Design and Implementation of Electronics Embedded System for Remote Healthcare Monitoring

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***Abstract*__**Healthcare must be as efficient as possible. Information and communication technologies (ICTs) have great potential to address some of the challenges faced by both developed and developing countries in providing accessible, cost-effective, high-quality healthcare services. Telemedical clinics use ICTs to overcome geographical barriers, and increase access to healthcare services. This is particularly beneficial for rural and underserved communities in developing countries – groups that traditionally suffer from lack of access to healthcare. This work **proposes** an Embedded system design using **web-based** technology to provide wide range of services in Telemedical clinics which facilitates the provision of medical aids from distance. So we implement Sensor nodes Circuit for collecting data and process them to extract useful body information. Sensors: are interfaced to microcontroller through analog module, the written software in the microcontroller processes data and the processing results are sent to the Laptop then to web-portal using Bluetooth connection and the flow chart of the written software is developed. The proposed System structure clarify 4 components (Medical Sensors, CCU Interface, Communication module, Application Platform). One of medical sensors is the temperature sensor, we used the temperature Resistance Equation to build the Algorithm to get the temperature measurements. We implement web-service using PHP-Programming and MySQL DataBase: To update and plot the response of sensors to the real world Remote Healthcare Monitoring center. An Experimental setup of Embedded system of sensors is tested. It is an effective solution for providing specialty healthcare in the form of improved internet-access and reduced cost to rural patients.

***Keyword*__**Telemedicine, Internet of Things IoT, ehealth, Healthcare, Medical Center, Information and communication technologies ICT, Rural Health Clinics.

I. Introduction

MORE than urban areas, rural communities depend on a system of small clinics and health centers to provide primary care services, often utilizing non-physician health professionals. This system consists of rural health clinics (RHCs). Rural areas are facing limited supply of pharmacists, dentists and mental health professionals. Because training programs have not kept pace with the rapid and growing demand for pharmacists, there are relatively few pharmacists available to serve rural areas[1]. Overall, the measured performance of rural physicians tended to be lower than performance of physicians in urban or suburban areas. Primary care physicians in both urban and rural areas identify diabetes, cardiovascular disease and cancer as major challenges and chronic conditions were major concerns. Mobile clinics equipped with new technology can move beyond traditional functions and provide broader range of clinics services. Advances in communications and information technology are transforming medical care by changing the way care is delivered and how people access medical services. One technology driving these improvements is telemedicine: the provision of clinical services using the electronic exchange of medical information, cross-site transmission of digital images and electronic communications (e.g, remote monitoring of vital signs and video patient consults with physicians). Rapidly emerging as a component of telemedicine is medical care that relies on mobile devices such as cellular phones, personal digital assistants and laptops (often referred to as mHealth). High resolution cameras, digital imaging, the use of smart phones and broadband high-speed connections have dramatically improved the scope and scale of telemedicine's applicability [2].

II. Telemedicine Used in Rural Healthcare

Telemedicine can expand capacity, foster coordinated care, improve the quality and efficiency of the delivery system and support more patient self-management. Fig.1 shows the types of telemedicine that are most functional expand the capacity of the rural healthcare delivery system, making it easier for patients to be seen and treated, especially by specialists[3][4].

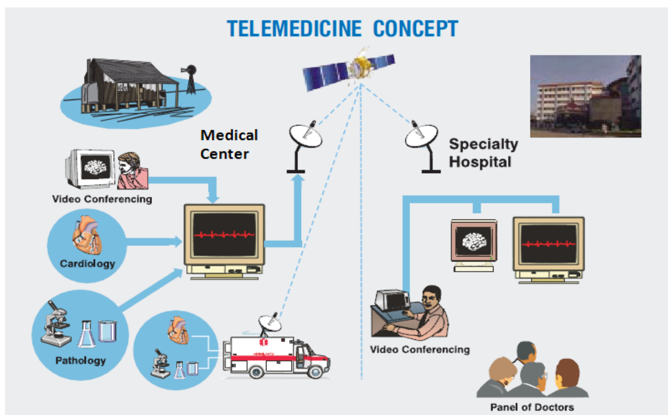

Fig.1. Telemedicine Usage in Rural [3]

III. Requirements in Medical Centers , Fig. 2

- Tele-consultation room
- Patient engagement facilities (bed, scopes, etc.)
- Medical equipment, IT compatible, with interface to Telemedicine and/or other software / hardware
- Computer hardware/software platform (PC, switch, etc.) and IT electronics equipment

- IP Video Conferencing Kit
- Digital ECG
- A3 Film Scanner
- Digital Microscope & Camera
- Glucometer & Haemogram analyzer
- Non-invasive Pulse & Blood Pressure unit
- Connectivity device & Router
- Video conferencing
- Accompanied by data and image transfer (live)
- Common software usage at both ends, thus globalization of a single database software
- Role of trained technical personnel is equally important and necessary at the patient end.

Fig.2 Requirements in Medical Centers

Distant Site: The Centers for Medicare and Medicaid Services (CMS) is the telehealth site where the provider/specialist is seeing the patient at a distance or consulting with a patient's provider. Others common names for this term include – hub site, specialty site, provider/physician site and referral site.

Digital Camera (still images): A digital camera is typically used to take images of a patient. General uses for this type of camera include dermatology and wound care.

Document Camera: A camera that can display written or typed information (e.g., lab results), photographs, graphics (e.g., EKG strips) and in some cases X-Rays.

Patient Exam Camera (video): is used to examine the general condition of the patient. Types of cameras include those that may be embedded with set-top videoconferencing units, handheld video cameras, gooseneck cameras, camcorders, etc.

IV. TELEMEDICINE'S EFFECT ON COST AND OUTCOMES

Telemedicine technology can reduce readmissions to hospitals, avoid unnecessary visits to physician offices, improve medication compliance and strengthen communication between patients and healthcare professionals holds significant promise in practice. Policy makers, researchers, healthcare professionals and consumers are interested in the widespread adoption of telemedicine technology to reduce costs and improve outcomes. Research on cost-effectiveness and health outcomes is, however, starting to generate some initial results:

• An extensive literature review reported that telemedicine reduced time-to-diagnosis, improved access to care for patients in remote areas and improved patient satisfaction [5].

• A Veterans Affairs study in Florida showed 50 percent reduction in hospital admissions and an 11 percent reduction in emergency room services using home telehealth services [6].

• A review of 13 tele-ICU studies found that telemedicine in the e-ICU reduced ICU mortality by 20 percent and reduced the average length of ICU stays by an average of 1.26 days[7].

V. STRATEGIES TO IMPROVE THE USE OF TELEMEDICINE

We discuss strategies to make full access of telemedicine :

1. Expand broadband connectivity: to enable growth of telemedicine adoption, physicians must have the necessary infrastructure access to broadband, video-conferencing technology and telemetry-enabled medical-devices.

2. Encourage physicians to incorporate telemedicine into their practice.

While telemedicine has the potential to benefit physicians and their patients, education and support are needed to ease the transition for many providers. As with electronic health record adoption, the adoption of telemedicine will also require structural changes in many practices: staff composition, work schedules and record keeping are all likely to evolve in practices that use telemedicine extensively [8]. Health plans, employers and public purchasers of care can all encourage providers in their networks to use telemedicine by educating them about its ability to serve patients better by combining telemedicine encounters with face-to-face care.

3. Use telemedicine to build primary Care capacity :

Rural areas without ease of access to specialists use telemedicine to provide care without the need for transporting patients from small hospitals or physician offices to urban centers. Through video conferencing, physicians located in urban hubs can visit with, treat and prescribe medications for patients in distant rural locations[9].

4. Increase access choices for rural beneficiaries.

Employers can provide greater choices for rural residents in how they communicate with health care professionals by making available telemedicine applications, such as video consultations, online care and patient kiosks. Telemedicine broadens the scope of care and types of provider networks available to rural residents and makes it more convenient[10].

5. Improve care coordination and patient safety.

Providers should consider adopting telemedicine to aide in efforts to improve patient safety and care coordination. Telemedicine can improve health system efficiency by connecting professionals to each other and to pertinent data (medical records, data from remote monitoring systems, and images). It can also enable greater follow-up with patients post-surgery. Remote patient monitoring in ICUs can improve patient safety and reduce the need for patient transfers. Data transfers from ambulances to hospitals can improve the speed and effectiveness of emergency care [11].

VI. Proposed Embedded System Design for Remote Health Monitoring Center

Sensor nodes Circuit Implementation :

It is data processing center. It is responsible for collecting data from different nodes through "Wi-Fi" network and process them to extract useful information. It must always be active since the arrival of information is random. This is why his energy should be unlimited. In a large sensor network where the charge is a little higher, we can find two or more Sink to lighten the load.

Sensors: are interfaced to the microcontroller through the analog module, the written software in the microcontroller processes data and the processing results are sent to the Laptop then to web-portal using Bluetooth connection and the flow chart of the written software is shown in Fig. 4

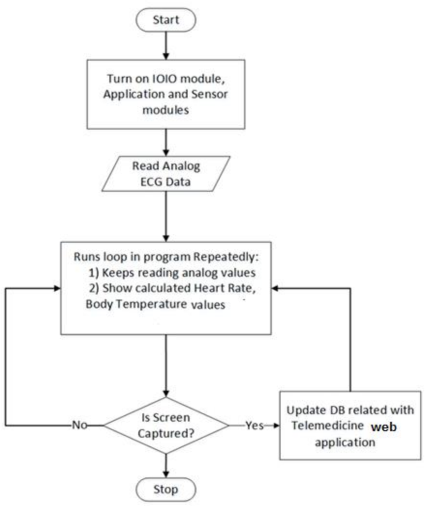

Fig. 4 Flow chart of Embedded software

Analog module: is used to get the electrical measured values from the real physical world and serve it to the brain (the microprocessor) into an understandable format for the processing phase.

Microcontroller: Contains the microprocessor and the peripherals necessary for the operation.

UART: Is the communication module between the Bluetooth module and the microcontroller.

Bluetooth module: It is responsible for decoding and encoding data with Bluetooth standard.

Web-portal: using PHP web-Programming and MySQL DB: To update and plot the response of sensors to the real world.

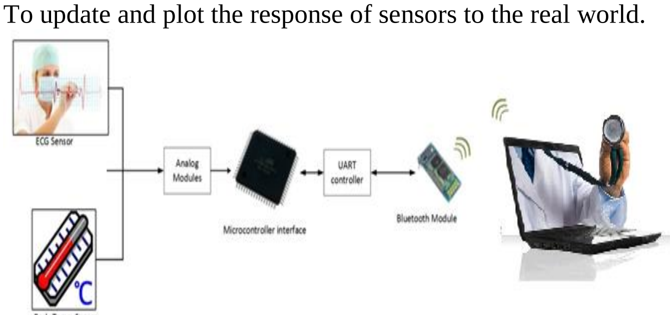

Fig.5 System structure; clarify 4 components (Medical Sensors, CCU Interface, Communication module, Application Platform)

One of these sensors is the temperature sensor, we used the Temperature Resistance Equation to build the algorithm to get the temperature measurements: the resistance of thermistors changes dramatically and sensitively with temperature, satisfying an exponential relationship. To convert the measured resistance to temperature, you can use an equation:

$$R_{TH} = \alpha\, e^{\beta / T_{abs}} \qquad (1)$$

Where: T the absolute temperature, T_{abs}, is in °Kelvin. The values of α and β depend on the thermistor used. We used as an example a Yellow Springs Type YSI 400 thermistor. This particular thermistor has a calibration point resistance of R_o = 2252 Ω at T_o = 25°C. Transforming the above equation to a ratio of thermistor resistance to resistance, R_o, at a reference temperature of T_o=25°C produces,

$$\frac{R_{TH}}{R_o} = e^{\beta\left(\frac{1}{T+273.15} - \frac{1}{T_o+273.15}\right)} \qquad (2)$$

Where: R_{TH} is the resistance at temperature , T (now measured in °C) and R_o is the calibration resistance (2252 ohms) at the calibration temperature, T_o, of 25 °C. The β in the equation is a parameter that represents the semiconductor's temperature slope. If the above equation is fitted to the chart data at the two temperatures of 25 °C and 45 °C to find the best slope between those two points, then the equation fits just about perfectly for 25 through 45 °C, and fits within ±0.1 °C for the 15-55 °C range, using β=393. Inverting the equation produces the equation you could use in an instrument to convert the measured resistance value to temperature in °C,

$$T = \frac{1}{(1/\beta)\ln(R/R_o) + 1/(T_o + 273.15)} - 273.15 \qquad (3)$$

But sometimes, you may need even greater accuracy. A commonly used formula used to fit thermistors uses a fifth order polynomial in the logarithm of the resistance, as,

$$T = \frac{1}{a + b\ln(R/R_o) + c\left(\ln(R/R_o)\right)^3 + d\left(\ln(R/R_o)\right)^5} - 273.15 \qquad (4)$$

The parameters, *a*, *b*, *c*, and *d*, are found by curve fitting the equation to the thermistor data over the temperature range of interest. Afterward, the above equation is used at run-time to compute temperature from the thermistor resistance[12,13].

```
private void valuesconversion(final float HR_val,final float TMP_val) {
    float measuredvolt,Rv,measuredtemp,measuredtemp_new=0,tempdiff; // temperature
    float measuredrate; // heart rate variabless
    measuredvolt=(float) ((TMP_val*1023)*(3.3/1024)); // map the input digital val
    Rv=(float) ((1000*measuredvolt)/(3.3-measuredvolt)); // get the value of the m
    measuredtemp_new=(float) ((1/(0.0002545*Math.log(Rv/2252)+0.0033535))-273.15);
    tempdiff=(measuredtemp_new-measuredtemp_old);
    measuredtemp=measuredtemp_new;
    if(tempdiff>0.2){
        measuredtemp=measuredtemp_new;
    }else{
        measuredtemp=measuredtemp_old;
    }
    measuredtemp_old=measuredtemp;
```

Fig.6 Algorithm used to get Body temperature measurements

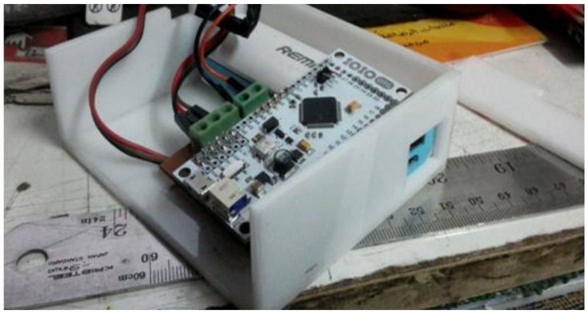

Fig.7. Experimental setup of Embedded system of sesnors

VII. PROPOSED WEB-APPLICATIONS OF REMOTE HEALTHCARE MONITORING CENTER

Fig.8 indicates the proposed telemedicine web-process through Medical center, is implemented in 4 main stages as follow:

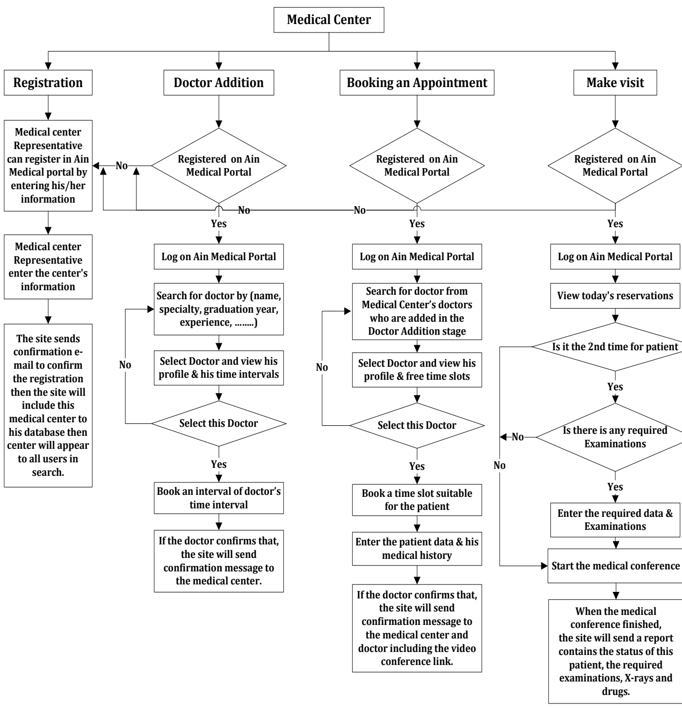

Fig. 8 Proposed web-Implementation of Remote Healthcare Monitoring center for Telemedicine system

First: Registration :

Medical center Representative can register in web-portal by entering patient's information (name, address, email, username, password and specialty), the center's information (center's name, address, image, specialty and Commercial No.), and doctors' information who work in the center (names, graduation year, emails, specialties and Trade union figure). The site sends email to confirm registration then the site includes this medical center to database then center will appear to all users in site.

Second: Doctor Addition

The medical center can search for doctor by (name, specialty, graduation year, experience,...). They can see doctor's profile then he can booking of time and if the doctor confirms that, the site will send confirmation message to the medical center.

Third: Booking an appointment

The medical center can search for doctor by (name, specialty, graduation year, experience,..). They find doctor's profile and see available timeslots and if these suitable to patient, he will insert patient's information and book a timeslot and if the doctor confirm that ,the site will send confirmation message to the medical center and doctor including the video conference link

Fourth: Make visit

First the medical center will review today's reservations and if it's the 2nd time for patient and he has required examinations or digital data so he will send them to the doctor then open the link of video conference and when the reservation ends the site will send a file contains the status of this patient, the required examinations, X-rays and drugs.

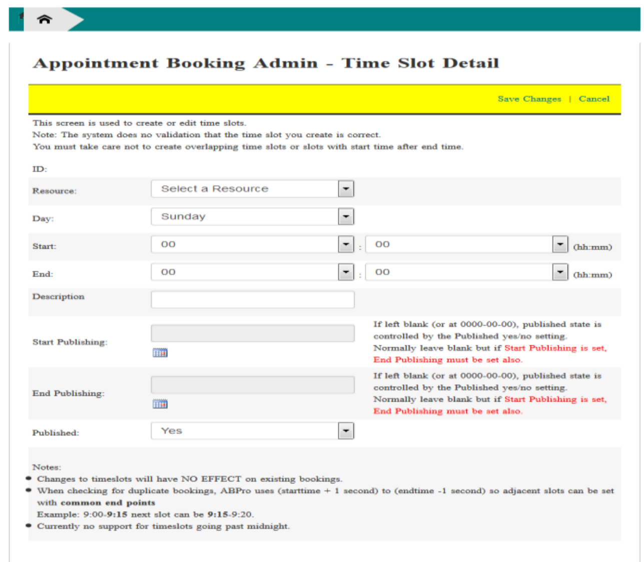

Fig.9 Screen shoot of Web service for Booking

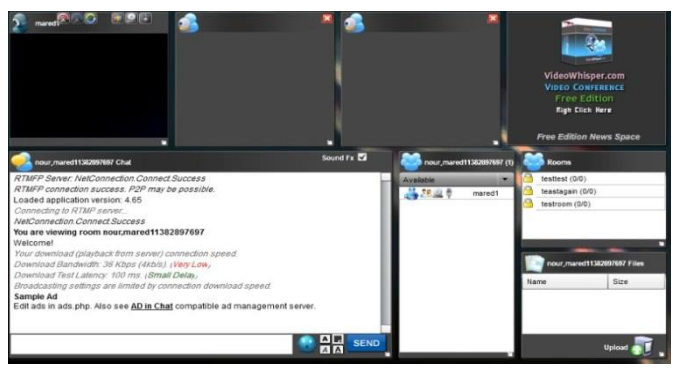

Fig. 10 Video conference screen to start telemedicine service

VIII. CONCLUSION

The Proposed Implementation of Embedded System Design for Remote Healthcare Monitoring center for Telemedicine system through web-Portal www.AinMedical.com is achieved and running. The equipped system with new technology is used to provide wide range of services in Telemedical center which facilitates the provision of medical aids from a distance. It is an effective solution for providing specialty healthcare in the form of improved access and reduced cost to the rural patients and the reduced professional isolation of the rural doctors. Telemedical centers can enable ordinary doctors to perform extra-ordinary tasks. While some forms of telemedicine, such as store and forward applications for imaging reads, are commonly in use, other uses of the technology are still in developing. So we implement Sensor nodes Circuit for collecting data and process them to extract useful body information. Sensors are interfaced to microcontroller through analog module. The proposed System structure clarify 4 components (Medical Sensors, CCU Interface, Communication module, Application Platform). An Experimental setup of Embedded system of sensors is tested. It is an effective solution for providing specialty healthcare in the form of improved internet-access and reduced cost to rural patients.

FUTURE WORK AND OUTLOOK

Other telemedicine technologies hold promise for the future, although their full realization may be some way off as :

• **Robotics**. Telemedicine robots allow doctors to travel virtually to a patient’s bedside. Robots are also beginning to be used in remote surgery, although most robotic surgery is still carried out by on-site surgeons.

• **Mobile Clinics**. These care sites may become a tool to bring medical care directly to patients and help increase access in areas with limited broadband connectivity. When fully realized, mobile clinics should be capable of taking biometric readings and allowing individuals to upload vital signs with the eventual providing full diagnostic evaluation and recommendations for treatment without the use of on-site personnel.

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