REAL-TIME HEALTHCARE MONITORING AND TRACKING SYSTEM USING GSM/GPS TECHNOLOGIES

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Abstract:
Healthcare monitoring system in hospitals and many other health centres has experienced significant growth, and portable healthcare monitoring systems with emerging technologies are becoming of great concern to many countries worldwide nowadays. The advent of Internet of Things (IoT) technologies facilitates the progress of healthcare from face-to-face consulting to telemedicine. This paper proposes a smart healthcare system in IoT environment that can monitor a patient's basic health signs as well as the room condition where the patients are now in real-time. In this system, five sensors are used to capture the data from hospital environment named heart beat sensor, body temperature sensor, room temperature sensor, CO sensor, and CO2 sensor. The error percentage of the developed scheme is within a certain limit (< 5%) for each case. The condition of the patients is conveyed via a portal to medical staff, where they can process and analyse the current situation of the patients. The developed prototype is well suited for healthcare monitoring that is proved by the effectiveness of the system.

Keywords Healthcare monitoring system · Internet of things · Sensors · ESP32

INTRODUCTION:

Health is characterized as a full state of physical, mental, and social well-being and not merely a lack of illness. Health is a fundamental element of people's need for a better life. Unfortunately, the global health problem has created a dilemma because of certain factors, such as poor health services, the presence of large gaps between rural and urban areas, physicians, and nurse's unavailability during the hardest time.

IoT is making any objects internally connected in the recent decade and it has been considered as the next technological revolution. Smart health monitoring mechanism, smart parking, smart home, smart city, smart climate, industrial sites, and agricultural fields are some of the applications of IoT. The most tremendous use of IoT is in healthcare management which provides health and environment condition tracking facilities. IoT is nothing but linking computers to the internet utilizing sensors and networks. These connected components can be used on devices for health monitoring. The used sensors then forward the information to distant locations like M2M, which are machinery for computers, machines for people, handheld devices, or smartphones. It is a simple, energy-efficient, much smarter, scalable, and interoperable way of tracking and optimizing care to any health problem. Nowadays, modern systems are providing a flexible interface, assistant devices, and mental health management to lead a smart life for the human being.

Heart rate and body temperature are the two most significant indicators for human health. Heart rate is the per-minute amount of heartbeats, commonly known as the pulse rate. To measure the pulse rate, an increase in the blood flow volume can be used by calculating

the pulses. Normal heart rate ranges between 60 and 100 beats per minute for healthy people.

Major hardware components

Some sort of hardware components is being used in the proposed system. The components which are used to develop the system are outlined as follows.

ESP32 Processor: ESP32 is one of the main IoT learning tools. This offers a full Linux system on a small platform at a very low price. ESP32 connects device sensors and actuators through GPIO pins. ESP32 and IoT merge to be a new technology for creativity in the healthcare system. ESP32 is designed extremely with integrated antenna switches, RF-balun, control amplification, low-noise amplifier, and filters as well as power management modules. It can function as a complete stand-alone scheme or as a slave to a host MCU, decreasing overhead interaction within the main application processor. EPS32 can communicate with other Wi-Fi and Bluetooth devices via its SPI/SDIO, or I2C/UART interfaces. The ESP32 microcontroller is shown in Fig. 1a.

Heart beat sensor

The heartbeat sensor is developed based on the plethysmography theory. It measures the change in blood volume through anybody's organ that causes the light intensity to move through that organ. The timing of the pulses is more critical in systems where the heart pulse rate is to be tracked. The rate of heartbeats determines the distribution of blood volume, and the signal pulses are equal to the pulses of heartbeat when light is consumed by the blood. The heart beat sensor is depicted in Fig. 1b.

Body temperature sensor(LM35)

The LM35 series are accurate optimized temperature circuits with output voltage, which is linearly relative to the temperature in centigrade. The LM35 has a vantage point over Kelvin's linear temperature sensors, as a realistic centigrade scaling does not allow the consumer to delete the huge constant voltage from the display. LM35 is shown in Fig. 1c.

Room temperature sensor(DHT11)

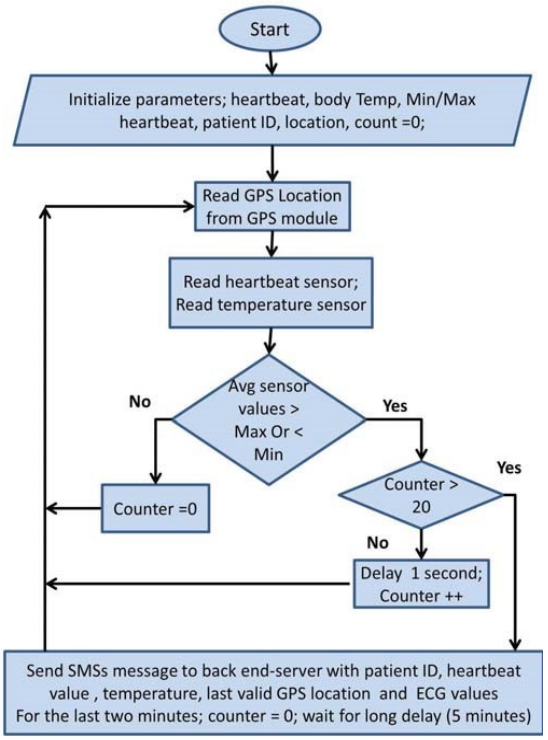
DHT11 is a sensor for temperature and humidity which is commonly used. The sensor comes with a dedicated temperature measurement NTC and an 8-bit microcontroller for the processing of temperature and humidity values in series. The sensor is also calibrated by the factory, making it easy to interface with other microcontrollers. The DHT11 sensor is depicted in Fig. 1d.

CO Sensor(MQ-9)

MQ-9 is appropriate for LPG, CO, and CH_4 detection. Owing to its high sensitivity and fast response time, measurements can be taken fastly. Using the potentiometer, the sensor's sensitivity can be modified. The MQ-9 sensor is shown in Fig. 1e.

Co2 Sensor(MQ-135)

For air quality control systems, the MQ-135 gas sensors are used for N H_3, Nicotine, Benzene, Smoke, and C O_2 detection as well as measurement. The MQ-135 sensor module comes with a digital pin that enables this sensor to work even without a microcontroller and is beneficial for detecting specific gases. The gasses in PPM are calculated using the analog pins. The analog pin is powered by TTL and works on 5 V, and hence it can be used with most modern microcontrollers.



System Flow-Chart

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 system: 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 con

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].

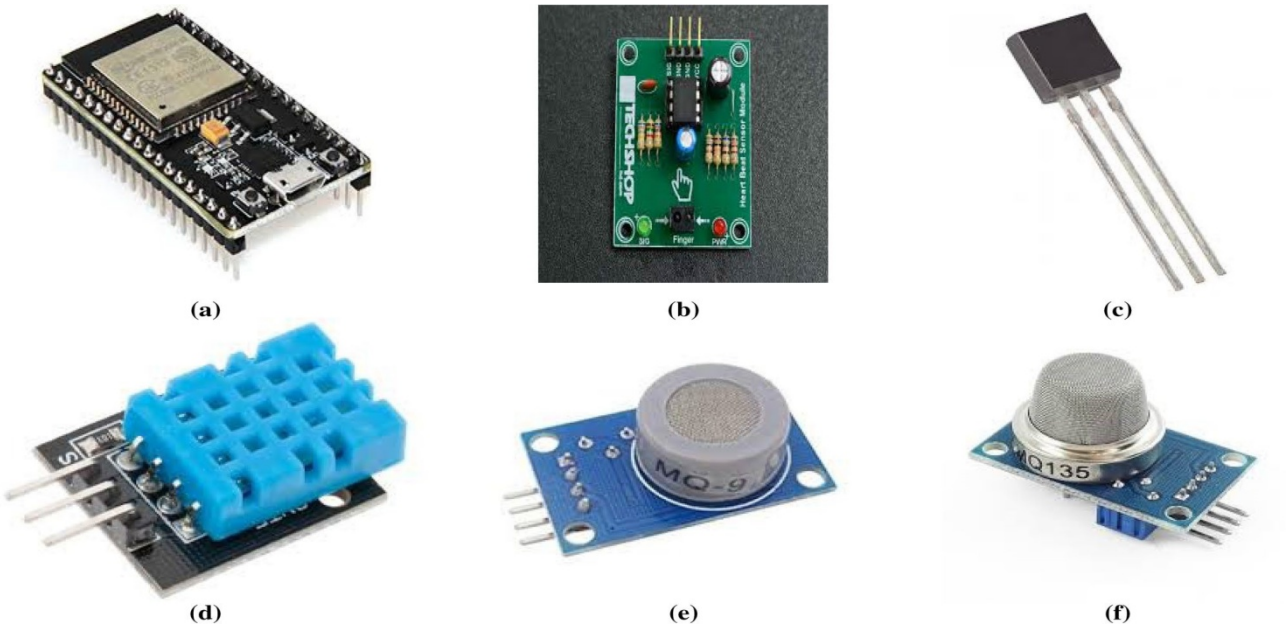


Fig. 1 The hardware components for the healthcare monitoring system. **a** ESP32 **b** heart beat sensor **c** body temperature sensor **d** room temperature sensor **e** CO sensor **f** CO_2 sensor

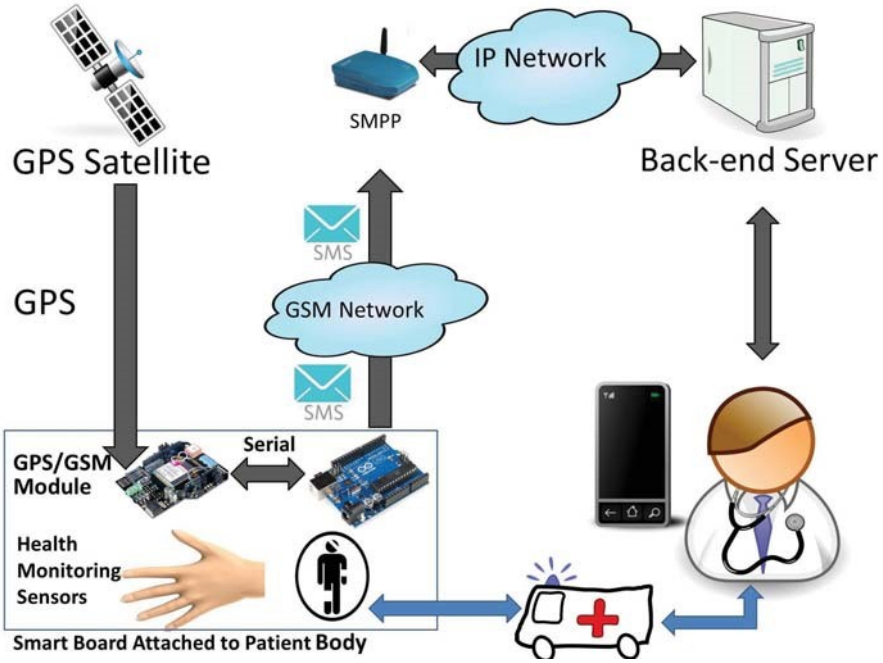


Fig. 3: Proposed System Model

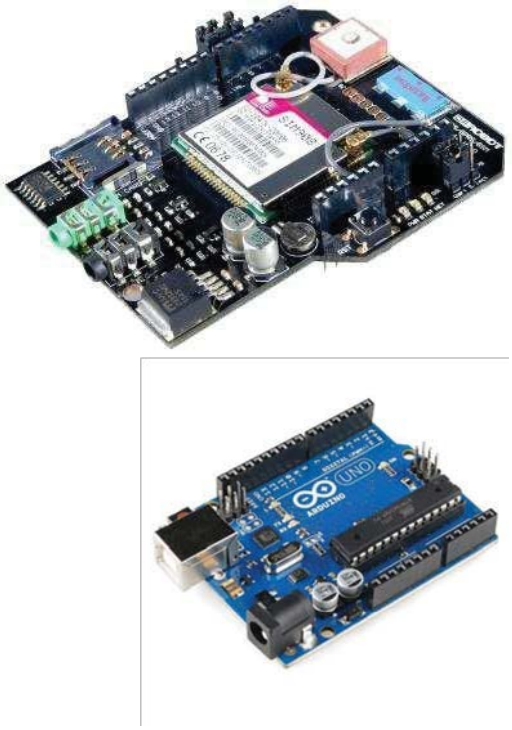


Fig. 2: Arduino Microcontroller

2)GPS/GPRS/GSM MODULE V3.0: This is a GPS / GPRS / GSM shield from DFRobot as depicted in Figure 6 is a Quadband 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: Dfrobot GPS/GPRS/GSM MODULE V3.0

3)Heart Beat pulse Sensor: Figure 5 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].

3)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. AlsoLilyPad as depicted in Figure 6 is

Fig. 5: Heart Beat Pulse Sensor

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. 6: 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 Javascriptclient 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 webpage 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

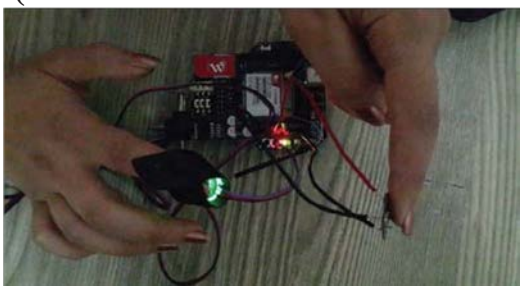


Fig. 7: System Hardware model

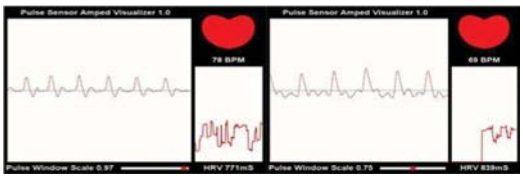


Fig. 8: Normal ECG

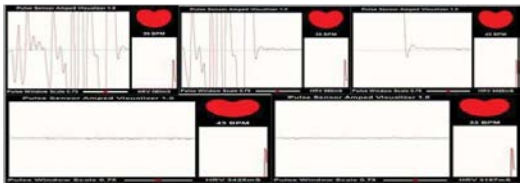


Fig. 9: Unconnected Pulse Sensor ECG

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.

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 softwarefor a healthy normal persons. It is clear that the normal heart rate is in the range of 60-90.

While Figure 10 shows the ECG when the sensor was unconnected to the human body.

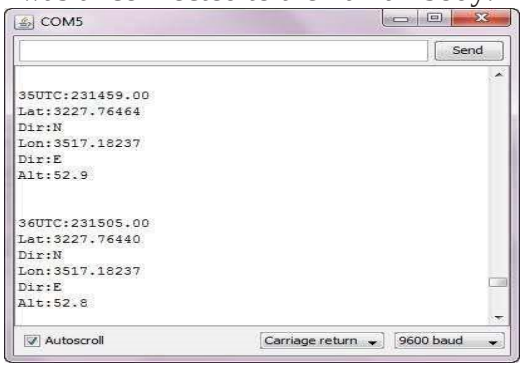


Fig. 10: The Position took by GPS Module

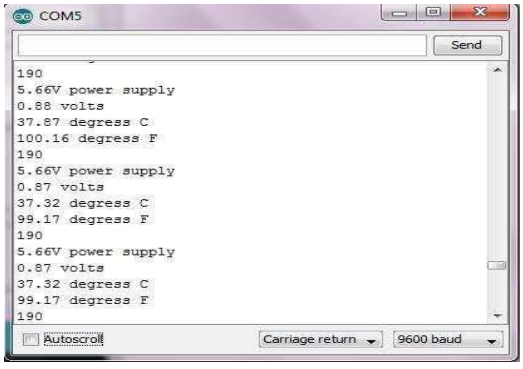


Fig. 11: LilyPad Temperature Sensor Readings

In the other hand Figure 10 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 11 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 12.

And by using Google Map the location of the patient could be determined, and appeared in the SMS shown in Figure 13.

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

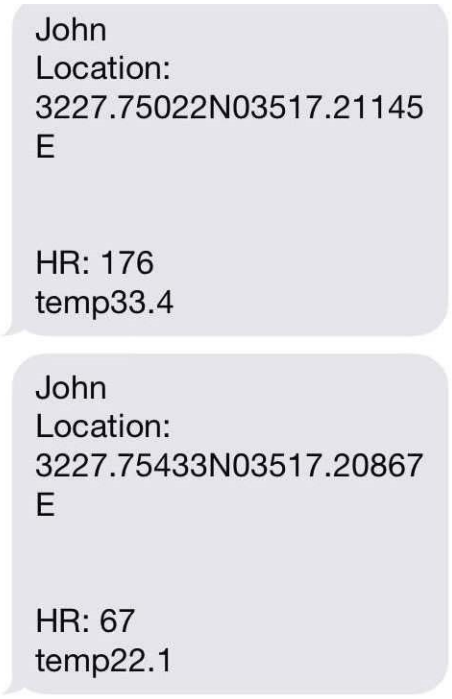


Fig. 12: The SMS Exchanged by the System

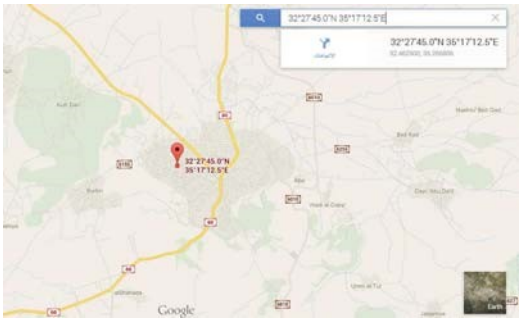


Fig. 13: Google Maps Patient Location

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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