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IOT BASED HEALTHCARE MONITORING SYSTEM FOR COMA PATIENTS

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Abstract - In this project discuss about health monitoring system using GSM and IOT(Internet of Things). Here the coma patients are monitored by the different types of sensors such as temperature sensor, heartbeat sensor, body movement sensor, by using these three sensors the coma patients are monitored regularly. The main aim of this project is the coma patients are failed to monitor by doctors at regular interval of time period. So this project improve if there is find any abnormalities from the coma patients the data will be send through GSM and Wi-Fi for IOT wherein "Thingspeak" is used to monitor the coma patient online via mobile phone. So consequently, there is no need for a lot of clinical staff for accompanying persons to be physically present to check the condition of the patient. This "Thingspeak" is used to regularly monitor the coma patient's condition status with appropriate time and date for result analysis. If there is any abnormalities in heartbeat it will detected by the heartbeat sensor as well as the temperature arises in human body will detected by temperature sensor. Similarly the patient's body movements are monitored through the body movement sensor.

Key Words: GSM, Internet of Things, Health Monitoring System, Sensors, Coma Patients.

1. INTRODUCTION

Coma is a state of prolonged unconsciousness with many possible causes. While it rarely lasts longer than a few years. Coma patients are not relatively reacting to the inner and outer environment and the coma patient monitoring technique are differing from the normal patient monitoring technique. Such cases require a serious attention and continuous monitoring to save the patients' lives. [1] Nowadays, having someone to watch critically ill person is very expensive and takes a lot of manpower. Besides, such a continuous supervision by a paramedical assistant may do error prone and may lead to difficulties due to human error. Furthermore, The patients cannot do anything with their capability but the heart beat is still beating, so continuously monitoring the health condition of the coma patients at regular interval of the is a tedious process for nurse, doctor and caretaker of the patient. In case of critically ill patients it requires to measure the vital parameters at least for every 15 seconds until the patient's condition stabilizes. By using the data transfer system abnormalities of the coma patient is easily catch through mobile phone. So the system is used to monitor the less sensors provide valuable real time information enabling the physicians to monitor and analyze a patient's current and previous state of health. According to statistics provided by World Health Organization (WHO), about 6.9 million children under 5 die from treatable and preventable diseases each year due to lack of number of health workers as well as so many countries face health workforce crisis. So it is important and necessary to propose health monitoring systems for a coma patient.

Such healthcare systems are needed to continuously monitor and record all the vital information of a particular subject by maintaining all the records of that comatose manually. Patient Monitoring Systems are systems wherein a surgeon can continuously monitor more than one patient, for more than one parameter at a time in a remote place [2]. The technical brilliance and development in different fields has led to a drastic change in our lives, one among them is embedded systems and telecommunications. The advances in information and communication technologies enable technically, the continuous monitoring of health related parameters with wireless sensors, wherever the user happens to be. They provide valuable real time information enabling the physicians to monitor and analyze a patient's current and previous state of health. However, the current systems for this monitoring are prohibitively expensive and can be only found at certain hospitals as well as the systems used in hospitals are complex and only certain people can use them.

Furthermore, in the existing healthcare systems, the medical world today faces two basic problems when it comes to patient monitoring, firstly the need of health care providers present bedside the patient and secondly the patient is restricted to bed and wired to large machines. In order to achieve better quality patient care, the above cited problems have to be solved. As the technologies are advancing it has become feasible to propose health monitoring system based on GSM. Lastly, according to aforementioned challenges it helpful and necessary to proposed system that can eliminate the burden of continuous supervision and send SMS message to the doctor or person in charge only when attention is needed. Therefore, the aim of this paper is to develop a prototype at a low cost that monitors the health condition of a critically ill patient/person in a coma. This aim can be achieved by the following objectives:

- Design an appropriate circuit for GSM patient health monitoring system.
- Test, implement and establish communication between the microcontroller, sensors, and GSM.

- Develop a GUI for live monitoring of the heart rate and temperature of the patient and physical body movements.
- Develop a system that is able to send SMS alert messages in case of emergency.
- Develop a system that can monitor patient condition online and store data on cloud.

This proposed system will be helpful in assisting the doctor about the health condition of the unconscious patient and alerting the doctor whenever care is required. The proposed system will assist the doctor by giving an alarm and send SMS message about the health condition of the patient, when the set of vital signals recorded are out of the normal range. This system is beneficial to relatives or guardians that are taking care of the patient. Where all the parameters results are displayed on the mobile application or in special website, in order to let the coma patient's family to check their relative patient online without needing to stay in the hospital or to call to the doctor for asking about their relative condition.

The remainder of this paper is organized as follows: section 2 investigates the literature review of health monitoring systems, section 3 presents the system design and implementation of the proposed system, section 4 discusses the findings and results, and finally section 5 concludes the paper.

2. LITERATURE REVIEW

In the literature, there are several approach proposed to develop health monitoring system. For example, [3] The system shows development of a pervasive health system enabling self-management of chronic patients during their everyday activities. It integrates patient health monitoring, status logging for capturing various problems or symptoms met, and social sharing of the recorded information within the patient's community, aiming to facilitate disease management. A prototype is implemented on a mobile device illustrating the feasibility and applicability of the presented work by adopting unobtrusive vital signs monitoring through a wearable multi sensing device, a service-oriented architecture for handling communication issues, and popular micro blogging services. The presented research constitutes a paradigm for accomplishing effective and user-accepted patient self management through an integrative approach, elaborating on both objective and subjective. [4] The paper presents an efficient embedded system based wireless health care monitoring system using ZIGBEE. Their system has a capability to transmit the data between two embedded systems through two transceivers over a long range. In this, wireless transmission has been applied through two categories. The first part which contains ARDUINO with ZIGBEE will send the signals to the second device, which contains Raspberry with ZIGBEE. The second device will measure the patient data and send it to the first device through ZIGBEE transceiver. The designed system is demonstrated on volunteers to measure the body temperature which is clinically important to monitor and diagnose for fever in the patients. [5] Evolution of mobile technologies and their rapid penetration to people's daily lives, especially in the developing countries, have highlighted mobile health, or M-health, as a promising solution to improve health outcomes. The system present an overview of the background and significance of M-health, and summarize and discuss the existing evidence for the effectiveness of m-health in the developing world.

Although statistically significant conclusions cannot be drawn since the majority of studies relied on small scale trials and limited assessment of long term effects, this paper provides a systematic and extensive analysis of the advantages, disadvantages, and challenges of m-health in developing countries in an attempt to determine future research directions of m-health interventions. [6] This paper focuses on a real-time pervasive healthcare monitoring system using IoT and cloud computing services which are more beneficial for elders and chronic diseases patients. The current methods available for realization of Healthcare services are surveyed and the challenges that are part of realization are also highlighted. Intelligent real-time patient monitoring system that monitors the subject's vital parameters such as temperature, pressure, fall detection, breath activity and ECG through PHD prototype model as well as detects any abnormality accurately. Appropriate medications are suggested based on the diagnosis of the provided set of symptoms. The system sends an alert message to the caretakers and doctors in case of any abnormality through WBAN. The system enables the clinicians to optimize the usage of available medical resources and minimize the costs in monitoring the patients. In the future, we will focus on improving wearing sensor experience by using softer materials and enabling controlled sharing of information among the doctors, the patient, and the patients' family through social networking paradigm.

[7] Health monitoring system for fitness related program, monitoring chronic diseases and for elderly persons. The system will monitor health parameters such as hemoglobin count, sugar level, blood cell count, pulse and temperature. These data are extracted from respective sensors and are sent to the local server using either Bluetooth or ZigBee. The health parameters are sent to the cloud via the ESP8266 Wi-Fi module. These data can be monitored using internet or the application named "Thing speak". [8] Designed a health monitoring system which is energy efficient and reliable. Doctors are able to monitor the parameters of the patient in real time like temperature, position and electro cardio gram. The proposed idea of the author would be useful for health care providers to improve diseases management. The system would also be beneficial for medical practitioners as it would provide better treatment and better monitoring. As transferring data via cable is a hassle, the ZIGBEE is introduced to the system as it is energy efficient compared the Bluetooth. It also provides higher number of nodes and better network flexibility.

This system can be enhanced by the integration of GPS. The location of the remote patient can be detected and can provide nearest emergency support. Other sensors could be introduced to the system to add more parameters that be monitored such as blood pressure, Galvanic – Skin Resistance Amenia and pulse oximeter. For patients suffering from asthma, the SY-HS-220 sensor which is used to measure

humidity could be used. In the biomedical patient monitoring, the Internet of Things is the latest trend.

Fig. 1 shows the block diagram for the IoT system. The ESP8266 enables the Wi-Fi communication between the sensors and the cloud. When the module is set as host mode, it can boot up the application processor directly from an external flash. To improve the performance of the system in applications and to minimize memory, a cache is integrated. The device also includes features such as sleep/wake switching which makes it power efficient. The cardiac arrest warning system consists of a sensor which measures the heart beat at a constant time interval. This can be integrated with the alerting system which can save a person's life immediately. The cardiac alerting system consists of a microcontroller (Arduino), a GSM/GSPRS module and the ESP8266 is used for the transmission of the sensed values to be monitored online. The readings is done from all sensors and then are transferred to the cloud using TCP IP protocols. In case the person got a heart attack, a message will be sent to the doctor or fried or relatives. The Wi-Fi module will keep the details about the rate of the heartbeat. This will enable the doctor or the monitoring staff to see when the patient goes the heart attack. The rate will be displayed as well as the time thus the doctor will know the exact time when the patient experienced the heart attack.

The authors in [9] proposed a health monitoring system integrated with IoT and with Mplab analysis. The system was implemented using an open API IoT platform known as Thing peak. With the help of an internet connection acting as a carrier between the connected 'things' and the cloud of things peak, data can be stored, analyzed and displayed in forms of graphs. The author used sensors such as light dependent resistor, air quality sensor, rain sensor, pressure sensor and humidity and temperature sensor. These sensors were used for IoT which will be transmitted using the ESP8266 Wi-Fi module.

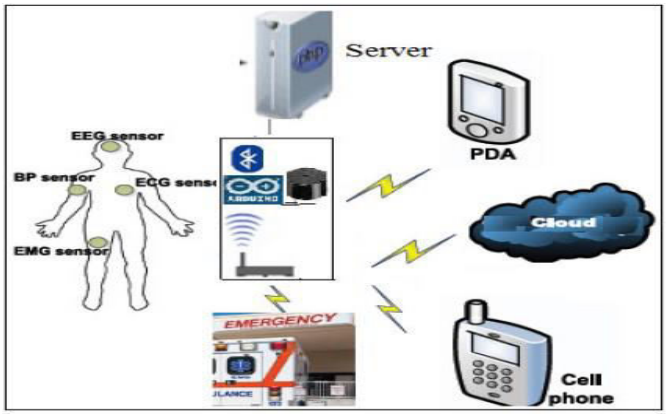

Fig – 1: Architecture of IOT

The Wi-Fi module can either host the function or to divest every Wi-Fi networking function. When programming of the system is done, it can just be booted from an external flash. [11] Proposed a monitoring system using HTTP and MQTT protocols. This enable lot of functions such as a web platform can be created and all data can be sent and displayed there. Login with verification can be implemented also and using the HTTP protocols, it enables the transmission to mobile phones easier. The system implemented by the author consists of Wemos D1 Mini and ESP8266 Wifi Module, DHT11 Temperature and Humidity sensor and an android Smartphone.

In summary, most of authors have proposed of health monitoring system for the patient in a coma. But, no one implements the three health parameters which are LM35 temperature sensor, heartbeat sensor, and accelerometer sensor together. Besides, the GSM module and Internet of Things (IoT) they did not implement together in any project. Thus, we introduce an integrated health monitoring system that considers all these features.

3. SYSTEM DESIGN AND IMPLEMENTATION

A. Proposed methodology

This proposed system consists of GSM, IoT, heartbeat, temperature, and body movement sensor. The heartbeat sensor used to monitor the pulse rate of the patient. The LM35 sensor measured the body temperature. The accelerometer sensor which is body movement sensor is used to sense changes in the patient and it placed on the hand of the patient. Additionally, IoT used to monitor a coma patient condition online and store data on cloud. Lastly, process the result and display to a LCD. In case of any abnormal parameters, SMS will be sent to the medical staff and respective relatives.

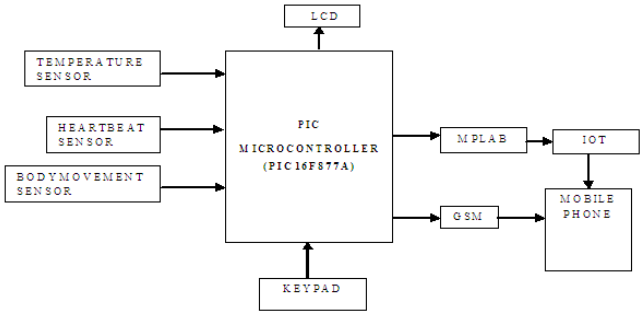

Fig - 2: proposed block diagram

As depicted in Fig – 2 the general block diagram of the proposed health monitoring system, all three sensors are used to acquire various different health parameters such as beats per minute of the heart, body temperature, pitch and roll of the coma patient in case he is awake and does any physical movement while under monitoring. All three sensors' output values are then checked whether they are above normal preset conditions or not. In case of any abnormality in any of the health parameters of the patient the microcontroller sends an alert command to the GSM module which triggers it to start sending messages to the relevant person in charge/ doctor or guardian.

The implemented design is shown below in Fig. 3. The hardware contains the central processing unit which is the PIC Microcontroller along with the temperature sensor, heartbeat sensor and the body movement sensor.

The GSM module and the WiFi module are also placed inside. Initially the body movement sensor is placed at a specific position as it is needed to be horizontal for calibration. This is because when the hardware will be tilt in any direction, it will trigger the buzzer for demonstration purpose. All sensors and modules were connected together with the PIC Microcontroller. A LCD screen was placed. While it is running, it will show the BPM, pulse rate, body movement and temperature of the sensors. In case any abnormal parameters were detected, it will trigger the SMS alert. Finally, all the sensed value was sent to the cloud of Thingspeak for IoT and can be monitored anywhere using the private channel authorization.

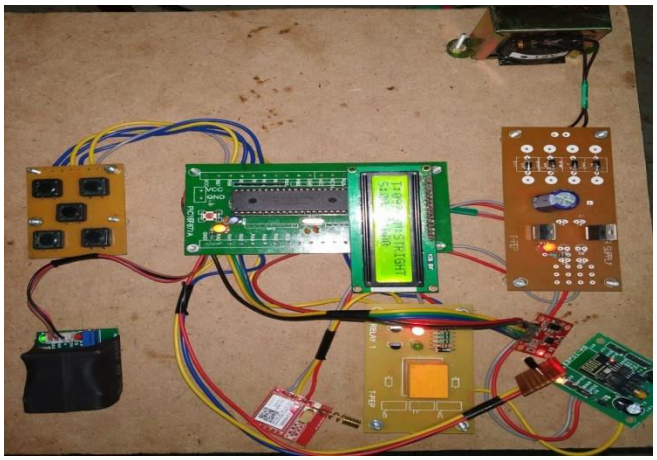

Fig -3: hardware design

After the temperature has been sensed by the LM35 and processed by the PIC Microcontroller, the ESP8266 will send the data online. For this to happen, the WiFi module need to be programmed. Firstly, it is connected to the power supply which is 3.3 V. Then it was connected to a WiFi network to be able to access the internet. The exact movement is sent and the value is Once received on the cloud, it will be plotted at that moment. The next sensed data will be then plotted with respect to time. The frequency of transmitting the data is set to be one minute. Two conditions were set for the temperature sensor. Firstly, if the temperature is more than 37°C, it means that the coma patient is either experiencing fever or is in a critical condition thus an alert will be sent via message to the doctor. The doctor will be able to see the temperature and the pulse also via the online monitoring system. If the temperature of the person is below the set value, it means that the patient is also in a critical condition and might be dying. Alerts will be sent to the responsible party and the doctor also.

For the heartbeat sensor data to be able to upload on the Thingspeak's cloud. The establishment of connection was similarly done as for the hearbeat. The output of the sensor will be converted into heart beat per minute (BPM). The BPM will be sent via the TCP IP protocol along with AT commands. The length of the data will be sent along with its values that was sensed previously. If the transmission of the data has not been successfully transmitted, it will do this step again due to the introduced loop. In case any abnormal BPM detected. That means if it is more than the set value. It will trigger a message to the responsible party to alert them that the patient has woke up from the coma or the patient is in a critical condition. Two condition were set, firstly if it is more than the normal rate, it will send an alert to the doctor alerting him of the issue and if the BPM is lower than the normal value, it will send the message to the responsible party and the doctor also. Both doctor and responsible party will be able to see the temperature and the BPM of the patient on the online monitoring system and in case of any issue, they will know when exactly it occurred.

The implemented health monitoring system is made for coma patient and for critically ill patient also consisting of paralysis issues. These patients need to be rested on the bed where they will be monitored 24/7. It can be used either in a clinical environment or in home based. The three vital signs which are essential for monitoring are heartbeat, temperature and the body movement. Thus, the temperature sensor will be placed on the index finger and the pulse on the middle finger. These will be placed and kept secured and stable by using Velcro or a glove which will stop light going through it affecting the pulse LED and will keep the temperature reading more accurate for the LM35. The body movement sensor will be placed on the wrist. In case the critically ill or the coma patient moves, a buzzer will be triggered and a message will be sent accordingly to the doctor and patient's members. The entire system is autonomous hence the reduction of clinical staff is decreased and if using at home, the need of physical presence for monitoring is lowered also. The cost of staff is decreased exponentially. In case of any abnormal parameters are detected, such as if the temperature or pulse sensor are above the threshold value, a SMS will be sent to the doctor notifying him of the issue and if it is below the threshold value, the patient lost his/her life, SMS will be sent to the doctor and the patient's members. A live monitoring system is also implemented using IOT.

Data parameters such as heartbeat and temperature are exported to Thingspeak's cloud via the ESP8266 module. For example, if the doctor has received an alert and if he is not around, he will be able to see the health status of the patient via his mobile phone. In case the patient passed away, it will be able to know when exactly it happened. The data exported to the cloud is encrypted and secured by the domain of the cloud website hence providing security of data and also for privacy concerns, these data will be able to be viewed to people with the login access of the channel.

4. EXPERIMENTAL RESULT AND DISCUSSION

This section explains the result analysis for each health parameters and the overall result of the systems in MPLAB platform. Fig. 4 shows the heart signal rate that is processed after its being acquired from the sensor and then plotted through PIC Microcontroller serial monitor.

Fig -4: Heart signal Rate

The figure -5 shows the patient's heart along with BPM (beats per minute).

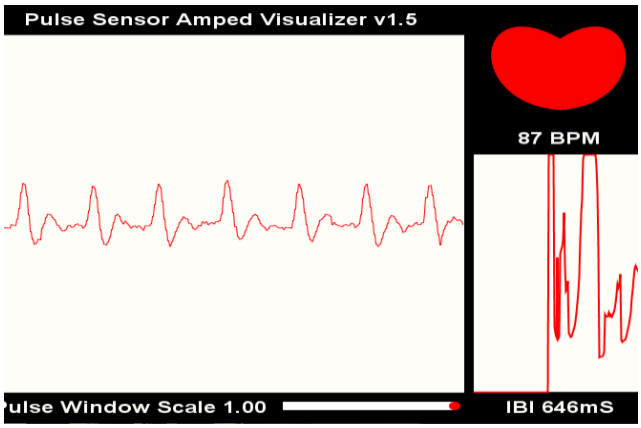

Fig -5: Heart rate graph

The body movement sensor is placed directly on the patient's hand, X- value and Y- values vary according to the physical hand movement of the patient. A physical movement is detected once those values exceed certain preset threshold which is usually set after several testing that takes into consideration the uncertainty of the sensor itself to avoid errors. The sensor also triggers a buzzer once a movement is detected to alert the doctor or the person in charge. The preset threshold can also be decreased in order to detect slight physical movements of the patient however, that would result in higher chances of errors. The X- value and Y- value graphs are shows in Fig -6 and Fig -7.

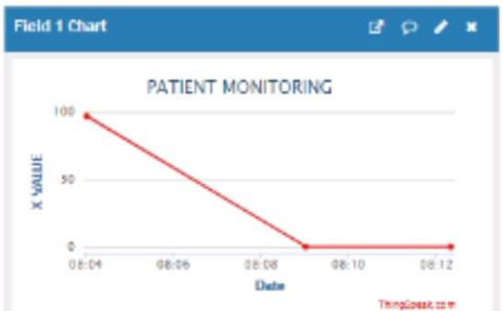

Fig -6: X- value of body movement

Fig -7: Y- value of body movement

Body temperature varies from one part of the body to another. Most suitable type of temperature measurement at mouth is at 37.0 °C. 37.0°C is the normal core body temperature. An axillary temperature degree is an external measurement taken in the armpit or between two sides of the skin in the body. This is the longest and most accurate measurement of body temperature, and decreases the normal temperature to 97.6 degrees Fahrenheit or 36.4 degrees Celsius. Straight temperature degrees are an internal measurement taken in the rectum, which is at 99.6 degrees Fahrenheit or 37.6 degrees Celsius. This is less time consuming and more accurate than the body temperature measurement, being the internal measurement. But certainly, to a large extent, it is not the most comfortable way to measure body temperature.

In this project, the LM35 sensor was placed on the arm beat in order to get accurate result and it's difficult to put the sensor in the mouth to get the actual temperature of the body. So, the result obtain for the body temperature is in range of 32.20 and 33.69. The temperature result via serial monitor and via Thingspeak in MPLAB given by Fig -8 and Fig. 11 respectively.

Fig -8: Temperature of the patient

Whenever an abnormal condition is detected such as if the temperature or the heart beat sensor is above or below the referred value, it will trigger the alert message thus respective messages will be sent to the doctor and the patient's members.

5. CONCLUSIONS

In this paper, we proposed a health monitoring system to monitor the coma patients using GSM and Internet of Things (IoT). In this proposed system, the vital parameters such as heart beat rate, body movement, and temperature are monitored and recorded in cloud storage. The proposed system analyzes the parameters values. In case these values are abnormal, GSM module will be triggered to send SMS message to predefined phone number. The overall accuracy of the system is above 90% in different conditions. However, some factors affected the overall accuracy of the project. However, we are seeking to enhance the overall accuracy of the project in the future.

Firstly, better algorithms can be implemented such that it allows the heart bear sensor to maintain its accuracy throughout various conditions. Secondly, multiple body movement sensor can be attached on different parts of the body to better monitor the physical body movements. Last but not least, a more accurate temperature sensor can be used to obtain accurate body temperature readings.

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