. Plastic-based materials, such as Polyethylene (PE) and Polyvinyl Chloride (PVC), have demonstrated favorable performance characteristics in terms of longevity, resistance to corrosion, and overall cost-effectiveness [26].

Poly materials are known for their durability, ability to withstand harsh environmental conditions, and excellent hydraulic performance. Additionally, plastic-based materials offer advantages in terms of ease of installation (e.g., trenchless method), reduced maintenance needs, and improved longevity compared to concrete and metal-based pipes. In addition, trenchless technology for pipe replacement offers a non-intrusive approach that eliminates the need for extensive excavation. Instead, the new plastic material is inserted into the existing pipe, minimizing disruptions to traffic, and reducing the impact on the surrounding environment. This method allows for efficient and cost-effective pipe replacement while maintaining the functionality of the network. By avoiding extensive excavation work, trenchless technology ensures reduced disruption to daily activities and minimizes the inconvenience caused to residents and businesses. These factors contribute to their current prioritization as the most suitable option for replacing aging or deteriorating pipelines.

Aging infrastructure has been identified as a key factor contributing to water supply leaks and interruptions, as highlighted by the findings of previous analyses. These findings emphasize the necessity of investing in maintenance and renewal projects to address the challenges posed by aging infrastructure. It is crucial to adopt effective maintenance and renewal programs that can enhance the resilience of water lines, especially during the demanding winter and spring months. By prioritizing these initiatives, we can mitigate the risks associated with aging infrastructure and ensure a reliable and uninterrupted water supply. Nevertheless, the current practices of WBIS are shaped by various interrelated factors, including organizational capacity and policy-related factors such as regulations, coordination, and climate change.

A. Organizational Capacity

1. Financial Resources and Investment

Studies by both researchers and Svenskt Vatten have indicated

the need for increased investment in Sweden's water and wastewater systems. However, due to financial constraints, TV still follows a reactive maintenance and renewal strategy based on risk assessment (Interviews 3, 4, 5). The Water Services Act requires water and wastewater operations to be self-financed through tariffs and conducted according to the cost price principle. Unfortunately, if the need for maintenance and renewal is not met with gradual increases in water tariffs, it will eventually become unsustainable and result in large sudden increases, which many municipalities have already experienced. Investments directly affect water quality and quantity [29]. The expansion of municipal water and sewerage systems implies that investment demands will only increase. However, investments are generally not raised to the necessary rate to meet the increased costs of maintenance and climate adaptation. Climate change in Sweden is expected to decrease both surface and groundwater quality and quantity [23], which may lead to problems with drinking water supply and increased pollution in connection with heavy rains and floods. To minimize emissions into lakes and watercourses, new residential areas connected to public water supply networks or municipal wastewater treatment facilities should have minimal nutrient, bacteria, and chemical compound discharge. TV has completed substantial refurbishment of the two waterworks in Linköping to address water quality and quantity issues [30]. Investment in small sewage treatment facilities and drinking water wells also lowers the risk of pollution of drinking water sources, groundwater, and surface water. Periodic investment in a new treatment plant is also necessary to comply with emission regulations. When selecting an appropriate solution, investment and running expenses should be considered from a life cycle viewpoint.

Investment is closely intertwined with technical, technological, and staff capacity [29], [31]. One crucial aspect of capacity is the availability of skilled employees and the specific expertise required. However, increasing the workforce comes with financial implications. Additionally, long-term planning poses challenges as it involves considering external factors and new investments.

To tackle these challenges, TV has implemented online detection methods in the drinking water network [28]. The aim is to promptly identify toxins that could harm human health and lead to societal costs. Unfortunately, the existing digitalized system for monitoring and detecting leaks and bacterial contamination has encountered technological issues such as errors, disconnections, limited sensor sensitivity, and unreliable detection (Interviews 3, 4, 5). Addressing these flaws requires increased technical capabilities and staff training in system-related matters, which in turn requires additional financial resources.

Another challenge lies in establishing a comprehensive database capable of handling various types of data and accessible to other networks in need (Interviews 3, 4, 5). Furthermore, improving maintenance efficiency requires more effective analysis methods for accurate project cost estimation, which may result in increased expenses. Therefore, addressing the challenges related to investment,

technical capabilities, technology reliability, staff training, and data management is crucial for enhancing operational efficiency and ensuring successful maintenance and renewal projects.

2. Policies and Regulations

In the case of Linköping, the municipal guidelines for managing the water networks express a desire for strategic planning (Interviews 4, 5, 6). The budget provided by the Municipal Council is not sufficient to realize that. The management needs to prioritize immediate expenditures to ensure the functionality of the networks. To achieve sustainable long-term management solutions, municipalities need to plan more strategically with adequate funding. This requires creating conditions for active ownership, which ensures the availability of necessary financial, human, and technological resources, and the ability to plan strategically. Without this, the focus on long-term sustainable urban development through maintenance and renewal may be short-sighted or lost.

Political leadership is important for establishing clearer roles and responsibilities for municipal organizations and asset owners [32], and for making necessary investments to secure the long-term functionality of the networks possible.

Furthermore, the responsibility for water supply according to the regulations does not consider factors beyond health and environmental performance [23]. This can result in discrepancies between areas where the municipality is responsible for water supply and where it is appropriate to develop housing. The uncertainty surrounding the boundaries set by Swedish laws places high demands on the municipality's authority functions when interpreting and implementing these laws.

In summary, to secure the long-term functionality of the water networks, there is a need to consider a broader range of factors, and incorporate strategic management and sustainability principles into planning practices.

3. Challenges of Coordinating Infrastructure Networks Due to Complex Decision-making Structures

The complex decision-making structure and lack of clear division lines between responsibilities between the municipality and the net owner as well within the net managing company create obstacles for effective management (Interviews 4, 5, 6).

For example, for limiting excavation and achieving the sustainability goals of Linköping, the coordination of maintenance and renewal operations with other infrastructure networks, such as district heating and traffic, is crucial. However, due to uncertainties in organizational boundaries within TV and differences in the laws and rules governing different areas, practical coordination with other networks often leads to conflicts of interest, delays, or even cancellations of operations, resulting in financial losses. Some maintenance and renewal projects even bring additional costs due to extra expenditure imposed by other networks, while other projects are delayed or canceled to align with the city's asphalt program dictated by the municipal roadworks department. Furthermore, there are cases where the municipal executive board opposes scheduling operations proposed by TV.

Coordination between different infrastructure networks is supported in Linköping municipality (Interviews 4, 5, 6). However, it is not always possible to maintain this coordination actively in practice. Although all networks are situated in close

proximity to one another, the management of each infrastructure system is yet handled separately. As a result, potential benefits in terms of cost savings, environmental effects, and city interference, from coordinating the maintenance and renewal operations of various structures are still a subject of development (Interviews 4, 5, 6). The perception on management is to be collaborative-based work (instead of a "one-network job") with giving clear responsibilities, and the lack of mandate to enforce collaboration and sustainability (e.g., through politically accepted plans) is understood to be the hindering factor against the application of efficient coordination.

To mitigate these challenges and synchronize maintenance and renewal operations with other networks, coordination must be improved. Clearer and more aligned rules would also facilitate smoother collaboration and reduce conflicts of interest. By addressing these issues, it will be possible to improve efficiency and avoid economic losses associated with delays and cancellations of projects.

B. An Issue of Increasing Concern of Climate Change

The increasing concern for climate change and its impact on water supply, both in terms of quality and quantity, have emphasized the need for long-term planning and management of stormwater to prevent damage to structures and soil caused by flooding, erosion, and groundwater subsidence. In the worst-case scenario, stormwater may also carry pollutants to receivers, further deteriorating the ecological and chemical state of supplied water. However, if well-planned, stormwater can be a valuable resource in urban environments, particularly during dry seasons. In certain regions of Linköping, rain with a specified return time may cause flooding, and the stormwater system should be able to handle such events to prevent damage to buildings and the environment. However, some areas remain vulnerable to flooding, and increased stormwater diversion may reduce groundwater storage and make operations more difficult and expensive during flooding times. As a result, TV's actions towards stormwater issues are currently risk-based, focusing on remediation of consequences rather than strategic solutions, primarily due to financial limitations. Legislation requires TV to dimension the functions of the stormwater system up to a reasonable level. [23].

Effective planning is essential for municipalities to ensure safe drainage routes, multifunctional surfaces, and proper management of stormwater at all stages of spatial building, from master planning and detailed planning to implementation and assessment.

The current law needs further clarification on the division of responsibilities and how day water issues should be handled in spatial planning, spatial building process, construction and establishment, street and road maintenance, operations, development, and supervision.

VI. CONCLUSION

To promote sustainable development and management of water networks, it is crucial to have systems knowledge about the current management practices and the various factors and

conditions that influence them. However, the research in this area has been mostly focused on engineering-driven investigations of specific technologies, rather than providing a systemic understanding of current management practices. Therefore, there is a lack of research-based knowledge on the link between sustainability development, urban infrastructure, and challenges related to maintenance and renewal management.

Although regulating management can support sustainability, the current cost-oriented regulations do not necessarily facilitate long-term, efficient, and sustainable management. It is essential to increase our ability to understand how systems are managed, their life length, and reliability. When it comes to water network maintenance and renewal management, it is crucial to take a holistic approach and plan for long-term demands in terms of organizational capacity, policies and regulations. This requires adapting policies' boundaries to support investments and fulfilling maintenance and renewal needs throughout active organizational roles and tools.

To make the current water network management more sustainable, it is essential to establish a clear management structure that facilitates better coordination with other actors in different networks. Directing people with active leadership and responsibilities can help enforce decisions on critical needs of maintenance and renewal. Ultimately, thinking beyond short-term solutions and seeing the big picture will promote the sustainable development and management of WBIS.

APPENDICES

A. Appendix (1): Interview Questions to Network's Owners

Briefly about the project and the purpose, then the interview followed by the interviewee describing their work role.

1. Organization and Regulation

- Can you briefly tell us how today's management of the water and sewage networks is organized in Linköping? Who are the most central actors, and what are their different roles and responsibilities?
- What is the role and responsibility of Tekniska verken in the management of water and wastewater networks?
- Which laws and requirements are most central to your business? How do these regulations affect your management of the collecting systems?
- Who and what influences the size of your budget for managing the water and sewer networks? What are the largest cost items for your business? What are the main priorities? How do you make different trade-offs when allocating this budget?

2. Key Challenges (actor-specific and societal)

- How has the management of the pipeline networks changed over time with you? What has been most decisive for this development?
- What are the main challenges related to the management of water and wastewater networks? Why are these challenges so important to solve (the consequences)? and for whom?
- How does your work meet these challenges? What do you think is your role and responsibility in solving these challenges, and what do other actors need to contribute to?

3. Maintenance and Renewal

- Can you describe your strategy for managing maintenance and renewal of the pipeline networks? Why have you chosen this strategy? What has most influenced the design of the strategy? Which actors have been involved in developing the strategy?
- Have you developed a concrete action plan for the maintenance and renewal of the pipeline networks and, if so, what does it look like? How do you identify maintenance and renewal needs in the pipeline networks? What is the basis for prioritizing actions/projects?

- What percentage of your budget is currently spent on maintenance and renewal of the existing pipeline networks?
 - How does your collaboration with other pipeline owners or other actors look like in connection with the maintenance and renewal of the water and sewer networks? What are your experiences of this collaboration?
 - Do you see any need to change how you work with maintenance and renewal of the pipeline network in the future? In what way and why?
4. Need for Action and Changes
- What are the most central needs for technology and knowledge development in the area? Why?
 - Do you see any need for changes in how the management of water and sewer networks is currently organized and regulated? In what way and why?
 - Is there anything else you would like to highlight in relation to the management of water and sewerage networks? Or is there a question you want to ask?
 - Suggestions for key people to interview?

B. Appendix (2): Example of Coding

Name: KF- Planning

<Files\Interviews\Eng. int4-Tekniska verken> - § 9 references coded [11.04% Coverage]

Reference 1 - 0.52% Coverage

On the one hand, that's the way it is. According to regulations, the principal must dispose of, for example, stormwater from an area of activity that slips into the area of activity.

Reference 2 - 0.82% Coverage

When we see that we are going to expand wiring, or there will be some slightly smaller settlement group somewhere, then we must have a depot, based on the decision if we think there should be the area of activity or not.

Reference 3 - 1.26% Coverage

We have some staff so far, but we would like to have a few more than what we have right now. It's hard to recruit people with knowledge and skills as well. When it comes to operations, we get the money that we need, then we have to work with the renewal management, so we keep the reached renewal rate for drinking water, which is at 0.4 percent at the moment.

Reference 4 - 0.96% Coverage

And then we have another investment in the exploitation category. It's something that we don't control ourselves. And also, if there is private development of land, they get a plan without permission from the municipalities. We start a detailed plan based on that. The municipality has a monopoly in the master plan. **1**

Reference 5 - 1.22% Coverage

The municipality that decides where the pipeline network will be built, so it takes a lot of time. Linköping is an expansive municipality, so quite a lot of money is allocated this year with a budget of 90 million for the pipeline network. About 30 to 35 million for new investments, and 8 to 10 million govern the rest is exploitation. **2**

Reference 6 - 0.82% Coverage

We still have streets or parts of the municipality where we don't have stormwater pipes. We expand every year streets where we lack stormwater. We build out stormwater pipelines, which started already in the 50's, and we continue to expand the local stormwater system. This has been going on all along. **3**

Annotations

1. When they report to the Municipality, will they be approved within the same year's budget? or in the following year budget? Or do they get extra budget during the same year?
2. What controls the amount of investments received? How is it distributed?
3. Why? consequences of the lack?

C. Appendix (3): Main Themes, Sub-themes, and Influencing Factors

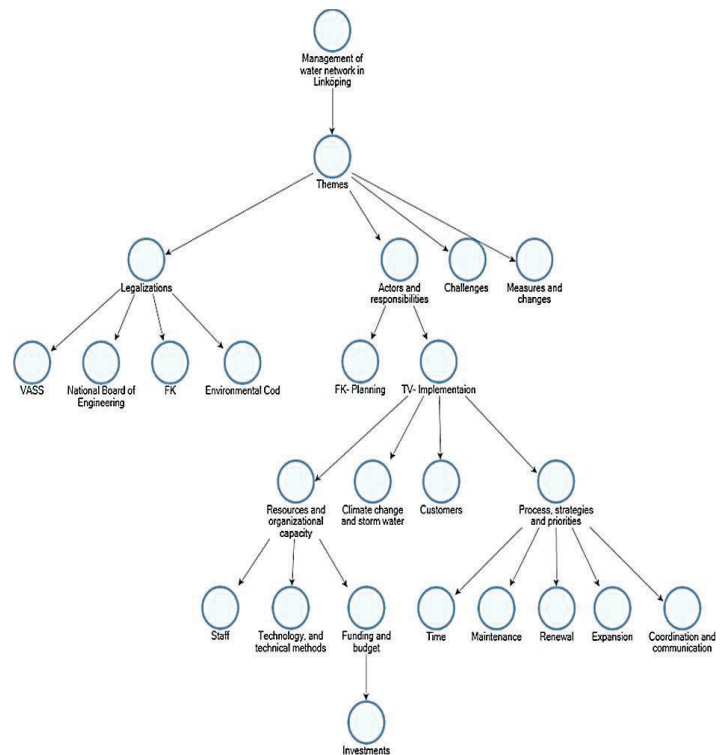


Fig. 11 Main Themes and Sub-themes of Interviews

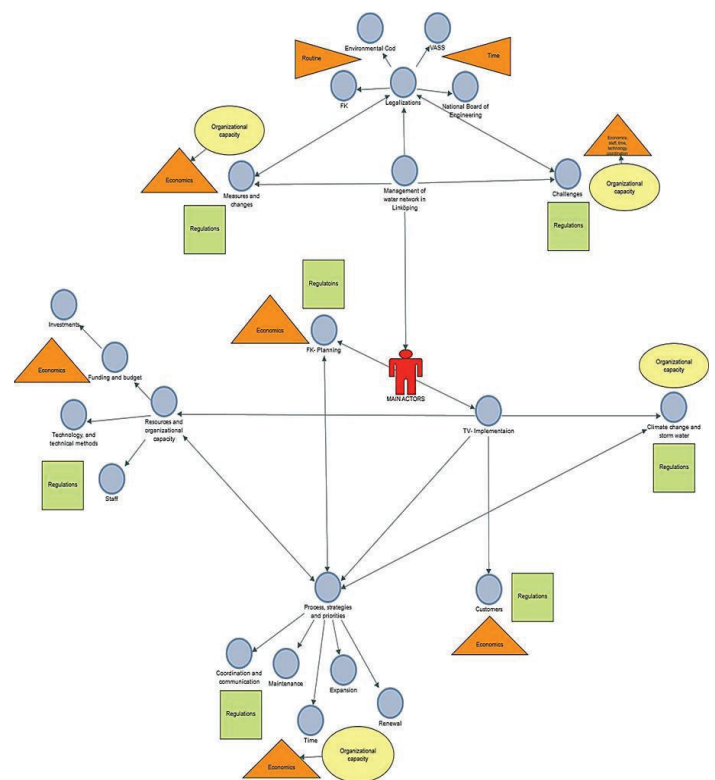


Fig. 12 Factors Influencing management practices of UWI

D. Appendix (4): Material Cod

TABLE II
MATERIALS COD

| Concrete base | Plastic base | Metal base |
|------------------------|------------------------------------|-----------------------------|
| BTG (Concrete) | PVC (Polyvinyl Chloride) | GJJ (Gjutjärn- Cast Iron) |
| BTGT (Concrete) | PE- PEH- PE-PEL- POLY (Polyethene) | SEGJ (Segjäm- Ductile Iron) |
| ETERNIT (Fiber Cement) | PP (Polypropene) | GALV (Galvanized Iron) |
| | | AC (Aluminum or Copper) |
| | | CU (Copper) |

E. Appendix (5): Calculations of Renewal Debt

To calculate the renewal debt for Linköping based on the given information, we need to consider the percentage of lines that need renewal, their total length, today's replacement cost, inflation, and discount rates. Renewal debt for 2020, 2030, 2100, and for the next five years (from 2023 to 2028) are as following:

1. Renewal debt for 2020:

- Length of lines over 80 years: 48 km
- Replacement cost per meter: 20,000 SEK
- Estimated renewal cost: 48,000 meters * 20,000 SEK/meter = 960,000,000 SEK
- Inflation rate for 2020: 1.5%
- Discount rate for 2020: 5%

To calculate the renewal debt for 2020, we need to account for inflation and discounting. The inflation rate of 1.5% and discount rate of 5% will be used for adjusting. First, we adjust the estimated renewal cost for inflation:

- Inflation-adjusted renewal cost = Estimated renewal cost * (1 + inflation rate)
- Inflation-adjusted renewal cost = 960,000,000 SEK * (1 + 0.015)
- Inflation-adjusted renewal cost = 960,000,000 SEK * 1.015
- Inflation-adjusted renewal cost = 974,400,000 SEK

Next, let's discount the inflation-adjusted renewal cost for the discount rate:

- Discounted renewal cost = Inflation-adjusted renewal cost / (1 + discount rate)
- Discounted renewal cost = 974,400,000 SEK / (1 + 0.05)
- Discounted renewal cost = 974,400,000 SEK / 1.05
- Discounted renewal cost ≈ 928,761,905 SEK

Therefore, the renewal debt for 2020, adjusted for inflation and discounting, is approximately 928,761,905 SEK (Nine hundred twenty-eight million, seven hundred sixty-one thousand, nine hundred five Swedish Krona.)

2. Renewal debt for 2030:

- Length of lines over 80 years: 100 km
- Replacement cost per meter: 20,000 SEK
- Estimated renewal cost: 100,000 meters * 20,000 SEK/meter = 2,000,000,000 SEK
- Inflation rate for 2030: 1.5%
- Discount rate for 2030: 5%

Present Value for 2030 = 2,000,000,000 / (1 + 0.05) ^7 * (1 + 0.015)^7 ≈ 1,673,638,251 SEK

To calculate the renewal debt for 2030, we take into account the provided information on the length of lines, replacement cost per meter, inflation rate, and discount rate.

The estimated renewal cost is given as 2,000,000,000 SEK. We start by adjusting this amount for inflation to bring it to the value in 2030.

Step 1: Adjust for inflation:

- Inflation rate for 2030: 1.5%
- Adjusted renewal cost = Estimated renewal cost * (1 + inflation rate)

- Adjusted renewal cost = 2,000,000,000 SEK * (1 + 0.015)
- Adjusted renewal cost = 2,000,000,000 SEK * 1.015
- Adjusted renewal cost = 2,030,000,000 SEK

The adjusted renewal cost for 2030 is 2,030,000,000 SEK.

Step 2: Calculate the renewal debt using the discount rate:

- Discount rate for 2030: 5%
- Renewal debt = Adjusted renewal cost / (1 + discount rate)
- Renewal debt = 2,030,000,000 SEK / (1 + 0.05)
- Renewal debt = 2,030,000,000 SEK / 1.05 Renewal debt ≈ 1,933,333,333.33 SEK

The renewal debt for 2030 is approximately 1,933,333,333.33 SEK (one billion, nine hundred thirty-three million, three hundred thirty-three thousand, three hundred thirty-three point thirty-three Swedish Krona).

3. Renewal debt for 2100:

- Length of lines over 80 years: 1970 km
- Replacement cost per meter: 20,000 SEK
- Estimated renewal cost: 1,970,000 meters * 20,000 SEK/meter = 39,400,000,000 SEK
- Inflation rate for 2100: 1.5%
- Discount rate for 2100: 10%
- Present Value for 2100 = 39,400,000,000 / (1 + 0.05) ^77 * (1 + 0.015) ^77 ≈ 3,441,119,358 SEK

To calculate the renewal debt for 2100, we need to consider the inflation rate and discount rate provided.

The estimated renewal cost is given as 39,400,000,000 SEK. We start by adjusting this amount for inflation to bring it to the value in 2100.

Step 1: Adjust for inflation: Inflation rate for 2100: 1.5%

- Adjusted renewal cost = Estimated renewal cost * (1 + inflation rate)
- Adjusted renewal cost = 39,400,000,000 SEK * (1 + 0.015) Adjusted renewal cost = 39,400,000,000 SEK * 1.015
- Adjusted renewal cost = 39,931,000,000 SEK
- The adjusted renewal cost for 2100 is 39,931,000,000 SEK.

Step 2: Calculate the renewal debt using the discount rate:

- Discount rate for 2100: 10%
- Renewal debt = Adjusted renewal cost / (1 + discount rate)
- Renewal debt = 39,931,000,000 SEK / (1 + 0.10)
- Renewal debt = 39,931,000,000 SEK / 1.10
- Renewal debt ≈ 36,300,909,090.91 SEK

The renewal debt for 2100 is approximately 36,300,909,090.91 SEK, (thirty-six billion, three hundred million, nine hundred nine thousand, ninety point nine one Swedish Krona.)

4. Renewal debt for the next five years (2023-2028):

- Length of lines over 80 years in 2020: 48 km
- Length of lines over 80 years in 2030: 100 km
- Estimated renewal cost: 48,000 meters * 20,000 SEK/meter = 960,000,000 SEK
- Estimated renewal cost: 100,000 meters * 20,000 SEK/meter = 2,000,000,000 SEK
- Inflation rate for 2030: 1.5%
- Discount rate for 2030: 5%

To calculate the values of renewal debt for the next five years (2023 to 2028) using linear interpolation, we first estimate the lengths of lines that need renewal for each year. Then, we calculate the corresponding renewal costs for each year, considering the inflation rate and discount rate.

Step 1: Estimate the lengths of lines that need renewal for each year using linear interpolation:

Growth rate of line length per year: (Length in 2030 - Length in 2020) / 10 years = (100 km - 48 km) / 10 years = 5.2 km/year

- Estimated length of lines for each year:
- Year 2023: Length in 2020 + (2023 - 2020) * Growth rate Year 2023: 48 km + (2023 - 2020) * 5.2 km/year. Year 2023: 48 km + 3 * 5.2 km = 48 km + 15.6 km = 63.6 km
- Year 2024: Length in 2020 + (2024 - 2020) * Growth rate Year 2024: 48 km + (2024 - 2020) * 5.2 km/year. Year 2024: 48 km + 4 * 5.2 km = 48 km + 20.8 km = 68.8 km
- Year 2025: Length in 2020 + (2025 - 2020) * Growth rate Year 2025: 48 km + (2025 - 2020) * 5.2 km/year. Year 2025: 48 km + 5 * 5.2 km = 48 km + 26 km = 74 km
- Year 2026: Length in 2020 + (2026 - 2020) * Growth rate Year 2026: 48 km + (2026 - 2020) * 5.2 km/year. Year 2026: 48 km + 6 * 5.2 km = 48 km + 31.2 km = 79.2 km
- Year 2027: Length in 2020 + (2027 - 2020) * Growth rate Year 2027: 48 km + (2027 - 2020) * 5.2 km/year. Year 2027: 48 km + 7 * 5.2 km = 48 km + 36.4 km = 84.4 km
- Year 2028: Length in 2020 + (2028 - 2020) * Growth rate Year 2028: 48 km + (2028 - 2020) * 5.2 km/year. Year 2028: 48 km + 8 * 5.2 km = 48 km + 41.6 km = 89.6 km

Step 2: Calculate the corresponding renewal cost for each year:

Renewal cost for each year = Estimated length * Replacement cost per meter

Renewal cost for each year = Estimated length * 20,000 SEK/km

- Year 2023: Renewal cost = 63.6 km * 20,000 SEK/km = 1,272,000,000 SEK
- Year 2024: Renewal cost = 68.8 km * 20,000 SEK/km = 1,376,000,000 SEK
- Year 2025: Renewal cost = 74 km * 20,000 SEK/km = 1,480,000,000 SEK
- Year 2026: Renewal cost = 79.2 km * 20,000 SEK/km = 1,584,000,000 SEK
- Year 2027: Renewal cost = 84.4 km * 20,000 SEK/km = 1,688,000,000 SEK
- Year 2028: Renewal cost = 89.6 km * 20,000 SEK/km = 1,792,000,000 SEK

Step 3: Adjust the renewal costs for each year based on the inflation rate and discount rate:

Inflation-adjusted renewal cost = Renewal cost * (1 + Inflation rate) Discounted renewal cost = Inflation-adjusted renewal cost / (1 + Discount rate)

Inflation rate: 1.5%

Discount rate: 5%

- Year 2023: Inflation-adjusted renewal cost = 1,272,000,000 SEK * (1 + 0.015) = 1,291,080,000 SEK Discounted renewal cost = 1,291,080,000 SEK / (1 + 0.05) = 1,229,600,000 SEK
- Year 2024: Inflation-adjusted renewal cost = 1,376,000,000 SEK * (1 + 0.015) = 1,397,440,000 SEK Discounted renewal cost = 1,397,440,000 SEK / (1 + 0.05) = 1,331,371,429 SEK
- Year 2025: Inflation-adjusted renewal cost = 1,480,000,000 SEK * (1 + 0.015) = 1,502,200,000 SEK Discounted renewal cost = 1,502,200,000 SEK / (1 + 0.05) = 1,430,666,667 SEK
- Year 2026: Inflation-adjusted renewal cost = 1,584,000,000 SEK * (1 + 0.015) = 1,607,760,000 SEK Discounted renewal cost = 1,607,760,000 SEK / (1 + 0.05) = 1,530,152,381 SEK
- Year 2027: Inflation-adjusted renewal cost = 1,688,000,000 SEK * (1 + 0.015) = 1,714,520,000 SEK Discounted renewal cost = 1,714,520,000 SEK / (1 + 0.05) = 1,630,933,333 SEK
- Year 2028: Inflation-adjusted renewal cost = 1,792,000,000 SEK * (1 + 0.015) = 1,819,680,000 SEK Discounted renewal cost = 1,819,680,000 SEK / (1 + 0.05) = 1,733,028,571 SEK

Step 4: Conclusion of the renewal debt for each year of the five-year period (2023-2028):

- Year 2023: The estimated renewal debt for 2023 is approximately 1,229,600,000 SEK: One billion, two hundred twenty-nine million, six hundred thousand Swedish Kronor.

- Year 2024: The estimated renewal debt for 2024 is approximately 1,331,371,429 SEK: One billion, three hundred thirty-one million, three hundred seventy-one thousand, four hundred twenty-nine Swedish Kronor.
- Year 2025: The estimated renewal debt for 2025 is approximately 1,430,666,667 SEK: One billion, four hundred thirty million, six hundred sixty-six thousand, six hundred sixty-seven Swedish Kronor.
- Year 2026: The estimated renewal debt for 2026 is approximately 1,530,152,381 SEK: One billion, five hundred thirty million, one hundred fifty-two thousand, three hundred eighty-one Swedish Kronor.
- Year 2027: The estimated renewal debt for 2027 is approximately 1,630,933,333 SEK: One billion, six hundred thirty million, nine hundred thirty-three thousand, three hundred thirty-three Swedish Kronor.
- Year 2028: The estimated renewal debt for 2028 is approximately 1,733,028,571 SEK: One billion, seven hundred thirty-three million, twenty-eight thousand, five hundred seventy-one Swedish Kronor.

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Chemotaxonomic Study Based on Flavonoids as Taxonomic Markers in the Roots of the Selected Species Belonged to Family Solanaceae, Sudan

Asaad Ahmed, Abdelgabar Guma'a

Abstract— This work is a taxonomic study on flavonoids in the roots of selected species belonged to family Solanaceae. These species considered as: *Lycopersicum esculentum*, *Solanum melongena* and *Solanum tuberosum*. These species distributed in different localities in Sudan. The selected members have nutritive, medicinal and economic importance, extra of that, the present study included botanical and chemical studies. The collected species have been updated due to nomenclature and synonymy. The geographical distribution of the selected members has been indicated. The chemical studies included identification of the flavonoid compounds using Gas Chromatography Mass Spectrophotometer (GC-MS). Eighty-three flavonoid compounds were detected in the roots of family Solanaceae. The highest number (32) was detected in the roots of *Solanum tuberosum*. A single flavonoid compound was restricted only to the roots of *Solanum melongena*. This was: (cyclohexanol-5-methyl-2-(1methylene), {1R-1.alpha, 2beta, 5.alpha}). Four taxonomic markers were identified for the roots of *Lycopersicum esculentum*. Ten taxonomic markers were identified in the roots of *Solanum tuberosum*.

Keywords— chemotaxonomic, flavonoids, medicinal plants, Sudan.

Locally Crafted Sustainability: A Scoping Review for Nesting Social-Ecological and Socio-Technical Systems Towards Action Research in Agriculture

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Abstract

Context: Positivist transformations in agriculture were responsible for top-down – often coercive – mechanisms of uniformed modernization that weathered local diversities and agency. New development pathways need to now shift according to comprehensive integrations of knowledge - scientific, indigenous, and local, and to be sustained on political interventions, bottom-up change, and social learning if climate goals are to be met – both in mitigation and adaptation.

Objectives The objectives of this research are to understand how social-ecological and socio-technical systems characterisation can be nested to bridge scientific research/knowledge into a local context and knowledge system; and with it stem sustainable innovation.

Methods To do so we conducted a scoping review to explore theoretical and empirical works linked to Ostrom’s Social-Ecological Systems framework and Geels’ multi-level perspective of socio-technical systems transformations in the context of agriculture.

Results As a result we were able to identify key variables and connections to 1- understand the rules in use and the community attributes influencing the resource management; and 2- how they are and have been shaped and shaping systems innovations.

Conclusion Based on these results we discuss how to leverage action research for mutual learning towards a replicable but highly place-based agriculture transformation frame.

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1. Introduction

a. Contextualising farming systems transformations

Agriculture, forests, and other human land use (AFOLU) is estimated to release a quarter of the global GHG [1]; at the same time, AFOLU has the capacity to convoy carbon neutrality since it relies on plants, microorganism and other biome synergies that draw and store CO₂ [2]. However, besides the mitigation agency, the sector must also deal with bioclimatic adaptation to guarantee food-security and -safety, alongside fulfilling market-oriented contexts [3]. Thus, AFOLU couples geographical, physical, biological, social, economic, and cultural subsystems that interplay in a nested hierarchy (Socio-Ecological Systems (SES)) [4]. Set this thread, development pathways able to accommodate climate goals need to shift accordingly to comprehensive integrations of knowledge - scientific, indigenous, and local [5], and to be sustained on political interventions, bottom-up change, and social learning (IPCC guidelines) [6, p. 72].

This process, contextualised by some authors as *social-environmental learning* [7], [8], is defined as a “collective and collaborative learning that links the biophysical to the social, cultural and political, the local to the global, and action to reflection and research” [8, p. 28]. Conceptually, it matches the recognised need of transforming agriculture systems innovations from linear, top-down expert technologies to “system-aware approaches” [9], since innovation is not necessarily something new but often a product of recombination of ideas or changes in context (*tinkering*) [10], [11]. Indeed, these positivist approaches based on the principle that an external reality is driven by immutable laws were responsible for top-down – often coercive – mechanism in favour of *uniformed modernization* in agriculture. Being irrespective to the context has weathered local diversities at multiple levels – biologic and genetic patrimony, knowledge and skills, local agency and democracy [12] [13]. Therefore, when taking efforts towards sustainable agriculture, it is essential to perceive it not as some specific, modular strategy (“ready-pack technologies”) [14].

To this end, *action research* for sustainable agriculture is one that is willing and able to learn from local farmers and local institutions, to support them on effectively - in environmentally just ways¹ - manage resources [14]. Institutions can be formal (organizations) or informal, as long as they represent a set of complex norms and behaviours that persist over time by serving some socially valued purpose [15]. And locality means a basis for collective action, for building consensus, for undertaking coordination of responsibilities, and for collecting, analysing, and evaluating information [13], [15]. This brings about *grassroot movements* towards bottom-up change [16] to regenerate local institutions routinely replaced by external entities, leading to the placement of decision drivers in higher, often distant levels of hierarchy. Although constraint by specific socio-political contexts, grassroots in the community unlock advantages through direct democracy that can influence policy frames by bridging strategic collaboration and action plans at multiple levels [17]. In this context, it is interesting to confront Hardin’s *tragedy of the commons* [18] with what Ostrom teaches us with *governing the commons* [19]. The first argues that to avoid *ruin* change must be instituted with “whatever force may be required to make the change stick”, a top-down position imposing strategies on the individuals. For Ostrom, however, “getting the institutions right is a difficult, time-consuming, conflict-invoking process” requiring reliable information about time, place, and cultural rules [19, p. 14]. Thus, opposing to a more rigid and somewhat alien *knowledge-first* approach, action research is process-oriented science, and researchers are responsible for strongly connect with stakeholders to establish, facilitate, and participate in mechanisms or dialogues for change rather than just being involved as knowledge providers [20] [21].

Approaches for collective action, however, deal with individual or harmonised groups of individuals that act not spontaneously but rather as consequence of opportunities and threats [22]. How these

¹ Reference to environmental justice

opportunities and threats are perceived is embedded on different levels of *time* and *urgency*, further linked to individual and institutional (structural) multi-level pathways of decision-making. On an analysis on “why people do what they do”, Eyster et al. [23] compiled eight action metatheories (talbe in annexes). Supporting people’s actions, there’s individual and socio-political structures, from small to large scales, driving action. Considering stakeholders in such depth, or at least recognising this depth when setting sustainability research, can bridge people and diversities to tackle climate change and identify underexplored leverages of transformation. In fact, it was noted how limited it is to overapply isolated economic drivers based upon assumptions of nature domination, instrumental use, endless growth, and corporate power [23]. John Stuart Mill, Adam Smith, among others, resumed human nature to utilitarian principles of maximization of self-benefits [24], [25] biasing the systems to act accordingly so [26]. However, these 18th century rooted classical economic principles do not explore the full spectrum of action drivers and, set-up as they are, economic principles offer the least leverage for tackling climate change [23]. In less industrialised contexts, where differences can be found in structural concepts such as time or temporality [27] and where vulnerabilities are higher [6], taking such an approach seems even more limited and inadequate. This, however, does not erase the need for and importance of an economic thought on sustainability. Instead, what is being argued is that economy is a means to achieve and enhance well-being, and well-being is more about accomplishing services than it is about usage of “primary energy and physical resources per se” [6, p. 117].

To this end, participatory approaches have been considered valuable for its capacity to bring about perspectives of diverse stakeholders [28]. Parallely to social learning, it enriches climate change mitigation options; and better identifies and addresses social and cultural constraints and opportunities to socio-economic, technological, and institutional change [6]. Indeed, responses cannot reach reasonably adequacy without it. The lack of a systems awareness neglects multiple tempos of threats and opportunities which can intensify social stresses and disruptions expected as consequence of, for example, lower crop yields and food shortages. [22] Participation is, in this sense, an approach for systems of learning and increased resilience.

According to this, we propose a framework bridging frameworks or a framework of *nested frameworks* where multiple interrelated and interconnected frameworks address different aspects towards farming systems transformations. To do so, we delineated the following research question: “*How can social-ecological and socio-technical systems be nested for multi-level transformations in agriculture?*”. The exploration will be performed through a scoping review with methods outlined in the section *b. Structure*.

b. Structure

Scoping review

Why a scoping literature review

The aim of a scoping review is to “map *rapidly* the key concepts underpinning a research area and the main sources and types of evidence available” [29, p. 21]. The in-depth coverage of such reviews varies according to the specificities of research, but they usually fall under one of these categories: 1) examining the extent, range, and nature of research activity; 2) determining the value of undertaking a full systematic review; 3) summarizing and disseminating research findings; and 4) identifying research gaps [29].

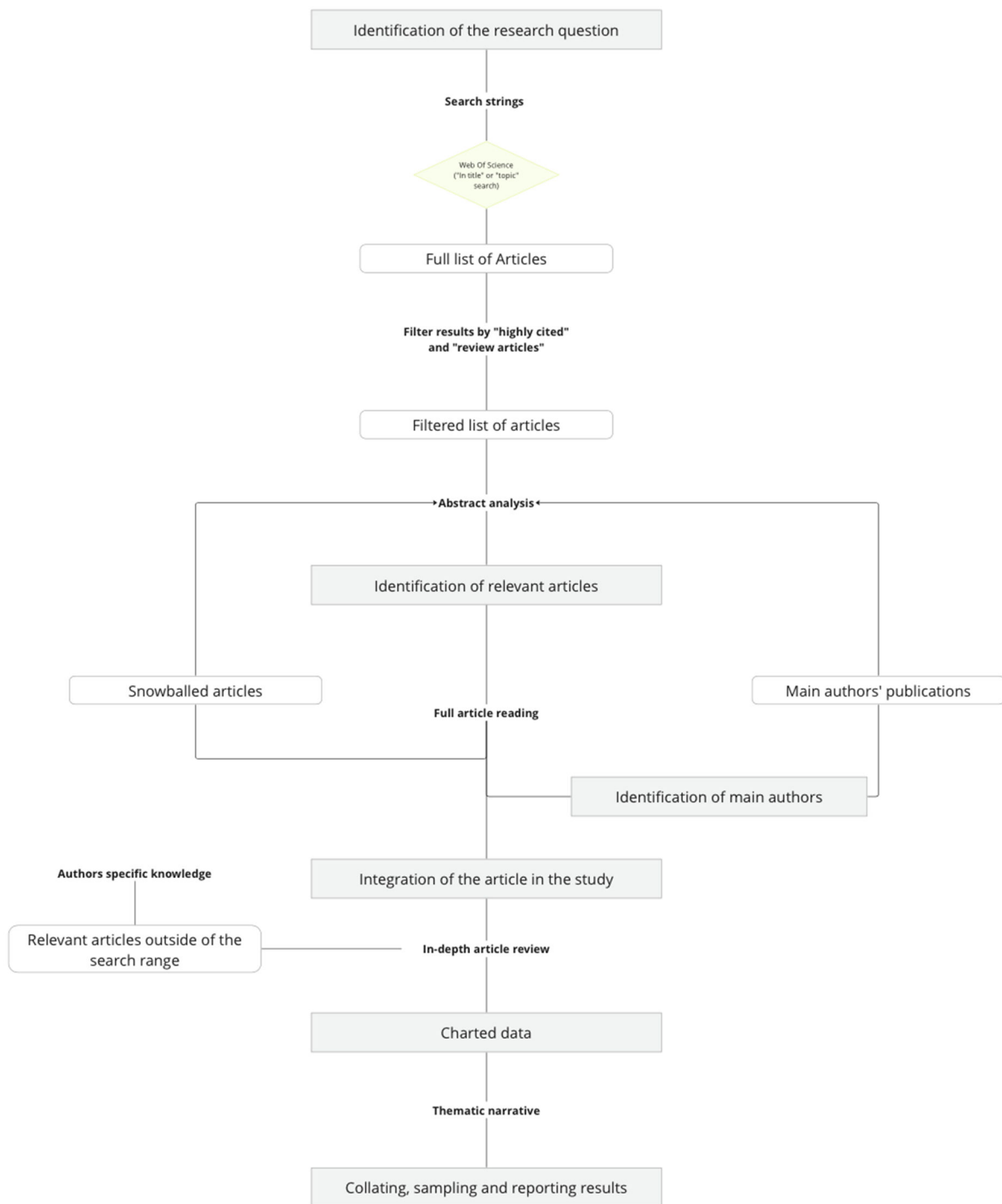
The methods of scoping reviews are less prescriptive than those of systematic reviews, since scoping is an iterative, non-linear approach and requires researchers to “engage with each stage in a reflexive way and, where necessary, repeat steps” [29, p. 22]. However, just as like in systematic reviews, scoping analysis are structured on a rigorous and transparent description of methods.

How to do a scoping review?

According to [29], a scoping review follows 5 steps:

- ;
- ;
- ;
- ;
- ;
- .

These structural steps were adapted and unfold into intermediate tasks and results as illustrated in figure xx. Keywords associated to the topics broken down from the research question were identified and transformed into search strings suitable to the *web of science* (WoS) search engine. Since the current context is to develop a broad conceptual description of ground theories, the search will aim for focused theoretical and methodological articles. The WoS results will further be filtered to highly cited and review articles. After an abstract review, the relevant articles will be fully read, and there is space for snowballing until achieving a final list of references – especially in terms of other works of identified main authors. Our specific knowledge on relevant literature outside of this range will be incorporated if justified. Lastly, the information gathered from the different topics and literature will be puzzled into a *nested framework*.



Nesting frameworks through a functional analysis

After defining the theories to be sampled by performing a scoping review, we propose a nested framework where each framework builds on and within the previous to provide a more comprehensive and integrated approach to sustainable farming systems innovation.

The outcome

2. Scoping the research question

The scoping review starts with breaking down the question into keywords. The keywords are then transformed into search strings connected by Boolean (and/or) terms. From the research question “*How can social-ecological systems framework and socio-technical transitions be nested for multi-level transformations in agriculture?*” there are four ground theories to be weaved: i) social-ecological systems; ii) socio-technical systems; iii) agriculture systems innovations.

The search yield on “social-ecological systems” was reduced to 35 articles after a first filter application of highly cited and / or review articles. The reasoning to select or reject a paper was related to its perceived relevance on theory insights and cross-over with topics such as governance and local participation.

| | | | |
|----------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Research Question | | | |
| “ <i>How can social-ecological and socio-technical systems be nested for multi-level transformations in agriculture?</i> ” | | | |
| Research Topics | | | |
| | Social-ecological systems framework | Socio-technical systems transition | Multi-level agriculture systems innovations |
| Search Strings on Web of Science | IN-TITLE (“Social-ecological system*”) | IN-TOPIC (“participatory planning” OR “collaborative planning” OR “co-creation” OR “co-design”) AND (farm* OR agricul* OR *crop* OR *food*) AND (sustainab*) | IN-TITLE (multi-level OR intersectional OR multi-layered or multidimensional OR “cross-sectorial” OR *tier* OR cooperative) AND (transformation* OR transition* OR change OR innovat* OR development) AND IN-TOPIC (sustainab*) |
| Total Results | | | |
| Review Articles | | | |
| Highly Cited Articles | | | |
| Combination of Review and | | | |

| | | | |
|---------------------------------------------------------------|--|---|---|
| Highly Cited Articles | | | |
| Articles included after abstract Review | | X | X |
| Articles included to build up the nested framework | | x | X |
| Snowballed articles | | X | X |
| Snowballed articles included to build up the nested framework | | X | X |

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| Research Question | | | | |
|----------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------|
| How can socio-ecological systems framework, social learning principles and local participation be nested for multi-level transformations in agriculture? | | | | |
| Research Topics | | | | |
| | Multi-level systems transformations | Local participation for sustainability | Social learning for systems transformation | Social-ecological systems framework |
| Search Strings on Web of Science | IN-TITLE (multi-level OR intersectional OR multi-layered or multidimensional OR "cross-sectorial" OR *tier* OR cooperative) AND (transformation* OR transition* OR change OR innovat* OR development) AND IN-TOPIC (sustainab*) | IN-TOPIC ("participatory planning" OR "collaborative planning" OR "co-creation" OR "co-design") AND (farm* OR agricul* OR *crop* OR *food*) AND (sustainab*) | IN-TITLE ("social learning" or "social environmental learning") AND IN-TOPIC (sustainab* transformation* OR transition* OR change OR innovat* OR development) | IN-TITLE (Social-ecological system* framework*) |
| Total Results | 564 | 333 | 911 | 137 |
| Review Articles | 25 | 30 | 42 | 13 |
| Highly Cited Articles | 9 | 2 | 2 | 8 |
| Combination of Review and Highly Cited Articles | 31 | 30 | 43 | 20 |
| Articles included after abstract Review | X | X | X | X |
| Articles included to build up the | X | X | X | X |

| | | | | |
|---------------------------------------------------------------|---|---|---|---|
| nested framework | | | | |
| Snowballed articles | X | X | X | X |
| Snowballed articles included to build up the nested framework | X | X | X | X |

Study the Effect of Lipoid Acid as a Protective Against Rheumatoid Arthritis Through Diminishing Pro-inflammatory Markers and Chemokine Expression

Khairy Mohamed Abdalla Zoheir

Abstract— One of the most severe complications of Rheumatoid arthritis is delayed recovery. lipoic acid possesses antioxidant, hypoglycemic, and anti-inflammatory activity. In the present study, the effects of lipoic acid were investigated on the key mediators of Rheumatoid arthritis, namely, CD4+CD25+ T cell subsets, GITR expressing cells, CD4+CD25+Foxp3+ regulatory T (Treg) cells, T-helper-17 (Th17) cells and pro-inflammatory cytokines Interleukin-1 β (IL-1 β), Interleukin-6 (IL-6) and Tumor Necrosis Factor- α (TNF- α) through flow-cytometry and qPCR analyses. Lipoic acid-treated mice showed a significant decrease in Rheumatoid arthritis, the frequency of GITR-expressing cells, and Th1 cytokines (IL-17A, TNF- α and Interferon- γ (IFN- γ) compared with positive and negative controlled mice. Lipoic acid treatment also downregulated the mRNA expression of the inflammatory mediators compared with the Rheumatoid arthritis mouse model and untreated mice. The number of Tregs was also found to be significantly upregulated in lipoic acid-treated mice. Our results were confirmed by the histopathological examination. This study showed the beneficial role of lipoic acid in promoting a well-balanced tool for the therapy of Rheumatoid arthritis.

Keywords— lipoic acid, inflammatory markers, rheumatoid arthritis, qPCR.

The Metabolomic Comparison Between HIV Infected and Uninfected Breastmilk from an African Cohort to Assess the Potential Effects on Feeding Infants

Tara Miller, Tariq Ganief, Jonathan Blackburn

Abstract— Still in 2022, millions of women infected with HIV give birth while on HAART. Due to the ramped-up global HAART plans, mother-to-child transmission is very low however, it remains a concern in developing countries due to resource-limitations. Due to the limited resources, WHO recommends HIV positive mothers breastfeed for at least 6 months for optimal infant health and nutrition. Breastmilk is a bioactive fluid containing immune cells, proteins, lipids, and microbes. This ‘golden’ fluid has a rich microbiome which seeds the feeding infants’ gut which works in synergy with the other milk components. However, HIV has shown to alter the microbiome of the host and therefore one would assume the breastmilk would also be altered. To investigate the metabolite concentrations and components in breastmilk infected with HIV will give insight into the nutrients supplied to HEU infants. The breastmilk helps seed the infants’ gut microbiome which is closely linked to immune development. Therefore, an altered breastmilk composition could be resulting in the weakened immune systems of HEU infants. This weakened immune system and poor health of the HEU infants leaves them vulnerable to opportunistic diseases, specifically in developing countries. By utilizing mass spectrometry, the metabolome of HIV infected breast milk will be compared to the uninfected counterpart. Data analysis will be performed using MS-Dial. We hypothesize the metabolome will shift when HIV and ARVs are present in the breastfeeding woman. This will open doors for further research into the effects of HIV and ARVs on breastmilk and HEU infants to help improve the HEU infants’ health.

Keywords—Breastmilk, HIV, mass spectrometry, metabolome.

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Limosilactobacillus Fermentum from Buffalo Milk Is Suitable for Potential Biotechnological Process Development

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Abstract— Probiotics are living microorganisms that give beneficial effects while consumed. Lactic acid bacteria and bifidobacteria are among the most representative strains assessed as probiotics and exploited as food supplements. Numerous studies demonstrated their potential as therapeutic candidate for a variety of diseases (Degnan, 2008) (restoring gut flora, lowering of cholesterol, immune response-enhancing, anti-inflammation and anti-oxidation activities). These beneficial actions are also due to biomolecules produced by probiotic such as exopolysaccharides (EPSs) that demonstrate plenty of beneficial properties such as antimicrobial, antitumor, anti-biofilm, antiviral and immunomodulatory activities (Angelin, 2020).

Limosilactobacillus fermentum is a widely studied member of probiotics, however, few data are available on the development of fermentation and downstream processes for the production of viable biomasses for potential industrial applications. However, few data are available on the development of fermentation processes for the large-scale production of probiotics biomass for industrial applications, and for purification processes of EPSs at industrial scale.

For this purpose, *L. fermentum* strain was isolated from buffalo milk and used as test example for

biotechnological process development. The strain was able to produce up to 10^9 CFU/mL on a (glucose based) semi-defined medium deprived of animal-derived raw materials up to the pilot scale (150 L), demonstrating improved results compared to commonly used, although industrially not suitable, media rich of casein and beef extract. Biomass concentration via microfiltration on

hollow fibers, and subsequent spray-drying allowed to recover about 5.7×10^{10} CFU/g_{powder} of viable cells, indicating strain resistance to harsh processing conditions. Overall, these data demonstrate the possibility to obtain and maintain adequate levels of viable *L. fermentum* cells by using a simple approach that is potentially suitable for industrial development. A downstream EPS purification protocol based on ultrafiltration, precipitation and activated charcoal treatments showed a purity of the recovered polysaccharides of about 70-80%.

Keywords— probiotics, fermentation, exopolysaccharides (EPSs), purification.

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Towards “Schism”: Ecclesiastical and Political Interactions between Latin Church and Melkite Churches of Jerusalem and Antioch 1098-1268

Krzysztof Kościelniak

Abstract— For many reasons, the history of the ecclesiastical and political interactions the Melkite Church in the period of 1098–1268 deserves a special study. Firstly, this church was represented by three patriarchates distinguishing by its great complexity. This church also gathered in Syria and Palestine, where the vast majority of Christians was. Secondly, the Melkites were representatives of Semitic Chalcedonian Christology. Thirdly, they made several attempts, with the support of Byzantium, using more or less effective methods, to bring about a reconciliation of the “Monophysite” and “Nestorian” communities, both conflicted with them. Fourthly, the unique position of the Melkites means that they cannot be synonymous with “Greek Orthodox.” In fact, the three Melkite patriarchates were simply “Chalcedonian churches” on specific intercultural crossroads. Finally, as a result of their ties with the Byzantine emperor, the Melkite communities suffered the most under Muslim rule, as the Muslims constantly suspected them of spying and favouring Constantinople.

The key term “Melkite Church” refers to the communities of Antioch, Jerusalem and Alexandria. As they shared the theological position of the Byzantine emperor, they were derisively described as “Royalists” or “Emperor’s Men” (from Syriac *malkā*: “king”). The Byzantine emperors developed their own traditions not only for selecting their church leaders but also to interfere in the affairs of the patriarchates. However, after 641 they had only partial, nominal relationships with the emperor. Due to their separation from Constantinople between the 7th and 9th century, the Melkite patriarchates were more or less independent in the Muslim world.

The Byzantine reconquest of Antioch in 969 by the Byzantine emperor Nicephorus Phocas did not restore this city to its former importance. The Greek presence in Antioch first caused the Byzantineization of this patriarchate (among other things, adjusting the liturgical customs and customs of the imperial city) and then Jerusalem, although it did not lie within the borders of the empire.

In 971, the Fatimids tried to capture Antioch, but it was in 1085 that the Seljuk Turks seized Antioch. On June 3, 1098, after a siege lasting from October 20, 1097, the city (with the exception of the citadel) was captured by the Crusaders of the First Crusade. A year later, the second Melkite Patriarchate, Jerusalem, was in the hands of the Crusaders.

The aim of this research is to present Ecclesiastical interactions between Latin Church and Melkite Churches of Jerusalem and Antioch, i.e. when the East and the West exerted intense and ambivalent (or even controversial) influences on this community. This research focuses on facts and sources related to the Melkite Church in the complex reality of the mediaeval Middle East.

The discussed period of interaction of the two church hierarchies concerns the period 1098-1268. It marks the period from the conquest of Antioch by the Crusaders of the First Crusade (1098) and ends with the takeover of this metropolis by the Sultan of the Egyptian Mamluks Baybars, who ended the 170-year history of the principality of Antioch. As for the Melkite patriarchate of Jerusalem, the period 1099-1187 will be analyzed, i.e. from the capture of Jerusalem by the Crusaders (1099) to the loss of this city to Saladin

in 1187. The second renewed Frankish dominance over Jerusalem was the period 1229-1244, when the Melkites were not ousted from their ecclesiastical offices.

It is symbolically assumed that the Great Eastern Schism, understood as a split in Christianity into the Eastern and Western Churches, occurred in 1054. In fact, it was not a one-off act, but a process that stretched over a wide chronological framework, lasting until the thirteenth century. Both Rome and Constantinople are blamed for its creation. Paradoxically, it also affected the Melkites to some extent, although by the thirteenth century, many Christians were unaware of the existence of the schism. Through the intense romanization of the Melkites, something happened that Constantinople had been unable to do from 1054 to 1085. The Crusaders brought the Melkite Church into the ongoing process of schism. This was because Latin patriarchs and bishops replaced the Melkite hierarchy everywhere the crusaders ruled except for the very weak Melkite Patriarchate of Alexandria. The Melkite Church, which has existed in this area for centuries, as a kind of Semitic-Greek orthodoxy, was forced to submit to Latin Christianity. The Latins professed the same creed, but they were culturally completely alien. A sort of alienation developed between the two communities. It is significant, however, that the Melkite patriarchates did not break off their relations with Rome by any official formal act.

Research will be conducted to answer the following questions:

- whether those multi-faceted interactions led to a specific type of Chalcedonian Arab orthodoxy associated with the Patriarchates of Antioch and Jerusalem;

- to what extent one can reinterpret Melkite activities in intra-Christian interactions with Greek (Constantinople) and Latin (Rome) Patriarchates and in external Muslim interactions with the Fatimid Caliphate, the Seljuk Empire, the Ayyubid Sultanate, etc.;

- to what extent the history of the Melkite Church of this period reflects the synthesis of Greek, Arab and Syriac elements in the contexts of the Arabization of the Melkite communities and the romanization of the hierarchy;

- to what extent inter-confessional rivalries, religious and political persecutions, relations not only with Constantinople and distant Rome but also with the four Crusader states: the County of Edessa, the Principality of Antioch, the Kingdom of Jerusalem and the County of Tripoli, strengthened the awareness of the Melkites’ distinctiveness as a group and their communal identity.

One of the main research difficulties is precision identification of the communities in terms of the imprecise terminology of *al-Suryāni* in Arabic sources, of *Syroi* in Greek sources and *Syriani/Suriani* in Latin source materials of the crusaders. The Arabic-speaking Melkites called themselves *al-Suryāni* because they still used Syriac as their liturgical language in period of 1098–1268. For this reason, the Melkites were referred to as *Syroi* in Greek sources and *Syriani* or *Suriani* in Latin sources. The problem is that “Monophysite Jacobites” (non-Chalcedonian Syriac Christians) were also referred to by these terms in various sources (Buck 2021: 317–331; Folda 1995: 80–91; Pahlitzsch 2001; Weltecke 2009: 115–125). Identifying this terminology does not generally pose problems in Palestine (in the Melkite Patriarchate of Jerusalem), where the Melkites constituted a majority. However, in northern Syria (in the

territory of the Melkite Patriarchate of Antioch), “Jacobites” outnumbered the Melkites in many regions. Thus, as both the Melkites and the “Jacobites” called themselves “Syrians,” the use of the terms: al-Suryāni, Syroi, Syriani/Suriani in many sources (especially those relating to northern Syria) is ambiguous.

Keywords— the Melkite Church, the Great Eastern Schism, The Crusades, Antioch, Jerusalem, Ecclesiastical Organization, Rome, Papacy, Constantinople.

Tattooing: Personal Markings with Meaning – Themes Uncovered While Making a Video Documentary

Byrad Yyelland, Robert Bianchi

Abstract—No longer the secret mark of outlaw bikers, criminals, and sailors, tattooing has become mainstream in much of the world. The current study showcases data gathered for a video documentary on the triangulated relationship connecting tattoos as a form of body modification, cultural norms, and personal meanings. This research has revealed that some religious belief systems, Buddhism in Thailand is one example, connect tattooing with spirituality in an intimate manner. Buddhist monks provide tattoos using traditional bamboo implements and processes, and they pray over the tattoo, infusing magic into the tattoo and consequently, into the body of the receiver. In contrast, although there is no direct mention of tattooing in the Qur'an, many Islamic scholars argue that permanent tattooing is considered *haram*—forbidden for Muslims. Only the temporary *henna* is acceptable. In fact, tattooing is illegal in Qatar. Some Indigenous belief systems in Canada adopt a similar stance on the basis that we were all created by the Creator and as such, we do not have the right to alter what the Creator has made. Still other belief systems such as Spiritism in Brazil and mainstream Christianity in the West are more inclined to regard tattooing as a matter of personal choice.

It is practically impossible for any culture to resist the dual impacts of time and globalization. Long term cultural change has resulted in mainstream acceptance of tattooing in the west and increased acceptance in Japan. Short-term cultural change is seen in Qatar where tattoos are on public display amongst expats and migrant laborers. This tolerance of tattooed individuals was clearly evident with the choice of David Beckham as ambassador for the FIFA World Cup and during the corresponding tourist celebrations.

Themes uncovered in this multicultural research also include individual meanings attributed to tattoo imagery and processes, experiences of personal empowerment, devotion to family, personal philosophy, gender identity, and aesthetics.

Keywords—Culture, norms, tattooing, spirituality, personal motivations and personal meanings.

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Post-Traumatic Growth: A Case Study of Coping with Civilian Exposure to War on the Homefront

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Abstract

Several studies have raised doubts about the effectiveness of posttraumatic growth as a mechanism that promotes functioning. This article explores this issue in several directions. First, it examines whether functioning is negatively associated with posttraumatic symptoms (PTS), dissociation, and depression. Secondly, it determines whether PTG is positively associated with functioning. Finally, the article investigates whether PTG moderates the relationship between functioning and PTS, as well as between functioning and dissociation and depression.

The participants were 301 residents of an area exposed to the second Lebanon war in northern Israel. A structured questionnaire assessing posttraumatic stress disorder, depression, dissociation, posttraumatic growth, and functioning was used six years following the war.

Functioning was found to be negatively associated with posttraumatic symptoms (PTS), dissociation, and depression. PTG was found to be positively associated with functioning. In addition, PTG was found to moderate the relationship between functioning and PTS, as well as between functioning and dissociation and depression.

Contrary to the approach that considers PTG to be a misconception, and possibly even a mechanism that can hinder a return to efficient functioning, the findings of this research suggest that PTG may reflect a growth phenomenon that includes functioning, thus implying a characteristic of the individual's relation to the world. Therefore, it may be concluded that PTG is not an misconception - a process that occurs only in one's head – but rather reflects actual functioning. The theoretical and practical implications of these findings are discussed.

I. INTRODUCTION

Recently, there has been a growing awareness regarding positive outcomes or salutogenic responses in self-conceptions and relations to others, as a result of exposure to traumatic experiences [1]-[4]. The most developed approach to understanding salutogenic responses to traumatic incidents has been posttraumatic growth (PTG) [5]-[7]. Calhoun and Tedeschi defined *PTG* as the individual's attempt to bring about a positive and meaningful change, which arises as a result of dealing with trauma, as well as its concrete and psychological results [8].

In recent years, it has remained unclear whether PTG may, in fact, have positive benefits [9]-[11]. If it is assumed that PTG is positive, then it may contribute to the quality of life and functioning of individuals who experience stressful events [12]. If PTG does not actually influence functioning, then it is a phenomenon which is limited to emotional and cognitive levels only, including the coping aspect. It has been claimed that there is still insufficient evidence supporting the positive outcomes resulting from PTG. This increases the need to examine whether PTG contributes to practical and appropriate functioning, and protects the individual from reduced functioning following stressful situations [13]-[15].

This study was part of a larger longitudinal study, in which exposure and acute stress disorder (ASD) were assessed during the Second Lebanon War and PTS, dissociation, depression, PTG, and functioning were assessed six years later. The war lasted for 34 days. From the very beginning of the war, Hezbollah began bombing the Israeli home front (the location of the present research) with mortar fire and dozens of rockets. In response to this attack, Israel army intensified its bombing on the Lebanon neighborhoods in Beirut. Over the course of the war, approximately 4,000 rockets were fired at Israel, causing serious injury to the life and property of civilians [16].

The current study examined PTG in civilians exposed to war as a moderating factor affecting functioning, which inhibits functioning disabilities resulting from posttraumatic stress, dissociation and depression. It was hypothesized that functioning would be negatively associated with posttraumatic stress symptoms (PTS), dissociation, and depression. Secondly, it was hypothesized that PTG would be positively associated with functioning. Finally, it was hypothesized that PTG would moderate the relationship between functioning and PTS, as well as the associations linking functioning with dissociation and depression.

II. METHOD

The research population included 301 women and men at least 18 years of age, Thirty-five percent of the study participants lived in the city; the rest lived in rural settings.

Six years after the Second Lebanon War, a questionnaire was distributed among residents in five cities, five *moshavim* (cooperative communities), four rural communities, and two *kibbutzim* (collective communities), all of which had been exposed to rocket fire during the war near Israel’s northern border. The areas where the sample population resided were all located at least 30 km from the border (an average of 14 km), and all were in range of rocket fire during the war.

The questionnaire included the following variables: Demographic variables; Posttraumatic growth, an internal consistency of $\alpha = .87$ was found; depression, an internal consistency of $\alpha = .91$ was found; posttraumatic stress disorder, an internal consistency of $\alpha = .94$ was found; dissociation, an internal reliability of $\alpha = .81$ was found.

III. FINDINGS

The findings in Table 1 show that the three regression models are significant, with 25% of the variance in functioning being explained when PTS was included in the model; 17% when dissociation was included in the model; and 36% when depression was included in the model. PTS, dissociation and depression were significantly and negatively associated with functioning, thus supporting the first hypothesis. PTG was significantly and positively associated with functioning, thus supporting the second hypothesis.

TABLE 1
 MULTIPLE REGRESSIONS PREDICTING THE LEVEL OF FUNCTIONING WITH PTS, DISSOCIATION, DEPRESSION, AND PTG (N= 301).

| | Functioning (with PTS) | | | Functioning (with dissociation) | | | Functioning (with depression) | | |
|-----------------|---------------------------|----------|-----------|------------------------------------|----------|-----------|----------------------------------|----------|-----------|
| | β | <i>B</i> | <i>SE</i> | β | <i>B</i> | <i>SE</i> | β | <i>B</i> | <i>SE</i> |
| Education | .12* | 0.10 | 0.04 | .14* | 0.11 | 0.05 | .05 | 0.04 | 0.04 |
| Economic status | .14** | 0.11 | 0.04 | .20*** | 0.16 | 0.05 | .09 | 0.07 | 0.04 |
| PTS | -.42*** | -0.33 | 0.05 | ----- | | | ----- | | |
| Dissociation | ----- | | | - | - | 0.06 | ----- | | |
| | | | | .33*** | 0.26 | | | | |

| | | | | | | | | | |
|-----------------------|------------------------|------|------|------------------------|------|------|------------------------|------|------|
| Depression | ----- | | | ----- | | | - | - | 0.04 |
| | | | | | | | .51*** | 0.41 | |
| PTG | .34*** | 0.27 | 0.04 | .27*** | 0.22 | 0.05 | .21*** | 0.17 | 0.04 |
| PTS x PTG | .30*** | | 0.05 | ----- | | | ----- | | |
| | | 0.25 | | | | | | | |
| Dissociation x PTG | ----- | | | .23** | 0.18 | 0.06 | ----- | | |
| Depression x PTG | ----- | | | ----- | | | .11* | 0.09 | 0.04 |
| ΔR^2 | .075*** | | | .029** | | | .012* | | |
| Total model | $R^2 = .251$ | | | $R^2 = .171$ | | | $R^2 = .359$ | | |
| | $F(5, 295) = 19.77***$ | | | $F(5, 295) = 12.20***$ | | | $F(5, 295) = 32.96***$ | | |

* $p < .05$, ** $p < .01$, *** $p < .001$

All three interactions with PTG were significant, and interpreted with simple slopes (17) (Figures 2 to 4). The interactions are graphed at one standard deviation above and below the mean, to reflect the two different trends in each. Results show negative associations linking PTS, dissociation and depression with level of functioning, at low levels of PTG (PTS: $B = -0.58$, $t = -7.23$, $p < .001$, dissociation: $B = -0.44$, $t = -4.21$, $p < .001$, depression: $B = -0.50$, $t = -9.20$, $p < .001$). However, no significant associations or significant but more moderate associations, were found at high levels of PTG (PTS: $B = -0.08$, $t = -1.47$, $p = .142$, dissociation: $B = -0.08$, $t = -1.63$, $p = .105$, depression: $B = -0.31$, $t = -5.31$, $p < .001$). In other words, PTG was found to moderate the associations linking PTS, dissociation and depression with level of functioning, thus supporting the study's third hypothesis.

IV. DISCUSSION

This study began by examining the relationships linking PTS, dissociation and depression with functioning. In accordance with the hypothesis, the higher the levels of PTS, dissociation and depression are, the lower the level of functioning will be. In addition, the study examined the relationship between PTG and functioning. In the regression analysis, it was found that, in accordance with the hypothesis, higher PTG was significantly associated with higher levels of functioning. This finding appeared in three separate regressions, which examined the contribution of PTS, dissociation and depression to functioning.

It was also hypothesized that the associations linking PTS, depression and dissociation with functioning would be moderated by PTG, suggesting that higher levels of PTG would be related to lower effects of symptomatology on functioning. These hypotheses were supported. When PTG was higher, the relationships between functioning and PTS, dissociation and depression, respectively, were weaker than when PTG was lower. It seems that PTG may inhibit reduced functioning in the presence of PTS, dissociation and depression.

Contrary to the approach that considers PTG to be a misconception, and possibly even a mechanism that may hinder efficient functioning [13, 15, 14], the current findings support the original idea [7], suggesting that PTG may be related with growth, including functioning, implying that it reflects the individual's relation to the world [1, 2, 3, 4].

Thus, it seems that PTG is not merely a misconception, nor is it a process that occurs only in one's head; it is a real phenomenon that may be related with actual functioning.

As mentioned, several studies have noted the importance of cognitive phenomena that accompany PTG, particularly emphasizing the importance of examining PTG's contribution to behavior and functioning [18]. To the best of our knowledge, the current study is the first to examine the relationship between PTG and functioning. The findings show that the importance of PTG is not only cognitive or emotional, but it is also behavioral and related with functioning.

It is important to note that the study findings show that posttraumatic growth moderates the association between depression and functioning to a lesser extent than it moderates the associations between PTS and functioning, and between dissociation and functioning.

These findings may be explained through additional research findings in this study, which show a stronger association between depression and functioning, than between PTS and dissociation, and functioning. In other words, PTG was related with a lower association of depression and functioning, similar to the way in which PTG was related with lower functioning, in association with PTS.

These findings show that the role of PTG differs in relation to cases of depression compared to cases of PTS and dissociation. Future studies should be conducted to examine PTG's contribution to functioning, following other stress-related events or situations.

The study findings shed light on a theoretical dilemma presented in the research literature. According to one approach, PTS and depression are the result of diagnosed etiologies, resulting from exposure to different situational and personal factors. Therefore, each response (PTS and depression) requires different types of interventions [19; 20]. According to the second approach, both of these disturbances (PTS and depression) are inter-dependent, influence one

another, and are related through similar situational and personal factors. Therefore, similar types of interventions are required [21-22].

The present study findings show that in the regressions in which PTG is integrated, the level of functioning was reduced, but not in the case of depression. Additional study findings, which show a different effect of background variables on PTS and depression, serve to strengthen the first approach, according to which PTS and depression are two different responses to trauma.

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Determinants of Standard Audit File for Tax Purposes Accounting Legal Obligation Compliance Costs: Empirical Study for Portuguese SMEs of Leiria District

Isa Raquel Alves Soeiro, Cristina Isabel Branco de Sá

Abstract— In Portugal, since 2008, there has been a requirement to export the Standard Audit File for Tax Purposes (SAF-T) standard file (in XML format). This file thus gathers tax-relevant information from a company relating to a specific period of taxation. There are two types of SAF-T files that serve different purposes: the SAF-T of revenues and the SAF-T of accounting, which requires taxpayers and accounting firms to invest in order to adapt the accounting programs to the legal requirements. The implementation of the SAF-T accounting file aims to facilitate the collection of relevant tax data by tax inspectors as support of taxpayers' tax returns for the analysis of accounting records or other information with tax relevance (Portaria No. 321-A/2007 of March 26 and Portaria No. 302/2016 of December 2). The main objective of this research project is to verify, through quantitative analysis, what is the cost of compliance of Small and Medium Enterprises (SME) in the district of Leiria in the introduction and implementation of the tax obligation of SAF-T - Standard Audit File for Tax Purposes of accounting. The information was collected through a questionnaire sent to a population of companies selected through the SABI Bureau Van Dijk database in 2020. Based on the responses obtained to the questionnaire, the companies were divided into two groups: Group 1 -companies who are self-employed and whose main activity is accounting services; and Group 2 -companies that do not belong to the accounting sector. In general terms, the conclusion is that there are no statistically significant differences in the costs of complying with the accounting SAF-T between the companies in Group 1 and Group 2 and that, on average, the internal costs of both groups represent the largest component of the total cost of compliance with the accounting SAF-T. The results obtained show that, in both groups, the total costs of complying with the SAF-T of accounting are regressive, which appears to be similar to international studies, although these are related to different tax obligations. Additionally, we verified that the variables volume of business, software used, number of employees, and legal form explain the differences in the costs of complying with accounting SAF-T in the Leiria district SME.

Keywords— compliance costs, SAF-T accounting, SME, Portugal.

Competencies of a Commercial Grain Farmer: A Classic Grounded Theory Approach

Thapelo Jacob Moloji

Abstract— This paper purports to present the findings in relation to the competencies of commercial grain farmers using a classic grounded theory method. A total of about eighteen semi-structured interviews with farmers, former farmers, farm workers, and agriculture experts were conducted. Findings explored competencies in the form of skills, knowledge and personal attributes that commercial grain farmers possess. Skills range from production skills, financial management skill, time management skill, human resource management skill, planning skill to mechanical skill. Knowledge ranges from soil preparation, locality, and technology to weather knowledge. The personal attributes that contribute to shaping a commercial grain farmer are so many, but for this study, seven stood out as a passion, work dedication, self-efficacy, humbleness, intelligence, emotional stability, and patience.

Keywords— grain farming, farming competencies, classic grounded theory, competency model.

Bi-objective Network Optimization in Disaster Relief Logistics

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Abstract— Last-mile distribution is one of the most critical parts of a disaster relief operation. Various uncertainties, such as infrastructure conditions, resource availability, and fluctuating beneficiary demand, render last-mile distribution challenging in disaster relief operations. The need to balance critical performance criteria like response time, meeting demand and cost-effectiveness further complicates the task. The occurrence of disasters cannot be controlled, and the magnitude is often challenging to assess. In summary, these uncertainties create a need for additional flexibility, agility, and preparedness in logistics operations. As a result, strategic planning and efficient network design are critical for an effective and efficient response. Furthermore, the increasing frequency of disasters and the rising cost of logistical operations amplify the need to provide robust and resilient solutions in this area. Therefore, we formulate a scenario-based bi-objective optimization model that integrates pre-positioning, allocation, and distribution of relief supplies extending the general form of a covering location problem. The proposed model aims to minimize underlying logistics costs while maximizing demand coverage. Using a set of disruption scenarios, the model allows decision-makers to identify optimal network solutions to address the risk of disruptions. We provide an empirical case study of the public authorities' emergency food storage strategy in Germany to illustrate the potential applicability of the model and provide implications for decision-makers in a real-world setting. Also, we conduct a sensitivity analysis focusing on the impact of varying stockpile capacities, single-site outages, and limited transportation capacities on the objective value. The results show that the stockpiling strategy needs to be consistent with the optimal number of depots and inventory based on minimizing costs and maximizing demand satisfaction. The strategy has the potential for optimization, as network coverage is insufficient and relies on very high transportation and personnel capacity levels. As such, the model provides decision support for public authorities to determine an efficient stockpiling strategy and distribution network and provides recommendations for increased resilience. However, certain factors have yet to be considered in this study and should be addressed in future works, such as additional network constraints and heuristic algorithms.

Keywords— humanitarian logistics, bi-objective optimization, pre-positioning, last mile distribution, decision support, disaster relief networks.

Domestic Trade, Misallocation and Relative Prices

Maria Amaia Iza Padilla, Ibai Ostolozaga

Abstract— The objective of this paper is to analyze how transportation costs between regions within a country can affect not only domestic trade but also the allocation of resources in a given region, aggregate productivity, and relative domestic prices (tradable versus non-tradable). On the one hand, there is a vast literature that analyzes the transportation costs faced by countries when trading with the rest of the world. However, this paper focuses on the effect of transportation costs on domestic trade. Countries differ in their domestic road infrastructure and transport quality. There is also some literature that focuses on the effect of road infrastructure on the price difference between regions but not on relative prices at the aggregate level. On the other hand, this work is also related to the literature on resource misallocation. Finally, the paper is also related to the literature analyzing the effect of trade on the development of the manufacturing sector. Using the World Bank Enterprise Survey database, it is observed cross-country differences in the proportion of firms that consider transportation as an obstacle. From the International Comparison Program, we obtain a significant negative correlation between GDP per worker and relative prices (manufacturing sector prices relative to the service sector). Furthermore, there is a significant negative correlation between a country's transportation quality and the relative price of manufactured goods with respect to the price of services in that country. This is consistent with the empirical evidence of a negative correlation between transportation quality and GDP per worker, on the one hand, and the negative correlation between GDP per worker and domestic relative prices, on the other. It is also shown that in a country, the share of manufacturing firms whose main market is at the local (regional) level is negatively related to the quality of the transportation infrastructure within the country. Similarly, this index is positively related to the share of manufacturing firms whose main market is national or international. The data also shows that those countries with a higher proportion of manufacturing firms operating locally have higher relative prices. With this information in hand, the paper attempts to quantify the effects of the allocation of resources between and within sectors. The higher the trade barriers caused by transportation costs, the less efficient allocation, which causes lower aggregate productivity.

Second, it is built a two-sector model where regions within a country trade with each other. On the one hand, it is found that with respect to the manufacturing sector, those countries with less trade between their regions will be characterized by a smaller variety of goods, less productive manufacturing firms on average, and higher relative prices for manufactured goods relative to service sector prices. Thus, the decline in the relative price of manufactured goods in more advanced countries could also be explained by the degree of trade between regions. This trade allows for efficient intra-industry allocation (traders are more productive, and resources are allocated more efficiently).

Keywords— misallocation, relative prices, TFP, transportation cost.

Engaging Conversational Leadership in Organizations: *An Interior Process View*

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Abstract

To effectively steer organizational change initiatives amidst growing global organizational uncertainty, Day et. al (2004); Carson et. al (2007) and other researchers have argued for the importance of developing an array of leadership capacities—a number of which are pertinent to the tasks of collective leadership. As this paper will argue, it is imperative that leadership development is assessed not only within individual leaders but also in terms of the quality of communication supporting the process and ends of collective leadership (Brown, 2011). Following from this focus on the communication of teams and its role in engaging collective leadership, there is an emerging need to identify and develop collective intelligence practices of communication (Briskin et al. 2009; Combs, 2009) that can be utilized as collective leadership means for implementing organizational change initiatives. To this end, I build upon and recontextualize the work of Varella’s three gestures of becoming aware (Depraz et. al, 2003) as a process model to establish preliminary criteria for identifying and establishing key elements for a collective leadership model of communication.

With sufficient practice and duration, management teams can learn to shift their communication orientation interiorly towards experiencing more *interdependent* processes of thinking together, which can with training—build collective intelligence capacities for sensing, indwelling and thinking together in synergistic and emergent ways. Shifting the ethos of conversation from individually-directed norms to an collective interiorly led process from the field of conversation itself, teams engage “an order of perception that happens from the whole field, not from within a separated perceiver” (Rosch and Scharmer, 1999, p. 21). This process of primary knowing requires the capacity to literally sense and align oneself with an order of knowing that arises directly from the field of conversation itself, as an emergent property of the teams commitment to unfolding new knowledge together.

More recent theorizing in this area indicates “co-intelligence” (Atlee, 2003a, 2003b) or “collective mind” (Weick and Roberts, 1993), signaling critical transitions in the nature of the team process of communication itself. These collective metaphors implicitly draw on an improved team *state* of synergistic thinking, which in drawing upon the sensed field of conversation and subtle relational connection, influences all involved towards in a collectively aligned and engaged manner. Given that each state of consciousness contains a distinctive self-sense, level of shared reality and scope of sensitivities (team memory, distributed subtle body-perception, altered sense of time and experience of the senses), in the context of experiencing deeper collective states through collective intelligence processes, team members who learn how to engage conversations in this

process manner draw upon a shared process by occasioning resonance, mutuality and working together from a place of heightened synchrony and synchronicity (Levi, 2005). Edwards (2003) elaborates:

Progressive states (which include peak experiences and flow experiences) are those that rise above the self-system's average level of development in its baseline waking state. In their healthy form these might also be called evolutionary states in that the self-system temporarily identifies itself with more advanced levels of developmental potential.

Though the post-conventional capacities of teams can support more effective mastery and management of the challenges of current complex and uncertain business environments that leaders face, little to no research has been explored concerning how this looks like within the context of the emerging field of collective leadership. Current research and interest in collective forms of leadership (Carson, Tesluk, & Marrone, 2007; Harris, 2007) has been identified as a significant development within the broader field of organizational leadership (Aviolo, Walumbwa, & Weber, 2009; Day, 2000). It is becoming a consensus view that leadership practice, when it is distributed across teams and organizations, is a highly adaptive and creative response to the growing complexity of managing today's global organisation (Leigh, Shapiro, & Penney, 2010). As a management style, collective leadership involves a movement away from unilateral action towards designing collaborative and synergistic processes for teams (Archer & Cameron, 2009).

Over the past decade, re-conceptualizing leadership as a collective process has become a landmark development within management thinking and practice. Yet despite this innovation, surprisingly little academic research exists documenting the team-based communication practices needed for leaders to effectively engage in this approach. Though team and interpersonal communication are among the primary means through which collective leadership processes are enacted within organizations (Pan & Howard, 2010), these processes have yet to be identified as facilitating collective leadership in any significant way. As such, the underlying communication and facilitation practices that catalyze *generative* collective leadership processes and outcomes in teams (Hannah, Lord, & Pearce, 2011; Zhang, Tsui, & Wang, 2011) need to be addressed in more depth. This article addresses this knowledge gap by considering the importance of collective intelligence processes as a communication means for engaging the dynamic, emergent and shared *process* and *state* of collective leadership (Day et al., 2004).

As a basis for contextualizing this specific shared process and state of leadership, I draw on Hurley and Brown (2010, p.2) use of conversational leadership, "the leader's intentional use of conversation as a core process to cultivate the collective intelligence needed to create business and social value." In this sense, conversation is recognized as a crucial generative means for leadership teams to access a latent creative and distributed (Barry, 1991) collective basis for leadership. Isaacs elaborates:

A system has “collective leadership” when people are attuned to each other so well that, even when separate, they naturally act in harmony with each other and the goals of the common enterprise. Most leadership teams, including those at senior levels, are far from fulfilling their potential. They meet as individuals, squeezing time from their more urgent work, debating from their individual perspectives and concentrating on their individual domains of authority. Their actions, and the actions of those who report to them, consequently take place at cross-purposes, and they often seem trapped in cycles of opposition and breakdown." (Isaacs, 2005)

In much of existing research on leadership, the focus has traditionally been on the individual. Until more recently, comparatively less attention has been given to teams, though this is changing in organizations, particularly those facing more complex problems requiring new approaches that creatively “combine the knowledge, efforts, and abilities of people with diverse perspectives (Eisenhardt 1990). Yet in conversational leadership, which is directed by team processes of collective intelligence, creative insight emerges not within a single individual, but rather across the interactions of multiple team members in the process. Collective intelligence based approaches draw from the capacities of individual leaders, but also their ability to facilitate synergistic interactions in the team field of conversation, which brings about enhanced patterns of thought, meaning and insight among the management team.

Recent theoretical and empirical work has developed the notion of collective cognition in organizations (Meindl et al. 1996, Thompson et al. 1999, Hutchins 1991) to explain cognitive processes that transcend individual thinking. Contributions arise from the collective presence and attentiveness to the subtle and emergent interactions with others in the team field. Through collective conversational leadership, leaders participate in the generation of synergistic processes that connects individual ideas and experiences in ways that both redefine and resolve the demands of emerging situations. A focus on the collective aspects of these conversational interactions helps individual leaders become receptive to the inherent limitations of past thinking and action, in turn shifting towards co-enacting emergent thinking and not-yet-conceived actions.

Collective intelligence perspectives and experiences are capable of working with problematic situations in ways that draw upon distinctive collective intelligence processes to arrive at new solutions. Collective intelligence based processes arise from conversations that bring forth new ways of being, thinking and acting within the organization that are dependent upon subtle collective creative processes. Though it is impossible to predict the emergence of this phenomena, the framework introduced in this paper provides a basis for understanding how collective intelligence can be more intentionally and mindfully enacted within leadership teams to bring about changes in participants way of being, quality of listening and collective sense-making (Manfred Mack, SOL article). In highlighting the particular subtle and deeper internal attentional processes that enable management teams to engage in collective leadership, connections between this inner and shared collective become the emerging interior context out of which new solutions can be engaged.

IV. Three Gestures of Collective Conversational Leadership

As this paper attempts to illustrate, recontextualizing Varela et. al's three gestures as a core practice for teams to engage collective intelligence processes can be helpful for guiding and directing the emergence of collective wisdom and collective leadership development (Gunnlaugson, 2011). The three gestures have been originally characterized as a more comprehensive mindfulness practice for creative purposes. Mindfulness practice, both as traditionally defined within eastern traditions and a western social science perspective provides a basis for cultivating enhanced learning experiences. Gunaratana (1992) points out that mindfulness training teaches us how to examine our own perceptual process with a more fine-tuned awareness, so that we can develop the capacity to engage with our own experience from a place of embodied calm and careful attention. Advocate for mindful learning, Harvard educator Langer (1997) unpacks the cognitive implications of mindfulness in the context of learning, "When we are mindful, we implicitly or explicitly view a situation from several perspectives, see information presented in the situation as novel, attend to the context in which we are perceiving the information, and eventually create new categories through which this information may be understood" (p. 111).

Traditionally, interior forms of mindfulness are taught (mindfulness of one's thoughts, emotions, body, and breath). When this work is taken up within field of conversation, more relational or intersubjective forms of mindfulness can also be cultivated as the counterpart to the inward cultivation of moment-to-moment nonjudgmental awareness or mindfulness. Mindfulness fosters clarity and individual presence through mindfulness of body, mind, emotion, and spirit, and when applied within the conversational field in a shared and collective manner, mindfulness helps invite a depth shift in the context out of which conversation arises, mirroring the shift in the self-sense of individuals which also shifts from being in a condition of separateness to experiential relatedness and interconnected emergence.

V. Three Gestures of Becoming Aware of Collective Intelligence Processes

Varela et al's (2000) three-phase structuring of the act of becoming aware, which consists of suspension, redirection, and letting go, offers a means for becoming aware collectively of essential and often heretofore excluded generative dimensions of conversation. As discussed, this cycle incorporates elements of several contemplative and mindfulness practices.

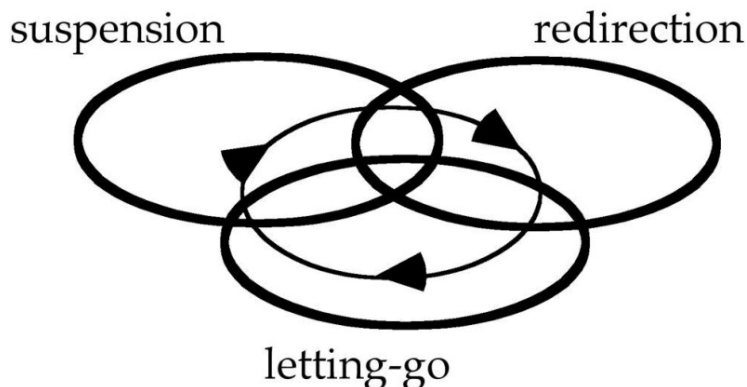


Figure 2. The three phases (Depraz, Varela, & Vermersch, 2000, p. 135).

When practiced by individual team members, suspension opens an interior space for the sincere reconsideration of thought and emotion, which draw upon memories and prior experience. The objective here is to discover anew the underlying assumptions, as well as hidden patterns and context out of which our thinking arises. When practicing suspension in teams for the purposes of collective leadership, suspension opens a shared inquiry space within the field of conversation. Suspension requires slowing down our speaking and allowing time for considering and re-considering our assumptions as well as emerging discoveries so that we can more clearly comprehend the complex nature of a particular challenging issue or problem. What is needed in suspension, is the ability to stay with the underlying complexity and tensions of the situation we're discussing, to bring a quality of consciousness and presence to the conversation that is capable of holding and staying with the underlying dynamic wholeness out of which the complex situation we're grappling with is situated within. Suspension requires slowing down so we can hold more of the subtleties of the context in our awareness, rather than simply attending to words or points made back and forth on the discursive surface of ideas that typically shape conversations from team members who participate in them in a distracted or unmindful manner.

Suspension involves learning to hold the complexity and tensions of our assumptions, biases, histories, and habitual ways of engaging with one another in conversation so they can be mindfully attended to, felt and reflected back to the team. In learning to discover a more comprehensive display of our thinking (as representations of a more comprehensive and complex reality) with others, creative space opens, allowing us to address the deeper incoherence of the process of thinking itself (Bohm, 1996), which when left unsuspected, tends to weaken our grasp and diminish our comprehension of this deeper complexity, which is reflected in the general poor quality of conversational cultures that are instituted within many organizations. Suspension then, as a generative leverage point, creates a climate where a shared willingness to be tentative, curious, and ultimately less invested in advocating or defending our existing knowledge can become the place from which we lead, rather than this creative edge being marginalized or left unattended to in the background of our awareness. Suspension, as a creative tool, helps us resist the temptation to give into the immediate pressure to know and be certain, particularly in

instances where no real basis for certainty exists. Suspension then becomes a place to engage with uncertainty within our team, helping direct conversations away from patterns of advocacy which are prevalent in management teams.

Varela (Depraz et al., 2003) describes the second gesture of “redirection” as the inner movement of our attention away from the content we have “suspended” and to sense into, be with, and perceive the hidden meaning or insight that is trying to emerge. Redirection directs our awareness to the subtle tacitly felt sense of what is arising within our experience and within the field of conversation, requiring a different order or way of deploying our attention. To the extent that we are attending to what has arisen, we are no longer following this leading edge of emergence and discovery. Thus redirection involves a subtle but discernable change in the location of one’s habitual mode of paying attention in conversation. The shift can be described as an inner movement from what has arisen or been shared to listening from the deeper collective interior context in which the content of a particular conversation arises from. Redirection also asks that in addition to attending to the level of thought and language in a conversation, we consult with and redirect our attention towards the underlying source of our experience as we inquire or discuss something.

Naturally and initially, this can be confusing, insofar as distinguishing between the action of reflecting on past knowledge and holding a context out of which new knowledge can emerge is generally not clear in the accustomed ways we experience clarity. An approach that I have found helpful is to invite others to periodically redirect attention to different levels of their experience as the conversation unfolds, engaging a mode of sensing that is similar to Gendlin’s subtly embodied felt-sense, where we listen to different levels of the larger gestalt of what others are sharing, as well as the deeper source of our individual experience. Whereas suspension requires slowing down; redirection may require stopping or shifting our awareness into underlying stillness so as to better perceive the new freshly. To discover in real-time what is emerging anew in contrast to the conditioned order of perception and habit that we are prone to operating from, what Scharmer (2007) describes as downloading is key here. The point is to come into contact with an inner stillness and to awaken the dormant perception found there. Inside that inner stillness, experienced within one’s own interiority and the team in the shared conversation field, a perceptual faculty of knowing and being is contacted, awoken and discovered through a renewed contact with our own presence in the present moment. In redirecting to this place of inner stillness (at first within oneself and with practice, the team).

According to Varela and Scharmer (Varella, 2000), the next gesture following redirection is the allowing experience of letting go, which gives rise to *letting come*. In the context of conversation, letting come involves a recursive movement of attention towards abiding in presence and being with the unknown—that is, entering into a receptive state of listening for new meaning, knowledge, and insights to emerge in one’s awareness. Letting come involves shifting one’s attention from “looking for something” to “letting something come to you,” to “let something be revealed” (Depraz et al., 2003). Depraz et al. elaborate:

You actively pay attention but at the same time you wait, since what you're reflecting on is by definition tacit, pre-reflective or pre-conscious. Thus you have to balance your self between a sustained act of attention and not having immediate fulfillment” (p. 37).

With practice, letting come fosters receptivity to the subtle textures and nuances of what is emerging within the inquiry in the conversational field..

VI. Conclusion

As discussed, this paper contributes to recent developments within the emerging field of collective leadership by proposing an interior approach to assisting communication within management teams. Varela et. al's (2000) three gestures, when recontextualized as a method to support collective intelligence processes, provides a framework through which to better understand and engage communication processes that contribute to collective leadership within management teams and organizations. Though this paper provides a preliminary inquiry into this timely issue, further research is needed to determine to establish how the proposed method of communication more effectively enacts collective leadership as the development of collective leadership processes from a communications perspective are currently not well understood. As such, this article sets the stage for further inquiries into methods for developing collective leadership capacities in teams through communication-based collective intelligence processes.

When applied as interpersonal and collective processes of communication within management teams, collective intelligence methods stand to significantly improve upon the quality and creative capacity of conversation. The general make-up and content of orthodox management education is based, most often, on the assumption that a manager is ‘‘a morally neutral technician’’ who must identify the best ways of reaching pre-determined goals (MacIntyre, 1981). This traditional paradigm of technical management, however, generally ignores the epistemological and ontological dimensions of management practitioners experience (their values, their needs, etc.) and the structures of meaning upon which they base their way of interacting with their people (e.g. mental models, action patterns) among other aspects. Without a process education in ways of accessing deeper collective intelligence capacities within teams, managers struggle with their existing mental models, failing to recognize the limitations and the destructive potential of their existing habits of mind and communication.

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Determinants of Inward Foreign Direct Investment: New Evidence from Bangladesh

Mohammad Maruf Hasan

Abstract— Foreign Direct Investment (FDI) has been increased at a remarkable position around the globe in which emerging economies are getting more FDI compared to industrialized economies. This study aims to examine the determinants of inward FDI flows in Bangladesh. To estimate the long and short-run impact of the FDI determinants for 1996-2020, we employed the Autoregressive-Distributed Lag (ARDL) model. Results show that: (1) macroeconomic determinants, such as economic growth, infrastructure, and market size, have a significant and strong positive effect. (2) Inflation exchange rate shows insignificant effects, while trade openness has mixed (short-run negative, long-run positive) effects on FDI inflows in both the long and short run. (3) Current institutional determinants rule of law has a positive effect on FDI inflows but is statistically insignificant, political stability has a negative, and the rule of law has a considerable beneficial impact on inflows of FDI. (4) The macroeconomic factors have been determined to impact Bangladesh's FDI inflows. Finally, a stable macroeconomic climate is more effective at luring FDI, as this study confirms. From a policy perspective, this study will help the government and policymakers to make a new investment policy.

Keywords— determinants, FDI, ARDL, Bangladesh.

A Review on the Evolution of Demand Forecasting Methods

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Abstract—

Our ancestors in ancient times prayed to the Almighty for rain during drought, rich harvest, peace and for all other things which were needed for their existence. However, they were never sure about the Almighty's wish even after performing any number of rituals. They lived a totally reactive life with no real prediction for the future. With the passage of time, people gradually devised ways to have a better understanding of future and began to comprehend what lied ahead. This way the science of forecasting took its shape. The evolution of Demand Forecasting which has taken its current shape has developed over time. The contribution of technology, customer and organization expectations and global perspective with respect to demand forecasting has been discussed in this review paper. Traditional versus Machine Learning forecasting methods have been reviewed. Inventory management and control is one of the key challenges faced by every organization in business. The common challenges are: competitive pricing, perishable products, stringent safety regulations of the government, fragile products, etc. Furthermore, business organizations have to deal with issues in global supply chain, seasonal fluctuations in demand and bottlenecks in transportations. However, developments in demand forecasting technologies offers solutions to deal with such an erratic environment. The use of latest software's and technologies provide accurate solution to every domain of demand forecasting. At present there are strong and accepted means to use software's and new technologies to trace, document, and analyse every aspect of demand forecasting. This review paper presents findings of literature and web research on the evolution of Demand Forecasting methods.

Keywords: Demand Forecasting, Traditional Methods, Machine Learning Methods, Supply Chain, Inventory Management

1. INTRODUCTION

In theory, demand forecasting entails predicting how much a product will be consumed or purchased by the customers and then attempting to meet those demands by producing that quantity. However, in reality demand forecasting is very complex. There will always be some level of error when the future is predicted and it's very crucial to calibrate those errors and account for those errors in the decision-making process. Forecasting inaccuracies can have a significant impact on any business therefore the magnitude of error is very important in decision making.

On the other hand, there might be circumstances where the demand of a product by the customer might be unintentionally underestimated, therefore the required number of products is not produced and the company is unable to fulfil and meet the customer's demand. As a result, current customers are dissatisfied, and potential customers are turned away. In either case, the business will run at a loss that could have been profitable. It could also mean pressurising the suppliers and manufacturers to meet orders when they don't have the capacity to fulfil the demand.

If there are not enough hands-on deck to keep the business running smoothly, forecasting could factor into the staffing decisions. Businesses lose a lot of money due to forecasting errors. Future predictions can be changed to improve the accuracy by calibrating errors and trying to understand which forecasting method is best suited for a business. During the course of time predicting the actual demand will come into picture which will help companies make lots of money and make huge profits while remaining competitive in the marketplace. (Kerkkänen *et al.*, 2009), (Chambers *et al.*, 1971)

2. LITERATURE REVIEW

Every financial decision taken by corporates is based on forecast. Predictions of demand and product trends have become mandatory to deal with seasonal variability, uncertain market scenarios and political crisis. Correct selection of forecasting techniques suitable for a particular business is important. Chambers *et al.* (1971) have explained the importance of forecasting with special focus on sales forecasting for products of Corning Glass Works. The rich blend of the right forecasting method and experience of managers help to ensure correct predictions.

Bandeiraa *et al.* (2020) research recommends using two mechanisms by combining prediction methods and the choice of forecasting methods depending on the correctness of the model. Data sets used were of a M-Competition and an elevator manufacturing industry. The results indicate that the amalgam have plausible application in demand forecasting and it surpasses other traditional models.

The realization of product demand forecasting has been ascertained by Kochak *et. al* (2015). The project is on consumer product for study of future average. The validity of forecasting the demand signals in the supply chain with ANN method and determining the best training method have been considered. This study has constructed a cooperative forecasting structure based on ANN and training methods. The recommended methodology, demand forecasting problem was scrutinized on a manufacturing company as a real-world case study.

Aamer *et al.* (2020) studied the variations and discrepancies in the machine learning. The research paper has considered the applications on three business domains, namely, agriculture, industry, and service sectors. It is stipulated that machine learning algorithms provide better predictions and economical computational cost for demand forecasting than traditional forecasting models. Machine learning applications in industrial sector find extensive use while it is limited in agricultural sector.

Fattah *et al.* (2018) developed an ARIMA model for demand forecasting of the finished product in a food manufacturing by using Box–Jenkins time series approach. The results obtained proves that the model can be used for modelling and forecasting the future demand in food manufacturing and provide insights to managers for taking correct decisions.

3. RESEARCH PROBLEM DEFINITION AND OBJECTIVES

3.1 Evolution of Demand Forecasting: Stone Age To AI

Humans were purely responsive to immediate customer requirements in the early stages of prediction. At an early stage, statistical demand forecasts were discovered. It was a big step forward. Bar charts showing aggregate demand from one period to the next could be created

using a time series of historical sales values. This led to the development of curve fitting in historical demand data resulting in moving averages and trend lines. Seasonal variations could also be included in the equation.

Demand Planning supported the prediction process by including additional hierarchical and causal effects. However, as time passed, organizations became more complex. At the same time, in other parts of the world, marketing and sales were trying to analyse customer behaviour and find out more about customer needs and preferences. At that time, the supply chain was still in its nascent stage. The accuracy of the forecasts did not improve much as huge amount of available data could not be integrated and leveraged for forecasting. There were companies with item-location accuracy as low as 70%.

This type of error is very common in companies that use a "top-down" predictive approach. With this approach, aggregate demand is predicted and categorized into SKU-Location details for inventory and replenishment planning. Averaging out eliminates local peaks and valleys in the curve, streamlines variations, and makes it convenient to create better quality and correct forecasting. The prediction quality at the SKU-Location level is very low as the demand signal details are filtered out along with the noise resulting in the loss of important information about volatility and tolerance.

To overcome this, a new type of forecasting using demand modelling developed which uses "bottom-up" approach. A demand model is developed that can recognize the unique demand pattern for each combination of SKU-Locations every day. This breaks down the demand flow into several components, primarily internal and external factors, and how each affects demand. These components may include baseline statistical forecasts, seasonal, calendar, and daily sales patterns. Demand formation for new product launch and other changes are taken into consideration. This greatly improves the accuracy of predictions at a very detailed level and reduces human involvement and intervention.

The adoption of this method is beneficial as it fits in the most valuable information about demand volatility and variability at the finest level. Forecasts at any level can be incorporated to support the delivery of operational inventory over SOP processes or networks. Due to the detailed channel data, there is an outside-in approach, also known as "demand sensing". Demand detection improves forecasts by transforming downstream channel demand into demand signals for each upstream SKU-Location, improving the reliability of statistical forecasts and reducing demand delays. (Chase, 2013)

In recent years, machine learning has captured and modelled complex patterns that form demand signals, enabling predictors to continually improve their signal-to-noise ratios. This state-of-the-art technology reveals hidden patterns and trends that are extremely difficult and time-consuming to grasp and discover using traditional statistical methods and human analysis. The results are used to improve future analysis, creating smarter and more accurate systems over time. This is most suitable for frequent sales, new product launches, high lead time demand, and extreme seasonality. For example, a machine learning system that uses web data to predict the success of a new product discovers and learns the existence of demand indicators, such as page views and specification downloads, and updates the model as the data changes. Changes in behaviour of customer can be tracked and updated to gain insight into their changing requirements. (Yildiz *et al.*, 2016), (Chase, 2013)

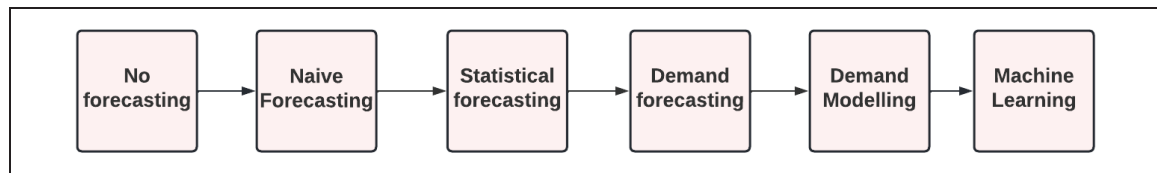


Figure 1: The Evolution of Demand Forecasting

4. METHODOLOGY

4.1 Demand Forecasting Methods: Traditional Versus ML Methods

Over the years, Artificial Intelligence (AI) has helped solve business problems. The success of Artificial Intelligence and Machine Learning applications depend to a large extent on evolving algorithms that can learn through trial and error and improve its reliability and accuracy over time span. Existing business processes that are supported by AI and ML tools are based on logical algorithms and decision-making capabilities and by adopting a decision matrix.

AI and Machine Learning applications will continue to revolutionize the business world as technology advances and takes a firm hold in forecasting. Due to its ease of use and the potential for cross-functional applications, the use of Artificial Intelligence and Machine Learning in predictions is of great importance and relevance to most enterprises and business houses. Historically, companies have entrusted on statistical prediction methods such as linear regression and exponential smoothing. This helped companies make decisions. Machine learning based demand forecasting has put away the use of conventional methods of many data and analytic initiatives across all business houses.

Choosing the most pertinent forecasting method has a considerable effect on the amount of time, effort, and money spent on the process. In the box below the benefits and drawbacks of traditional versus Machine Learning forecasting methods, as well as the scenarios in which each technique might be most useful is depicted. (Stoll, 2020), (Bandeira *et al.*, 2020), (Shahrabi *et al.*, 2009)

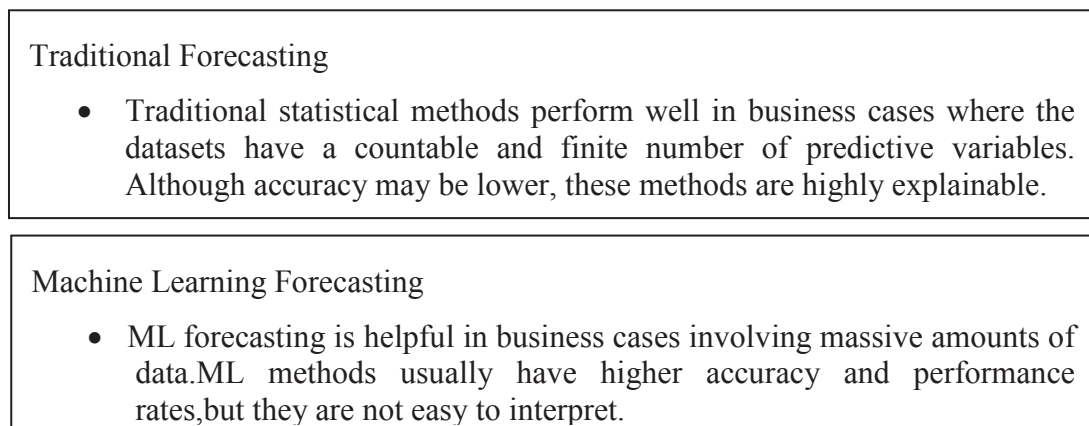


Figure 2: Traditional vs Machine Learning Forecasting

4.1.1 Traditional forecasting

The principles for classical algorithms are to use preformulated approaches and statistical models such as linear regression, autoregressive integrated moving averages (ARIMA) and autoregressive integrated moving averages and explanatory variables (ARIMAX). The goals of traditional forecasting methods are primarily expressive and descriptive. Traditional prediction methods aim to analyze univariate or multivariate datasets with finite, countable and explainable predictors. (Fattah *et al.*, 2018)

A forecast model's goal is to forecast future value based on previously recorded data or records of business performance metrics. A assurance interval, which indicates the level of validity in a given indicator, is also included in forecasts. Business realization data is frequently univariate, which means that the data type only contains observations on a single variable.

Traditional statistical methods can provide reasonable forecasting accuracy based on historical data when forecasting sales for fast-moving specialty products such as dairy products. This prediction is possible because the number of factors that can affect the sale of such products is limited and measurable. The machine learning algorithms used to forecast sales can improve accuracy but at the expense of complexity and high need of computational resources. Some of the classic models described below are used effectively and with high accuracy when used to process univariate data.

Moving average

The time series decomposition method is a classical method which was first used in 1920s and was used commonly and widely used until the 1950s. This forms the basis of many time series decomposition methods such as simple exponential smoothing method. Simple exponential smoothing is one of the easiest ways to predict a time series. This model works on the basic principle that the future demand will be same as demand trend of the past. Therefore, the only pattern this model learns from the history of demand is its level and quantity. The level is the average that demand fluctuates over time. In the image below, the level is a smoothed demand fit. As a final assessment of the level, the exponential smoothing model predicts future demand.

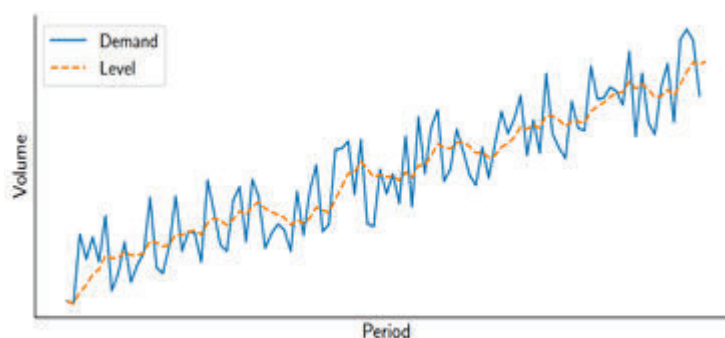


Figure 3: Demand vs Time period

Holt – Winters

Holt-Winters prediction algorithms allow smoothening of time series data and use the appropriate data to predict areas of interest and importance. Exponential smoothing assigns exponentially decreasing bias and weightage to historical data to reduce the bias values of the old data and gives more bias and importance to the new data than to the old data in the prediction.

| Algorithm | Level | Trend | Seasonal | Cyclic |
|------------------------------|-------|-------|----------|--------|
| Single Exponential Smoothing | Yes | No | No | No |
| Double Exponential Smoothing | Yes | Yes | No | No |
| Triple Exponential Smoothing | Yes | Yes | Yes/No | Yes/No |

Figure 4: When to use Holt-Winters Smoothing Models

Linear regression

Linear regression is most common and popularly used for predictive analysis. Two parameters are examined in particular. It is ascertained whether the selected set of input parameters produces the correct output of the dependent variable. The most influencing input parameters are also determined. The demand function may be single-variable or multi-variable depending on the number of variables affecting the demand.

The regression method estimates the demand function of a product wherein the demand is the dependent variable and the variable that drives demand is the independent variable. If only one variable affects demand, the demand function is single variate. In such cases, a simple regression technique is used. When demand is affected by many variables, it is called a multivariable demand function. Therefore, multiple regression is used in such cases.

Auto Regressive Integrated Moving Average

ARIMA is a family of models that describes a particular time series model depended on its own past values. In other words, it explains its own lag and delayed forecast errors, so that correct equations can be deployed to predict future demand level. (Fattah *et al.*, 2018)

Unobserved component modeling

The unobserved component model (UCM) breaks down the time series into smaller parts and variables such as trends, seasonal variations, repetitive cycles and regression effects from predictor series. The most important aspect of the classic model is the ease and transparency of its operation method. The results demonstrated by these classical models are easy to understand and trace back.

4.1.2 Machine learning forecasting

Machine Learning prediction algorithms use approaches that include more multifarious functions and prediction methods, the purpose of ML prediction being same as traditional methods i.e., to improve prediction accuracy while minimizing losses. The method used for minimization is the main feature that distinguishes between the two methods. Most traditional methods use a descriptive linear process to minimize the loss function, while most ML methods use non-linear methods. The following are examples of the ML predictive models used in business and enterprise applications. (Carbonneau *et al.*, 2008), (Aamer *et al.*, 2020)

Neural network models

Artificial neural networks are prediction techniques based on simple mathematical models of the brain. It allows complex non-linear relationships between response variables and their predictors. A neural network is similar to a network of "neurons" organized in layers. The bottom layer is made up of predictors (or inputs), and the top layer is made up of predictors (or outputs). There could also be an intermediary layer containing "hidden neurons". (Vairagade *et al.*, 2019)

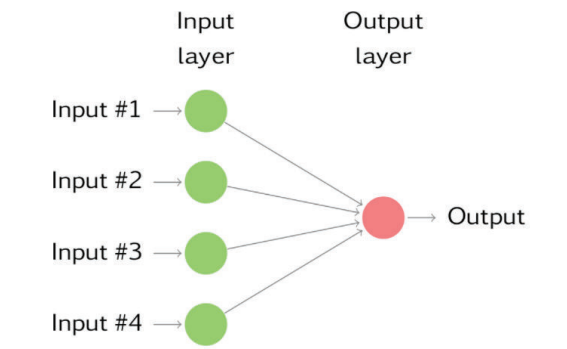


Figure 5: Neural Network Model

Long short-term-memory-based neural network

Long and Short-Term Memory (LSTM) is an artificial recurrent neural network (RNN) architecture used in the domain of deep learning. It can process individual data points (such as images) as well as entire data sequences (such as audio and video).

A cell, an input port, an output port, and an oblivion port make up a typical LSTM unit. The three gates regulate the flow of information in and out of the cell, and the cell stores the values at arbitrary time intervals. Due to the potential delays of unknown periods between important time-series events, LSTM networks are better disposed for processing, classification, and prediction based on time-series data. LSTMs allows the time-series prediction models to predict future values based on previous sequential data. (Kochak and Sharma, 2015), (Abbasimehr *et al.*, 2020)

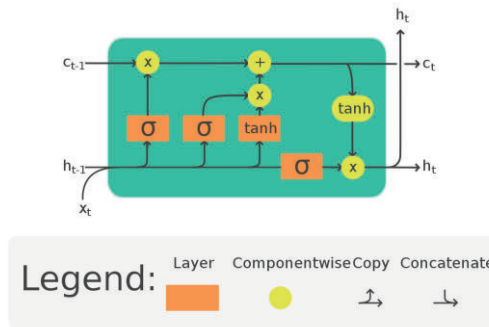


Figure 6: Long short-term-memory-based neural network

Random forest

Random forest is a well-known machine learning algorithm that belongs to the supervised learning method. This is an ensemble learning method that builds multiple decision trees during training and outputs a class that is the mode(classification) of the class or the average / average prediction (regression) of each tree. It is used to solve both ML classification and regression problems using machine learning. By manually creating lag and seasonal component variables, it can also be used in time series predictions for both univariate and multivariate datasets[6].

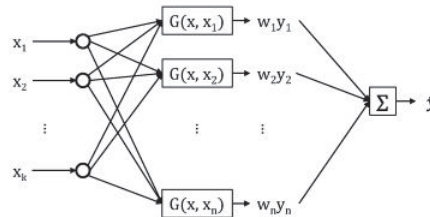


Figure 7: Random Forest Model

K-nearest neighbors' regression

The K-nearest neighbor method is a simple algorithm that stores all available cases and predicts a numerical target based on similarity. KNN has been used for statistical prediction and pattern recognition.

Classification and regression trees

Classification and Regression Tree (CART) is a prediction algorithm used in machine learning. It predicts the value of a target variable based on other values. The Classification and Regression Tree (CART) methodology is one of the oldest and most basic algorithms. Used to predict results based on specific predictors. Ideal for data mining tasks as it requires little data preprocessing. The decision tree model is easy to understand and implement, and has significant advantages over other analytical models.

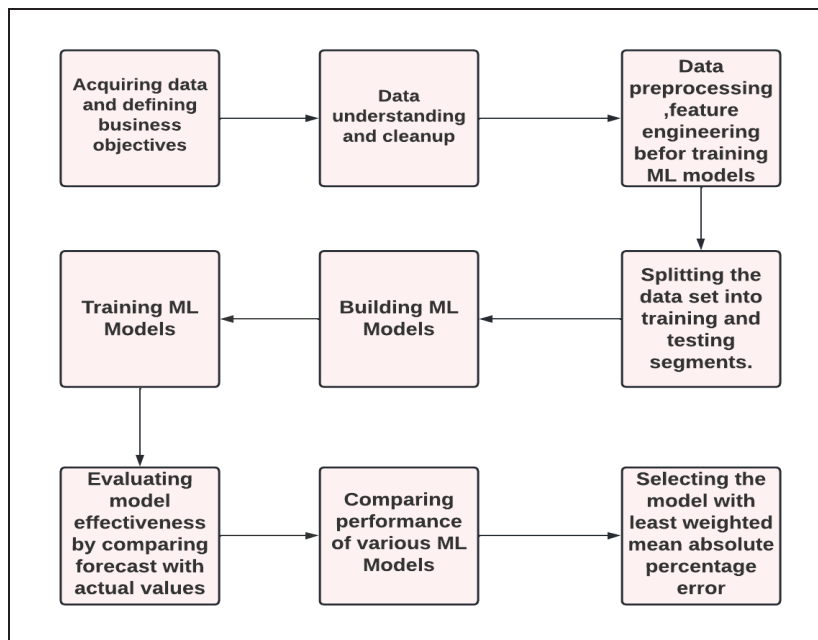


Figure 8: The machine learning forecasting process

4.2 Crucial Elements And Trends In Demand Forecasting In 2022

During challenging economic times, many companies are paying attention to forecasts and internal processes, making them more efficient and observing that they can achieve more with limited resources provided by the enterprise. To make the forecasts very accurate, the following factors and current trends needs to be considered:

Appropriate Product History

Historic data is typically used as a standard for predicting future data or trends. Therefore, the data of products or commodities which were sold in the past is an indicator of what can be sold in the future. The entire data is not equally useful in creating demand forecasts. Retrieving historical data for periods that are too old to correlate with today's requirements will result in inaccurate predictions. The same erroneous situation occurs if enough data is not used to create the forecast, so it's important to have the right amount of historical data.

To get the most reliable forecasts, demand-based data should be used instead of using sales-based data. The disparity between the sales data and the demand data is that, in sales the data shows how much sales were made in a particular time period, and the demand data shows how much sales were made or the true opportunity in the market. A good example of this is the loss of sales when there were no products in stock.

Internal trends

These are consumption trends which are based on historical data. Internal trends reflect one or another sales pattern of a product or product group. The right method and model of forecasting our sales pattern needs to be chosen.

It is also very important to understand which parts of the pattern are related. Selecting the wrong method can affect the accuracy of the forecasts, which can result in over-planning or under-planning the inventory. Depending on this, it can lead to excess inventory, frozen capital, delays in sales, out of stock, customer dissatisfaction and loss of sales.

External trends and Global Variability

The world is becoming more dependent on global factors. Government changes, assassinations, and terrorist attacks are the order of the day globally. Global markets are affected by events such as malicious software's, competition among business houses and tensions between countries. One thing is certain: what affects one area is affecting another more than ever.

External trends usually have a stronger impact on business than internal trends. Various external factors can affect the ability of a company or investment to reach its targets and goals. These external factors include competition, sociocultural, legal, changes in technology, economic and political environment.

The society greatly influences the personal values, such as the types of products the customers purchase and the services used by the customers. Therefore, cultural changes are increasing the demand for new gadgets with new technologies, clothing, food, clothing, music and even business systems. Technology has always been a big game changer, especially when it's rapidly and widely adopted. There are many examples where industry leaders have ignored the technology changes and the businesses have suffered a lot. Therefore, the historical data should be ignored sometimes and instead depend on common sense and expert advice to make manual adjustments in demand forecasting.

Events and Promotions

Various events and promotions tend to have a big influence on future demand for the products. It is certain that when the products are promoted, there will be an increase in sales.

Even in the general case of launching a new product or replacing an old product with a "new product", it is important to make good forecast. Obviously, holidays and calendar events also have a big impact on sales and marketing. Products on Deepavali, Black Friday, or Christmas may sell more for one day than for the usual 30 days. Calendar events should be planned out very carefully and as accurately as possible.

Triple P: People, Planet and Profit Requirements

In addition to managing sound sales and profit figures, companies around the world reduce carbon dioxide emissions and cater to the rights of people above and below the value chain. Businesses need to do good in the community and think about the welfare of its employees rather than just being focused on making profits.

Public opinion can quickly become negative or can be against the products causing pollution, disrespect for workers' rights, or value chains that have adverse effects on the community and globe. Due to these reasons the demand can plummet quickly and unexpectedly.

Ideological leaders in business and sustainability promote that the value chain viewpoint needs to shift from a linear "value chain" to a more cyclical "value cycle". This value cycle is focused on reducing or eliminating waste as much as possible.

Holistic, Cross-Functional Demand Planning

For many companies, requirements planning is still too isolated. Many times, the demand planning teams focuses only on processing department numbers. In all aspects of their organization the demand planners must consider themselves as strategic business partners. It is essential to decompose the information available from small groups created by using excel

and point solutions in the department. All corporate teams and divisions have to run their business on the same data and information. The common goal should be horizontally deployed across all functions. This can be achieved through latest technologies and common business processes.

Crunching the Numbers: Outgrowing Excel

Big data, predictive analytics, and AI are recent buzzwords and but there is no doubt that data-driven companies are establishing and expanding their place and position in the market. If any organization has a solid foundation in terms of people, processes, and tools, the company's demand planning capabilities should leverage big data.

Simple, often scattered sets of spreadsheets are no longer sufficient. The tools which are available for the forecasting function should be modified and enhanced. Selection and implementation should ideally be organic and step-by-step.

Zealous, 360-Degree Sensing Demand Planning

The supply chain has conventionally been receptive rather than proactive. In today's market, the supply chain's ability to adapt to changing demand is much more complex than responding to implied or accurate order dates. Due to fluctuations in demand, the reactive model fails. And in most industries the likelihood of such uncertainties is increasing.

5. RESULTS AND DISCUSSIONS

Machine Learning demand forecasting methods are suitable for business applications where the model has to learn from data having a lot of features. In such cases, ML forecasting techniques perform better with a great degree of precision. Forecasting by statistical methods or traditional methods is more suitable for business applications having lesser degree of parameters.

No forecasting model guarantees but use of the correct method which helps a great deal in providing insight of the future requirements. We should look into the following parameters to select the correct forecasting methods for our business: Right selection of forecasting model is critical to business profitability. The following should be considered:

- ***Data***

If sufficient data is available, quantitative forecasting models should be used. Qualitative forecasting techniques should be used in applications where enough data is not available.

- ***Forecasting accuracy***

The selection of the demand forecasting method depends on the degree of accuracy required. Some applications require only a rough estimate while others require forecasting which have a higher accuracy. Predictions which have a higher degree of accuracy are costly involving huge amount of data collection and expensive computational requirement.

- ***Duration of forecast***

Some forecasting techniques are best suited for short-term requirement while others are more suitable for long term requirement. Selecting the right model is important considering the duration of the forecast period.

- **Optimization of inventory level and optimization of cash flow.**

Here, multiple forecasting methods should be considered. Average of these predictions will provide a great degree of accuracy.

- **Number of products an organization is offering.**

For a large spectrum of products or services, simple techniques such as exponential smoothing may be used. In case of only one or two key products, it will be fruitful to apply more complex and time-consuming forecast for each product.

6. CONCLUSION

Business cannot run without demand of products in the market. A deep knowledge and comprehension of demand pattern is essential for making correct decisions about investment, quantity of production, staffing, procurement and more. Prediction of demand can never be hundred percent accurate. However, we can formulate plans to cut down production time, improve operation efficiencies, reduce expenditure, introduce new products in market and provide delightful customer experience. With proper understanding of the strengths and limitations of the demand forecasting tools available, management can forecast the demand correctly and use the results confidentially for business growth. A rich blend of forecasting tools and experience is required. This will result in corporates making informed decisions about inventory planning and supply chain optimization. Customer requirements and expectations are changing rapidly. The correct tools and methods should be used to accurately predict demand.

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Plant Extracts: Alternative Stains for Mitotic Chromosomes of Onion

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Abstract - The study aimed to determine the effectivity of plant extracts (mangosteen, mayana and red sweet potato) as an alternative stain for the mitotic chromosomes of onion. Experimental method was used in the study, it started with harvesting fresh root tips, then fixation for 2 days using farmers fluid, then incubation for 15 minutes with 45% acetic acid for 60 degrees, then washed with distilled water, dehydrated with absolute alcohol, cleared using a clove oil, and staining the specimens with different plant extracts (mangosteen, mayana and red sweet potato) including the control (acetocarmine) followed by squashing for microscopic observation (Amoroso, 1994). Basically, there were 4 treatments, each treatment has 5 replications, and these specimens were rated by 20 research participants. Staining properties which includes staining capacity, staining stability and shelf life were evaluated. The statistical treatment performed in this study was Kruskal-Wallis Test and Analysis of Variance (ANOVA) to determine which treatment means significantly differ from each other. Using the results of the study, the three (3) different plant extracts showed great effects because all the parameters presented a significant difference, however, it revealed that mangosteen plant extract showed the highest effect among all parameters. The plant extract from the fruit peel of the mangosteen contained tannin and anthocyanin which is popularly known and used as a natural colorant.

Keywords: *Plant extracts; Alternative stains; Mitotic chromosomes; Mangosteen; Mayana; Red sweet potato*

I. INTRODUCTION

Laboratory activities have been suggested to have rich benefits in learning, it was given a central distinctive role in Science Education. The productiveness of Science teaching requires not only the teacher's knowledge, skills and attitude but also includes the completeness of instruments and chemicals that are available in the laboratory.

According to a global news article on UChicago-led study, students who undergo experiments or experience different scientific concepts themselves, are able to comprehend concepts more deeply, since students will be able to have a first-hand experience of an experiment, it creates a life-long learning (Ingmire, 2015).

Basic activities/lessons in a Science class may involve, studying of cells and tissues and this may require the use of microscope and staining. Specimens such as cells needs to be stained and fixed to increase the perceptibility and highlight its features and structures (Adeyemo, et. al, 2017).

Staining is a technique used by many scientists, in the field of microscopy to enhance contrast in the microscopic image. It allows better visualization of the specimens with the use of microscope. In making spores, plant and animal tissues visible, the use of certain stains is a must. Stains are generally used to add colors making a specimen more visible to the naked eye. Mostly, stains that we have in the market today are chemically synthesized from cheap petroleum sources, unfortunately these may cause skin allergies and can undeniably harm our environment. Thus the use of non-allergic, non-toxic, eco-friendly stains has become a matter of significant importance (Deepaki, Deepali & Lalita, 2014).

In this peak of technological expansion and advancement, many people would rather use natural and organic substances if given a chance to pick over commercial and chemically

synthesized substances (Bondoc, 2018). Natural herbal dyes used in staining specimens such as microorganisms are found out to be extracted from the different parts of a plant, such as the fruits, leaves, flower, stem, stem bark or fruit skins (Akinloye, et.al, 2010).

Plant extracts or stains such as from mangosteen (*Garcinia mangostana*), mayana (*Coleus blumei*) and red sweet potato (*Ipomea batatas*), might be one of the alternative sources of stains because of its pigments. Pigments from the plants when oxidized may be able to use as suitable alternative for staining certain specimens (Adeyemo, et. al, 2017).

The above mentioned plant extracts are chosen since they contain anthocyanins with them. Anthocyanins are an important group of water-soluble plant pigments commonly found in various fruits and vegetables (Aishah, et. al, 2012). Anthocyanin is stable to light, that specimens with this, are stable to light, and can be stored in a long time and still be viable (Arellano, et al, 2013).

The interest arises due to the pigments wide range of attractive color spectrum from pink, red, purple and blue that has a great potential for use as natural plant and animal tissues colorant to replace expensive synthetic dyes. More so, the procedure in making alternative stains is simple, cheap, and materials are readily available for the students. In addition to that, these natural plant extracts are found to be non-toxic, biodegradable and eco-friendly (Adeyemo, et. al, 2017).

II. METHODOLOGY

This study used the quantitative type of method using experimental design to find out what plant extract can be used as an alternative stain for the mitotic chromosomes of Onion (*Allium cepa*). Quantitative methods highlight objective measurements and statistical, mathematical or numerical

analysis of data collected. Its focal point is gathering numerical data and generalizing it across groups of people or to explain a particular case (Babbie, 2010). The experimental research design was used to prove the queries if the plant extracts of mangosten (*Garcinia mangostana*), mayana (*Coleus blumei*) and red sweet potato (*Ipomea batatas*) will be able to stain the mitotic chromosomes of Onion (*Allium cepa*). The researcher thinks that this is the most appropriate design because as stated by SAS (2005) experimental design is the process of planning a study to meet specified objectives. Planning an experiment properly is incredibly vital so as to ensure that the right type of data and a sufficient sample size and power are available to answer the research questions of interest as clearly and efficiently as possible.

There were four (4) treatments prepared: acetocarmine (control), mangosteen (Treatment 1), mayana (Treatment 2), red sweet potato (Treatment 3), with five (5) replications for each, yielding a total of twenty (20) glass slides with the specimens. Moreover, there were twenty (20) microscopes used in the study. Each plant extracts were prepared differently to obtain the extracts that were used as an alternative stain for the mitotic chromosomes of Onion (*Allium cepa*).



Staining Setting of the Specimens

To determine the ability of the alternative stains staining capacity, staining stability and shelf life. A rating scale was used, it records the judgment or opinions and indicates the degree or amount of different degrees of quality.

| STAINING CAPACITY | | | | |
|-------------------|----------------|------------------------------------------------------------------------------------------------------|-----------------|--|
| Scale | Interpretation | Description | Picture (Basis) | |
| | | | LFO RFO | |
| 4 | Very strong | The stain used in the specimen presented very clear mitotic chromosomes of the onion root tip. | | |
| 3 | Strong | The stain used in the specimen presented a clear mitotic chromosomes of the onion root tip. | | |
| 2 | Light | The stain used in the specimen presented a slightly clear mitotic chromosomes of the onion root tip. | | |
| 1 | Very Light | The stain used in the specimen presented an unclear mitotic chromosomes of the onion root tip. | | |

Sample Rating Scale – Staining Stability

In determining the average responses of the respondents on the staining capacity and stability of the stains, arithmetic mean statistical tool was used. In determining the significant difference on the biological staining properties of each

treatment with regard to staining capacity, stability and acceptability of mitotic chromosomes of Onion (*Allium cepa*) the Kruskal-Wallis Test was used.

III. RESULTS AND DISCUSSION

The significant findings of the study, analysis and interpretation of data gathered to elucidate the effects of the use of different plant extracts as an alternative stain for the mitotic chromosomes of Onion (*Allium cepa*).

Table 1. Staining capacity of plant extracts on the mitotic chromosomes of onion root tip (including control)

| Plant Extracts | Rated by 20 Raters in the Average of 5 Replicates* | |
|---------------------------------------|----------------------------------------------------|--------------------------------------------------------------------------------------------------|
| | Over-all Rating | Description |
| 1. Control (T ₀) | 3.9 | - The stain used in the specimen presented very clear mitotic chromosomes on the onion tip |
| 2. Mangosteen (T ₁) | 3.3 | - The stain used in the specimen presented a clear mitotic chromosomes of the onion tip |
| 3. Mayana (T ₂) | 2.4 | - The stain used in the specimen presented a slightly clear mitotic chromosomes of the onion tip |
| 4. Red Sweet Potato (T ₃) | 2.8 | - The stain used in the specimen presented a clear mitotic chromosomes of the onion tip |

*See Appendix C for the numerical values

Table 1 shows the average results of the staining capacity of plant extracts on the mitotic chromosomes of onion root tips as rated by 20 raters for 5 replications. The over-all average rating of plant extracts (mangosteen, mayana, red sweet potato) and with the control which is the acetocarmine is shown in the Table 1, the highest over-all rating in the plant extracts is the T₁ (mangosteen) with the average staining capacity rating of 3.3 that indicates that the stain presented a clear mitotic chromosomes. Results also showed that T₃ (Red Sweet Potato) has the average staining capacity rating of 2.8 that indicates that the stain presented a clear mitotic chromosomes. The results also indicated that the lowest over-all staining capacity rating was T₂ (mayana) with average rating of 2.4 that indicates that the stain presented a slightly clear mitotic chromosomes.

Table 2. Staining stability of plant extracts on the mitotic chromosomes of onion root tip (including control)

| Plant Extracts | Rated by 20 Raters in the Average of 5 Replicates* | |
|---------------------------------------|----------------------------------------------------|-----------------------------------------------------------------------------------------------------------|
| | Over-all Rating | Description |
| 1. Control (T ₀) | 4.0 (Very Stable) | - The stain used in the specimen presented very stable mitotic chromosomes after 10 or more observations. |
| 2. Mangosteen (T ₁) | 3.0 (Stable) | - The stain used in the specimen presented very stable mitotic chromosomes after 7-9 observations. |
| 3. Mayana (T ₂) | 1.0 (Not Stable) | - The stain used in the specimen presented very stable mitotic chromosomes within 3 observations. |
| 4. Red Sweet Potato (T ₃) | 1.5 (Less Stable) | - The stain used in the specimen presented very stable mitotic chromosomes after 4-6 observations. |

*See Appendix C for the numerical values

Table 2 shows the results of the staining stability of plant extracts (mangosteen, mayana, red sweet potato) on the mitotic chromosomes of onion root tips as rated by 20 raters for 5 replications the table also includes the control

(acetocarmine). For the staining stability, the highest over-all rating in the plant extracts is T₁ (mangosteen) with the average staining stability of 3.0 that indicates that the stain used in the specimen presented very stable mitotic chromosomes after 7-9 observations. Followed by T₃ (red sweet potato) with the average staining stability of 1.5 that indicates that the stain used in the specimen presented very stable mitotic chromosomes after 4-6 observations and the last is T₂ (mayana) with an average staining stability rating of 1.0 that showed that the stain used presented a very stable mitotic chromosomes within 3 observations.

Table 3. Shelf life of plant extracts on the mitotic chromosomes of onion root tip (including control)

| Plant Extracts | Rated by 20 Raters in the Average of 5 Replicates* | |
|---------------------------------------|----------------------------------------------------|-----------------------------------------------------------------------------------------------|
| | Average Number of Days | Description |
| 1. Control (T ₀) | 30.0 | - The stain used in the specimen presented very stable mitotic chromosomes within 30 days. |
| 2. Mangosteen (T ₁) | 25.3 | - The stain used in the specimen presented very stable mitotic chromosomes within 21-27 days. |
| 3. Mayana (T ₂) | 6.8 | - The stain used in the specimen presented very stable mitotic chromosomes within 9 days. |
| 4. Red Sweet Potato (T ₃) | 10.5 | - The stain used in the specimen presented very stable mitotic chromosomes within 12-18 days. |

*See Appendix C for the numerical values

Table 3 shows the results of the shelf life of plant extracts (mangosteen, mayana, red sweet potato) on the mitotic chromosomes of onion root tips, in which it consist of 10 observations in 30 days. The highest shelf life in the plant extracts is T₁ (mangosteen) with the average of 25.3 days followed by T₃ (red sweet potato) with the average of 10.5 days and last is T₂ (mayana) with an average shelf life of 6.8 days.

Table 4. Test of significant difference of the effects of the different plant extracts including control on the following staining properties

| Staining Properties | Test Statistics | Probability Value | Decision of the Hypothesis | Interpretation |
|-----------------------|--------------------|-------------------|----------------------------|----------------|
| 1. Staining Capacity | H Value = 54.232 | 0.000 | Accept | Significant |
| 2. Staining Stability | H Value = 74.949 | 0.000 | Accept | Significant |
| 3. Shelf Life | F Value = 7717.313 | 0.000 | Accept | Significant |

*See Appendices D.1, D.2, and E for the SPSS Output

Table 4 shows that by using the different plant extracts (mangosteen, mayana and red sweet potato) there is a significant difference in terms of staining capacity, staining stability and shelf life. Based on the test statistics of staining capacity, the H value is 54.232 with a probability of 0.000 that indicated that it is significant. The staining stability also has 74.949 H value which also has a probability value of 0.000

that states that it is significant. Shelf life test statistics resulted to an F value of 7727.313 with a probability value of 0.000 which indicates that it is significant.

Table 5. Post hoc analysis in Kruskal-Wallis test for the significant difference of the effects of the different plant extracts in staining capacity

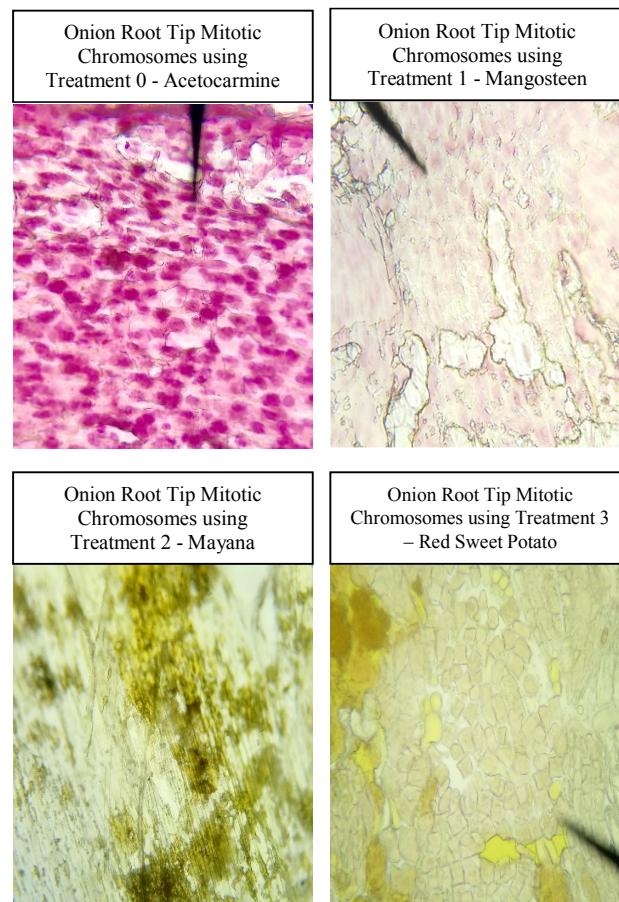
| Treatment | Mean Rank | Significance* |
|----------------|-----------|---------------|
| T ₀ | 68.48 (a) | a b, a c, a d |
| T ₁ | 46.36 (b) | b a, b c |
| T ₂ | 18.10 (c) | c b, c a |
| T ₃ | 29.05 (d) | d a |

* Mean rank having paired letter designation is significantly different from each other

**See Appendix D.1 for the SPSS Kruskal-Wallis Output

Table 5 shows the Post hoc analysis in Kruskal Wallis test for the significant difference of the effects of the different plant extracts in staining capacity, T₀ (acetocarmine) has a mean of 68.48 (a) which is significantly different with T₁ (mangosteen), T₂ (mayana) and T₃ (red sweet potato).

It also reveals that T₁ (mangosteen) has a mean of 46.36 (b) is significantly different from T₀ (acetocarmine) and T₂ (mayana). The T₂ (mayana) has a mean of 18.10 (c) is significantly from T₁ (mangosteen) and T₀ (acetocarmine). The T₃ (red sweet potato) has a mean of 29.05 (d) is significantly different from T₀ (acetocarmine).



Based on the result of the post-hoc analysis in Kruskal-Wallis test for staining capacity, the best chemical used is the control, but in terms of the specific plant extracts being studied, the best alternative stain was Mangosteen (T₁). Tannin and anthocyanin has been commonly known to be one of the components of the mangosteen fruit peel/pericarp, this has been considered and used by Asians as a natural colorant (Lanny, 2012).

Table 6. Post hoc analysis in Kruskal-Wallis test for the significant difference of the effects of the different plant extracts in staining stability

| Treatment | Mean Rank | Significance* |
|----------------|-----------|---------------|
| T ₀ | 70.50 (a) | a c, a d, a b |
| T ₁ | 50.50 (b) | b c, b d, b a |
| T ₂ | 15.50 (c) | c b, c a |
| T ₃ | 25.50 (d) | d b, d a |

* Mean rank having paired letter designation is significantly different from each other

**See Appendix D.2 for the SPSS Kruskal-Wallis Output)

Table 6 shows the Post hoc analysis in Kruskal Wallis test for the significant difference of the effects of the different plant extracts in staining stability, T₀ (acetocarmine) has a mean of 70.50 (a) is significantly different with T₁ (mangosteen), with T₂ (mayana) and T₃ (red sweet potato).

It also reveals that T₁ (mangosteen) has a mean of 50.50 (b) is significantly different from T₀ (acetocarmine), with T₂ (mayana), and T₃ (red sweet potato). The T₂ (mayana) has a mean of 15.50 (c) is significantly from T₁ (mangosteen) and T₀ (acetocarmine). While, T₃ (red sweet potato) is not significantly different from T₁ (mangosteen) and T₂ (mayana).

Based on the result of the post-hoc analysis in Kruskal-Wallis test on the staining stability, the best extract that was used is T₀ (acetocarmine) which is the control, it has a different stability with the next plant extract which is T₁ (mangosteen). T₂ (mayana) and T₃ (red sweet potato) has the same staining stability which is lower than T₁. But in terms of the specific plant extracts being studied, the best alternative stain was Mangosteen (T₁). One of the reasons why this plant extract is most effective is that a mangosteens' pericarp usually contains anthocyanins and tannin these components has been known to mankind as a natural colorant that can provide a long lasting stain (Lanny, 2012).

Table 6.2. Post hoc analysis using Duncan multiple range test (DMRT) for the significant difference of the effects of the different plant extracts in shelf life

| Treatment | Mean | Significance* |
|----------------|-----------|---------------|
| T ₀ | 30.00 (a) | a b, a c, a d |
| T ₁ | 25.30 (b) | b a, b d, b c |
| T ₂ | 6.75 (c) | c d, c b, c a |
| T ₃ | 10.50 (d) | d c, d b, d a |

* Means having paired letter designation is significantly different from each other

**See Appendix E for the SPSS DMRT Output

Table 6.2 shows the Post hoc analysis using Duncan Multiple Range Test (DMRT) for the significant difference of the effects of the different plant extracts in shelf life, T₀ (acetocarmine) has a mean of 30.00 (a) is significantly different with T₁ (mangosteen), with T₂ (mayana) and T₃ (red sweet potato).

It also reveals that T₁ (mangosteen) has a mean of 25.30 (b) is significantly different from T₀ (acetocarmine), with T₂ (mayana), and T₃ (red sweet potato). The T₂ (mayana) has a mean of 6.75 (c) is significantly from T₁ (mangosteen), with T₀ (acetocarmine) and T₃ (red sweet potato). The T₃ (red sweet potato) has a mean of 10.50 (d) is significantly different from T₀ (acetocarmine), with T₁ (mangosteen) and T₂ (mayana).

Based on the post hoc analysis of the different plant extracts based on the shelf life, T₀ (acetocarmine), T₁ (mangosteen), T₂ (mayana), and T₃ (red sweet potato) are all different from one another, but the best extract with highest shelf life is T₁ (mangosteen). Mangosteen plant extract is obtained from the pericarp of the plant, in which the pericarps contains pigments such as tannin and anthocyanins that is widely known and used as a natural dye (Lanny, 2012).

IV. CONCLUSIONS

With paramount consideration to the foregoing findings of the study, this research study finally inferred that the levels of biological staining properties of mangosteen, mayana and red sweet potato showed considerable effects on the mitotic chromosomes of the Onion root tip as rated by 20 raters.

Moreover, using the Kruskal Wallis Test for staining capacity and staining stability, it revealed that there is a significant difference on the biological staining properties of mangosteen, mayana and red sweet potato plant extracts on the mitotic chromosomes of Onion (*Allium cepa*). For the shelf life, after 30 days of observation the Analysis of Variance (ANOVA) showed that there is also a significant difference on the biological staining properties of the different plant extracts (mangosteen, mayana and red sweet potato) used on the mitotic chromosomes of Onion (*Allium cepa*). Finally, based on the post hoc analysis, the plant extract that showed the greatest biological staining property on the mitotic chromosomes of Onion (*Allium cepa*) is mangosteen (Treatment 1), it showed that on the results it has the greatest average among the three variables based on the three parameters: staining capacity, staining stability and shelf life.

Based on the strength of the findings on the biological staining property of different plant extracts (mangosteen, mayana, red sweet potato) on the mitotic chromosomes of Onion (*Allium cepa*), it revealed that the different plant extracts (T₁, T₂, T₃) including the control (acetocarmine) significantly stained and showed the mitotic chromosomes of Onion in terms of its staining capacity, staining stability and shelf life. The findings also on the different plant extracts appears that (T₁, T₂, T₃) resulted in a significant difference in terms of its staining capacity, staining stability and shelf life. It implies that it can benefit the students in rural areas, who do not have available chemicals in their school. Using the

results of the study, it gives awareness of utilizing alternative stains aside from the chemicals that may cause environmental problems which are also expensive, with these plant extracts, they can be able to experience activities without spending much money.

V. ACKNOWLEDGMENTS

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Boundary Objects for Value Co-Creation in Digital Education

Arja-Tuulikki Malin

Abstract— Background: The background of this presentation is a case study in Finnish virtual education. The Finnish University of Applied Sciences has provided master's degree programs in management, which are completed for 100 % online. Studies include topics like strategic management, management of service processes, and customer relations. In virtual classrooms, students participate in various collaborative learning activities, lectures and complete learning tasks. The central developmental question in online management education is, how education may promote value creation both to management students and their employers? Previous studies have revealed that there is a gap between provided teaching and work-life learning environments. There seems to be quite a weak interplay between educational and work-life objectives. Aim of the project: This paper presents a model for value co-creation in digital education. The model is based on a case study, which developed different types of work-life-based learning tasks into virtual courses on management. Theoretically, this novel model for promoting better results in virtual education is based on two main concepts – value-co-creation [1; 2] in learning ecosystems [3], which has promoted promising results in health service development. In this study, work-life-related learning tasks in virtual education have been conceptualized as boundary objects [4], which emphasized the importance of boundary work [5] between different social worlds (education, students, work-life). In this presentation, the main focus is on the theoretical basis for developing online education. Results: The model was applied in a case study in Finnish virtual education on management studies. The preliminary results suggest that the presented model may promote value co-creation through boundary work in management education. Discussion: There is a need to develop theoretical models for developing digital education. Implications to teachers' education [6] are also discussed.

Keywords— value co-creation, boundary object, boundary work, management education, virtual education.

Peculiar Spectral Evolution of the Type I Supernova 2019eix: A Possible Double Detonation from a Helium Shell on a Sub-Chandrasekhar-mass White Dwarf

E. Padilla Gonzalez, D. Andrew Howell, J. Burke, Y. Dong, D. Hiramatsu, C. McCully, C. Pellegrino, W. Kerzendorf, M. Modjaz, M. Williamson

Abstract— We present photometric and spectroscopic data for the nearby Type I supernova (SN) 2019eix (originally classified as a SN Ic), from its discovery day up to 100 days after maximum brightness. Before maximum light SN 2019eix resembles a typical SN Ic, albeit lacking the usual O I feature. Its lightcurve is similar to the typical SN Ic with decline rates of ($\Delta M_{15,B} = 1.2$) and absolute magnitude of $M_B = -17.3$. However, after maximum light this SN has unusual spectroscopic features, a large degree of line blending, significant line blanketing in the blue ($\lambda < 5000\text{\AA}$), and strong Ca II absorption features during and after peak brightness. These unusual spectral features are similar to models of sub-luminous thermonuclear explosions, specifically double-detonation models of SNe Ia. Photometrically SN 2019eix appears to be somewhat brighter with slower decline rates than other double detonation candidates. We modeled the spectra using the radiative transfer code TARDIS using SN 1994I (a SN Ic) as a base model to see whether we could reproduce the unusual features of SN 2019eix and found them to be consistent with the exception of the O I feature. We also compared SN 2019eix with double detonation models and found them to match the observations of SN 2019eix best, but failed to reproduce its full photometric and spectroscopic evolution.

Keywords—Supernova, double detonation, white dwarf, SN 2019eix.

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Religious Reform and Secularism

Djehich Mohamed Yousri

Abstract— Religious Reform and Secularism present the title of the research paper (Religious Reform and Secularism) is the subject of this research paper. The researcher proceeded to address it through three main axes, in addition to an introduction and a conclusion that indicated the most important results of the study. Where the first axis dealt with the concept of the secular, while the second axis dealt with religious reform, and we devoted the third axis to discussing the relationship between them. It is a treatment that requires the researcher, at the level of methodology, to critically rethink the concepts of (religious) and (secular), and accompany the radical revisions that have been made in the field of (post-secular) studies in this regard. The paper concluded that caution should be exercised in dealing with the terms "religious reform" and "secularism". There are different and diverse viewpoints on (religious reform) and on (secularism) as well, and therefore it is wrong, according to the perspective of the paper, to deal with either of them as representing one comprehensive, homogeneous, closed and semantically stable category.) or (secularism) with a set of diverse and divergent points of view from each other, a path that ultimately leads to confusion, confusion, ambiguity and misunderstanding.

Keywords— secularism, post-secularism, religious reform, concept of religion, the concept of secularism.

International Protection Mechanisms for Refugees

Djehich Mohamed Yousri

Abstract— In recent years, the world has witnessed a phenomenon of displacement that is unprecedented in history. The number of refugees has reached record levels, due to wars, persecution, many conflicts and repression in a number of countries. The interest of United Nations bodies and international and regional organizations in the issue of refugees has increased, as they have defined a refugee and thus Determining who is entitled to this legal protection, and the 1951 Convention for the Protection of Refugees defines rights for refugee protection and sets obligations that they must perform. The institutional mechanisms for refugee protection are represented in the various agencies that take care of refugee affairs. At the forefront of these agencies is the United Nations High Commissioner for Refugees, as well as the various efforts provided by the International Committee of the Red Cross and the United Nations Relief and Works Agency for Palestine Refugees in the Middle East (UNRWA).

Keywords— protection, refugees, international, persecution, legal.

Biotech Processes to Recover Valuable Fraction from Buffalo Whey Usable in Probiotic Growth, Cosmeceutical, Nutraceutical and Food Industries

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Abstract

The main objective of this study regards the setup of an efficient small-scale platform for the conversion of local renewable waste materials, such as whey, into added-value products, thereby reducing environmental impact and costs deriving from the disposal of processing waste products. The buffalo milk whey derived from the cheese-making process, called second cheese whey, is the main by-product of dairy industry. Whey is the main and most polluting by-product obtained from cheese manufacturing consisting of lactose, lactic acid, proteins and salts, making whey an added-value product. In Italy, and in particular in Campania region, soft cheese production need to a large volumes of liquid waste, specially during late spring and summer. This project is part of a circular economy perspective focused on the conversion of a potentially polluting and difficult to purify waste into a resource to be exploited, and it embodies the concept of the three “R”: reduce, recycle and reuse. Special focus was paid to the production of health-promoting biomolecules and biopolymers, which may be exploited in different segments of food and pharmaceutical industries. These biomolecules may be recovered through appropriate processes and re-used in the attempt to obtain added value products. So, ultrafiltration and nanofiltration processes were performed to fractionate bioactive components starting from buffalo milk whey. In this direction, the present study focused on the implementation of a downstream process that converts waste generated from food and food processing industries into added value products with potential applications. Owing to innovative downstream and biotechnological processes, rather than a waste product may be considered a resource to obtain high added value products, as food supplements (probiotics), cosmeceuticals, biopolymers and recyclable purified water. Besides targeting gastrointestinal disorders probiotics such as Lactobacilli have been reported to improve immunomodulation and protection of the host against infections caused by viral and bacterial pathogens. Interestingly, also inactivated microbial (probiotic) cells and their metabolic products, indicated as parabiotics and postbiotics, respectively, have a crucial role and act as mediators in the modulation of the host's immune function. To boost the production of biomass (both viable and/or heat inactivated cells) and/or the synthesis of growth-related postbiotics, such as EPS, efficient and sustainable fermentation processes are necessary. Based on a “zero-waste” approach, wastes generated from local industries can be recovered and recycled to develop sustainable biotechnological processes to obtain probiotics as well as post and parabiotics, to be tested as bioactive compounds against gastro-intestinal disorders. The results shown it was possible to recover an ultrafiltration retentate with suitable characteristics to be used in skin dehydration, to perform films (i.e. packaging for food industries) or as wound repair agent and a nanofiltration retentate to recover lactic acid and carbon sources (eg. lactose, glucose..) used for microbial cultivation. On the side the last goal is to obtain purified water that can be reused throughout the process. In fact, water reclamation and reuse provide a unique and viable opportunity to augment traditional water supplies, a key issue nowadays.

Keywords: Biotech process, downstream process, probiotic growth, from waste to product, buffalo whey.

Production of Biotechnological Chondroitin from Recombinant E. coli K4 Strains on Renewable Substrates

Donatella Cimini, Sergio D'ambrosio, Saba Sadiq, Chiara Schiraldi

Abstract— Chondroitin sulfate (CS), as well as modified CS, and unsulfated chondroitin, are largely applied in research today. CS is a linear glycosaminoglycan normally present in cartilage-rich tissues and bones in the form of proteoglycans decorated with sulfate groups in different positions. CS is used as an effective non-pharmacological alternative for the treatment of osteoarthritis, and other potential applications in the biomedical field are being investigated. Some bacteria, such as E. coli K4, produce a polysaccharide that is a precursor of CS (unsulfated chondroitin). This work focused on the construction of integrative E. coli K4 recombinant strains overexpressing genes (kfoA, kfoF, pgm and galU in different combinations) involved in the biosynthesis of the nucleotide sugars necessary for polysaccharide synthesis. Strain growth and polymer production were evaluated using renewable waste materials as substrates in shake flasks and small-scale batch fermentation processes. Results demonstrated the potential to replace pure sugars with cheaper medium components to establish environmentally sustainable and cost-effective production routes for potential industrial development. In fact, although excellent fermentation results have been described so far by employing strains that naturally produce chondroitin-like polysaccharides on semi-defined media, there is still the need to reduce manufacturing costs by providing a cost-effective biotechnological alternative to currently used animal-based extraction procedures.

Keywords— E. coli K4, chondroitin, microbial cell factories, glycosaminoglycans, renewable resources.

An Overview of Corporate Social Responsibility in India and the United Kingdom - A Comparative Study

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Abstract

The term "Corporate Social Responsibility" refers to the responsibility of both private and public companies, as well as their attention to social and environmental issues. Corporate Social Responsibility has a significant impact in today's world and is practised by many Indian businesses. Corporate Social Responsibility has balanced its relationship with society in general and its financial resources through strong policies. The concept of social responsibility could be defined as improving the neighbourhood as a whole. Following an amendment to the Companies Act, 2013, in April 2014, India became the first country in the world to make Corporate Social Responsibility mandatory. Both India and the United Kingdom have worked on the concept of Corporate Social Responsibility, but their approaches to this field differ. This demonstrates that India follows a "Mandatory" strategy for Corporate Social Responsibility expenditure, as opposed to the UK, which follows a "Voluntary" strategy. The author is attempting to demonstrate the concept of Corporate Social Responsibility in both countries using secondary resources as part of the research methodology. The goal of this research paper is to gain a better understanding of Corporate Social Responsibility operations in India and the United Kingdom, as well as how organisations in both countries are pursuing it. We will gain a deeper understanding of the important factors that are most likely to have an impact on organisational decisions regarding social responsiveness by using a comparative study approach, as well as how the government and corporate houses are working towards and improving Corporate Social Responsibility on a daily basis.

Keywords: Corporate Social Responsibility, Strategy, India and United Kingdom, Organizations.

I. INTRODUCTION

If we look back from the middle to end of the 1800s, Corporate Social Responsibility (CSR) was visible when industrialists started to become more concerned about worker productivity and well-being. There has been a recent upswing in the acknowledgment of CSR. However, major CSR activities have evolved in management practices throughout the country in recent years.²

² Jóhannsdóttir, & Davídsdóttir, & Latapí Agudelo, M.A. (2019). A Literature Review of The History and Evolution of Corporate Social Responsibility. *International Journal Corporate Social Responsibility*.

After examining India's CSR regulations, it is evident that the nation combines traditional philanthropy and strategic projects under this framework. The United Nations (UN) has contributed significantly to the widespread acceptance of CSR initiatives. It sponsored the "Global Compact," a document that many nations have signed.

The World Business Council for Sustainable Development (WBCSD) has defined CSR as "the continuing commitment by business to contribute to economic development while improving the quality of life of the workforce and their families as well as of the community and society at large." "CSR" is also known as the "Triple-Bottom-Line Approach"³ and focuses on the three Ps: profit, people, and the environment. The "Triple-Bottom-Line Approach" to corporate social responsibility (CSR) refers to how CSR enables businesses to uphold their social obligations while also advancing their financial interests. Priority in the new era of globalisation has switched to balancing economic growth with employee welfare. Media outlets, non-governmental organisations, individuals, and governmental authorities turn to the pots to undertake sustainable business practices. CSR encompasses a wide range of conditions, such as charitable giving, addressing human rights, labour difficulties, etc., in order to undertake sustainable business practices.

However, the preparation for CSR varies from company to company.⁴ The goal of CSR is to protect and support society as a whole, and the participation of major corporations has helped to increase the value of CSR globally. CSR is now not only affecting the company's management structures, but also the economies of its business partners.

It is important to consider and comprehend the CSR initiatives that have been assigned to various corporate organisations. Corporate entities' fundamental tenet is to do business, use resources to generate benefits, and then use those advantages to promote social welfare. For this reason, it is essential to understand how the government and corporate entities are advancing CSR and improving it every day. In addition to their obligation to the community, firms have a legal and moral obligation to take care when implementing CSR practices.

The main objective of the study is to understand the Indian CSR companies and the United Kingdom based on the CSR working promotion by the government. To study whether CSR forms a part of the business framework in India as well as the United Kingdom. To look at the seriousness of the companies regarding CSR methodology and approach to make it successful.

In this research work, India and the United Kingdom were compared using a comparative analysis method. In the proposed study, the theoretical underpinnings of CSR policy and governance practices are studied. Information for this research project was gathered from the Ministry of Corporate Affairs, annual reports, sustainability reports journals, online academic journals, newspapers, and CSR legislation, policies, and journals (APA).

India, a developing nation, embraced the CSR strategy to maintain reliable and positive ties with the businesses. However, when we compare it to the UK and India, we see that both countries have chosen various strategies in an effort to have a positive effect on businesses and societies. There is a new paradigm in CSR that includes stakeholder participation and philanthropy.

³What is CSR? (2021). *United Nations Industrial Development Organization*. UNIDO.

⁴Sarwar Uddin Ahmed; Uchida, S. (2009). *Corporate Social Responsibility and Financial Performance Linkage*: Nagasaki University's Academic Output SITE.

II. SCOPE AND NEED OF CORPORATE SOCIAL RESPONSIBILITY⁵

Corporate Social Responsibility (CSR) means a company's on-going commitment to the 'profitable and social development of the communities' in which it operates. Since the pre-independence period in India, the generality of marketable social responsibility of large artificial groups has enthralled a prominent place in the lower public discourse on profitable issues.

Gandhi referred to large corporations as "trusts" of the "wealth of the people," emphasising the larger social purpose that artificial wealth should serve in independent India. Under the heavy influence of Nehruvian illiberalism in the early days of the post-independence period, the Indian state encouraged private enterprise to play an active role in the "profitable and social development of the backward sections" of society, while simultaneously establishing a massive public sector to serve larger societal interests.

As Nehru's gentle 'illiberalism' gave way to Indira Gandhi's more radical programmes of nationalisation and extensive state regulation, artificial groups desperate to avoid the draconian state programmes and regulations in profitable affairs resorted to large scale marketable wealth programmes to demonstrate that private wealth also played an important role in poverty relief and the nation's socio-profitable development.

The Rajiv Gandhi and Narashima Rao governments ended the "licence raj" and implemented significant-requested profitable reforms as a result of the upcoming economic crisis in India. This was the beginning of India's profitable liberalisation and the free-request frugality. The country's expanded presence of multinational corporations and the development of Indian businesses into significant worldwide corporations have been the main effects of these successful reforms. In this scenario, there is an increased focus on the social role of these private enterprises by both the proponents and opponents of liberalization in India.⁶ There has been a revolution in implementation of corporate social responsibility programs at the ground level⁷.

Is there any need for corporate social responsibility?

In actuality, a much larger set of objectives - currently referred to as CSR- must direct an enterprise's operations. In theory, the laws of economics, which demand a sufficient financial return on investments made, must control the interests of shareholders and the decisions of managers of any company enterprise.

A company enterprise obtains numerous benefits from society, so it must be required of the corporation to give back to society as well. This is the general justification for a new set of ethics for corporate decision-making that readily develop, create, or uphold a corporate social

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⁶Gosh J. (2003). strategy for development. No. 18. Frontline.

⁷ Goyal S.K. (1996) "Political Economy of India's economic reforms; working paper of the institute for studies in industrial development", New Delhi, India.

responsibility. If it does not the company will not be able to survive. Thus, it is simple to demonstrate the interest of a business group in the wellbeing of the society to which it belongs.

More crucially, in this era of extensive communication and increasing emphasis on transparency, customers of any good or service are unlikely to be pleased in purchasing from a company that is viewed to go against standards of what is intended to be moral and socially responsible behaviour. It is less and less evident that businesses that actually uphold the principles of socially responsible behaviour are also well-liked by the general populace and are the go-to source for their goods and services.

III. CORPORATE SOCIAL RESPONSIBILITY EVOLUTION IN THE UNITED KINGDOM

In the United Kingdom (UK), Corporate social responsibility (CSR) has developed by incorporating elements of both the American and European models. In terms of awareness and application of the CSR idea, the UK is in an advantageous position. 90%⁸ of the UK's leading corporations publish reports on social and environmental issues; 33%⁹ Despite the fact that the majority of people in the UK give social responsibility to businesses when making purchase decisions, many people are still unclear, particularly when it comes to climate change-related issues. The media has a big impact on how business conditioning is handled in the UK. Practices like hand volunteering, the biggest day of action for hand levies in the UK, etc. encourage employees of publishers to volunteer for CSR training during their regular working hours. The UK's CSR strategy, according to Fair Bass (2008), focuses on three areas: profitable, social, and environmental.

1. Measures that limit carbon emissions, save water, reduce waste, promote recycling, and safeguard biodiversity are considered environmental elements.
2. Human rights are protected by laws, and pots collaborate with other pots, to address concerns like poor wages, child labour, etc., the government, NGOs, etc.
3. Equal opportunities - The Right to Equality as per the law encourages parity in terms of age, gender, ethnicity, and other factors. Every company is required to report on the gender pay disparity under the new equivalence laws.
4. Sustainable Products and Services - Promoting green and eco-friendly products to promote environmental sustainability.

V. CORPORATE SOCIAL RESPONSIBILITY- HISTORY

⁸ Andre C. (2019). Supply Chains Cause 90% of Companies' Environmental Impacts. How Can They Be Improved? Retrieved August 5, 2022, from <https://youmatter.world/en/sustainability-supply-chain-27935/>

⁹ Financial for Sustainable Development Report (2021). IS THERE A PLACE, CITY TO INCLUDE ?

The evolution of CSR in India has been classified into four periods that have resulted in various ways to CSR being used.¹⁰ These phases run parallel to the historical development of CSR. These phases are not constant, and elements from one phase or more of these phases may appear in another phase:

The First Phase

Charity and philanthropy were the main contributors to CSR during the first phase. Rapid industrialization, family values, culture, and religion all had an impact on the development of CSR. Rich merchants-built temples for religious purposes during the Pre-Industrialization era as a way of sharing some of their riches and income with the general public.

Additionally, by providing food and money and securing a crucial place in the community, these merchants assisted society in battling pandemics and shortages. The approach to CSR underwent a transformation when social rule came to India. The artificial families of the 19th century, such as the Tata, Godrej, Birla, and others, had a strong propensity for financial and social issues. Nevertheless, their efforts to promote social as well as artificial growth were not only motivated by altruistic and religious ideals, but also by estate groupings and political ideologies.

The Second Phase

The Alternate stage saw the Independence Movement. By then, incredible uneasiness and tension built upon the Indian Entrepreneurs to impress their dedication and responsibility towards society's development and progress. This was the point at which the thought or origination of 'Trusteeship' was presented in the country by Mahatma Gandhi. As per the origin of 'trusteeship', the enormous and the fat industrialists should oversee and involve their abundance so that it could give the greatest advantages to the average person. The impact and the effect left by Gandhi made tension upon the industrialists and the organizations to make a nation where socio-productive improvement is given the top priority.

Gandhi accepted that the Indian organizations were practically equivalent to spots of exaltation, comparative as sanctuaries, and in this way, he called them the 'sanctuaries of ultramodern India'. Under his authority and direction, organizations laid out trusts for theological schools and universities and assisted with setting up a few preparation and logical foundations. The trusts considerably worked in arrangement to the changes achieved by Gandhi. These trusts sought to annul distance, energize commission of ladies, and advance a rustic turn of events.

The Third Phase

The next phase of post-independence India saw the emergence of the public sector as a decisive driver of development. The third phase involved the idea of a 'mixed economy' and laws relating to labour and environmental standards. During this period, the private sector was forced to take a back seat. PSUs have been set up by the state to ensure that wealth, food etc. are handed over and distributed equitably. In 1965, Indian scholars, politicians and

¹⁰ Saloni Gautam, Legum Vox, CSR and the phases, last accessed from <https://legumvox.in/evolution-of-corporate-social-responsibility-in-india/> on July 30, 2022.

businessmen established a public CSR factory focused on peace. They emphasized transparency, social responsibility and regular discussions with stakeholders. However, the public sector was only effective to a limited extent. This has led to a shift in expectations from the public to the private sector for their active involvement in the socially profitable development of the nation.

The Fourth Phase

In the fourth phase (1980 until the present), Indian businesses started abandoning their traditional engagement with CSR and included it right into a sustainable business strategy. In the 1990s the first inauguration toward globalization and profitable liberalization were popular. The economy was boosted by the insufficient completion of controls and licensing mechanisms, which is clearly visible now. The enlarged boom sparked by frugality allowed Indian enterprises to grow quickly, which increased their willingness. India has become a crucial location in terms of product and TNC manufacturing bases due to globalisation. Indian companies who export and transport goods for the developed world wish to pay particular attention to compliance with the transnational norms as Western demands have grown increasingly concerned about both labour and environmental standards within the developing countries.

VI. LEGAL FRAMEWORK OF CSR IN INDIA AND UK

As CSR gained popularity, some nations included some of its principles in their corporate laws and mandated that businesses adhere to them. India was the first nation to pass legislation addressing corporate social responsibility. In 2013, India updated its Companies Act to include CSR under Section 135¹¹, which mandates that all enterprises with net income must:

- The company's net value should exceed Rs. 500 crore.
- The company should have a yearly revenue of at least Rs. 1000 crore.
- The company's annual net income should be at least Rs. 5 crore.

Hence, an organization that qualifies for the above expressed net gain, that organization from the preceding three monetary times should spend something like 2 out of their normal complete pay upon CSR exercises, and the organization should frame another new commission which ought to compare the directorate who might take care of the CSR use. This newly arranged commission on CSR should have 4 new individuals from the Company's Board of Directors and under Section 135 of the Companies Act its fundamental interest for them to meet no less than two times as an opportunity to examine and gauge the “CSR conditioning”. This commission will suggest a formal CSR strategy, exercises, spending plan, how the plan will be implemented and straightforward styles for covering progress.

¹¹ Section 135 of India's Companies Act, (2013).

CSR conditioning in India is in consonance to the 7th schedule of Companies Act 2013¹² which sets down a list of conditions similar to fighting hunger, promoting healthcare and sanitation, education, women's commission, etc.

The origin of CSR advanced and arose in the British Islands in the 1800's. Albeit no comparative thing like CSR was in reality around then, there were sure managers who gave for early on day-to-day environments and government backed retirement plans to their labourers to keep the specialists fulfilled and battled, prompting their better adequacy in work. 'Under the laws and rules of UK, CSR isn't a mandatory exertion for companies, unlike India, where CSR is obligatory. In the UK, CSR is a bare voluntary exertion with no legislation made for regulating and governing it'. An organization that follows the triple nethermost line approach needs to satisfy the circumstances given under the Companies Act, 2006. This act has made it an obligation for the heads of the organizations to think about the natural and the social effects of their organizations.

As of now, there are different regulations in the UK that agree with CSR. These are – Accounts Modernisation Directive, which requires that large Public Limited Companies must intimately report the issues significant to the environment, The Working Time Regulations (2001), ¹³The Health and Safety at Work Act (1974)¹⁴ These legislations only act as guiding forces for the companies to invest in CSR conditioning, without assessing any accreditation on them to do the same. A lack of legislation calling CSR has resulted in the companies 'espousing a voluntary approach towards CSR' conditioning. The Confederation of Business Industry expressed that, UK has a wilful CSR use and the organizations put resources into CSR relying on their staff and capacity. It's accepted that the normalization of CSR standards will not be guaranteed to raise the standards of CSR use, however will rather; put a significant weight upon the little and medium position undertakings. Under the Tony Blair government, the UK was the primary country to have a pastor for 'CSR ' under the Trade and Industry Department, to advance CSR conditions in legislative divisions. This prompted a more severe guideline of CSR by the public authority. The Companies Act of 2006, has resulted in a significant transformation by diminishing the compass of the executive board that drove CSR use from lead done by the organizations simply unreservedly, to the direct performance by the organizations to address their merchandise to the general public. CSR has come publicizing or a precautionary work out. Assimilation of the merchandise of the organization has additionally reduced the compass of CSR. It has diminished the adequacy of CSR because of the absence of centre capacities to lessen their risky products. Thus, despite the fact that there's no order of regulation in the UK that approves consumption, the rules set down have reduced the compass of CSR in the UK. The Judiciary has not instructed CSR use, yet has perceived that the overseers of an organization aren't simply capable or obligated to their investors, yet additionally to any remaining partners. In the UK, CSR is the methodology embraced by organizations to add to the advancement of society. This approach is grounded on philanthropic grounds and is evaluated as a commitment upon organizations to take over CSR conditioning. A report called '**Business Social Responsibility Call For Views**'¹⁵ taken from the public authority of UK and distributed on 27th July, 2013, expressed that,

¹² Schedule 7 of India's Companies Act, (2013).

¹³ Work Time Regulations Act, (2011).

¹⁴ The Health and Safety at Work Act, (1974).

¹⁵ Good for Business & Society: government response to call for views on corporate responsibility (2014). *Department of Business Innovations and skills*.

“There’s no getting away from the way that corporate obligation has become substantially more conspicuous and complex in the last multiple times. High on the list of the UK Government's priorities is to accomplish reasonable and productive development for the nation, as well as to lay out a more grounded and a more attractive society”.

Most organizations in the UK expect to apply the universally respected standards and rules while deciding their own corporate obligation strategy. ‘CSR is viewed as a part of dependable power chain activity, where there's a deliberate responsibility made by the organizations to deal with their relationship with the providers in a capable manner’. Business obligation isn't only material on a large business, however it's a product that each business can and should get. In the UK, the general public anticipates that organizations should contribute towards ‘social speculations’ through unique productive advancement endeavors. In the UK, Public Relations and CSR remain closely connected. The public authority and general society have understood that, without relevant measures and guidelines, affiliations will benefit and flourish at the consumption of others. This has become ‘redundant in a few administrative and wilful standards’ to ensure that the pots take up and satisfy their obligations and liabilities towards the general public.

Discussing values and merits, the morals of a relationship in the UK habitually go past the legitimate circumstances and sentiments. Business morals are the activity of moral qualities to business conduct. ‘Most relationships in the UK concentrate upon the parts of business leadership, from meeting room procedures and how organizations treat their labourers and providers, to bargains ways and local area rehearsals’. CSR is each about an affiliation's methodology concerning what it's liable for and to whom it's liable, and this will be supported by its moral qualities and the endless programs set up to make those values utilitarian.

According to a MORI study done in September 2006, the majority of the British public (83 percent)¹⁶ said that a company's social responsibility is the most significant criterion when determining whether to use or acquire any product or service. The study also revealed that businesses have what is known as a "permission to work." For their business to remain active, they require society's support. Moral traits are valued highly and play a crucial role in providing the team with guidance when it's unclear what has to be done.

VII. NEW PARADIGM OF CSR

Up until the 1990s, corporate social responsibility was only thought of in terms of philanthropy or charity. Welfare initiatives or programmes were created as a type of philanthropy meant to highlight the virtues of the organisation or firm, not as a duty or responsibility. Many artificial organisations, such as the Tatas or Birlas, established charity trusts that provided financial support for a variety of deserving charities. Although there were some instances where the pot played a more active role, such as when the Birlas founded the Birla Institute of Technology in Pilani¹⁷ or when several large artificial groups established

¹⁶ The comparison of CSR in India and UK, <https://thelawbrigade.com/wp-content/uploads/2022/05/Siddharth-Rawat-ALPPR.pdf> accessed on July 30, 2022.

¹⁷ John, Peloza (n.d.). Corporate Social Responsibility as Reputation Insurance. Retrieved August 7, 2022, from

primary schools for the children of their workers, in these instances the approach was philanthropic. The issue with it is that the model is a type of social enterprise that does not feel the need for community participation in the designing or operation of similar enterprises and people participation, if any, is confined to limited perpetration aspects. The lack of involvement from the primary resource provider leads to low situations of responsibility and translucency at the perpetration position.

Still the post-liberalization phase has seen a fundamental shift from this philanthropy-based model of commercial social responsibility to a stakeholder- participation grounded model. The change is apparent in the statements about commercial social responsibility being made by India's leading artificial groups like the Tata's, "over the times, the nature of the company's involvement with the community has experienced a change. Over the past ten years, their corporate social responsibility activities have undergone a smooth transition from charity and reliance to commission and partnership. According to the stakeholder model, the community where the pot is located is considered a stakeholder in the business, and as such, it is subject to the same obligations and duties as its other stakeholders (guests, workers, shareholders). "It is a recognition of the fact that companies perform in non-financial arenas such as human rights, business ethics, environmental policies, corporate contributions, community development, corporate governance, and workplace issues and company should be held accountable for its 'triple bottom-line' that includes social, environmental, and financial performance and not just the financial aspect".¹⁸

The question at this point is, what are the reasons for the paradigm shift in corporate social responsibility in the post-liberalization era-

- Recognize the significance of "reputation capital"¹⁹ in capturing and sustaining markets. As a result, corporate social responsibility is essentially a new business strategy to reduce investment risks and maximise profits by gaining the trust of all key stakeholders.
- In order for a free-market economy to survive over the long term, "eco-social" stability—that is, social and environmental stability and sustainability—is becoming increasingly important.
- In the age of globalisation, accountability, transparency, and social and environmental investment are seen as essential components of corporate governance.

VIII. FEW COMPANIES WHO ADOPTED CSR IN INDIA

TATA Group- 'Numerous CSR systems have been and are carried out by the Tata group empire in India, utmost of which are directed towards poverty relief and community enhancement'. Through the means of tone- help groups, it has also been involved in the creation of women commission, rural community development, as well as income generation along with

https://escholarship.org/content/qt7258w42x/qt7258w42x_noSplash_da00c14828130443f9b8de0dd708e5ca.pdf

¹⁸ Amita V. Joseph. (n.d.). EFFECTIVENESS OF CORPORATE SOCIAL RESPONSIBILITY (CSR) GUIDELINES IN INDIA. Retrieved August 6, 2022, from <https://dro.deakin.edu.au/eserv/DU:30103698/joseph-effectivenessof-2017.pdf>

¹⁹ JSTOR, *Successful examples of CSR*, <https://www.jstor.org/stable/27768213>, accessed on July 30, 2022.

other social welfare programs. As far as the area of Education is concerned, the Tata group provides bents and literacy to colourful institutions. It also indulges into healthcare systems similar to spreading mindfulness about AIDS, along with the facilitation of child education and immunization.²⁰ It makes an immense contribution in furnishing profitable commissions through terrain protection programs, agricultural programs, furnishing sports literacy, structure development similar to exploration centres, hospitals, educational institutions, artistic centres, etc.

Ultra tech Cement – The largest cement company in India is engaged in social conditioning in 407 communities across the country with the goal of fostering self-reliance and sustainability. The company's CSR initiatives are primarily focused on family welfare initiatives, healthcare, infrastructure, geography, education, social welfare, sustainable livelihoods, etc.²¹ . To date, it has organised a number of medical camps, sanitation campaigns, registration drives for academies, immunisation campaigns, artificial training programmes, water conservation initiatives, and organic husbandry initiatives.

Mahindra & Mahindra²² – The K.C. Mahindra Education Trust was founded in 1954 by an Indian automobile manufacturing company, and the Mahindra Foundation was established in 1969 with the goal of advancing education. The company's primary area of interest is the educational sector. Communities that are socially and economically disadvantaged are helped and given education. It manages initiatives like Mahindra Hariyali, through which over 1 million trees have been planted throughout the nation, enhancing the country's green cover, Nanhi Kali, which focuses on education for girls, Mahindra Private Schools, which incorporates artificial training, and Lifeline Express, which provides healthcare services in rural areas. The business also supported employee stock ownership plans (ESOPs) to provide opportunities for workers to participate in social activities.

ITC Group- The ITC Group's operations span the FMCG, hotel, and agriculture sectors, among others. The ITC primarily organises environmental and livelihood protection programmes. Through its CSR activities, the company has created sustainable livelihood opportunities for approximately 6 million people. Their e-Choupal programme, which aims to connect rural farmers with the intranet for agricultural product procurement, covers approximately 4 million farmers and 40,000 villages²³. Farmers can convert wastelands into pulpwood plantations thanks to its farm and social forestry programmes. Various social empowerment programmes, such as micro-enterprises or loans, have resulted in more than 40,000 rural women gaining sustainable livelihoods.

²⁰ We dream of a better world: Tata Group and the SDGs. (n.d.). . Retrieved August 6, 2022, from <https://www.tatasustainability.com/pdfs/Highlights/WeDreamofaBetterWorld-TataGroupandTheSDGs.pdf>

²¹ Community Development. (n.d.). Ultra tech cement. Retrieved August 7, 2022, from <https://www.ultratehcement.com/about-us/sustainability/community-development>

²² in India. (n.d.). . Retrieved August 7, 2022, from <https://indiafreenotes.com/corporate-social-responsibility-csr-in-india/>

²³ ITC Portal . (n.d.). <https://www.itcportal.com/businesses/agri-business/e-choupal.aspx>

Reliance diligence Initiated²⁴– With the goal of helping economically disadvantaged Indians who are visually impaired regain their lost sight, the company started "Project Drishti." Over 5000 people have received new lives as a result of this design, and it has also made us uneasy about the increased awareness of the urgent need for eye donation.

Infosys – It intends to provide computer and language instruction as a top software firm. The company has introduced special programmes through which it imparts knowledge and seeks to alter the perspectives of students from underprivileged groups in society. The Company gives generously to those in need. The company's CSR conditioning includes setting up blood donation camps, protecting the environment, promoting social recovery, etc. Additionally, it has been active in the fields of healthcare and education.

Gail Ltd. – It is one of the biggest state-owned natural gas processing and distribution firms. It generously supports the GAIL Charitable and Educational Trust, the SC ST Minority population, and any natural disasters.

IX. UK BASED FIRMS GETTING CSR RIGHT

Thornton's UK based Firm

Thornton's, a decorative chocolate manufacturer, has made it their mission to provide delicious dark, milk, and white chocolates to customers all over the UK. Their mission has been to make their guests smile with these delightful products. They also advocate a wide range of CSR initiatives and take delight in giving back to society. In order to give back to the community, Thornton's actively supports a variety of unique causes. Staff members promote community-led systems through volunteerism and fund-raising initiatives. Smile Train, the world's top charity for people with split lips, is a vital charity ally and the focus of the business's main fundraising pursuits.

Some environment approachable Policies:-

- Recycling – Thornton's training on a committed integrated waste operation firm with recycling titleholders on point used a cooperative technique to drive the ideal of zero waste to tip in the appropriate direction.
- • Energy: Conserving energy is a top priority. The company consistently exceeds the Food and Drink Federation's Climate Change Agreement targets, and their consumption of gas and electricity has decreased by more than 10 from the previous time to 3,688 kWh/tonne of goods produced.
- • Water – Devoted to lowering water use on-site, the company signed the Federation House Commitment in 2011, which aims to cut water use throughout the food and beverage industry by 20 by 2020.

BT Firm

²⁴National Federation of Blind. (n.d.). *NFB Karnataka*.

BT is a global dispatch service provider that offers services to consumers in the UK and more than 170 other nations. Fixed line services, mobile technologies, television, and broadband products and services are all part of their service immolation. Their corporate governance places a strong emphasis on corporate social responsibility, and they have been recognized as a leader in sustainable, ethical business. Online job opportunities provided by SOS Children's Villages give young people in remote African areas the possibility to enhance their quality of life.

- Message Stick: An example for Aboriginal entrepreneurs. Together with BT One Collaborate services, Aboriginal technology company Communication Stick conquered the commercial market in Australia.
- Perfecting Lives—Last time, they raised over 85 million pounds for charitable causes by utilizing their skills and financial resources in technology. As an example, their special emergency response team assisted in restoring dispatches after Typhoon Haiyan hit the Philippines. By 2020, BT plans to reduce the carbon intensity of its global operations by 80%. By becoming energy efficient and increasing their use of renewable energy, they have currently reduced their carbon footprint by 43%.²⁵

X. CSR STRATEGIES ADOPTED SUCCESSFULLY BY UK BASED COMPANIES

Establishment of a Sound Commercial Environment that is also Healthy, Inclusive-

CSR is the search for jobs that have fluently laid down morals, ethics, and support to the workers at the time of their joining the business. This includes a range of issues, from diversity and addition, to well-being at the plant, payment of a fair stipend, as well as a good work- life balance. One of the companies in the UK that has adopted CSR strategies is the Dispatches Agency.

Follow the on-going CSR strategies and get feedback from stakeholders-

It is crucial to keep an eye on emerging patterns and problems and to formulate appropriate responses. It is also crucial to actively solicit feedback from the stakeholders the programme is intended to influence. By doing this, the risk that the company may hire a tone-deaf business or continue with conditioning that is no longer having the desired effect is avoided. Fortunately, we live in a social media-rich era where businesses may more easily track customer opinion regarding their CSR initiatives and get feedback.

Choose Relevant and Applicable CSR Strategies that are agreed to Community Needs-

Society is watchful of conditions that are fake or “tone deaf” to the requirements of communities. Similarly, CSR strategies should play to the strengths and moxie of the business while being applicable to problems being addressed. This has a binary benefit of capitalising on being chops within the organisation and aligning with its core purpose while serving society.

²⁵ Harnessing data to empower a sustainable future. (n.d.). Accenture . Retrieved August 8, 2022, from https://www.accenture.com/_acnmedia/PDF-164/Accenture-BT-ThoughtLeadershipReport2021-FINAL.pdf

UK bakery Greggs is leading its CSR strategy with its “Greggs Pledge” to do good “for people and earth” with a programme of ten pledges that align with the UN’s sustainable development pretensions. In the 1960s, the company offered free pie “n” peas suppers to senior residents in its birthplace of Gateshead. This has evolved to become a free breakfast club for school children, furnishing 70,000 free meals per day.²⁶ Importantly, as a fast- food business, Greggs also acknowledges its part in driving rotundity and food waste, showing that it is responsive to the requirements of society and isn't ducking its duty on health and environmental issues.

XI. SUGGESTIONS

- Multinational organisations have the resources, labour, aptitude, and logical reasoning to promote massive communal changes; therefore, they should form strong alliances with NGOs and follow the law of the land; all of this can result in faster social improvement, which would only benefit corporates with many large opportunities in the future. As a result, mandating CSR is necessary to align corporations with government policies and the United Kingdom must work to make CSR policies mandatory.
- Companies should be encouraged to work toward environmental protection and climate change management, as research by CDP, a group that supports companies carrying out environmental activities, has found that those whose CSR activities are geared toward climate change management have seen an 18 percent higher return on equity than those who are not engaged in climate change management.
- Companies, despite having a pool of capital funds, are unable to direct them properly because they are unaware of current social issues and policy measures that have or have not been implemented. As a result of companies being unaware of social problems, their funds and resources are misdirected, and they are thus unable to help society with long-term benefits, which is why companies need to have a separate department in the CSR committee who will be required to prepare a report on the public problem describing where the country is still lacking in solving the problem, and in those spheres a company can use its resources.
- If a business specialises in a specific product, it should make better use of it. CSR entails more than just spending money. Apart from money, CSR resources can be anything. For example, if a multinational corporation manufactures preserved food, it should work to provide some to those who are below the poverty line, thereby helping the country to eradicate hunger. Similarly, if a corporation provides telephone services, it should work to establish a network and provide services in rural areas where there is no proper network and telecom facility. Thus, CSR can be anything other than finance, and companies should spend it wisely.

XII. FINDINGS AND CONCLUSION

The emphasis must be on viewing CSR from a practical lens rather than from the perspective of a theoretical discussion as it continues to develop as an emerging legal reality. The most crucial question is: Should CSR be "promoted" or "assessed"? Stakeholders all over the world still fundamentally have this issue. Nevertheless, from a pragmatic standpoint, whatever

²⁶ Social Responsibility. (n.d.). GREGGS. Retrieved August 8, 2022, from <https://corporate.greggs.co.uk/>

benefits society and promotes the general well-being of the populace should be the way to go, despite the political and financial challenges that each nation may encounter in the process.

The arrival of CSR legislation has transformed the entire landscape and ecosystem of CSR in India and the UK. Notwithstanding, the legal provisions are still evolving as is apparent from periodic amendments in CSR Rules in India. Indian Government is not only asking companies to follow CSR but the government itself is engaging in CSR, benefactions to the PM CARES²⁷ Fund for illustration, would be called CSR. This action of the Indian Government is to encourage pots to make benefits towards society. The United Kingdom always had a corporate terrain towards CSR and companies in the UK have always considered CSR in its business frame.

The UK Government has also played an important part in promoting CSR by ensuring that stakeholders bear in a socially accepted behaviour. With the appointment of the Social Responsibility Minister in the UK, it encouraged many companies in the UK to appoint a member from the Board to take charge of CSR. It can be seen in the UK how CSR has advanced significantly over time, with pointers similar as the FTSE4Good Index, which is a series of ethical investment stock request indicators that measures a company's social responsibility. UK companies have accepted the verity that in order to exceed and sustain the same in future they will have to work for the society, also only they can stay in the long race.

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Winning the “Culture War”: Greater Hungary and the American Confederacy as Sites of Nostalgia, Mythology, and Problem-making for the Far Right in the US and Hungary

Grace Rademacher

Abstract—Following the recent obsession of the American far right with Viktor Orbán and the Fidesz party, this paper explores the reliance of political actors and pundits in both nations on their respective industries of nostalgia: the “Trianon Trauma” of the Kingdom of Hungary and the “Lost Cause” of the American Confederacy. Applying Nicole Maurantonio’s articulation of “confederate exceptionalism” and Svetlana Boym’s definition of “restorative nostalgia”, this article argues that, via memorialization and public discourse, both far right bodies flood their constituencies with narratives of nostalgia and martyrdom to sow existential anxieties about past and prophetic victimhood, all under the guise of protecting or restoring heritage. Linking this practice to gamification and conspiracy theorizing, and following the work of Patrick Jagoda, this article identifies such industries of nostalgia as means by which the far right in both nations can partake in the “immanent and improvisational process of problem making.” Reified through monuments and references to the Trianon Trauma and the American confederacy, political actors “problem make” by alleging that they are victims of the West or the Left, subject to the cruel whims of liberalism and denial of historical legitimacy. In both nations, relying on their victimhood, pundits and politicians can appeal to white supremacists and distract citizens from legitimate active conflicts, such as wars or democratic rollbacks, redirecting them to fictional, mythical attacks on Hungarian or American society and civilization. This article will examine memorials and monuments as “lieux de memoire” and identify the purposeful similarities between the discourse of public figures and politicians such as María Schmidt, János Lázár, and Viktor Orbán, with that of Donald Trump and pundits such as Tucker Carlson.

Keywords—Nationalism, White Supremacy, Greater Hungary, Culture War.

The Impact of Resettlement Challenges in Seeking Employment on the Mental Health and Well-Being of African Refugee Youth in South Australia

Elvis Munyoka

Abstract— While the number of African refugees settling in Australia has significantly increased since the mid-1990s, the marginalisation and exclusion of young people from refugee backgrounds in employment remain a critical challenge. Unemployment or underemployment can negatively impact refugees in multiple areas, such as income, housing, life satisfaction, and social status. Higher rates of unemployment among refugees are linked in part to the intersection of pre-migration and daily challenges like trauma, racism, gender identity, and English language competency, all of which generate multiple employability disadvantages. However, the intersection of gender, race, social class, and age in impacting African refugee youth's access to employment has received less attention. Using a qualitative case study approach, the presentation will explore how gender, race, social class, and age influence African refugee youth graduates' access to employment in South Australia. The intersectionality theory and capability approach to social justice is used to explore intersecting factors impacting African refugee youth's access to employment in South Australia. Participants were 16 African refugee graduates aged 18-30 living in South Australia who took part in the study for one year. Based on the trends in the data, the results suggest that long-term unemployment and underemployment, coupled with ongoing racism and marginalisation, have the potential to make refugees more vulnerable to several mental disorders such as depression, hopelessness, and suicidal thoughts. The analysis also reveals that resettlement challenges may limit refugees' ability to recover from pre-migration trauma. The impact of resettlement challenges on refugee mental health highlights the need for comprehensive policy interventions to address the barriers refugees face in finding employment in resettlement communities. With African refugees constituting such an important part of Australian society, they should have equal access to meaningful employment, as decent work promotes good mental health, successful resettlement, hope, and self-sufficiency.

Keywords— African refugees, employment, mental health, Australia, underemployment.

A Validation of the German Version of the Basic Empathy Scale (BES) in a Community Sample

Katja Witte, Andra Biesok

Abstract — Empathy is the capacity to understand and share another's emotional state and context and is the evolutionary mechanism behind altruism, prosocial behavior, human civilization, and subsequently, resistance to violence. High levels of empathy are associated with prosocial behavior, lack of empathy is associated with antisocial behavior, including aggression, delinquency, and criminal offense recidivism. The present study aims to validate the German version of the Basic Empathy Scale (BES), which measures both cognitive and affective empathy and has been validated in multiple languages but not in a German community sample.

The study sample contains $N = 321$ healthy individuals ($M_{age} = 18.93$, $SD_{age} = 4.23$) who completed the German version of the BES, consisting of 20 items. The German version of the BES consists of 20 items. Responses are given on a 5-point rating scale.

Psychometric validation consisted of several steps. First, factorial validity was examined. Therefore, separate models for both factors (affective & cognitive) were computed. Then the models were fitted, based on the modification indices. In a last step, the separate models were integrated into an overall model. The two-factorial structure was confirmed with necessary adjustments. The final model showed a good fit to the data: $RMSEA = .063$; $SRMR = .070$; $CFI = .902$. The two subscales correlated significantly ($r = .45$, $p < .01$).

Second, construct validity was examined. In terms of convergent validity, we found significant correlations between the two subscales of the BES and another empathy measure, the Interpersonal Reactivity Index (IRIS). Regarding discriminant validity, correlations between the BES subscales and the Big Five dimensions could be revealed.

In a final step, we examined concurrent validity and investigated whether sex differences (on average higher mean values of empathy for women) could be replicated for our sample. We found higher mean values for women on both, cognitive ($M_{women} = 4.48$, $SD_{women} = 0.64$ vs. $M_{men} = 3.90$, $SD_{men} = 0.54$) and affective ($M_{women} = 5.02$, $SD_{women} = 0.71$ vs. $M_{men} = 4.64$, $SD_{men} = 0.69$) empathy.

We estimated internal consistency with McDonald's omega. Omega ranged from $\omega = .72$ (affective) to $\omega = .87$ (cognitive).

Keywords— Basic Empathy Scale, Empathy, Germany, Validation Study.

The Possibility of Assessing Perceived Influence and Participation among Young People with Intellectual Disabilities

Karina Göransson, Heléne Dahlqvist, Maria Warne

Abstract— Young people with an intellectual disability (ID) generally have poorer conditions for good health. Their opportunities to participate in society and to influence what is important in their lives are lower than for others. The possibility to participate and have influence in social life is a fundamental right and a necessity so that their lives, as far as possible, are characterized by independence and self-determination. There is a need for more knowledge about how this should be made possible in activities for young people with ID. Previous studies have measured factors such as e.g. how young people with intellectual disabilities manage to achieve goals in terms of participation in daily activities, knowledge, problem-solving, self-determination, and belief in their own ability to handle problems (self-efficacy). Few studies have focused on participation as a primary outcome measure. There is a need for further research to find ways to investigate and supplement how participation is experienced. The purpose of this study was to investigate how participation and influence for young people with intellectual disabilities (ID) are defined, applied, can be assessed, and contribute to developing their everyday skills. Specific research questions were: How is the concept of participation defined? How do teachers in upper secondary special schools define students' influence and participation? How do parents of young people with ID view their children's opportunity to be involved and influence their everyday life? To answer the research questions, a literature review and interviews were conducted. Participants in the study were parents of nine students with ID in a special high school and five school staff who work with the students. A semi-structured interview guide was used to collect descriptions of the participants' definitions of participation and their views of the students' possibilities for participation based on their definitions. The school staff also discussed how they assessed student participation. Data were collected by two researchers and were audio recorded and transcribed verbatim. The interviews were analyzed with thematic analysis. A literature review was conducted by systematic searches in the databases SCOPUS, Pubmed, and ProQuest. The results are in progress and will be presented at the conference.

Keywords— intellectual development disorder, measurements, participation, youth.

Photovoice-Through Photographs to Feelings: Investigation of Experience Reporting in a Randomized Controlled Study

Selina Studer, Maria Kleinstäuber, Cornelia Weise

Abstract—

Background: Finding words to report what you have been through may be challenging, especially when dealing with stressful or highly emotional experiences. Photovoice (PV) represents a possible way of facilitating experience reporting. In this approach, people take photos about a particular topic (in our study: worries about the future) and talk about the topic based on the photos. So far, the benefits of Photovoice have been quantitatively insufficiently tested. There is a lack of randomized controlled trials investigating PV in comparison to other methods. This study aimed to fill this research gap.

Methods: 65 participants took part in the study and were randomly assigned to the PV group, the writing group (WG), or the control group (CG). The PV group received the task to take photos of worries regarding the future for one week and send max. 5 of them to the interviewer before the interview. The WG had to write down the worries about the future and send max. 5 of them to the interviewer before the interview. The control group did not receive a specific assignment. The semi-structured interview consisted of six open-ended questions and was applied to all future worries. The questions included the content of the future worries, the meaning, and how the worry expressed itself emotionally and physically. The interview was recorded and later transcribed. After the interview, online questionnaires were filled out. They covered a range of variables such as access to emotional content, ability to describe feelings, the extent of self-disclosure, and relationship quality.

Results: Contrary to our hypotheses, one-way ANOVA revealed no differences between the three conditions concerning all variables (access to emotional content, ability to describe feelings, the extent of self-disclosure, and so on), all p 's > 0.14 , $BF_{01} = 1.78-7.66$. In a subsequent step, the words in the transcribed interviews were analyzed. The LIWC program counted how many emotional words occurred in the text and assigned them to predefined categories. Planned contrasts revealed that the PV reported more negative emotional words compared to the two groups $t(62) = 2.62$, $p = .011$, and also compared to the WG only, $t(62) = 2.36$, $p = .022$, $BF_{01} = 0.62$.

Conclusions and implications: The applied self-report instruments did not reveal any differences between the groups. However, the PV group used more negative emotional words than the other two groups. The discrepancy between self-report and observation variables regarding emotionality is noticeable. It is suggested that the highly educated and above-average female sample may not have needed PV to access emotional content. It is possible that the approach would yield clearer results in a clinical sample. This and other approaches are currently being investigated in a follow-up study.

Keywords— photovoice, controlled randomized study, online intervention, emotional awareness, self-disclosure, data triangulation, interviews.

Study of Polish and Ukrainian Volunteers Helping War Refugees. Psychological and Motivational Conditions of Coping with Stress of Volunteer Activity

Agata Chudzicka-Czupala, Nadiya Hapon, Liudmyla Karamushka, Marta Żywiołek-Szeja

Abstract

Objectives: The study is about the determinants of coping with stress connected with volunteer activity for Russo-Ukrainian war 2022 refugees. We examined the mental health reactions, chosen psychological traits, and motivational functions of volunteers working in Poland and Ukraine in relation to their coping with stress styles. The study was financed with funds from the Foundation for Polish Science in the framework of the FOR UKRAINE Programme.

Material and Method: The study was conducted in 2022. The study was a quantitative, questionnaire-based survey. Data was collected through an online survey. The volunteers were asked to assess their propensity to use different styles of coping with stress connected with their activity for Russo-Ukrainian war refugees using The Brief Coping Orientation to Problems Experienced Inventory (Brief-COPE) questionnaire. Depression, anxiety and stress were measured using the Depression, Anxiety and Stress (DASS)-21 item scale. Chosen psychological traits, psychological capital and hardiness, were assessed by The Psychological Capital Questionnaire and The Norwegian Revised Scale of Hardiness (DRS-15R). Then The Volunteer Function Inventory (VFI) was used.

The significance of differences between the variable means of the samples was tested by the Student's t-test. We used multivariate linear regression to identify factors associated with coping with stress styles, separately for each national sample.

Results: The sample consisted of 720 volunteers helping war refugees (in Poland 435 people, and 285 in Ukraine). The results of the regression analysis indicate variables that are significant predictors of the propensity to use particular styles of coping with stress (problem-focused style, emotion-focused style and avoidant coping). These include levels of depression and stress, individual psychological characteristics and motivational functions, different for Polish and Ukrainians. Ukrainian volunteers are significantly more likely to use all three coping with stress styles than Polish ones. The results also prove significant differences in the severity of anxiety, stress and depression, the selected psychological traits and motivational functions studied, which led volunteers to participate in activities for war refugees.

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Conclusions: The results show that depression and stress severity, as well as psychological capital and hardiness, and motivational factors are connected with coping with stress behavior. The results indicate the need for increased attention to the well-being of volunteers acting under stressful conditions. They also prove the necessity of guiding the selection of people for specific types of volunteer work on the basis of psychological characteristics.

Keywords

Anxiety, Coping with Stress Styles, Depression, Hardiness, Mental health, Motivational functions, Psychological capital, Resilience, Stress, War, Volunteer, Civil society.

The Role of Cognitive Impairment in Asthma Self-Management Behaviors and Outcomes in Older Adults

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Abstract:

Objective: Cognitive impairment (CI), whose incidence is greater among ethnic/racial minorities, is a significant barrier to asthma self-management (SM) behaviors and outcomes in older adults. The aim of this study was to examine the relationships between CI, assessed using the Montreal Cognitive Assessment (MoCA), and asthma SM behaviors and outcomes in a sample of predominantly Black and Hispanic participants. Additionally, we evaluated whether using two different MoCA cutoff scores influenced the association between CI and study outcomes. **Methods:** Baseline cross-sectional data were extracted from a longitudinal study of older adults with asthma (N=165) age ≥ 60 years and used for analysis. Cognition was assessed using the MoCA. Asthma control, asthma-related quality of life (QOL), inhaled corticosteroid (ICS) dosing, and ICS adherence were assessed using self-report. The inhaler technique was observed and rated. **Results:** Using established MoCA cutoff scores of 23 and 26 yielded 45% and 74% CI rates, respectively. CI, defined using the 23 cutoff score, was significantly associated with worse asthma control ($p=.04$) and worse ICS adherence ($p=.01$). With a cutoff score of 26, only asthma-related QOL was significantly associated with CI ($p=.03$). Race/ethnicity and education did not moderate the relationships between CI and asthma SM behaviors and outcomes. **Conclusions:** CI in older adults with asthma is associated with important clinical outcomes, but this relationship is influenced by the cutoff score used to define CI.

Keywords: cognition; respiratory; elderly; testing; adherence; validity.

Introduction

Older adults with asthma have an estimated 78% increased risk for global cognitive impairment (CI) compared to those without asthma (1), potentially due to lower oxygen saturation or a reduction in hippocampal metabolites secondary to asthma medication (2). Across studies in asthma and other research areas, CI has been consistently identified as one of the most significant barriers to disease self-management (SM) behaviors (3). Cognitive dysfunction can affect patients' ability to comprehend, recollect, and organize information regarding their care and ultimately lead to missed medical appointments, low adherence to medications, and consequently worse asthma control (3, 4). Moreover, older adults with asthma who are unable to

achieve asthma control are at increased risk for periods of intermittent or prolonged hypoxia, which can have detrimental effects on cerebral functions and thus cognition (2, 5-10). Indeed, lower levels of oxygen in arterial blood have been found to be correlated with reduced scores in several cognitive domains (7).

CI has been associated with longer asthma duration, asthma severity, reduced lung function, and reduced disease control, though results have been inconsistent across studies (11-13). For example, Ray et al. (11) found that CI was significantly associated with poor asthma control and lower FEV₁, a measure of lung function. However, after adjusting for covariates such as age and education, these findings were no longer significant. A meta-analysis identified asthma severity as a key factor in the relationship between CI and asthma, with the highest level of CI being associated with greater asthma severity (12).

Higher levels of CI are associated with racial and ethnic minority status (14, 15). One study found that Black adults were twice as likely to have mild cognitive impairment (MCI) or dementia compared to White participants, and Hispanic participants had even greater odds of having MCI or dementia than Black participants (16). Among asthma patients, cognitive deficits have been found to be most common among racial and ethnic minorities (12).

Similar relationships have been found between cognition and education level, though these results have been inconclusive (17, 18). Higher levels of education are associated with higher levels of cognition and lower levels of cognitive decline in adults (19, 20). A 2021 twin study found that even when controlling for genetic-related factors, high educational attainment was associated with greater cognition later in life (21).

In addition to CI, racial and ethnic minority status and education level have also been found to be associated with worse asthma outcomes and SM behaviors (22-26). Black and Hispanic adults with asthma are also twice as likely to visit the emergency department for asthma, demonstrate greater reliance on quick relief asthma medication, and have worse medication adherence (24, 25). A low level of education has been found to be a risk factor for poorly-controlled asthma, though these results have been inconsistent across studies (22, 23, 26). These racial and educational disparities in both cognition and asthma outcomes and SM behaviors are not surprising considering the demonstrated relationships between worse cognitive functioning and worse disease outcomes and SM behaviors (27-30).

One study found that worse general cognitive functioning, as measured by the Montreal Cognitive Assessment (MoCA), was significantly associated with lower adherence to inhaled corticosteroids (ICS) in Black and Hispanic older adults (30). Another study found that impairment in fluid ability (a measure of cognitive ability focused on reasoning and not heavily dependent on previously-learned skills) was associated with worse controller medication adherence, dry powder inhaler (DPI) technique, and metered dose inhaler (MDI) technique (31). These results suggest that cognitive functioning may be a key predictor of asthma SM.

Identifying optimal cut-off scores for diagnosing CI is a key component of accurate diagnosis (32, 33). A 2018 analysis suggested that the original recommended cutoff score of 26 on the MoCA for MCI may be too high for accurate detection, especially in racial and ethnic minorities (34). A 2017 meta-analysis found the MoCA to have sensitivity of 83% and specificity of 88% to detect MCI with the cutoff of 23. This is compared to a sensitivity of 94% and a specificity of 66% for the cutoff of 26. The authors of the meta-analysis concluded that the cutoff score of 23 may lower the rate of false-positive results of MCI and improve overall diagnostic accuracy of the MoCA (35). A study of African Americans with type 2 diabetes found that, when using the cutoff score of 26 to indicate CI, 94% of their participants had CI, compared to 48% when

assessed using the Modified Mini Mental State Examination (10). When stratified by race and ethnicity, 23 was identified as the optimal MoCA cutoff score for non-Hispanic Black patients and 24 for Hispanic patients (10).

The aim of the present study was to examine the relationship between CI, asthma SM behaviors, and asthma outcomes in a sample of predominantly Black and Hispanic older adults while considering different MoCA cutoff scores. We first hypothesized that CI, as measured by a MoCA cutoff of <23, would be associated with worse asthma SM (e.g., worse controller medication adherence) and worse asthma control. We then tested the hypothesis that race/ethnicity and education would moderate the relationships between cognition and asthma outcomes.

Methods

Procedures

Baseline cross-sectional data were extracted from a longitudinal study of older adults with asthma. The MoCA was administered in-person by formally-trained research assistants. Asthma SM (e.g., self-reported ICS adherence and observation of MDI technique), demographic information, and other questionnaires assessing asthma outcomes (i.e., Asthma Control Questionnaire, Mini Asthma Quality of Life Questionnaire) and depression (i.e., Beck Depression Inventory-II) were also collected during the same visit. The institutional review board at Mount Sinai Hospital approved this study. Data collection began in January 2020 and was halted in March 2020 due to the COVID-19 pandemic. Data collection resumed virtually in May 2020 after receiving IRB approval for virtual interviewing and consenting, though all MoCAs were conducted in-person.

Settings and Participants

Participants were adults aged 60 and older (N = 165) from New York City. Participants were eligible if they spoke English and had a physician diagnosis of asthma. Exclusion criteria included: chronic obstructive pulmonary disease (COPD) or other chronic lung conditions, a smoking history of 15 or more pack-years, history of dementia, comorbidities such as inflammatory bowel disease, use of omalizumab, asthma biologics, or immunosuppressives, and abnormal lab values consisting of hemoglobin < 7.4 (females), < 8.1 (males), white blood cells < 2×10^3 , platelet < 75, alanine aminotransferase and aspartate transferase >1.5 times normal range, and liver function tests two times normal range. Participants were referred by providers within Mount Sinai Hospital in East Harlem (N = 87) or Montefiore Medical Center/Jacobi Medical Center in the Bronx (N = 78). Participants were contacted for initial screening by the research team. Once deemed eligible, their electronic medical records were then assessed for eligibility. Eligible participants provided informed consent at the time of their baseline visit.

Measures

Cognitive functioning: General cognitive functioning was assessed using the MoCA (36), a brief screening tool that aims to differentiate healthy cognitive aging from MCI. The MoCA assesses multiple cognitive domains, including short-term memory recall, attention, working memory, delayed memory, language, visuospatial abilities, orientation, and executive functioning (37, 38). While the MoCA was designed with an intended cutoff score below 26 out of 30 to be suggestive of impairment (36), recent studies have suggested that this can often lead to an inflated rate of false positive results, particularly in those of older age, Hispanic ethnicity, Black race, and/or lower education (10, 34). Recent meta-analyses have indicated that a cutoff score of 23/30 yielded the best diagnostic accuracy across a range of parameters (34).

Asthma Outcomes: Asthma control was assessed using the Asthma Control Questionnaire (ACQ-6), a brief continuous measure that asks how often participants were awoken by their asthma during the night, how bad their asthma was in the morning, how limited they were in their activities, presence of shortness of breath and wheezing, and quick relief inhaler use over the week prior to assessment (39). The abbreviated version of the Asthma Quality of Life Questionnaire (mini AQLQ) was used to continuously measure the physical and emotional impact of asthma. This 15-item tool measures functional impairments in 4 domains: symptoms, activity limitation, emotional function, and environmental stimuli (40). Self-reported ICS dosing was collected during the baseline visit and was categorized as low, medium, or high using the Global Initiative for Asthma (GINA) guidelines (41).

Asthma SM: Medication adherence was collected through the Medication Adherence Rating Scales (MARS) (42), a 10-item questionnaire that measures self-reported adherence to controller medication and correlates well with objective measures of adherence (42-44). Patients with MARS scores of 4.5 and above were classified as adherent (43). Research assistants assessed MDI technique by observing participants using placebo inhalers and using a standardized checklist to measure how closely participants adhered to the suggested technique (45).

Additional Measures: Depressive symptoms were assessed using the Beck Depression Inventory (BDI-II), a 21-item, self-report inventory that measures characteristic attitudes and symptoms of depression over the two weeks prior to administration (46). Finally, medical comorbidities were calculated using the Charlson Comorbidity Index (CCI) based on medical chart review (47). Education was dichotomized to \leq high school education and $>$ high school education. Race/ethnicity was dichotomized to White versus non-White.

Statistical Analyses

Descriptive statistics were run (i.e., mean, standard deviation, frequency, percentage) to characterize the sample of adults. Multiple linear regressions analyses were conducted to examine the continuous outcomes (e.g., ACQ, AQLQ, MDI technique) with MoCA score as the predictor. Binary logistic regression was used for the binary MARS variable, and multinomial logistic regression for the categorical ICS dosage level outcome with the MoCA as the predictor variable. All regression models included age, sex, education, race/ethnicity, BDI-II, and CCI as covariates. Regressions were repeated using MoCA cutoff scores of 23 and 26. Statistical analyses were performed using SAS statistical software, version 9.4 (SAS Institute, Inc., Cary, NC). PROC GENMOD was used to analyze the moderating effects of education and race/ethnicity by examining the interactions between MoCA and education and MoCA and race/ethnicity.

Results

Descriptive characteristics are displayed in Table 1. The mean age was 67.7 years old (SD: 5.7). The majority of the sample (N = 165) was female (85.5%), Hispanic (34.4%), or Black, non-Hispanic (38.6%), and 70.9% had completed some college. A majority of participants were non-adherent to controller medications (54%). When using the MoCA cutoff score of 23 for CI, 44.9% of the sample was impaired. However, when using the original cutoff score of 26, 73.9% of the sample were impaired.

Table 2 presents the unadjusted and adjusted associations between CI and asthma SM for each cut-off score.

Unadjusted model results-MoCA cut-off=23: MoCA scores below 23 were associated with deficits in SM behaviors and asthma outcomes. General CI (MoCA < 23) was significantly associated with worse asthma control (as indicated by a higher ACQ score) $\beta = 0.21$, 95% CI 0.06 – 0.36, $p = .007$, worse self-reported non-adherence to ICS, OR = 4.10, 95% CI 1.93 – 8.66, $p = .0002$, and worse MDI technique $\beta = -0.23$, 95% CI -0.4 – -0.05, $p = .01$. Asthma quality of life (QOL) was not significantly associated with CI, $\beta = -0.14$, 95% CI -0.3 – 0.007, $p = .06$.

Unadjusted model results-MoCA cut-off=26: there was a significant association between CI and worse asthma QOL, $\beta = -0.16$, 95% CI -0.32 – -0.01, $p = .03$. Associations between CI and ACQ, MARS, MDI technique, and ICS dosing were not statistically significant.

Adjusted model results-MoCA cut-off=23: In adjusted analyses, MoCA scores below 23 were associated with worse self-reported asthma control, $\beta = 0.17$, 95% CI 0.002 – 0.33, $p = .04$ and worse self-reported adherence, OR = 3.17, 95% CI 1.30 – 7.71, $p = .01$. Asthma QOL, ICS dosing, and MDI technique were not significantly associated with general CI in adjusted models with MoCA score cutoff of 23.

Adjusted model results-MoCA cut-off=26: Similarly, in adjusted models using the cut-off score of 26, general CI was associated with worse asthma QOL $\beta = -0.19$, 95% CI -0.37 – -0.02, $p = .03$, but no other significant associations were found.

Using a generalized linear model, we also assessed whether race/ethnicity and education moderated the relationship between MoCA scores and asthma outcomes. There were no significant interactions between MoCA score and education ($F = 0.34$, $p = 0.56$) or race/ethnicity ($F = 2.96$, $p = 0.09$) in the relationship between MoCA score and asthma control. Similarly, there were no significant interactions between MoCA score and education ($F = 0.12$, $p = 0.88$) or race/ethnicity ($F = 0.07$, $p = 0.79$) in the relationship between MoCA score and asthma-related QOL. There were no significant interactions between education and MoCA score ($Wald \chi^2 = 0.23$, $p = .63$) or race/ethnicity and MoCA score ($Wald \chi^2 = 0.34$, $p = .56$) for self-reported adherence to ICS. Finally, there were no significant interaction effects for education ($F = 1.51$, $p = 0.22$) or race/ethnicity ($F = 0.20$, $p = 0.66$) in the relationship between MoCA and MDI technique.

Discussion

The present study examined the relationship between CI, asthma SM, and asthma outcomes in older and predominately Black and Hispanic adults with asthma. We also considered the MoCA score cutoffs of 23 and 26 to define CI. Our results confirmed the critical role of cognition in asthma SM, and, consequently, asthma control. We found that CI on the MoCA was associated

with worse asthma control and poor ICS adherence when using a cut-off score of 23. Further, we did not find that race/ethnicity or education moderated these relationships.

When using a MoCA cutoff score of 26 to define CI, only worse asthma QOL was associated with CI. Mosen et al. (48) found that Black adults were more likely to report lower asthma QOL compared to White adults. Studies have suggested using a lower MoCA cut-off score for Black patients than Hispanic patients (10). Therefore, Black participants may have been falsely diagnosed with CI at a higher rate than Hispanic participants. If Black participants are more likely to report worse asthma QOL, this potential false-diagnosis may have impacted the relationship between CI and asthma QOL when we used a MoCA cutoff score of 26. This highlights the potential significance of using a lower MoCA cut-off score in future research to avoid erroneous diagnosis of CI and resultant negative associations with clinical outcomes. Further, it indicates that considering the suggested MoCA cut-off scores for patients based on their race or ethnicity may lead to more precise diagnosis of CI.

When we used a cutoff score of 23, there were significant associations between CI, asthma control, and ICS adherence. These associations are similar to previous results of studies looking at CI and disease outcomes and SM, and therefore suggest that the lower cut-off score may allow for more appropriate use of the MoCA as a tool for assessment of CI (12, 13, 49-51). When using 26 as the cut-off score, 74% of the sample was detected as having CI, compared to 45% when using the cutoff score of 23. The high ratio of participants identified as having CI when using a cut-off of 26 further implies that this higher cut-off leads to false-positives.

The relationships between disease CI and worse disease outcomes and ICS adherence have been shown repeatedly in other studies (12, 13, 49-51). The findings from the present study move beyond the extant literature to demonstrate the key role that cognitive functioning plays in asthma control and medication adherence in older adults.

Our results do not indicate a directionality in the relationship between CI and poor asthma outcomes. It is possible that worse cognition leads to poor asthma control and consequently poor outcomes. It is also possible that poor asthma control leads to increased inflammation and hypoxia, which can affect the central nervous system and, consequently, cognitive functioning (52, 53). Another mechanistic possibility includes the use of medications. Specifically, long-term ICS use can impact cognition (54) and even reduce temporal lobe volume (55), though the present study did not find a relationship between CI and the strength of ICS dose prescribed. However, we did not consider long-term ICS use. Finally, and equally important, psychological factors such as depression and anxiety can also impact cognitive functioning and tend to be comorbid in patients with asthma (56-58). Nevertheless, our results indicate that screening older asthma patients for CI may be prudent, allowing physicians to more accurately determine when asthma SM interventions may be needed.

The present study explored the potential moderating effects of education and race/ethnicity on the relationship between CI and asthma SM behaviors and outcomes. No significant moderation was found for education or race/ethnicity in this sample despite previous studies reporting relationships between these factors and CI and asthma SM behaviors and outcomes (12, 14, 15, 20, 25, 26). Alternative potential moderators such as age and depression status should be considered in future research.

This study has a number of limitations. Our analyses included associations based on the MoCA cut-off score of 23 for CI, which is the recommended cut-off for non-Hispanic Black participants (38.6% of our sample) as well as the standard cut-off score of 26. However, the suggested MoCA cut-off score for CI for Hispanic participants (34.3% of our sample) is 24 and cut-offs

were not tailored based on participant's race (10). While the use of a lower MoCA cut-off score showed promising results, using the same cut-off for all participants could have impacted the validity of reporting CI in our study.

The cross-sectional nature of our analyses is a limitation, as the single measurements of cognitive functioning and asthma SM may be better assessed in a longitudinal fashion to account for any cumulative effects of poor SM on cognitive performance. Future longitudinal research is needed to identify these potential effects of poor SM.

Our sample was also largely comprise of women (85.5%). Though, older women do have a higher reported prevalence of asthma than older men, this overrepresentation in our sample could impact the generalizability of our findings across genders (59).

Despite these limitations, our results offer clinical implications for greater understanding and treatment of asthma in older ethnic and racial minority adults. The significant associations between CI, asthma control, and medication adherence demonstrate the importance of cognitive screening in older adults to alert providers of patients who are likely to benefit from enhanced care in these domains. The large difference in participants being classified as having CI using the MoCA cut-off of 23 compared to 26 highlights the importance of considering cutoff scores used to determine CI in both research and clinical settings.

Conclusion: CI, as defined by a cutoff score of 23 on the MoCA, was significantly associated with worse asthma medication adherence, inhaler technique, and asthma control irrespective of race/ethnicity or education.

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| | <i>N</i> | % |
|-----------------------------------|----------------|----------------------------|
| Age | <i>N</i> = 165 | <i>m</i> = 67.7 (SD = 5.7) |
| Sex, % Female | 141 | 85.5 |
| Race | | |
| Black, non-Hispanic | 63 | 38.6 |
| White, non-Hispanic | 32 | 19.6 |
| Hispanic | 56 | 34.3 |
| Other | 12 | 7.4 |
| Education | | |
| High school graduate or lower | 48 | 29.1 |
| Some college | 64 | 38.8 |
| College graduate or higher degree | 53 | 32.1 |
| Income | | |
| ≤\$3000/month | 92 | 71.3 |
| Cognitive Functioning | | |
| MoCA < 26, Impaired% | 122 | 73.9 |
| MoCA < 23, Impaired% | 74 | 44.9 |

| | | |
|------------------------------------------|----|------|
| Medication Adherence Rating Scale | | |
| Adherent | 57 | 46.0 |
| Non-adherent | 67 | 54.0 |
| ICS Dosing | | |
| High | 34 | 40.0 |
| Medium | 26 | 30.6 |
| Low | 25 | 29.4 |

Table 1. Characteristics of Study Participants.

Table 2. Unadjusted and adjusted models

| Outcome | MoCA Cut-off 23 | | | | MoCA Cut-off 26 | | | |
|-------------------------|--------------------------------------------------------------------|---------------|--------------------------------------------------------------------|-------------|--------------------------------------------------------------------|-------------|--------------------------------------------------------------------|-------------|
| | Unadjusted | | Adjusted ^a | | Unadjusted | | Adjusted ^a | |
| | Standardized Estimate (Standardized 95% CI) or Odds Ratio (95% CI) | p-value | Standardized Estimate (Standardized 95% CI) or Odds Ratio (95% CI) | p-value | Standardized Estimate (Standardized 95% CI) or Odds Ratio (95% CI) | p-value | Standardized Estimate (Standardized 95% CI) or Odds Ratio (95% CI) | p-value |
| ACQ score | 0.21 (0.06, 0.36) | 0.007 | 0.17 (0.002, 0.33) | 0.04 | 0.10 (-0.05, 0.26) | 0.18 | 0.05 (-0.12, 0.21) | 0.58 |
| AQLQ score | -0.14 (-0.30, 0.007) | 0.06 | -0.14 (-0.32, 0.04) | 0.14 | -0.16 (-0.32, -0.01) | 0.03 | -0.19 (-0.37, -0.02) | 0.03 |
| MARS score ^b | 4.10 (1.93, 8.66) | 0.0002 | 3.17 (1.30, 7.71) | 0.01 | 1.91 (0.83, 4.41) | 0.13 | 1.06 (0.39, 2.83) | 0.91 |
| MDI Score | -0.23 (-0.40, -0.05) | 0.01 | -0.18 (-0.39, 0.03) | 0.1 | -0.13 (-0.35, 0.05) | 0.14 | -0.11 (-0.35, 0.11) | 0.3 |

| ICS Dosing ^c | | | | | | | | |
|--------------------------|-------------------|------|-------------------|------|-------------------|------|-------------------|------|
| Medium dose ^b | 1.27 (0.42, 3.83) | 0.67 | 1.55 (0.41, 5.84) | 0.52 | 0.87 (0.26, 2.92) | 0.83 | 1.02 (0.25, 4.14) | 0.98 |
| High dose ^b | 1.27 (0.45, 3.59) | 0.65 | 1.11 (0.32, 3.79) | 0.87 | 1.08 (0.34, 3.44) | 0.9 | 0.87 (0.22, 3.43) | 0.84 |

Abbreviations: ACQ, Asthma Control Questionnaire; AQLQ, Asthma-related Quality of Life; MARS, Medication Adherence Response Scale; MDI, Metered Dose Inhaler; ICS, Inhaled Corticosteroid.

^a Adjusted for Age, Sex, Race/Ethnicity, Education, BDI score, and Charlson score

^b Odds ratio (95% confidence interval) provided; reference: Adherent MARS; reference: Low ICS Medication Dosing

Directivity in the Dramatherapeutic Process for People with Addictive Behaviour

Jakub Vávra, Milan Valenta, Petr Kosek

Abstract— This article presents a perspective on the conduct of the dramatherapy process with persons with addictive behaviours with regard to the directiveness of the process. Although drama therapy as one of the creative arts approaches is rather non-directive in nature, depending on the clientele, there may be a need to structure the process more and, depending on the needs of the clients, to guide the process more directive. The specificity for people with addictive behaviours is discussed through the prism of the dramatherapeutic perspective, where we can find both a psychotherapeutic component as well as a component touching on expression and art, which is rather non-directive in nature. Within the context of practice with clients, this theme has repeatedly emerged and dramatherapists themselves have sought to find ways of coping with clients' demands and needs for structure and guidance within the dramatherapy process. Some of the outcomes from the supervision work also guided the research. Based on this insight, the research questions were approached. The first research question asks: in what ways is directive in dramatherapy manifested and manifested in the process? The second research question then complements the first and asks: to which phenomena are directivity in dramatherapy linked? In relation to the research questions, data were collected using focus groups and field notes. The qualitative approach of Content analysis and Relational analysis was chosen as the methodology. For analyzing qualitative research, we chose an Inductive coding scheme: Open coding, Axial coding, Pattern matching, Member checking, and Creating a coding scheme. In the presented partial research results, we find recurrent schemes related to directive coding in drama therapy. As an important element, directive leadership emerges in connection with safety for the client group, then in connection with the clients' order and also the department of the facility, and last but not least, to the personality of the drama therapist. By careful analysis and looking for patterns in the research results, we can see connections that are impossible to interpret at this stage but already provide clues to our understanding of the topic and open up further avenues for research in this area.

Keywords— dramatherapy, directivity, personal approach, aims of dramatherapy process, safety.

Four Museums form one (Hi)Story

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Abstract

A number of scholars around the world have analyzed the great architectural and urban planning revolution proposed by Skopje 2014, but so far there are no readings of the parallels between the museums in the Balkan area (including Greece) that share the same name as the museum at the center of that political and cultural revolution. In the former FYROM (now renamed North Macedonia) a museum called "Macedonian Struggle" was born during the re-construction of the city of Skopje-as the new "national" capital. This new museum was built under the "Skopje 2014" plan and cost about 560 million euros (1/3 of the country's GDP). It was been a "flagship" of the government of Nikola Gruevski, leader of the nationalist VMRO-DPMNE party. Until 2016 this museum was close to the motivations of the Macedonian nationalist movement (and later party) active (including with terrorist actions) during the 19th and 20th centuries. The museum served to narrate a new "nation-building" after "state-building" had already taken place. But there are three other museums that tell the story of the "Macedonian struggle" by understanding "Macedonia" as a territory other than present-day North Macedonia. The first one is located in Thessaloniki and primarily commemorates the "Greek battle" against the Ottoman Empire. While the first uses a new dark building and many reconstructed rooms and shows the bloody history of the quest for "freedom" for the Macedonian language and people (different from Greeks, Albanians, and Bulgarians), the second is located in an old building in Thessaloniki and in its six rooms on the ground floor graphically illustrates the modern and contemporary history of Greek Macedonia. There are also a third and a fourth museum: in Kastoria (toward the Albanian border) and in Chromio (near the Greek-North Macedonian border). These two museums (Kastoria and Chromio) are smaller, but they mark two important borders for the (Greek) regions bordering Albania to the east and dividing it to the northwest not only from the Ottoman past, but also from two communities felt to be "foreign" (Albanians and former Yugoslav Macedonians). All museums reconstruct a different "national edifice" and emphasize the themes of language and religion. The objective of the research is to understand, through four museums bearing the same name, what are the main "mental boundaries" (religious, linguistic, cultural) of the different states (reconstructed between the late 19th century and 1991). Both classical historiographic methodology (very different between Balkan and "Western" areas) and on-site observation and interactions with different sites are used in this research. An attempt is made to highlight four different political focuses with respect to nation-building and the Public History (and/or propaganda) approaches applied in the construction of these buildings and memorials tendency often that one "defines" oneself by differences from "others" (even if close)

Keywords: Balkans; boundaries; nationalism; nation building; Public History.

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Hotel Deposit Contract and Coverage of Risks Resulting, Through Insurance Contracts, in Tourism, Within the Horeca Domain. Alternative Dispute Resolution Methods (ADR) on These Contracts

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Abstract

The issue of the risks of companies providing tourist and hotel services in the field of HoReCa related to goods belonging to tourists left in deposit in a hotel warehouse has acquired a new dimension with the recent economic and geo-political influences globally. Thus, hoteliers and beyond had to re-examine their contractual mechanisms on risks and business protection in this field of activity. This situation has led to a reassessment of the importance of insurance, in particular with regard to hotel liability insurance - premises liability, safety, and security of goods. Interpretation of clauses in contracts concluded between hoteliers and tourists consuming hotel services and products, all the more so in the current pandemic context of Covid 19, stressed the increase in the number of disputes generated by them. This article presents a general picture of the significance of the risks related to the activity carried out in the hospitality industry and tourism, respectively, within the HoReCa field. The study mainly marks the specificities of the hotel deposit contract as well as the related insurance specific to the field as a way to cover these risks. The article also refers to alternative methods of out-of-court settlement of disputes (ADR) in the HoReCa domain, generally used in both Romania and the European Union.

Keywords: consumer tourist, disputes and ADR methods, deposit contract, hotel warehouse and hotelier insurance, hotel services and tourist products, HoReCa.

1. Introduction

A. HoReCa domain definition.

The hospitality industry is an important part of the global economy, especially the European one, which has proven to be a long-term and which is now, it is considerably influenced by technological, socio-political, economic and geo-strategic changes.

In this industry, tourism, travel (including business) as well as the standardized tour service package system, are activities with a strong economic impact in the world, in the member countries of the European Union.

In this respect, the HoReCa domain in particular encompasses the scope of business and refers, in particular, to the food industry (public catering) and in the alternative, at accommodation services as well as other services ancillary to them. Being a particularly vast field of activity with a majority impact on the development of the world economy and implicitly of the European one, it is estimated that, before the Covid-19 pandemic crisis, it had a turnover of around \$ 260 billion worldwide where almost 8 million people were employed in Europe alone.

The term HoReCa results from the abbreviation of the words: Hotel, Restaurant, Catering or Cafes/Cantine, which together make up the expression of English origin „ Hotel & Restaurant Category”.

B. Protection of tourist consumers in the HoReCa domain.

Therefore, the HoReCa field expresses a part of the hospitality industry that includes a varied range of professional providers that offer packages of tourist services and/or associated travel services, accommodation services, public catering (food and drink) as well as other tourist relaxation services related to them (hereinafter referred to as "hotel activities"). All these are provided in

favor of consumer tourists - as the final beneficiaries of these services, outside their residences, respectively within tourist reception structures with accommodation and catering functions (called hotels).

Both at the European Union level and at the national level, a legal authorization system operates regarding the conduct of hotel activities, through patents and tourist licenses.

Also in this sense, the provision of hotel activities within the HoReCa domain, at European quality standards, automatically involves appropriate intervention measures through mechanisms for the protection of consumer tourists, with the help of the control systems of each Member State.

C. The risk of the hotel business caused by the goods brought by tourists.

In the field of hotel activities, we encounter the risk regarding the hotel business determined by certain situations regarding the goods belonging to consumer tourists and brought by them in hotels.

In this respect, hoteliers - as professionals (companies, legal entities) have adapted the types of clauses in contracts for the provision of hotel activities on the basis of which they operate, in order to prevent as well as strengthen the legal certainty of such situations. Thus, the clauses regarding the theft, loss, destruction, damage of the entrusted goods (total or partial) left for safekeeping (stored) by tourists, under the supervision of the hotelier were taken into account. They also implicitly concern cases of liability of the hotelier for damages caused to tourists of guilt or negligence as well as his exemption from liability for cases of force majeure, etc.

We will refer further, to the hotel deposit contract related to the existing risk in this field regarding the goods brought and entrusted by tourists to the hotel as well as to the alternative methods of out-of-court settlement of disputes regarding it.

2. HoReCa hotel deposit contract

A. The headquarters of matter. Parties.

The general regulation of the hotel deposit contract in Romanian law, applicable to the HoReCa domain, we find it within the provisions of art. 2127-2137 which is completed with those of art. 2124-2126 regarding the necessary deposit, from the Romanian Civil Code.

Through the hotel storage contract, the hotelier is liable (in accordance with the rules on the liability of the depositary) for the damage resulting from the destruction, theft or damage of the goods brought by the consumer tourist customer, within the hotel. Therefore, the hotelier is thus obliged to receive in the warehouse the goods belonging to its customers.

The storage of goods may be refused by the hotelier only if they are particularly valuable or are dangerous or uncomfortable, in relation to the conditions of normal operation and operation of the hotel. Thus, the hotelier may examine the goods handed over and entrusted to storage and may require that their storage take place in a specific space arranged and sealed for *this purpose*.

B. Considerations regarding the hotel warehouse. Rights and obligations of the parties.

The necessary nature of the tourist consumer's storage of his goods in a hotel is due to the fact that, although the choice to stay in that hotel represents his exclusive will, he is, however, forced to deposit his property in that hotel.

The goods are considered to be brought to the hotel and entrusted for storage, storage, the goods: either (i) inside the hotel, throughout the tourist accommodation period, or (ii) outside the hotel and for which the hotel (or a member of his family / a forerunner) undertakes to supervise them, throughout the tourist accommodation, or (iii) in or out of the hotel and for which the hotel (or a member of his family / a forerunner) undertakes to supervise them, for a reasonable period of time (previous or subsequent) tourist accommodation. The hotel is also responsible for tourists' vehicles left in the garage or parking lot belonging to the hotel, as well as for the goods in them.

The hotel deposit contract is for consideration (with payment) and thus the liability of the depositary hotel is rigorous in the sense that it is responsible for any form of fault, guilty.

At the same time, the hotel room is also responsible if the stored goods are destroyed, damaged or stolen (i) by the hotel's employee, (ii) by other tourists staying at the hotel or (iii) by other people attending the hotel (whether or not they are accommodated).

The hotel warehouse, assimilated with the necessary deposit, thus represents an accessory of the tourism contract, of the contract for the provision of tourist and travel services or of other legal relations in the field.

The hotel's liability is limited to a hundred times the price shown for one day's accommodation in the hotel room offered for rent to the tourist. In this sense, the hotelier usually limits its liability to goods with a normal value, respectively those that tourists currently hold on to them (for example, mobile phone, the camera, wristwatch, etc.) and keep in the hotel room (possibly in the safe / room of values in the room) and not in the safe located at the hotel reception.

In the case of goods with a higher value, the hotelier informs its tourists that it is responsible only if they are stored in the safe at the hotel reception.

Instead, the hotel liability is unlimited in situations where: a) the damage is caused by the fault of the hotelier or a person for whom he is responsible; b) the hotelier received for storage the goods entrusted by the tourist; c) the hotel refused to receive for storage the goods belonging to the tourist, which he was obliged to receive, according to the law. The last two situations do not concern the decline of the tourist from the right to repair the damage suffered.

However, the tourist is deprived of the right to repair the damage suffered by the destruction, theft or damage of the goods which he himself brought to the hotel or which were brought for him, if: a) within a maximum of 24 hours from the time when he knew the damage, did not inform the hotel management of this fact; b) within 6 months from the date of the damage, did not exercise its right to act in reparation. In such cases, the provisions of common law concerning the general limitation period shall apply.

On the other hand, the hotelier does not respond in the situation where the stored goods are damaged, destroyed, stolen due to: either (i) of the tourist, the person accompanying him / her/ is under his supervision / his visitors; either (ii) a case of force majeure; or (iii) their nature.

In order to engage the hotel manager's liability, the tourist will have to prove the value of the goods (regardless of their value) as well as their introduction into the hotel, which can be done by witnesses, there is no need for proof that they were handed over to surveillance at the reception.

In the event of non-payment by the tourist of the price of the accommodation as well as of the hotel services provided, the hotelier has a right of retention regarding the goods brought by him, except for personal ones without commercial value. Therefore, the latter has the right to capitalize on the goods of tourists, in respect of which he has exercised his right of retention, through the procedures regarding the (immovable) foreclosure.

3.HoReCa hotel liability insurance policy for hotel services

A. Obligation of the hotel to conclude a civil liability insurance policy.

Europe is the favourite tourist destination in the world, where, in 2013 alone, more than 560 million international tourists travelled, of which about 40% of the European citizens spent their holidays.

Thus, 95% of tourists in Europe expressed satisfaction with most aspects of their holiday, especially those related to the safety and quality of accommodation services.

At European legislative level we find the EEC Directive on package travel, package holidays and package tours, which regulates the rights of the consumer tourist with regard to package travel, including those relating to hotel accommodation services.

It also concerns the liability of the tourist service provider, hotel (in our case, of the hotelier) towards the consumer tourist, for the non-execution or defective execution of the services included in these packages.

In this respect, within the hotel activity carried out, the hotelier has the obligation to hold a civil liability insurance policy, concluded with the insurance company (the insurer) based on the hotel insurance contract. Thus, depending on the type of risk insured, the insured may be the owner of the hotel business or the hotel workshop, the insurance contractor may be the hotel management company /the hotel operator and the third party beneficiary can be the consumer tourist, as a beneficiary of the hotel services. Therefore, in order to ensure a hotel risk related to another person or his goods / activities, the person concluding the hotel insurance contract is the insurance contractor.

The hotel civil liability insurance policy is the proof of concluding the hotel insurance contract between the insured and the insurer.

B. Hotel liability insurance - premises liability, safety and security of goods.

In our case, from the perspective of insured risk, hotel liability insurance refers to the liability for covering the personal property of tourists of the insured hotel also called premises liability, safety and security of goods. This includes, for example, the situation of burglary and / or acts of robbery produced on goods belonging to tourists, material damage caused to motor vehicles and located in the hotel parking area, etc. In this sense, the tourist's goods are considered to be brought inside the hotel: (i) located within the hotel during its accommodation, (ii) outside the hotel and in respect of which he or a (employee) has assumed the obligation to supervise during the accommodation or for a certain period of time, before or after accommodation.

The object of this type of insurance consists in covering the damages caused to consumer tourists, for the deeds produced as a result of the fault of the hotel insured, in order to attract his civil liability, during the insurance period.

Therefore, the hotelier - as depositary of goods belonging to tourists and brought to his location, is responsible for the damage caused by destruction, damage or theft caused to them. In this regard, in the course of the hotel activity carried out, the hotel insurer will apply appropriate procedures in order to guarantee the safety of tourists and their property, in accordance with the applicable legal provisions in force.

According to the provisions of the insurance contract, in the event of an insured risk, the insurance contractor or the insured, undertakes to pay a premium to the insurer and the latter undertakes to pay an allowance, where applicable, either to (i) the insurance beneficiary, (ii) insured, or (iii) in our case, to the consumer tourist as a damaged third party.

Thus, the damages due can be granted following the sending by the tourist to the insured, of a claim for compensation regarding his goods in the hotel warehouse.

In this sense, the tourist will formulate the request, within the insurance period / after it, but before operating the extinctive prescription regarding the right of the affected person to request the repair of the damage suffered.

If the tourist injured in his rights is not compensated for the damage suffered, through the liability insurance policy premises liability, safety and security of goods, there may be situations of dispute between him and the hotelier.

Thus, the tourist - in his capacity as a European consumer, all the more so as a result of the current context of the Covid 19 pandemic crisis, can address the competent European and national institutions, legally empowered to settle the dispute amicably, by accessing the European online dispute resolution platform (SOL) or other ADR or ODR mechanisms (for example, in the case of conciliation, mediation, the body of the European Ombudsman, etc.). European platforms help, through these flexible and efficient mechanisms for amicably resolving disputes between the consumer tourist and the tourism service provider, to avoid increasing litigation between them. If this is not possible, call for another alternative method of resolving disputes (ADR).

4. Methods for alternative dispute resolution regarding the hotel deposit agreement and hotel liability insurance - premises liability, safety and security of goods, in the field of HoReCa

The category of alternative out-of-court dispute resolution methods (ADR), in a narrow sense, includes the following: mediation, conciliation, arbitration, early neutral assessment (early neutral or expert evaluation), mini-trial, type arbitration "baseball" or "final offer", joint out-of-court expertise of the parties, litigation commissions, etc.

Regarding the disputes that may occur in the activity specific to the HoReCa domain, they can be: (i) B2C type disputes (business-to-consumer), in which the dispute arises between the service provider and HoReCa products, on the one hand, and their consumer tourists, on the other hand, (ii) B2B disputes (business-to-business), in which the dispute arises between the owner of the HoReCa unit and other companies with which it has commercial relations, such as: wholesalers, travel agencies, franchisors, suppliers, insurers, etc.

The analysis of the advantages of alternative out-of-court dispute resolution differs depending on the previously presented categories. Disputes resulting from contracts concluded between HoReCa owners or operators and consumer tourists fall into the B2C type category. These may include an international or national commercial component, namely, they may or may not intervene between parties domiciled in the same jurisdiction of disputes that include elements of internationality.

The general advantages of using these ADR methods are the following: they represent private, informal, confidential and transparent procedures, ensuring the speed and autonomy of the parties in resolving disputes, compared to those carried out before state courts; guarantees the neutrality and impartiality of the case concluded between the contracting parties as well as the solution rendered; the resulting risks are effectively managed; the involved parties conclude harmoniously in order to materialize

their interests towards the signing of a mutually beneficial agreement; can be applied in practically all fields of activity, by legal or natural persons, in the private or public sector, etc.

As far as arbitration is concerned, its confidential nature gives it the character of promoting and protecting the fundamental principles of international commercial arbitration such as: the efficiency and neutrality of the arbitral procedure as well as the autonomy and consent of the parties involved. Thus, it ensures the protection of the commercial business secrets of the parties, even more so in the context of research, innovation and technological development activities carried out on the basis of intellectual property rights. At the same time, it represents an important way of protecting the rights and interests of the parties and, finally, the legitimacy of the arbitral commercial procedural system. Also, regarding the efficiency of the procedure, confidentiality helps the parties to save time and costs regarding the resolution of disputes between them.

In the context of the reflection of the effects of the Coronavirus Covid19 pandemic, the implementation and conduct of digitized arbitration, through the use of remote hearings, thanks to the robotic automation of procedures, with the help of virtual or semi-virtual technological means, has proven to be a viable alternative in the resolution of disputes between parties.

Thus, the application of three-dimensional holograms in RA and RV has led to increased flexibility and efficiency in the course of the augmented arbitration procedure and has determined considerable cost and time savings in this regard.

Regarding the use of ADR methods such as mediation, negotiation, conciliation, in particular, the parties can introduce multi-step clauses in the contracts. By means of them, it is stipulated that any dispute arising from a contractual relationship can be resolved, for example, through the mediation procedure - by the Mediation Center attached to the The Bucharest Chamber of Commerce and Industry (CCIB) or by the ADR Center Romania. With their help, the parties thus avoid reaching arbitration or judicial disputes, which automatically involve a series of disadvantages such as: considerable time and money costs that will have to be allocated regarding their resolution; high energy consumption, stress and negative publicity, etc. Also, the use of these clauses within the contractual relations, causes the parties to be able to continue their commercial business relations in parallel with the implementation of alternative dispute resolution procedures between them.

At the same time, in order to improve the procedures related to the use of the mediation method, in 2018 the United Nations Convention on international settlement agreements resulting from mediation was adopted, called the "Singapore Convention on Mediation". The convention thus applies to international agreements concluded and signed by the parties and the mediator, following the completion of the mediation procedure, in the case of the settlement of cross-border commercial disputes.

The advantages of its use in mediation reports consist of the following: an accessible procedure for the execution of mediation agreements as well as substantially reduced costs of money and time due to this mechanism which, otherwise, would involve other judicial procedures or hybrid methods necessary for the execution of a report contractual.

4. Conclusions

Within the activities provided by the hotelier in favor of its tourist customers, the activity of storing personal goods belonging to them, accessory to tourist services, travel is also included. In order to protect the commercial operations of hoteliers - as providers of tourist services, hotel liability insurance - premises liability, safety and security of goods is also included, regarding the goods belonging to consumer tourists, hotel customers. The safe storage and storage of tourist property is a moral and ethical responsibility of the hotelier, through this type of civil liability, the hotel insurer demonstrating both professionalism and respect for its customers. At the same time, the hotelier demonstrates predictability in ensuring their rights and needs, in order to protect the continuity, sustainability and operational efficiency of its hotel business.

Addressed to both state governments and all public or private stakeholders as well as to consumer tourists themselves, the use of ADR methods in the field of HoReCa strengthens the trust of consumer tourists in their relationship with tourism service providers and thus facilitates the environment of relaxation and travel to become even more attractive, by creating a sense of comfort and mental security for tourists. In essence, they constitute mechanisms for resolving disputes, in a fast, fair, equitable and non-discriminatory manner of any kind, while respecting the fundamental rights and freedoms of the consumer tourist, framed in equal, impartial conduct for the parties involved.

At the same time, it certifies the continued maintenance of the contractual relations between the tourist service providers and the insurers, regarding the insured personal goods of the tourists, left in the care of the hoteliers through the hotel warehouse.

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hsa-miR-1204 and hsa-miR-639 Prominent Role in Tamoxifen's Molecular Mechanisms on the EMT Phenomenon in Breast Cancer Patients

Mahsa Taghavi

Abstract— In the treatment of breast cancer, tamoxifen is a regularly prescribed medication. The effect of tamoxifen on breast cancer patients' EMT pathways was studied. In this study to see if it had any effect on the cancer cells' resistance to tamoxifen and to look for specific miRNAs associated with EMT. In this work, we used continuous and integrated bioinformatics analysis to choose the optimal GEO datasets. Once we had sorted the gene expression profile, we looked at the mechanism of signaling, the ontology of genes, and the protein interaction of each gene. In the end, we used the GEPIA database to confirm the candidate genes. after that, I investigated critical miRNAs related to candidate genes. There were two gene expression profiles that were categorized into two distinct groups. Using the expression profile of genes that were lowered in the EMT pathway, the first group was examined. The second group represented the polar opposite of the first. A total of 253 genes from the first group and 302 genes from the second group were found to be common. Several genes in the first category were linked to cell death, focal adhesion, and cellular aging. Two genes in the second group were linked to cell death, focal adhesion, and cellular aging. distinct cell cycle stages were observed. Finally, proteins such as MYLK, SOCS3, and STAT5B from the first group and BIRC5, PLK1, and RAPGAP1 from the second group were selected as potential candidates linked to tamoxifen's influence on the EMT pathway. hsa-miR-1204 and hsa-miR-639 have a very close relationship with the candidates genes according to the node degrees and betweenness index. With this, the action of tamoxifen on the EMT pathway was better understood. It's important to learn more about how tamoxifen's target genes and proteins work so that we can better understand the drug.

Keywords— tamoxifen, breast cancer, bioinformatics analysis, EMT, miRNAs.

Medical Imaging Fusion: a Teaching-Learning Simulation Environment

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Abstract—The use of computational tools has become essential in the context of interactive learning, especially in engineering education. In the medical industry, teaching medical image processing techniques is a crucial part of training biomedical engineers, as it has integrated applications with health care facilities and hospitals. The aim of this article is to present a teaching-learning simulation tool, developed in Matlab using Graphical User Interface, for medical image fusion that explores different image fusion methodologies and processes in combination with image pre-processing techniques. The application uses different algorithms and medical fusion techniques in real time, allowing you to view original images and fusion images, compare processed and original images, adjust parameters and save images. The tool proposed in an innovative teaching and learning environment, consists of a dynamic and motivating teaching simulation for biomedical engineering students to acquire knowledge about medical image fusion techniques, necessary skills for the training of biomedical engineers. In conclusion, the developed simulation tool provides a real-time visualization of the original and fusion images and the possibility to test, evaluate and progress the student's knowledge about the fusion of medical images. It also facilitates the exploration of medical imaging applications, specifically image fusion, which is critical in the medical industry. Teachers and students can make adjustments and/or create new functions, making the simulation environment adaptable to new techniques and methodologies.

Keywords—Image fusion, image processing, teaching-learning simulation tool, Biomedical engineering education.

I. INTRODUCTION

Computational tools have become an almost permanent element and must be present in new interactive learning schemes, practically for all educational topics in engineering education [1]. Since the beginning of the 1990s, tools with a graphical interface have been developed for teaching image processing in the area of health and engineering [2], [3], [4], [5]. More recently, studies on the development of these tools open new perspectives, exploring more enriching learning scenarios where students and teachers engage in real practices. Learning spaces for the development of new experiences in collaborative environments, so that students transform everyday life scenarios into experiential learning spaces [6] as the case of a study of third-year Biomedical Engineering students on complementary activities of learning in "Second Life" focused on learning oral and written skills of scientific content [7] or the applied case study in Biomedical Engineering for

the development of a learning module for segmentation of digital images of Computed Tomography and detection of their specific anatomical features [8].

The teaching of medical image processing techniques and tools is an important part of the training of a Biomedical Engineer, since this process is integrated in health units, hospitals and the medical industry. The analysis of different types of medical images has become, in the last century, an important tool for medical diagnosis. Sometimes, to diagnose a specific pathology, an image showing metabolic activity is complemented by another image showing the anatomical structure of the same region. It is in this sense that the fusion of images (anatomical or functional) has great technological potential, as it helps in the diagnosis, in the decision of surgeries and in the development of certain pathologies. For example, the combination of data obtained from different exams in a single image makes it possible to specify the extent of anatomical impairment (for example, with a Magnetic Resonance Image (MRI)) and physiological (for example, with an infrared image), accurately diagnosing the location of changes in blood level and their physiological effect. It is, therefore, a critical area in the training of biomedical engineers.

This work arises from observation in the orientation of the final projects of the Degree in Biomedical Engineering, where most of the students end up spending a lot of time trying to generate efficient programming routines than learning the concepts and techniques of medical image processing, since the majority of these students are not programmers. Hence the objective of presenting a teaching-learning tool developed in Matlab using the Graphical User Interface (GUI), for the fusion of medical images using some algorithms and image processing techniques. The image fusion modeling can be obtained by different algorithms and using some preprocessing techniques implemented to "improve" the original images through the adequate definition of some parameters.

II. MEDICAL IMAGE FUSION METHODS

In image fusion, there are two major steps: first, image registration and secondly, the fusion of the relevant characteristics of the registered images. When recording images, a method is needed to correct the spatial misalignment resulting from changes in scales and/or rotations, and pre-processing techniques to improve the quality of the image. In image fusion there are currently several methods, with different limitations. In more classic methods, the images have a weak correlation,

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either due to the time difference between the acquisition of the two images, or due to the spectral differences between them. In the most recent fusion methods, the distortion of the spectral information is much smaller, or even non-existent, however distortions may occur at the spatial level [11].

- Morphological methods: The concept of morphology operators is widely used in image processing as it allows segmenting and identifying regions of interest in digital images. In medical images, morphological operators perform a sequence of mathematical operations that allow the identification and detection of specific features in image fusion, mainly MRI and Computed Tomography (CT) [9].
- Knowledge-based method: The domain of medical knowledge is necessary to restrict the segmentation of the region of interest. In this case, great reliance is placed on the physician's experience and the images are compared with known standards of human vision. However, it has the limitation of human appreciation, subject to errors, mainly in images with noise and variations in intensity. [9].
- Methods based on Wavelets functions: The original images usually have different frequencies in time and space, and can be transformed with Wavelet functions so that it is possible to analyze them on an identical time scale and frequency, improving the quality of their fusion. There are two types of Wavelet Transforms: Continuous and Discrete.

III. METHODOLOGY

During the 2021-2022 school year, a simulation tool was developed that intends to explore different image fusion processes and methodologies in combination with image pre-processing techniques and methods. The tool was implemented in Matlab [10] because it is freely available throughout the entire campus of the Coimbra Institute of Engineering and because of the possibility of using several image processing toolboxes. This tool, in addition to being widely used in environment academics, allows the creation of a Graphic User Interface (GUI), regardless of the implemented routines. The structure of the developed application is presented in Figure 1 and is divided into two stages. Step 1 (on the left) is responsible for all the registration of the two images A and B, that is, the loading of the original images (A and B), their pre-processing, where techniques and algorithms are applied to correct the brightness, noise removal, image filtering, histogram equalization, etc. to improve image quality (A1 and B1). And finally the adjustment of the images leaving them aligned with each other, through scales, rotations, etc. (A2 and B2). In step 2 (on the right), the fusion is applied to images A2 and B2. The three defined methods are: "Addition", "Fusion" and "Fusion using Wavelets".

Although there are several image fusion methods, in this work only three of these methods will be used, namely the "Addition" method, the "Fusion" method and the "Fusion using Wavelets" method. The first method adds to each element in the matrix image A2 the corresponding element of the

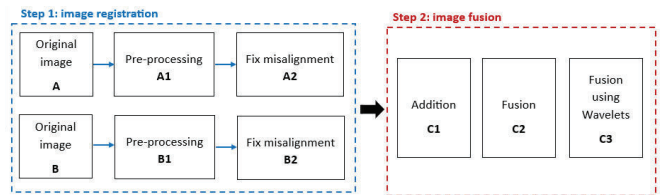


Fig. 1. Flowchart of the developed application

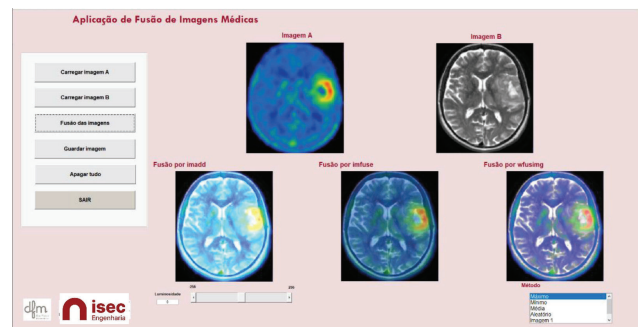


Fig. 2. Fusion of two PET and MRI brain images

matrix image B2 and returns the resulting matrix image (C1), sum of these elements. The "Fusion" method, on the other hand, initially converts color images into A2 and B2 grayscale images by matching the color of a color pixel to a grayscale intensity. In this scale, the darkest pixel is represented by 0 and the lightest by 1. The method allows choosing the way of scaling the image through a definition parameter. This means that both images can be scaled separately or together. Finally, each grayscale image is placed in a different color channel, and the resulting image is a composite image of these images (C2). The third method uses the principle of fusing images (A2 and B2) with procedures similar to the previous method but using Wavelets to fusing the resulting image (C3).

The application developed and represented in figure 2, allows choosing two original images of different types of medical exams A and B (upper button in the left menu) and viewing them in the application (top right). According to the chosen fusion algorithm, the final image of the fusion of the two initial images is visualized (bottom right). It is possible to obtain the fusion of the initial images using different algorithms or for the same algorithm to choose different initial images. The tool also allows, the visualization of the original images and the fusion image in real time.

It is also possible to change the brightness of the images resulting from the first two methods using the bar located in the lower left corner, or even define the type of fusion ("Maximum", "Minimum", "Medium" or "Random"), to be chosen to apply the Wavelet fusion, using the list in the lower right corner.

Another possibility, implemented in this application, is the possibility of monitoring over time images of different types or of the same type obtained at different times, which after being saved in different formats, can later be compared using different fusion techniques.

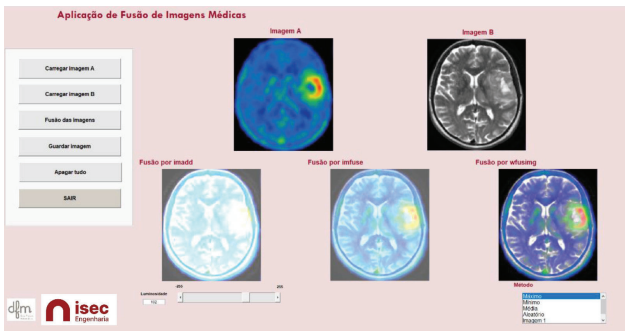


Fig. 3. Fusion of two brain images PET and RM with intensity level of 120

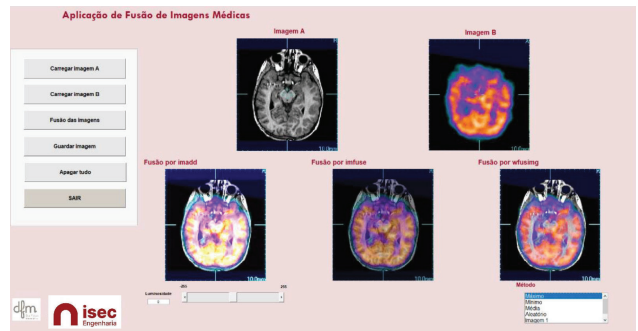


Fig. 5. Fusion of two brain images CAT and PET

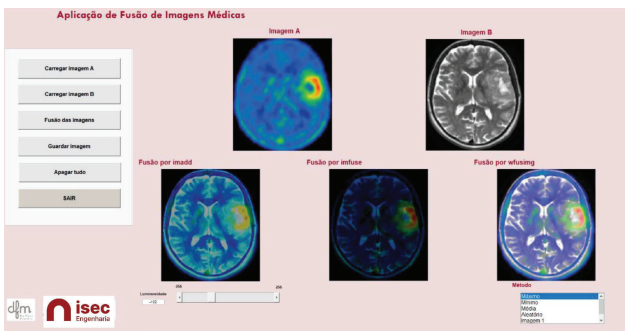


Fig. 4. Fusion of two brain images PET and RM with intensity level of -120

IV. RESULTS AND ANALYSIS

Several tests were carried out on the application using medical images in an open format on the internet. A first simulation consisted of merging two brain images (figure 2). The first image loaded in the application, image A is a Positron Emission Tomography (PET) type with contrast (left upper) and image B is a Magnetic Resonance Image (MRI) type in grayscale (right upper). The result obtained by fusion these two images using the three different methods can be found below. The C1 image obtained as a result of the first fusion method is an image with greater luminosity as it is the sum of the colors of 2 images, while C2 from the fusion method is a less clear image, since the fusion only is performed after each of these images is converted to grayscale and pre-processed. However, in each of these cases, it is also possible to control the lighting in the final image (C1 and C2), either by increasing the intensity (figure 3) or by decreasing the intensity (figure 4) using the application's intensity bar. In figure 3 the intensity has been changed to 102 while in figure 4 it has been changed to -102. The Wavelet fusion method (on right), on the other hand, remains identical for the application of luminosity (C3), in each of the cases. Finally, the Wavelet fusion method combines the decompositions of the two original images using fusion methods applied to approximation coefficients. It is also possible to vary the filters applied to the Wavelet fusion image.

In figure 5 it is possible to observe the fusion with Wavelets of two images of the brain. Computed axial tomography (CAT) image A and PET image B with Wavelet fusion "Maximum" type.

The figure 6 represents the fusion of images A and B of the

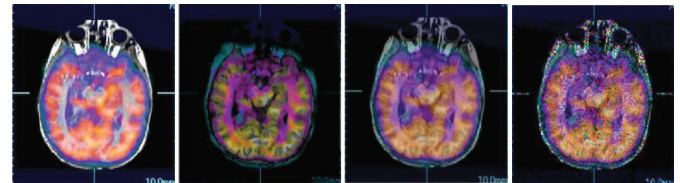


Fig. 6. Fusion two brain CAT and PET images using Wavelet fusion: "Maximum", "Minimum", "Median" and "Random" (from left to right)

figure 5 using the four types in Wavelet fusion: "Maximum", "Minimum", "Average" and "Random" (from left to right). The first image has a higher lightness than the other 3 and in the case presented here, the fusion with the "Random" type, in this case is the "Average" type fusion.

Two other examples of the sequence of images obtained after applying the fusion methods implemented in the application can be seen in figure 7 and 8. In the upper the original images A and B (from left to right) and in the lower the Wavelet fusion obtained by four types: "Maximum", "Minimum", "Average" and "Random" (from left to right).

In the figure 7 a PET image (A) with contrast and CT image (B) obtained in [12] allow the fusion to more adequately display the two images together and extract different aspects of the anatomy. In the figure 8 a CT image (A) and a PET image (B) with contrast (marker) obtained in [13], for the identification of small cancerous nodules. The patient is placed in the scanner, which, in addition to CT, has a nuclear medicine camera, which also captures the images emitted by

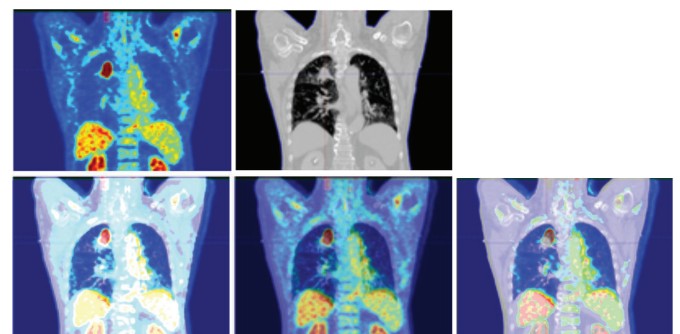


Fig. 7. Fusion of fluorodeoxyglucose (FDG) PET and a CT image using Wavelet fusion: "Maximum", "Minimum", "Median" and "Random" (from left to right) [12]

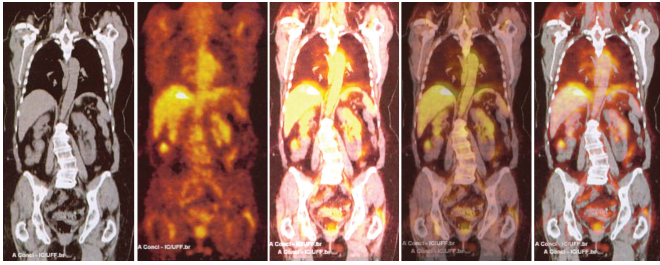


Fig. 8. Fusion of 2 images: CT image; PET image; fusion with wavelet methods maximum; minimum, median and aleatory method (from left to right) [13]

the marker. Thus, the resulting color images accurately show the regions where the marker is absorbed.

In the developed application, it is possible to view the entire processing flow carried out, change the parameters through the menu and save the image in different formats. In this way, it is possible to monitor and analyze the development of certain pathologies through the comparison between images of different types obtained in different situations, being able to compare images of the same type or different types through fusion. It is intended to use this application in classes as a pedagogical support tool. This tool will allow teachers to create a more dynamic and motivating teaching environment for their students. And students will be able to visualize the effects of the techniques they learned in class in a real way. It will also be possible for teachers and students to make changes to functions already implemented or even create new functions, allowing to adjust the acquired knowledge, making the simulation environment adapted to new techniques and methodologies.

V. CONCLUSION

Medical image fusion is a method of recording the combination of multiple images into a single or multiple imaging modalities to improve image quality and reduce randomness and redundancy in order to increase the clinical applicability of medical images for diagnosing and evaluating medical problems [14]. This paper presents an application developed in Matlab that allows merging two medical images from different modalities, for example the merging of a CAT scan image (in grayscale) with an image (in color), according to 3 different fusion models using different parameters. The objective of the developed application is to allow students of Biomedical Engineering to learn the basic methodologies and techniques of digital medical image processing in a real context. The possibility of customizing the application, including other image pre-processing or fusion techniques, can be adapted by students and encouraged by teachers.

With the use of this application, teaching-learning in the classroom is ensured by learning in a simulation environment, allowing the student to acquire the different skills necessary for his training as a Biomedical Engineering.

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Relationship between Glycated Hemoglobin in Adolescents with Type 1 Diabetes Mellitus and Parental Anxiety and Depression

Evija Silina, Maris Taube, Maksims Zolovs

Abstract—

Background: Type 1 diabetes mellitus (T1D) is the most common chronic endocrine pathology in children. The management of type 1 diabetes requires a strong diet, physical activity, lifelong insulin therapy, and proper self-monitoring of blood glucose and is usually complicated and, therefore, may result in a variety of psychosocial problems for children, adolescents, and their families. Metabolic control of the disease is determined by glycated haemoglobin (HbA1c), the main criterion for diabetes compensation. A correlation was observed between anxiety and depression levels and glycaemic control in many previous studies. It is assumed that anxiety and depression symptoms negatively affect glycaemic control. Parental psychological distress was associated with higher child self-report of stress and depressive symptoms, and it had negative effects on diabetes management.

Objective: The main objective of this paper is to evaluate the relationship between parental mental health conditions (depression and anxiety) and metabolic control of their adolescents with T1DM.

Methods: This cross-sectional study recruited adolescents with T1D (N=251) and their parents (N=251). The respondents completed questionnaires. The 7-item Generalized Anxiety Disorder (GAD-7) scale measured anxiety level; The Patient Health Questionnaire – 9 (PHQ-9) measured depressive symptoms. Glycaemic control of patients was assessed using the last glycated haemoglobin (HbA1c) values. GLM mediation analysis was performed to determine the potential mediating effect of the parent's mental health conditions (depression and anxiety) on the relationship between the mental health conditions (depression and anxiety) of a child on the level of glycated hemoglobin (HbA1c). To test the significance of the mediated effect (ME) for non-normally distributed data, bootstrapping procedures (10,000 bootstrapped samples) were used.

Results: 502 respondents were eligible for screening to detect anxiety and depression symptoms. Mediation analysis was performed to assess the mediating role of parent GAD-7 on the linkage between a dependent variable (HbA1c) and independent variables (child GAD-7 un child PHQ-9). The results revealed that the total effect of child GAD-7 ($B = 0.479, z = 4.30, p < 0.001$) on HbA1c was significant but the total effect of child PHQ-9 ($B = 0.166, z = 1.49, p = 0.135$) was not significant. With the inclusion of the mediating variable (parent GAD-7), the impact of child GAD-7 on HbA1c was found insignificant ($B = 0.113, z=0.98, p = 0.326$), the impact of child PHQ-9 on HbA1c was found also insignificant ($B = 0.068, z=0.74, p = 0.458$). The indirect effect of child GAD-7 on HbA1c through parent GAD-7 was found significant ($B = 0.366, z = 4.31, p < 0.001$) and the indirect effect of child PHQ-9 on HbA1c through parent GAD-7 was found also significant ($B = 0.098, z = 2.56, p = 0.010$). This indicates that the relationship between a dependent variable (HbA1c) and independent variables (child GAD-7 un child PHQ-9) is fully mediated by parent GAD-7.

Conclusion: The main result suggests that glycated haemoglobin in adolescents with Type 1 diabetes is related to adolescents' mental health via parents' anxiety. It means that parents' anxiety plays a more significant role in the level of glycated haemoglobin in adolescents than depression and anxiety in the adolescent.

Keywords— type 1 diabetes, adolescents, parental diabetes-specific mental health conditions, glycated haemoglobin, anxiety, depression.

Adjustment of Parents of Children with Autism: A Multivariate Model

Ayelet Siman-Tov, Shlomo Kaniel

Abstract—

Objectives: The research validates a multivariate model that predicts parental adjustment to coping successfully with an autistic child. The model comprises four elements: parental stress, parental resources, parental adjustment and the child's autism symptoms.

Background and aims: The purpose of the current study is the construction and validation of a model for the adjustment of parents and a child with autism. The suggested model is based on theoretical views on stress and links personal resources, stress, perception, parental mental health and quality of marriage and child adjustment with autism. The family stress approach focuses on the family as a system made up of a dynamic interaction between its members, who constitute interdependent parts of the system, and thus, a change in one family member brings about changes in the processes of the entire family system. From this perspective, a rise of new demands in the family and stress in the role of one family member affects the family system as a whole.

Materials and methods: 176 parents of children aged between 6 to 16 diagnosed with ASD answered several questionnaires measuring parental stress, personal resources (sense of coherence, locus of control, social support), adjustment (mental health and marriage quality) and the child's autism symptoms.

Results: Path analysis showed that a sense of coherence, internal locus of control, social support and quality of marriage increase the ability to cope with the stress of parenting an autistic child. Directions for further research are suggested.

Keywords— stress, adjustment, resources, Autism, parents, coherence.

Our Journey to CT Dose Optimization and Continual Learning

Corwin Burton

Abstract— CT radiation dose is always a hot topic and we as academic hospitals need to find ways to ensure we are constantly learning, educating and reviewing our CT protocols and dose levels. Our dilemma was; 5 hospital sites with 17 CT scanners, different vendors/scanner types with legacy protocols and varying protocol terminology, varying CT dose levels for similar scan procedures across the sites, varying technologist understanding/education on protocol management and equipment abilities, no definitive protocol change process, and the absence of a consistent communication tool. We first created a Protocol change management approach to support the review of CT protocols and dose levels across our imaging sites right away. This consisted of Identifying, Planning, Executing, and Monitoring. Other assessment tools needed to be built to support the review and education around protocol changes and dose levels.

Results or Findings

Achieved CT dose consistency and/or dose reduction over 75 major groups of protocols across 5 radiology divisions (Chest, Abdomen, Neuro, MSK and IR)

Attained an average of 35% lower CT radiation dose for high volume protocols without negative effect on image quality

Constructed and implemented consistent naming convention for all CT protocols

Established a sustainable structure and protocol change management framework

Increased patient safety by ensuring CT consistent protocol delivery

Cemented educational “Tip of the month”.

Keywords— Protocol, CT, Quality, Radiation, Operational.

Arthroscopic Investigation of Cyclops Lesions and Clinical Outcomes after Remnant Preserved Anterior Cruciate Ligament Reconstruction: A Comparison Study of Two Types of Truncated Remnant Preservation Techniques

I Sac Kim, Suc-hyun Kweon, Jin sung Park

Abstract—

Background: The purpose of this study is to compare the prevalence and clinical outcome of cyclops lesions between two types of anterior cruciate ligament (ACL) reconstruction using a truncated remnant technique: tie with allograft ACL reconstruction and re-tensioning of remnant ACL with allograft ACL reconstruction.

Method: This is a retrospective study of 58 cases of ACL reconstruction using a truncated remnant preservation technique performed by a single surgeon from March 2010 to December 2012. Second-look arthroscopy was performed in each group, and pathologic evaluation was performed focusing on cyclops lesions. The cases were divided into two groups according to the type of remnant technique: tie with allograft ACL reconstruction group (n=16) and re-tensioning of remnant ACL with allograft ACL reconstruction group (n=42). We evaluated the prevalence of cyclops lesions and the clinical outcomes in the two groups.

Results: No difference in patient characteristics was observed between the two groups. The clinical outcomes showed no significant differences between the two groups.

Conclusions: The re-tensioning of remnant ACL with allograft ACL reconstruction group showed no significant difference in clinical outcomes to the tie with allograft ACL reconstruction group. However, the re-tensioning of remnant ACL with allograft ACL reconstruction group produced no cyclops lesions, which was statistically significant, and showed subjectively improved symptoms, although vague owing to insignificant differences in clinical scores, compared with the tie with allograft ACL reconstruction group. Therefore, we recommend re-tensioning of remnant ACL with allograft ACL reconstruction.

Keywords— Anterior cruciate ligament (ACL), Cyclops, Reconstruction, Remnant.

Feedback Loops in Addiction: Unravelling Mechanisms and Implications

Ines Da Mata Annes

Abstract—The following paper delineates the complexity of addiction via feedback loops. Positive feedback loops can involve the rewarding properties of drugs and/or alcohol. When an individual consumes drugs or drinks alcohol, the brain's reward system is activated, releasing neurotransmitters like dopamine that create pleasurable sensations and in turn reinforcing the behaviour, increasing the likelihood of its repetition. Over time, the individual becomes more dependent on the substance feeling the need to seek it out more frequently and needing to take it in larger amounts to maintain the desired effect. This cycle continues, driving the addiction further. Negative feedback loops come into play as the body and brain attempt to adapt to the presence of the addictive substance. With prolonged substance use, the body may develop tolerance, requiring higher doses of the substance to achieve the same effects. This tolerance is a result of the body's efforts to counteract the substance's effects and maintain stability. In response to chronic substance use, the brain may reduce its production of certain neurotransmitters or adjust receptor sensitivity, dampening the initial pleasurable effects of the substance. As a result, individuals with addiction may escalate their substance use to overcome tolerance and achieve the desired effect, perpetuating the negative feedback loop. The abstract showcases feedback loops' pivotal role in sustaining addictive behaviors, shedding light on addiction's underlying mechanisms.

In sum, positive feedback loops reinforce addictive behaviours by enhancing pleasure and reward, while negative feedback loops drive the need for increased substance use to overcome tolerance and maintain the desired effects.

Keywords—Addiction, feedback loops, addictive behaviour, substance use, substance misuse, Addiction treatment.

Self-actualization and the Integration of Psychedelic Experience: The Mediating Role of Perceived Benefits to Narrative Self-functioning

Nicole Amada, Jacob Shane

Abstract— According to the eudaimonic perspective of well-being, the stories we create about who we are (self-insight) and who we can become (personal development) are key aspects of narrative self-functioning that either constrain or facilitate self-actualization. Psychedelic substances engender self-transcendence and malleability in narrative self-functioning, perhaps providing opportunity for instantiating insight- and growth- oriented narratives. The present study investigated how integration of psychedelic experience is linked with eudaimonic well-being via perceived benefits to narrative self-functioning. We tested our model with clinical and non-clinical populations of psychedelic users self-administering in naturalistic settings. Results show that integration was a stronger predictor of perceived benefits to narrative self-functioning than either frequency or duration of psychedelic use, and that these perceived benefits partially mediate the relationship between integration and self-actualization. When the model was tested between clinical and non-clinical participants, no significant differences were found. Findings from the present study evidence that self-insight and personal development aspects of narrative self-functioning are one pathway through which integration may be linked to self-actualization. As the present study is one of the only to explicitly model the role of integration, future research should continue to investigate the unique effect of integration in promoting well-being. The results of the present study should be interpreted as a preliminary model for future longitudinal research to test, as our cross-sectional methods preclude any causal inferences to be made from this mediation analysis.

Keywords— Psychedelic, Self-Actualization, Well-Being, Narrative Self, Integration.

A Small-Scale Survey on Risk Factors of Musculoskeletal Disorders in Workers of Logistics Companies in Cyprus and on the Early Adoption of Industrial Exoskeletons as Mitigation Measure

K. Clerides, P. Herodotou, C. Polycarpou, E. Xydas

I. INTRODUCTION

Abstract— Background: Musculoskeletal disorders (MSDs) in the workplace is a very common problem in Europe which are caused by multiple risk factors. In recent years, wearable devices and exoskeletons for the workplace have been trying to address the various risk factors that are associated with strenuous tasks in the workplace. The logistics sector is a huge sector that includes warehousing, storage, and transportation. However, the task associated with logistics is not well-studied in terms of MSDs risk. This study was aimed at looking into the MSDs affecting workers of logistics companies. It compares the prevalence of MSDs among workers and evaluates multiple risk factors that contribute to the development of MSDs. Moreover, this study seeks to obtain user feedback on the adoption of exoskeletons in such a work environment. **Materials and Methods:** The study was conducted among workers in logistics companies in Nicosia, Cyprus, from July to September 2022. A set of standardized questionnaires was used for collecting different types of data. **Results:** A high proportion of logistics professionals reported MSDs in one or more other body regions, the lower back being the most commonly affected area. Working in the same position for long periods, working in awkward postures, and handling an excessive load, were found to be the most commonly reported job risk factor that contributed to the development of MSDs, in this study. A significant number of participants consider the back region as the most to be benefited from a wearable exoskeleton device. Half of the participants would like to have at least a 50% reduction in their daily effort. The most important characteristics for the adoption of exoskeleton devices were found to be how comfortable the device is and its weight. **Conclusion:** Lower back and posture were the highest risk factors among all logistics professionals assessed in this study. A larger scale study using quantitative analytical tools may give a more accurate estimate of MSDs, which would pave the way for making more precise recommendations to eliminate the risk factors and thereby prevent MSDs. A follow-up study using exoskeletons in the workplace should be done to assess whether they assist in MSD prevention.

Keywords—musculoskeletal disorders, occupational health, safety, occupational risk, logistic companies, workers, Cyprus, industrial exoskeletons, wearable devices.

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During the past decade the world has been making the shift towards Industry 4.0, among the characteristics that describe this progress, is increased automation across all sectors of the industry with the objective to enhance productivity. Technological advances in recent years have allowed for improved and more complex automations, however workplace size and design parameters rarely allow for full automation solutions and situations where the dexterity, agility and decision-making of the human factor are unavoidable.

Increased research and observations from survey data over the last years highlight the concerns for health and safety in the workplace and the adoption of ergonomically designed workplaces for the avoidance of work-related injuries and the improvement of life quality. Work related musculoskeletal disorders are among the most common reported injuries in physically demanding workplaces and it is observed when the human body exceeds its biomechanical capacities repeatedly [1], [2]. The development of such acute or chronic MSDs lead to an increase in absenteeism and impacts the industry in terms of productivity [1], [3], [4]. In fact, over 25% of Europeans experience back injury due to work, and workplace injuries cost European countries up to 4% of their gross national product [3], [2]. Considering the need for increased productivity while minimizing risk for the employees, wearable devices for the workplace have seen an increase in research and development and exoskeleton solutions try to address the various risk factors that are associated with strenuous tasks in the workplace.

A. Objectives of survey

The objective of this study is to:

- 1) Identify which occupational tasks with the highest injury risks, MSDs and fatigue problems in the logistics industry in Cyprus. These are identified based on frequency, posture and other factors explained below.
- 2) Identify the movements and postures that have high risk of MSD. Also determine which joints/body parts are affected the most by MSDs.

- 3) Gather a user perspective on the adoption of exoskeletons in such work environment such as: determining how much assistance the workers need and determining which characteristics are important in designing practical augmentative exoskeletons which can help reduce fatigue in an industrial workspace.

B. Literature Findings

A literature review is conducted as part of this preliminary study. During the study an overview of the existing health issues and their associated factors in the workplace was performed. Also, an overview of the impact of current state of industrial exoskeletons was made with the main aim to determine adoption of an exoskeleton for assistance in the workplace.

1) Results on Health issues:

The available information from national sources shows that a very large percentage of workers (up to 60%) report being affected by musculoskeletal disorders (MSDs) [3]. Higher levels of discomfort associated with MSDs are reported in some specific sectors, such as construction, agriculture/fisheries, industry, transport, or health care [5]-[8]. Greater age is also associated with a significantly higher probability of reporting MSDs (in the upper limbs, lower limbs and back) [1], [7].

2) Occupational Tasks:

Information from the literature clearly state the relationship with high physically demanding tasks and the increased risks for MSD development. Occupational tasks that involve the lower back in various dynamic movements pose the most risk, these tasks most commonly are associated with manual labor and manual material handling such as Lifting/Lowering, Push/Pulling, Carrying [9], [8].

3) Joints that benefit from Assistance:

There is a significant amount of stress on the back muscles for squatting and stooping-related activities on the back muscles [10], [11], [12]. The studies almost unanimously establish that the back muscles (thoracic and the lumbar erector spine) are the most benefitted muscle group for activities related to picking and placing weights - either by squatting, stooping, or freestyle lifting [13]-[24].

4) Evaluation metrics for exoskeletons:

Metrics of the muscular domain were considered when evaluating an exoskeleton. The conclusions of this literature review are as follows:

- Literature shows benefit for the user in using a lifting assistive device for occupational worker-related tasks like squatting, kneeling, stooping, and freestyle weight lifting, [13], [15], [18].
- There are considerable benefits of using either an active or a passive hip exoskeleton on the back muscles - particularly: Thoracic and Lumbar erector spine muscles [19].

5) Passive or Active Support:

The literature survey has examined both passive and active actuation approaches on how they address the occupational

risk factors and while both have shown to assist effectively in physical loading tasks, each approach has its strengths and limitations.

- Important considerations that set the comparison standards for active and passive exoskeletons is the kinematic compatibility with the user during the tasks and how effectively muscle activities are reduced [17].
- Passive exoskeletons are less complex, less expensive, and more lightweight than active exoskeletons. Active devices, on the other hand, offer a greater potential for versatility and hence a larger range of applications. Open technological challenges for active exoskeletons include optimization of the control to utilize their versatility to broaden their potential impact [18], [19].
- Soft robotic suits are lighter and less obstructive to movement than rigid exoskeletons, but they reduce biomechanical joint loading to a lesser extent than active ones. In terms of kinematic compatibility, soft back support devices, do not change the body's kinematics and simply transmit forces in the form of tensions. However, one of their drawbacks is that they are usually limiting the range of motion [20].
- There are considerable benefits of using either an active or a passive hip exoskeleton on the back muscles - particularly: Thoracic and Lumbar erector spine muscles. A study also showed a considerable reduction in muscle activation of the leg muscles - rectus femoris and the gastrocnemius, upon wearing an active knee exoskeleton with passive support for the hip [21], [13]-[15].

II. MATERIALS AND METHODS

A. Questionnaires

The researchers employed questionnaires as the means of data collection from the potential user groups. In the current study, questionnaires were distributed to workers of some logistics companies based in Cyprus. The worker's daily tasks involve manual labor. We conducted a survey of workers (from ACS Courier LTD and other companies) to observe their working tasks, the pain they have in their lower back during working hours, and their wishes for an exoskeleton that will assist them during their work. The sampling method was *simple random sampling*. The objects in this sample are chosen at random, and each member has exactly the same probability of being selected.

B. Data Management

Data was managed through Google forms and the results were exported in excel sheets.

C. Study Population description

Even though the study aimed for higher sample size, only 38 participants completed the questionnaires, of which only 4 are women. 17 participants were from ACS Courier LTD, 1 from Panmare and 20 from other companies.

This sample size accounts for a 95% confidence interval with 16% error margin, for a population size over 10000. The estimated labor force in Cyprus in the logistics sector is estimated 80000 [25].

The age groups were distributed between 20-59 years old with most being between 20-39. Most responses at 40% were from the age group of 30 – 39 and the least from the age group of 50- 59 at 5%. The daily duties included couriers, warehouse workers and general workers with the most reported duty being courier at 55%. Most questionnaires were obtained from the company ACS Courier LTD. The name of the company that the questionnaires were obtained is optional, thus some participants did not specify.

D.Tasks and risk factor categorization

The duties were specified in different categories, and most of the workers worked as couriers. The other categories were warehouse, general worker, warehouse and other.

III. RESULTS

The results from the tests are presented in the figures below.

A. Work/Tasks and task frequency

The work hours were mostly over 40 hours per week with 69%. Most workers (55%) stated that they worked more than three years and 24% reported working 1-3 years, while 21% have been at their position for less than a year.

The section of tasks description consisted of 5 questions regarding daily load range, frequency, height, posture and intensity of the tasks. The workers generally work with loads in the light range as 55% reported to work within the range of 1 – 10 Kg followed by 34% within the 10 – 20 Kg range. While only 8% (3) reported to work with the heavy range of 30 – 40 Kg.

Participants were asked to define the frequency of lifting, carrying, push or pull, prolonged support and working on uneven floor. **Most frequent daily tasks are Lifting, carrying and Push or Pull while carrying is the most frequently reported** which is expected as most participants are couriers. Prolong support and handling weight on uneven floor occurs the least in the daily tasks.

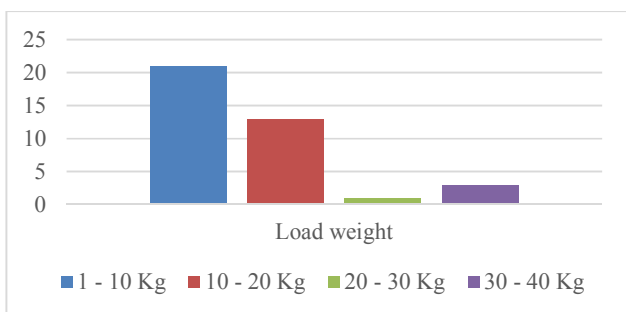


Fig. 1 Daily load Weight

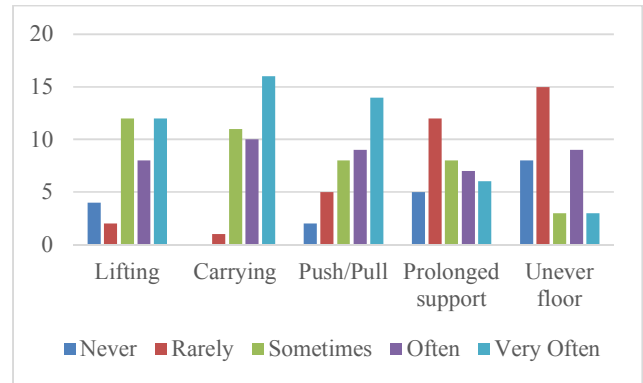


Fig. 2 Task frequency

Examining the height at which the load is handled, the most frequently reported are waist followed by floor while shoulder height and over the shoulder occurs rarely. In terms of posture the participants (31%) reported that **awkward or restrictive posture occurs sometimes**.

Intensity of the daily tasks is reported to be in the upper range with only 2 (3%) people reporting little to no intensity at all, the majority of participants reported medium intensity (55%) while 16 (42%) participants reported very much to extreme intensity.

1) Task height (with respect to user's body)

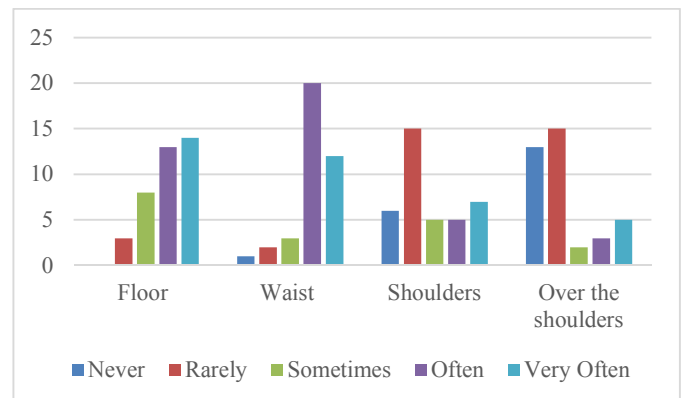


Fig. 3 Load landing height

2) Awkward or restrictive posture

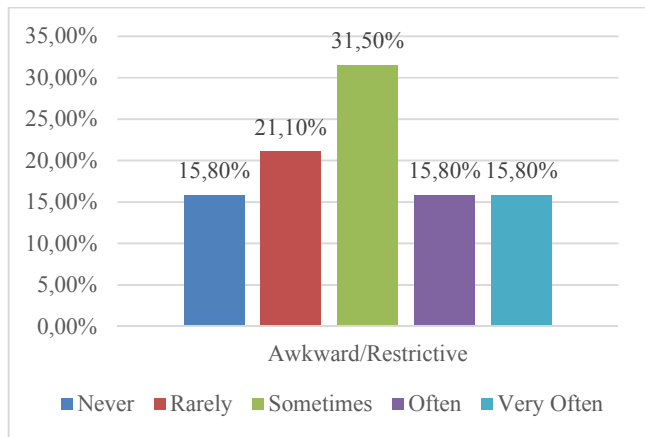


Fig. 4 Posture

3) Work Intensity

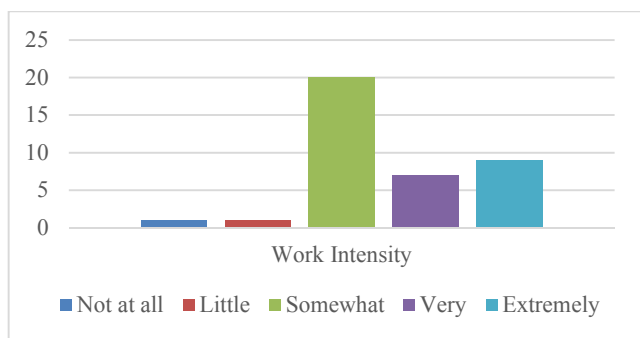


Fig. 5 Work Intensity

B. MSDs and Health

The participants were also required to answer 5 questions regarding pain or discomfort, affected performance, tiredness, absence due to pain and if there were any cases of MSDs in the last year. The body regions with the less reported pain or discomfort are thighs and glutes with 16 (42%) participants never experiencing pain or discomfort followed by 16 (42%) participants experiencing pain sometimes per month. The **back region is reported to be the most affected region with 22 (58%) participants experiencing upper back discomfort** sometimes per month and more so, 15 (39%) participants are experiencing lower back pain weekly followed by at least 10 participants experiencing lower back issues almost daily. **Shoulders, arms, hands and knees are reported to be in the same range with 39 – 42% experiencing pain or discomfort sometimes per month.** Lower back is also the leading issue that somewhat affects performance during work as reported by 13 (34%) participants followed by 6 (16%) affecting them very much to extremely. **Almost all participants experience high levels of tiredness after work** as only 4 (11%) participants reported to be slightly tired after work.

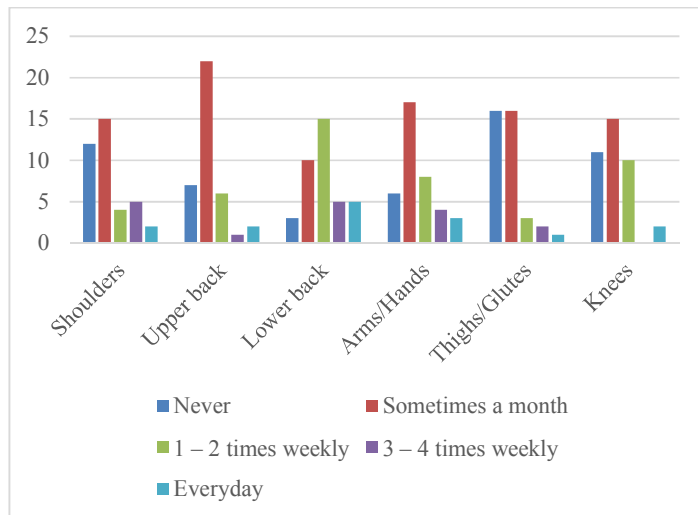


Fig. 6 Pain or Discomfort

In the case of absenteeism in the last year due to pain or discomfort in any of the body regions the results do not deviate much for any particular region, with all regions being between 8 - 18%, the **lower back comes first with 7 (18%) participants being absent from work in the last year.** This is reflected in the case of **12 (32%) participants reporting an MSD episode** in the last year with 8 cases including the lower back, also from the 12 cases of MSD, 9 had to visit a doctor for their issue.

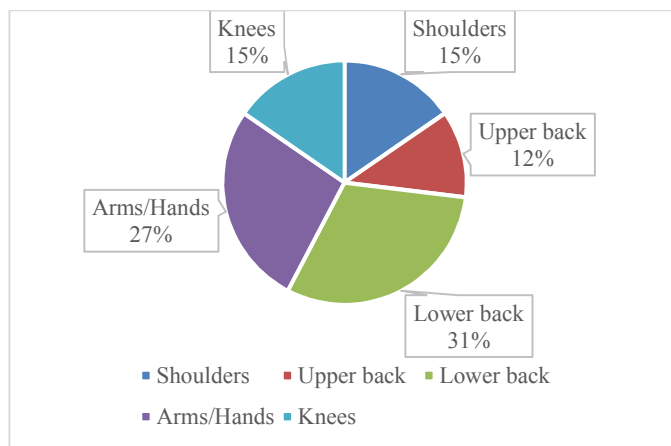


Fig. 7 MSD Region

C. Exoskeleton adoption

The participants were also asked to provide their input on exoskeleton assistance devices and their functional characteristics. When asked to indicate importance level on types of assistance among muscle load reduction, fatigue reduction and posture support the answers were mostly in the slightly to somewhat important while only 9-11 (24- 29%) consider each type as very or extremely important. A significant number of participants **29 (76%) consider the back region as the most to be benefited by external assistance** followed by the knees and arms at 11% and 8% respectively. **Half of the participants would like to have at least 50% reduction in their daily effort** while performing

tasks followed by 12 (32%) participants with 25% effort reduction.

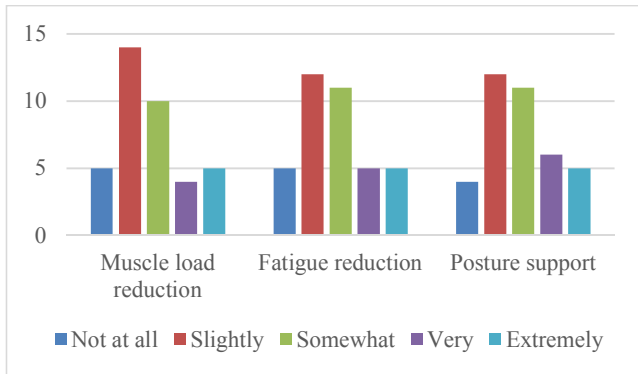


Fig. 8 Assistance Importance

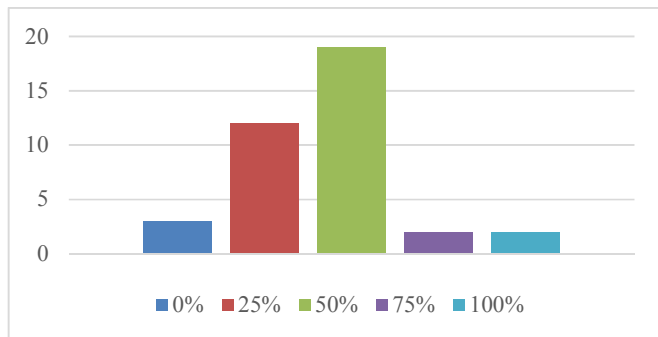


Fig. 9 Desired Effort reduction

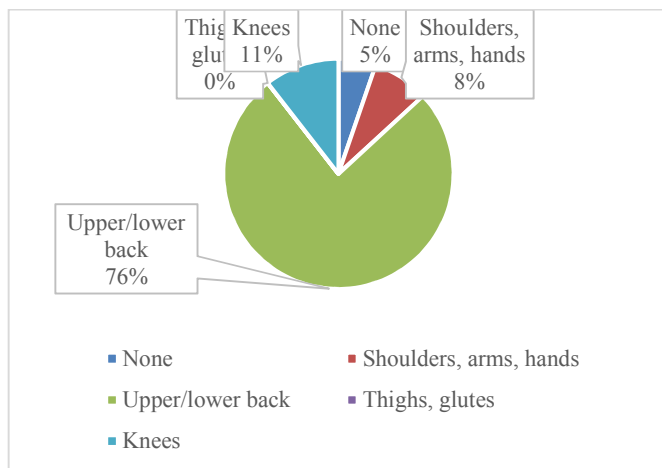


Fig. 10 Desired body part assistance

The participants rated various characteristics of the device in terms of importance, aesthetics and water resistance were rated as low importance with aesthetics being the least important. The most important characteristics for the user are **how comfortable the device is with 50% of the participants rating it as extremely important** followed by **how lightweight it is at 45%**, as is expected the weight of the device will play an important role on how comfortable it will be. **Easy attachment and detachment along with easy adjustments are rated as 39-42% extremely important.**

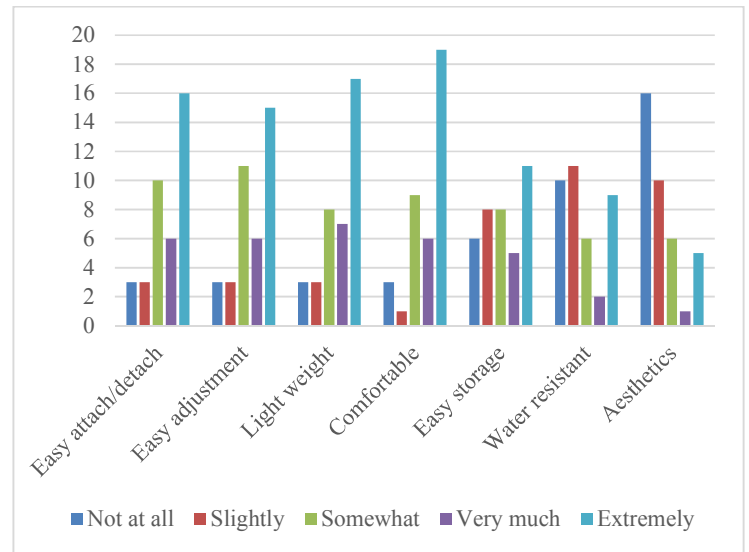


Fig. 11 Importance of exoskeleton characteristics

Lastly, a large percentage of 69% were considering using a such a wearable device. 18% would not try it at all while 13% would slightly consider it. The largest proportion 37% would somewhat consider wearing it. 32% were very positive to trying the device.

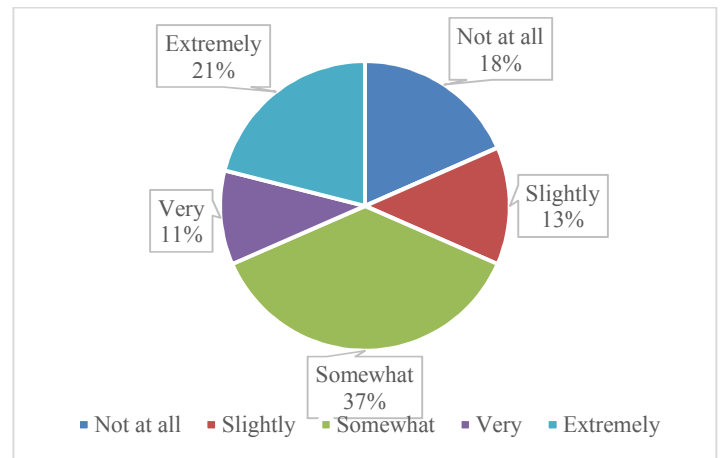


Fig. 12 Consideration of exoskeleton usage in work environment

IV. DISCUSSION AND CONCLUSION

A. Conclusions

This study is the addressed risk factors regarding MDS, in workers of logistics companies in Cyprus. Moreover, the adoption of exoskeletons was addressed, which is a relatively new way of mitigating risks in the workplace. In summary, the results show that :

Based on the occupational tasks, the following risks are based on specific factors:

- Almost all workers handle weights from 1-20kg.
- Most frequent daily tasks are Lifting, carrying and Push or Pull
- Most frequently reported task heights are waist and floor

heights which imply back bending

- 1/3 reported that awkward or restrictive posture occurs sometimes
- majority of participants reported medium and high intensity of tasks.

The conclusion we extract are: the occupational tasks with the highest injury risks, MSDs and fatigue problems in the logistics industry are lifting, carrying and push or pull. These are the most frequent tasks, intensive and sometimes awkward posture occurs. The factors that may constitute risks are the frequency, height where the load is handled, posture and task intensity. The daily weight handled between 1-20 kg may be a risk factor as well.

Movements and joints/body parts that have high risk of MSD are:

- The back region is reported to be the most affected region with over half of participants experiencing upper back discomfort 4/10 participants are experiencing lower back pain weekly followed by at least 1/3 participants experiencing lower back issues almost daily
- Almost all participants experience high levels of tiredness
- About 1/5 participants reported being absent from work in the last year due to Low back pain.

The conclusion is that the back region (upper and lower) has a high risk of MSD, because most participants report discomfort, low back pain and absenteeism. These results agree with most of the literature.

Regarding adoption of exoskeletons the results show:

- Most consider load reduction, fatigue reduction and posture support assistance slightly to somewhat important
- A significant number of participants (76%) consider the back region as the most to be benefited by external assistance
- Half of the participants would like to have at least 50% reduction in their daily effort while performing tasks
- The most important characteristics for the user are how comfortable the device is, lightweight, easy attachment and detachment along with easy adjustments
- 7/10 were considering using a such a wearable device in their work.

Therefore, the conclusion is that external assistance at the back region is considered to bring the most benefit by the participants. Most participants would like to bear half of the load and be assisted to the rest. Lastly, according to the participants the most important characteristics of an industrial exoskeleton are comfort, being lightweight, easy attachment and detachment along with easy adjustments. Therefore these attributes shall be taken into consideration when designing such a device. Most participants are willing to test an exoskeleton device, which concludes that there is compliance towards this technology.

B. Limitations of the study

This study has its pitfalls. First of all, the sample size was relatively small for any definite conclusion with 38

participants, thus the error margin is high. One pitfall is that the population may be selection-biased towards males, since only 4 women participated. Moreover, most participants were from only one company. As a consequence, some results could be diluted.

C. Future work

This study conducted in a much higher scale, could provide useful indications of risk factors and risk assessment by using wearable devices, with smaller error margin. A future step is to test an exoskeleton in an industrial setting and then conduct another study to determine the satisfaction and acceptance level of the workers.

ACKNOWLEDGMENT

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Percutaneous Femoral Shortening Over a Nail Using On-site Smashing Osteotomy Technique

Rami Jahmani

Abstract—Closed femoral-shortening osteotomy over an intramedullary nail for the treatment of leg length discrepancy (LLD) is a demanding surgical technique, classically requiring specialized instrumentation (intramedullary saw and chisel). The paper describes a modified surgical technique of performing femoral shortening percutaneously, using a percutaneous multiple drill-hole osteotomy technique to smash the bone, and then, the bone is fixed using intramedullary locked nail. Paper presents the result of performing nine cases of shortening as well.

Keywords—Femoral shortening, Leg length discrepancy, Minimal invasive, Percutaneous osteotomy.

The Role of Gastric Decompression on Postoperative Nausea and Vomiting in Orthognathic Surgery

Minna Salim and Dr. James Brady

Abstract—Postoperative nausea and pain (PONV) are adverse effects following surgical procedures. It is especially pronounced in patients undergoing orthognathic surgery, as their mouth is closed postoperatively using wires or rubber bands. Postoperative mouth closure increases the discomfort and risk of complication associated with nausea and vomiting. Many surgeons and institutions apply gastric decompression in hopes of aspirating stomach contents and therefore, decreasing PONV incidence. However, different studies indicate conflicting outcomes of gastric decompression on PONV therefore, the efficacy of gastric decompression is debated. A majority studies indicate that PONV incidence was not affected by gastric decompression. This paper summarizes the findings of gastric decompression on PONV and to determine the need for it in orthognathic surgery.

Keywords—Gastric decompression, Nasogastric tube, Orthognathic surgery, Postoperative nausea and vomiting.

I. INTRODUCTION

THE role of gastric decompression on postoperative nausea and vomiting (PONV) is the most common adverse event that occurs following anesthetic and surgical procedures, with an incidence rate of 40 - 60% [1]. A patient's risk for PONV incidence is multifactorial. The four main categories that determine the level of PONV risk are patient characteristics, preoperative factors, intraoperative factors, and postoperative assessments [2]. Patient characteristics such as high BMI, females, PONV or motion sickness history, nonsmokers, and patients aged < 50 are predicted to have higher PONV incidence [2], [3]. Preoperative factors such as suboptimal prophylaxis prior to surgery is shown to increase PONV incidence [3]. Additionally, acquiring a higher simplified risk score (3–4) preoperatively is shown to result in higher PONV incidence. Intraoperative factors that affect PONV incidence are surgical and anesthetic factors [2]. Major surgical procedures, as well as procedures that are longer than 60 minutes are typically associated with higher PONV [2], [3]. Additionally, volatile anesthesia intraoperatively, or the use of long-acting opioids during anesthesia is shown to increase the risk of PONV [3]. Postoperative factors such as pain and postoperative opioid use are thought to cause increased PONV incidence [2].

Because of the various factors that can elicit PONV, there is still no clear approach to reducing PONV incidence. However, a number of surgeons and institutions use gastric decompression tools such as nasogastric (NG) or orogastric (OG) tubes to potentially decrease PONV.

Gastric decompression aims to reduce stomach contents and therefore, is thought to decrease the incidence of postoperative

emesis in patients. This process may be performed preoperatively, intraoperatively, postoperatively, or perioperatively. Differences in the method of tube insertion and the time of when the tube is inserted depends on the institution or surgeon. The approach of our institution, at Dalhousie University, is perioperative nasogastric decompression for patients undergoing orthognathic surgery. The efficacy of gastric decompression in reducing PONV is variable which is why different institutions and surgeons have different preferences according to the variable literature results.

Discomfort caused by PONV is greater than postoperative pain, therefore PONV is considered a major patient concern after surgery and a major reason for decreased patient satisfaction [4]. It would be valuable to find the different institution and surgeon preferences regarding gastric decompression. Gathering more information and developing a more standardized solution to PONV can help prevent its occurrence while also eliminating common practices that are potentially not effective. Limited studies have been conducted regarding the effects of gastric decompression on orthognathic surgery therefore, other studies involving different surgery types have been considered in this paper.

II. METHODS

All cases with the PubMed Text Words: (1) “gastric decompression” OR “nasogastric tube” OR “gastric aspiration” OR “orogastric tube” AND “PONV”, (2) [“orthognathic surgery” OR “jaw surgery”] AND [“gastric decompression” OR “nasogastric tube” OR “gastric aspiration” OR “orogastric tube”], (3) “nasogastric tube” AND “PONV” were included to access previously reported observations of gastric decompression effects on PONV.

All reported cases directly reference PONV. All primary research articles were included, and their outcomes were evaluated.

III. RESULTS

A table of the publications that included information about the surgery performed, tube insertion method, incidence of PONV with GD, incidence of PONV without GD, sample sizes, and observations is listed below (Table 1).

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TABLE I
THE EFFECTS OF GASTRIC DECOMPRESSION ON NAUSEA AND VOMITING

| Surgery | Tube Insertion Method | PONV Incidence <i>With</i> GD (%) | PONV Incidence <i>Without</i> GD (%) | Sample Sizes | Observations | |
|---------------------------------|-----------------------------------------|-----------------------------------|----------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------|-----------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| GD DECREASED PONV | Cardiac [5] | NGT | Vomiting incidence: 10% | Vomiting incidence: 24% | NGT: n = 99 No NGT: n = 103 | No significant difference in nausea between the two groups, but there is a significant increase in vomiting in the control group compared to the study group. This suggests that NG tube use decreases vomiting. |
| | ENT [6] | NGT | 1 st hr: 10% 2 nd hr: 18.6% 8 th hr: 11.4% 24 th hr: 4.3% | 1 st hr: 52.2% 2 nd hr: 64.2% 8 th hr: 64.2% 24 th hr: 25.4% | GD: n = 70 No GD: n = 67 | PONV was found to be much more severe in the group that did not receive gastric decompression, compared to the one that did. Therefore, GD presented a significant decrease in PONV incidence. |
| | Gastrectomy [7] | NGT | PONV: 21% | PONV: 29% | NGT: n = 43 No NGT: n = 41 | PONV incidence was found to be significantly higher in patients that did not receive gastric decompression, compared to those that did. This suggests that NG tube use decreases vomiting incidence. |
| | Hepatic resection [8] | NGT | Nausea: 20% Vomiting: 2% | Nausea: 31% Vomiting: 10% | NGT: n = 100 No NGT: n = 100 | The use of an NG tube significantly decreased vomiting incidence. |
| | Orthognathic surgery [9] | OGT | Vomiting in males: 0% Vomiting in females: 19% | Vomiting in males: 25% Vomiting in females: 46% | OGT: n = 39 No OGT: n = 44 | There was a statistically significant difference between the control and study groups in the overall PONV incidence showing that GD can reduce the effects of PONV. |
| | Abdominal hysterectomy [10] | OGT | PONV: 79% | PONV: 70% | OGT: n = 100 No OGT: n = 101 | There was found to be no significant difference between the use of an orogastric tube vs not. |
| | Coronary revascularization surgery [11] | NGT | Nausea: 32.6% Vomiting or retching: 13.4% | Nausea: 25% Vomiting or retching: 11.5% | NGT: n = 52 No NGT: n = 52 | There was found to be no significant difference in PONV between groups that received or did not receive GD. |
| | Esophagectomy [12] | NGT | Nausea: 13.6% Vomiting: 9.1% | Nausea: 16.7% Vomiting: 11.1% | NGT: n = 22 No NGT: n = 18 | There was no difference between the two groups in the incidences of nausea and vomiting. |
| | Liver surgery [13] | NGT | Nausea: 11.1% Vomiting: 6.5% | Nausea: 11.8% Vomiting: 7.8% | NGT: n = 108 No NGT: n = 102 | It was found that the incidence of nausea and vomiting between the two groups was comparable. |
| | Multiple Surgeries Observed [14] | NGT | Intraoperative decompression: 44.4% Perioperative decompression: 27.8% | Intraoperative decompression: 41.5% Perioperative decompression: 31.3% | NGT: n = 1185 No NGT: n = 2743 | Intraoperative use of NG tube was not significantly associated with a reduction in nausea, vomiting, or PONV. |
| GD CAUSED NO DIFFERENCE IN PONV | Orthognathic surgery [4] | Either OGT or NGT | Nausea: 33.3% Vomiting: 16.7% | Nausea: 33.3% Vomiting: 25% | GD: n = 12 No GD: n = 12 | There was no significant difference between the gastric decompression, and non-gastric decompression groups. |
| | Radical gastrectomy [15] | NGT | No PONV detected | No PONV detected | NGT: n = 69 No NGT: n = 67 | It was found that the group without decompression had a significantly shorter operating time when compared to the group that received gastric decompression. This suggests that the time used to manipulate and reposition the NG tube during operation could be saved by omitting |

| GD INCREASED PONV | | | | | | |
|---------------------------|----------------------------------|----------------------------------------------------------------|-------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------|
| | | | | | | |
| | Tonsillectomy [16] | OGT | PONV: 85% | PONV: 74% | OGT: n = 39 No OGT: n = 35 | the use of an NG tube. This study showed that nasogastric decompression was unnecessary after radical gastrectomy. |
| | Multiple Surgeries Observed [17] | OGT | Nausea: 36.3% Vomiting: 22.0% | Nausea: 41.7% Vomiting: 28.8% | NGT: n = 132 No NGT: n = 133 | There was no significant difference between the two groups. |
| Orthognathic surgery [18] | NGT | <u>One day later:</u> Nausea: n = 12% Vomiting: n = 6.8% | <u>One day later:</u> Nausea: n = 26.6% Vomiting: n = 16.7% | PONV: 41.1% – NG tube removed after gastric decompression at the end of surgery PONV: 25.5% – NG tube retained for at least 24h PONV: 20.6% | NGT: n = 120 No NGT: n = 252 There was no significant difference in the overall nausea and vomiting incidence between the two groups. However, the incidence of nausea and vomiting after discharge from the day of surgery was higher in patients whose stomachs had been aspirated. | |

NGT = nasogastric tube, OGT = orogastric tube, n = sample size.

IV. DISCUSSION

Reporting the results of different studies regarding the effect of gastric decompression on PONV is a step forward towards discovering if gastric decompression is truly useful in decreasing PONV incidence. Very little studies were found on orthognathic surgery specifically therefore, results from various surgeries were assessed to find a common trend in the effect of gastric decompression on PONV. It was observed that many of the articles reviewed suggest that gastric decompression has no significant effect on PONV incidence. Each of the three orthognathic surgery papers referenced in Table 1, shows different results with respect to the effect of gastric decompression on PONV incidence. Although Schmitt et al. found that gastric decompression had no effect on PONV, the sample size of the study was small which may have affected the results [4]. In contrast, Apipan et al. suggested that NG tube insertion led to higher PONV incidence compared to participants with no NG tube insertion [18]. However, their study mentioned that it was still not clear whether NG tube use reduced PONV incidence which suggests uncertainty. DeJesus et al. showed a significant decrease in PONV incidence with respect to gastric decompression however, the study used an orogastric tube as opposed to a nasogastric tube which may have led to less mucosal damage and therefore, less PONV incidence caused by the tube. Further research should be done to assess the need of gastric decompression in reducing PONV. Obtaining more results can lead to finding appropriate techniques to decreasing PONV.

Although most of the reviewed studies concluded that gastric decompression does not have a significant effect on PONV, there are still other studies that suggest PONV is either increased or decreased via the use of nasogastric/orogastric tubes. Therefore, published results are not very clear and there still is not a good understanding on what the best way to decrease PONV incidence is.

Tube insertion for gastric decompression can cause various complications. Lesser complications such discomfort and

sinusitis may occur and typically resolve with the removal of the nasogastric tube [19]. However, tube insertion may cause esophageal trauma which can lead to patient discomfort [19]. Blind placement of the tube may cause intracranial placement in patients with injured cribriform plates. Prolonged use of an NG tube may lead to GI (gastrointestinal) lining irritation and can cause GI bleeding [19]. Therefore, gastric decompression complications are variable and may become life threatening to the patient. Due to this, deducing if gastric decompression affects PONV outcomes is valuable so that unnecessary tube insertion can be eliminated to decrease incidence of these possible complications.

Future studies can focus on collecting data from OMF (oral and maxillofacial) surgeons across Canada to examine the different techniques and protocols for gastric decompression at different institutions (Curry et al., manuscript in process). The use, method, and timing of gastric decompression is heavily related to either the institution or surgeon preference, therefore collecting information from different practitioners will result in a better understanding of what the general understanding of orogastric and nasogastric tubes are amongst the field.

V. CONCLUSION

The scope of study on the effects of gastric decompression on PONV is limited, especially in orthognathic surgery. Understanding the effect of gastric decompression on PONV is useful to prevent unnecessary practice of tube insertion if it provides no significant resolution to nausea and vomiting.

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