Smart Real-Time Healthcare Monitoring and Tracking System using GSM/GPS Technologies

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***Abstract*—Health monitoring systems have rapidly evolved recently, and smart systems have been proposed to monitor patient current health conditions, in our proposed and implemented system, we focus on monitoring the patient's blood pressure, and his body temperature. Based on last decade statistics of medical records, death rates due to hypertensive heart disease, shows that the blood pressure is a crucial risk factor for atherosclerosis and ischemic heart diseases; thus, preventive measures should be taken against high blood pressure which provide the ability to track, trace and save patient's life at appropriate time is an essential need for mankind.**

Nowadays, Globalization demands Smart cities, which involves many attributes and services, such as government services, Intelligent Transportation Systems (ITS), energy, health care, water and waste. This paper proposes a system architecture for smart healthcare based on GSM and GPS technologies.

The objective of this work is providing an effective application for Real Time Health Monitoring and Tracking. The system will track, trace, monitor patients and facilitate taking care of their health; so efficient medical services could be provided at appropriate time. By Using specific sensors, the data will be captured and compared with a configurable threshold via microcontroller which is defined by a specialized doctor who follows the patient; in any case of emergency a short message service (SMS) will be sent to the Doctor's mobile number along with the measured values through GSM module. furthermore, the GPS provides the position information of the monitored person who is under surveillance all the time. Moreover, the paper demonstrates the feasibility of realizing a complete end-to-end smart health system responding to the real health system design requirements by taking in consideration wider vital human health parameters such as respiration rate, nerves signs ... etc. The system will be able to bridge the gap between patients - in dramatic health change occasions- and health entities who response and take actions in real time fashion.

***Index Terms*—smart healthcare; sensors; smart city; monitoring**

I. Introduction

Based on the analysis of worldwide data of the global burden of hypertension heart diseases [4], the study shows that the high blood pressure or hypertension affects more than 1 billion people worldwide. Rather than the hypertension heart diseases, the high blood can be a factor and attribute to cause many other disorders, such as stroke aneurysms, ischemic heart, and kidney disease. The risk of heart failure, due to Hypertension is almost increased by factor two or three-fold [5], and may accounts for about 25% of all heart failure cases [6]. Moreover, the hypertension or high blood pressure in 90% of cases preceded or advanced the heart failure telescopically for elderly. Hypertension was ranked 13th in the leading global causes of death for all ages [7]. A world map shows the distribution of diseases caused by high blood pressure in Figure 1. Statistics for the numbers of heart diseases were not available due to the bad condition of many countries of the middle east region, so this project may encourage relevant institutions to collect such statistics.

In an era of laziness and lack of physical exercises, fat, sugar, meats, smoking, obesity, and the lack of eating fruit and vegetables. Under the shade of difficult economic situation, physical fatigue, stress and to having dignified life the blood pressure disease has been the famous one in the last century due to poor eating habits. These neurological conditions are chief of this kind of illness, in many countries. Not only medical intervention is required to detract the effects but Smart and Innovative solutions should be adopted to increase the responsive actions quality in both time and level; and since Sarwant Singh [1] has identified eight key aspects that define a smart city as shown in figure 2 which depicts the smart city concepts: smart governance; smart building; smart infrastructure; smart energy, smart technology; smart citizen; smart mobility; and smart healthcare. In this paper we propose a system architecture for smart healthcare based on GSM and GPS technologies.

Based on visiting hospitals, it was approved of the effectiveness of this project and its ability to facilitate communication between the patient and his doctor. Utilizing the available services of GSM and GPS technologies to build a smart

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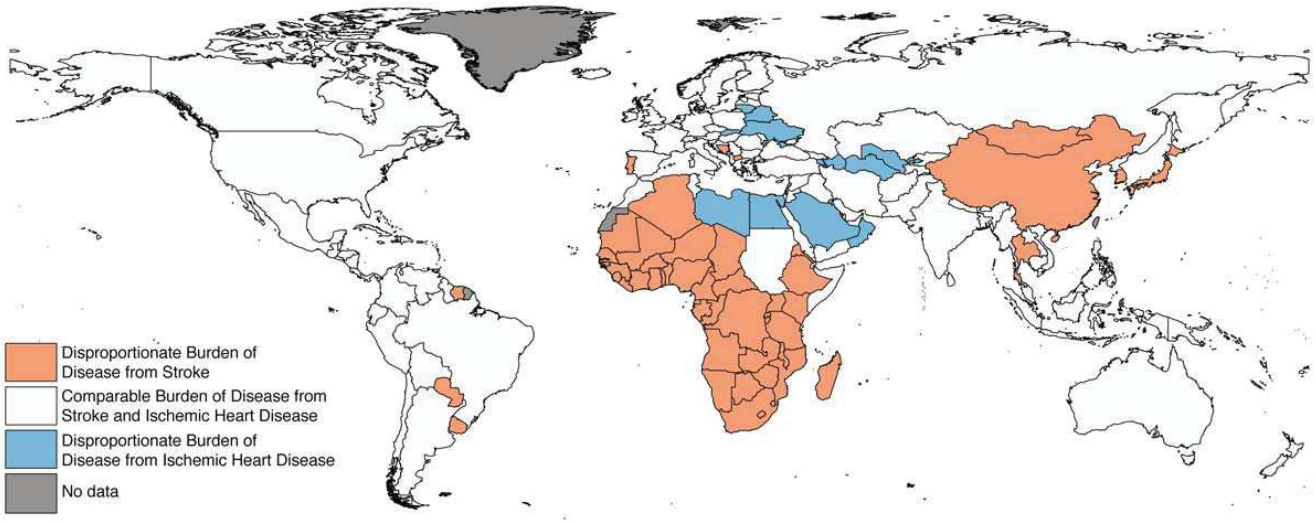

Fig. 1: Distribution of Diseases Caused by High Blood Pressure [8]

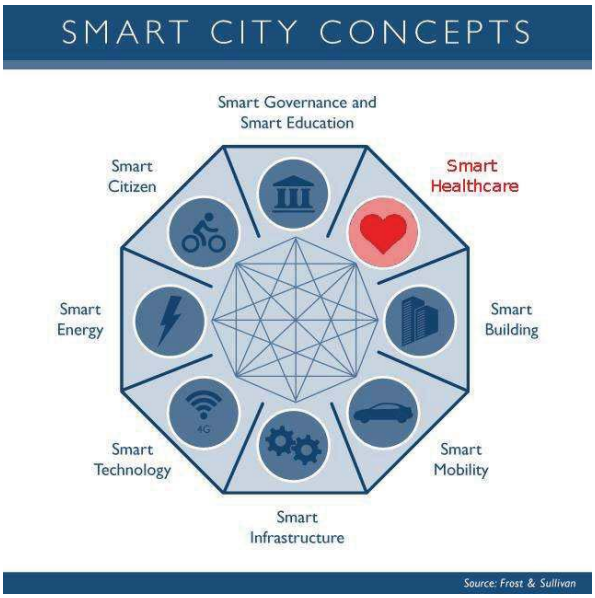

Fig. 2: Smart City Concepts

health monitoring system can improve and enhance the real time monitoring, where: GSM services are used for global communications any time and anywhere, GPS technology is applied for outdoor positioning.

Figure 3 describes the flow chart of the suggested system, starting with reading the heart rate and body temperature by using specific sensors: pulse sensor and temperature sensor; the captured data will be compared via microcontroller i.e. Arduino with a given threshold. The Arduino also keep checking the position twenty times using the GPS module. The readings will be compared with the maximum and minimum stored values in the microcontroller, in the case that the measured values where out of the allowed threshold range a SMS will be sent immediately to the relevant person contains: the patient name, heart rate, body temperature, the patient's location and the corresponding UTC time-stamp. Electrocardiogram (ECG) could be drawn by sending the reading to a specialized processor.

The paper is organized as the following: Section I introduces the importance of the Smart Health system. Section II provides a brief summary of similar research projects and papers. Section III presents insights structure of the proposed system and explains the main building blocks and the interconnection relationships among the system blocks. Preliminary results and their discussion are collected using the implemented parts of the proposed system are shown in Section IV. Finally, Section V conclude the paper and presents the future plans to enhance the proposed system.

II. Related Work

Mikhail St-Denis,designed Life line project that can monitor heart rate, blood sugar levels, human's body temperature, and by using a wireless communication technologies to synchronize and display these information into a smart mobile phone or a standard computer. such device gather data from user and display some related graphs in order to encourage users to remain aware of their health conditions by providing a week to week feedback [2].

Eli Hariton, designed Gluco (M) wristband which monitors the blood glucose levels [9]. LUMO BodyTech(2011), created a platform for tracking human biomechanics, starting with a unique sensor-based solution for posture and back pain. This solution is comprised of a discreet biomechanics-monitoring sensor, an engaging mobile app, and intelligent algorithms for a personalized user experience. Patent-pending solution harnesses the power of human movement data to provide real-time actionable feedback and to enable healthy behaviors [10]. Dr. Sailesh Chutani(2009), founded a Mobisante for ultrasound imaging that will be displayed. Health care workers in remote

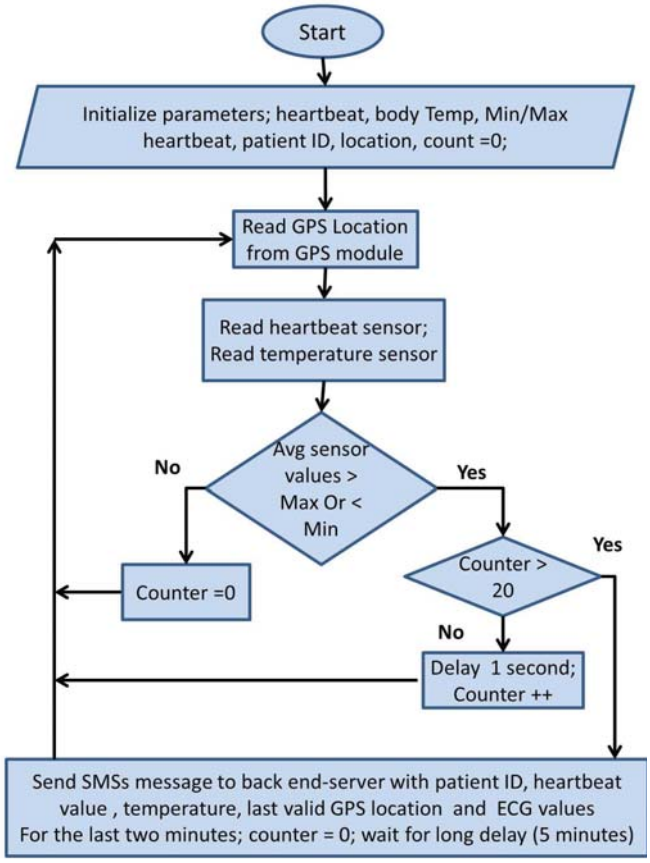

Fig. 3: System Flow-Chart

locations can check pregnant women, monitor a baby's health, examine patients for heart and lung problems, and triage other problems. Their phone can then transmit the images to a hospital for consultation [11]. In this paper, a tracking system will be designed and implemented for monitoring heart rate and body temperature.

III. ARCHITECTURE AND IMPLEMENTATIONS

This section provides insights structure of the proposed system and explains the main building blocks and the interconnection relationships among the system blocks. Mainly, the proposed system aims to cover an end-to-end smart health application that can be build up from two functional building blocks. However the main function of the first building block is to gather all sensory data that are related to the monitored persons, whereas the second block functions are to store, process and present the resulted information of this stage to the doctors and nursery staff that are fallowing the case of the monitored person.

As depicted in Figure 4, which illustrates the overall model, when the patient's heartbeat rate changes badly, the Arduino which recorded Pulse and LilyPad Temperature Sensors readings, orders GSM shield to send an SMS message containing these readings, patient ID and the location of the patient which has been taken via GPS shield, to his doctor's mobile phone, who -by his turn- send an ambulance to the patient's location.

A. Smart Embedded Board (SEB)

This subsection provides the hardware components details used to compose a smart board attached to the human body. Periodically, the Smart board senses the human health conditions using several dedicated sensor devices and then the broad conveys the raw sensed data to the back-end server application using GSM SMS.

1) Microcontroller: It is the core part of the SEB design; the microcontroller acts as the brain of the smart board that is holding the main board flow chart logic. However, there are many microcontrollers available in market and can perform well the main board logic such as PIC, Beagle-Bone, and Arduino. For the sake of demonstration proposes the choice falls on Arduino Uno according to its specifications and simplicity of use. Arduino Uno as depicted in Figure 5 this board is based on ATmega32 microcontroller, which has a set of 14 input/output digital pins, where 6 out of 14 can be used as a PWM output pins, also, the microcontroller board has 6 analog inputs, a ceramic resonant of 16 MHz, an USB interface, a DC power jack, a reset button, and ICSP header. The USB interface, simplifies the connection of the microcontroller with the computer, also the USB can be a power supplier for the microcontroller board [12].

Fig. 5: Arduino Microcontroller

2) GPS/GPRS/GSM MODULE V3.0: This is a GPS / GPRS / GSM shield from DFRobot as depicted in Figure 6 is a Quad-band GSM / GPRS engine that works on frequencies EGSM 900MHz/DCS 1800MHz and GSM850 MHz / PCS 1900MHz. It is also Supports GPS technology for satellite navigation.[14] Sending messages via GSM network controlled via AT commands (GSM07.07, 7:05 and SIMCOM enhanced AT Commands). The design of the shield allows driving the GSM and GPS function directly with any computer and Arduino board. GPS/GPRS/GSM shield includes a high-gain SMD antenna for GPS and GSM. The consumption expenditure of SIM548C is an embedded chip from SIMCom [13].

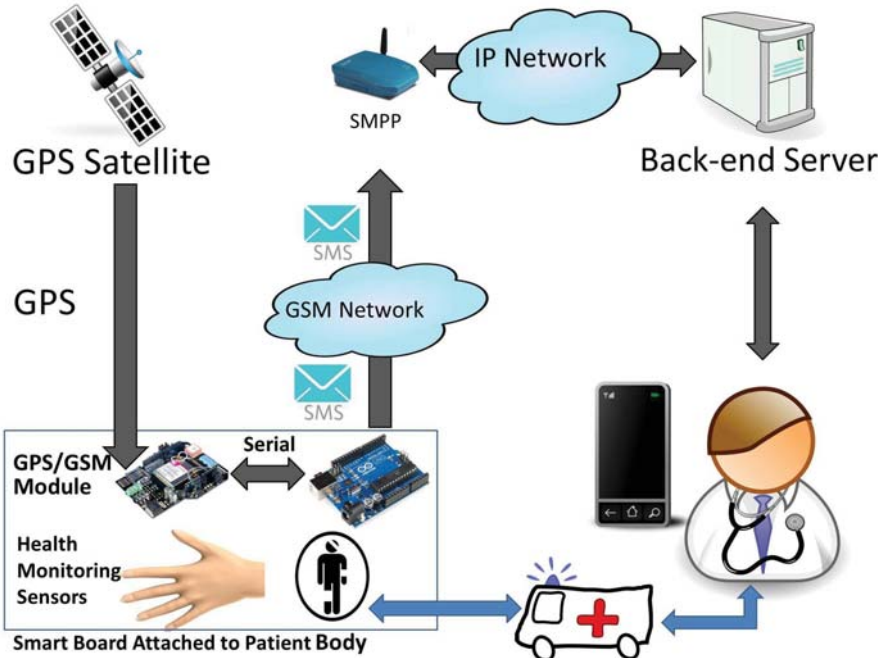

Fig. 4: Proposed System Model

Fig. 6: Dfrobot GPS/GPRS/GSM MODULE V3.0

Fig. 7: Heart Beat Pulse Sensor

3) Heart Beat pulse Sensor: Figure 7 shows the heart beat pulse rate sensor, whereas the pulse measurement is not an easy task;pulse sensor measures the heart rate optically, amplifies the signal and eliminate the noise by connecting the sensor directly to Arduino or any other controller with working voltages from 3 to 5V. Simply plug the sensor on the ear or finger sensor and consider that the maximum wire length of about 60 cm [14].

4) Human Body Temperature Sensor: Detecting temperature changes has become easier using MCP9700 which is a small thermostat type temperature sensor. The output will be 0.5V at 0 degrees C, 0.75V at 25 C, and 10mV per degree C. Doing an analog to digital conversion on the signal line will allow to establish the local ambient temperature. Detect physical touch based on body heat and ambient conditions with this small sensor. Also LilyPad as depicted in Figure 8 is a wearable e-textile technology developed by Leah Buechley and cooperatively designed by Leah and SparkFun where each LilyPad was creatively designed to have large connecting pads to allow them to be sewn into clothing. Moreover, various input, power, output and sensor boards are available. They are even washable [15].

B. Online-Web Based Monitoring Application

Doctors and Nurses are provided with a simple web-based application to track and monitoring the patient's health conditions. The implemented web application is accessible through

Fig. 8: LilyPad Temperature Sensor

a standard web browser, smart phone and tablets devices. The REST (RESTful) software architectural style has been adapted to insure the resulted web application is scalable and flexible. Moreover, communication among the web application modules uses JSON data representation. Furthermore, the implemented system leveraging on the well-known three-tier architecture [3]:

1) The front-end represents the web-page which is accessible by the Doctors and Nurses. This part uses several web technologies such as HTML5 (Hypertext Transfer Markup Language version 5), CSS (Cascading Style Sheet), the open source JQuery software library and Javascript client side programming language. However, a bidirectional data communication channel is maintained between this tire and the middle tire through the Asynchronous JavaScript AJAX technology. The final web-page is responsive and is running on smart phones, tablet devices and standard PCs.
2) The middle tire which hosts the main server logic has been developed using PHP programming language and this logic has been deployed on an Apache web server. This tire uses RESTful style to expose its internal functionality towards the client side web-page as well as this software tire leverage on the MySQL native driver for PHP in order to store and retrieve data.
3) The back-end tire which hosts the MySQL database server and this database is used to store all the patient data, system users(doctors, patients and nurses , patients medical profiles and their corresponding alerts. This design of this module is based on a relational database structure. However, health data records and patients' positioning information are time stamped using the standard UTC reference time.

Ina RESTful software architectural style every thing is a resource and for each resource there is a URI (Universal Resource Identifier) that represents the corresponding resource unique address. Moreover, there are four verbs that are usable to transfer and manipulate any resource representation. Finally, the word CRUD refers to these four verbs and the C letter is coming from create, R from read, U from update and D from delete.

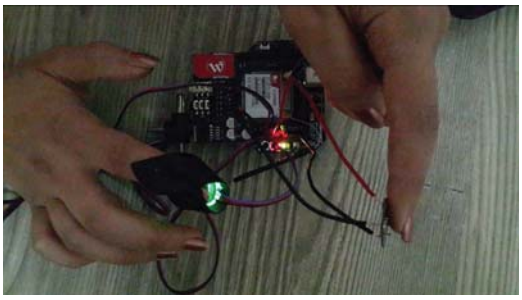

Fig. 9: System Hardware model

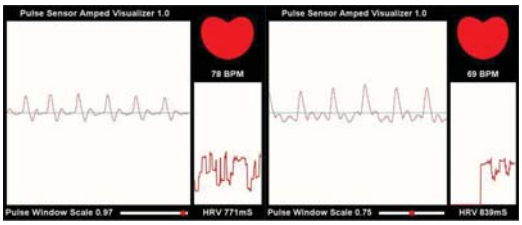

Fig. 10: Normal ECG

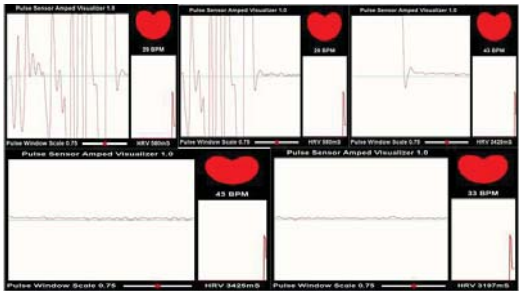

Fig. 11: Unconnected Pulse Sensor ECG

IV. Results and Discussion

A well functioning system prototype was build composed of the following hardware components: LilyPad Temperature Sensor, Pulse Sensor, GPS / GPRS / GSM MODULE V3.0 and the Arduino integrated together to perform a healthy system as shown in Figure 9

In order to analyze, test and validate several experiments has been performed and the results presented in Figure 10shows the ECG -which had been drawn using simulation software- for a healthy normal persons. It is clear that the normal heart rate is in the range of 60-90.

While Figure 11 shows the ECG when the sensor was unconnected to the human body.

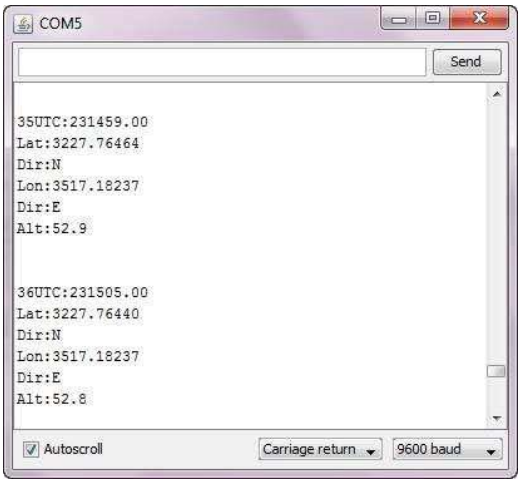

Fig. 12: The Position took by GPS Module

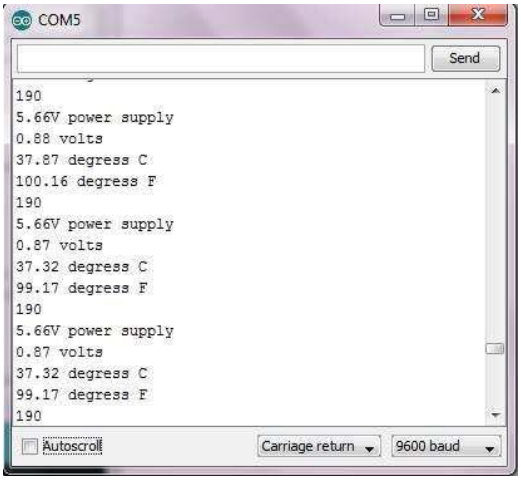

Fig. 13: LilyPad Temperature Sensor Readings

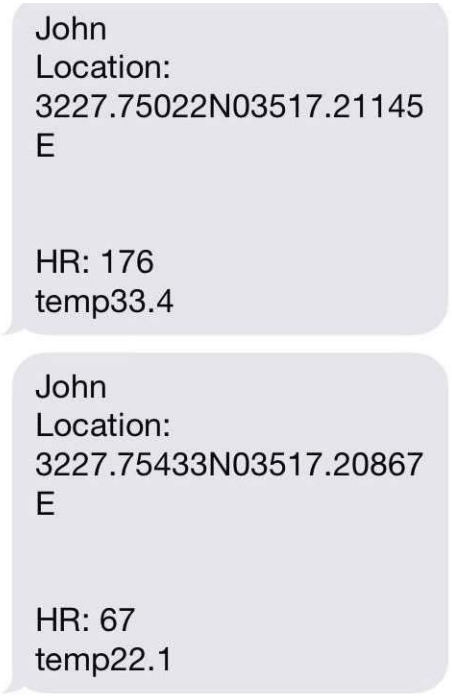

Fig. 14: The SMS Exchanged by the System

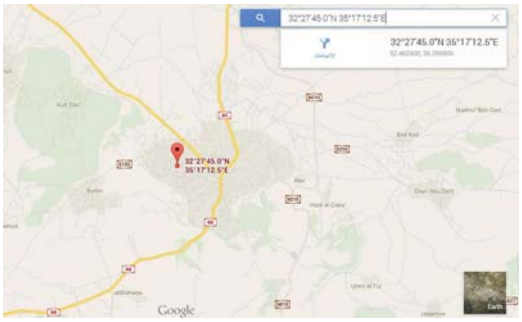

Fig. 15: Google Maps Patient Location

In the other hand Figure 12 demonstrate the position (geographical position longitude and latitude) which was collected using GPS/GPRS/GSM module.

While the LilyPad Temperature Sensor readings are illustrated in Figure 13 in terms of corresponding voltage level and temperature degrees both in Celsius degree and Fahrenheit degree. Finally, all these results are displayed on the serial monitor.

The sent SMS including Patients name, heart rate, body temperature, longitude and latitude of the position are exhibited on Figure Figure 14.

And by using Google Map the location of the patient could be determined, and appeared in the SMS shown in Figure 15.

V. Conclusion

Aim of Smart City concepts is to provide better life to society and provide innovative and creative solutions in each of the eight pillars of smart city. Healthcare field is one of most delicate and important fields to be developed and enhanced by Smart systems designed to present sustainable medical interventions at manner time where the smart system should be simple, low energy consumption and real time feedback.

The system designed experimented and shown in the paper grantee to improve the quality of health services and to reduce the total cost in healthcare by avoiding unnecessary hospitalisations and ensuring that those who need urgent care get it sooner.

It is a system which can measure heartbeat rate and body temperature and communicate them in cases of extraordinary behaviours to supervision medical entities using GSM, GPS and web technologies to deliver immediate actions to rescue patients life with potentiality in the future to add other vital factors measurements according to available sensor in the market which can achieve the objective of providing a reliable effective application for real time health monitoring and tracking.

The merit of this project relies on two factors; first its multi-uses and services by making some modification on the software many diseases and illnesses like Alzheimer, mental and motion patients could be benefited from this system; secondly, wireless technologies cloud be used to avoid wired connections which somehow may limit the patient mobility.

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