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Enhancing Remote Monitoring of Patients Using GSM/GPRS Technique

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Abstract:

This Work addresses remote monitoring of patients using GSM/GPRS Technology. It is made up of three sectors. The first sector being detection of patient's vitals using sensors, while second sector involves sending data to Hospital Management storage and the last part is providing the detected data for remote viewing. Remote viewing of the data enables a doctors to continuously monitor the patients' health status, GSM based patient health monitoring system was developed which will be helpful to doctors to work digitally and remotely. The system calculates the heart rate, blood pressure and body temperature of patients. The system efficiently update the doctors about health status of the patients and accurately measures the parameters of the patient and the data will be sent to a registered number via GSM with relatively low cost design, user-friendly interface and ease of installation. The system design consists of an Adriano controller and GSM modem. On detecting abnormal state, the system energizes a buzzer and the information is passed on to appropriate officers through the GSM. In case of monthly check up, there is no need for the patient to go and meet the doctor physically. With the proposed system, patients can send an SMS to check health conditions from the ECG signal. From the result obtained, it can be concluded that using this techniques, gave an impressive result with 75% improvement.

Keywords **— Healthcare, Heart-Rate, Wearable sensors, GSM/ GPRS..**

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I. INTRODUCTION

The prime goal of the Remote Health system is to come up with a reliable patient monitoring system that will enable a medical doctor or health care professional to monitor patients and execute their health care daily life activities without being present in the hospital. Real-time remote monitoring of patients aims at improving and facilitating the accessibility to data about the vital signals of the patients, or patients that need to be closely monitored while at their home, by medical care professionals. (Duarte 2020).

Remote Patients Monitoring (RPM) uses digital technologies to collect medical and other forms of health data from individuals in one location and electronically transmit the information securely to health care providers in a different location for assessment and recommendations. Monitoring patients (checking them and their health) regularly while and taking action if they show signs of becoming worse can help avoid serious problems.

This research presents a way to solve a healthcare problem facing the society through Internet of Things (IoT), which is the emerging technology, which contains huge amount of smart objects and devices connected to the internet for communication with each other. The systems have a wireless detection system that sends the sensed information wirelessly to a remote server. Some have even adopted a service model that requires one to pay a subscription fee. In developing countries this is a hindrance as some people cannot use them due to cost issues involved. There

is also the issue of internet connectivity where some systems do not have good quality internet for a real-time remote connection.

Aim and Objectives

The aim of this work is to Enhance Remote Patient Health Monitoring System using GSM/GPRS. The aim will be accomplished using the following:

i. To characterize existing system based on hospital management reports
ii. To develop enhanced algorithms for patients monitoring system that can work remotely.
iii. To develop a virtual environment that will be used to implement objective i and ii
iv. To test the whole system and validate it with existing systems.

Statement of the Problem

The area of healthcare is involved with handling of patients' sensitive data. Security and privacy of these data is very important. Remote health monitoring can provide useful physiological information from the home. This monitoring is useful for elderly or chronically ill patients who would like to avoid long hospital stay. During design, the following characteristics of the future medical applications were adhered to (a) Integration with current trends in medical practices and technology, (b) Real-time, long-term, remote monitoring, miniature, wearable sensors and long battery life of designed device. (c) Assistance to the elderly and chronic patients. The device should be easy to use with minimal buttons.

Significance of the Study

The significance of this project is solving the health-care problem with engineering approach by developing a remote health care system using GSM/ GPRS Technology. In so doing, bridging the gap between the doctor and patient with modern current available components sensors attached to it. Other Significance is giving back to society. This is to help the senior citizens who most of the time is alone and it is common for falls to occur without someone nearby to assist. Falls result in injuries in most of the 75 years and above age group and elderly. Severity of the fall may cause fractures that lead to serious health complications or even fatalities. This is where a fall detector can come in handy. A fall detector could be configured to detect whether or when a fall occurred. In some cases the patients have memory recall problems, the fall detection system can account for frequency or severity of the falls. The same age group of people is known to have heart problems. A heartbeat detector is also necessary to monitor their heart conditions.

Limitation – Scope of the Study

The scope of the work was limited to body temperature, blood pressure, Cardiac signal, and remote viewing of the collected data on cardiac. The second physiological category comprising of EEC monitor were designed with more strict specifications. The most important specification considered was that they should be safe to use and accurate. This is because the physiological information being detected determines the severity of a critical life threatening situation.

Conceptual Framework

The remote health monitoring systems are generally based on wearable sensors on the patient's body that collect data and remotely and transfer it to a database. The system calculates the heart rate, blood pressure and body temperature. The system efficiently updates doctors with health status of the patient and accurately measures the parameters of the patient and the data (is then accessed remotely by doctor or health care specialists who monitors and may make decision based on the data) been sent to a registered number via GSM. (Babu, 2018).

Theoretical Framework

Several systems for the same purpose have been proposed but they met few limitations. Indoor health monitoring system has been developed by some researchers to use this system for non-technical users but the main drawback of this system was its range of operation which was

limited by the Bluetooth technology which has the range of around 10 meter.

With improvement in technology and miniaturization of sensors, there have been attempts to utilize new technology in various areas to improve the quality of human life. One main area of research that has seen an growth in technology is the health care sector. Daily monitoring of health condition at home is important for an effective scheme for early diagnosis, treatments, and prevention of lifestyle-related diseases such as adipose, diabetes and cardiovascular diseases. While many commercially available devices for home health care monitoring are widely used, those are cumbersome in terms of self-attachment of biological sensors and self-operation.

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II. DESIGN METHOD

A proper understudy of the records and process of remote monitoring system was carried out through research, data gathering from various sources, such as interviewing and personal discussion with Medical Personnel at Enugu State University Teaching Hospital (Park lane) as well as international journals which is shown in the Table 1 in order to ensure appropriate enumeration of the various target of the system as it affects the various users. This enables the understanding of information needed and assignment of tasks to the various users in the different segments of the hospital.

Table 1: Methods of data collection

Method	Data Collected
Interview	Doctors and other personnel were interview to understand the standard operating procedure of the Remote monitoring of Patients at Hospital (clinic) and at Home.
Hospital records	The kind of data required for every user was collected towards building the database.
Observation	The service level agreement of the Hospital (clinic) was deduced by careful observation
Literature	Books and journals were consulted to understand the various need in building management software for the hospital and applying Remote Monitoring of Patients

After the various observation and consultation, the following required information is determined to be needed for the system. This determination is fitting to the defined need of the Hospital (clinic) and remote monitoring of the patients. The information required for the hospital management system database and remote monitoring of Patients are as follows:

i. Patients main information
ii. Hospital staff main information and roles
iii. Medical condition
iv. The drugs dataset, laboratory test dataset and costing information for medical activities.

Materials

This system contains the following material/ components.

i. Heart Beat Sensor
ii. Temperature Sensor
iii. Blood pressure Sensor
iv. GSM and SIM Cards
v. Medical Server
vi. And others

Characterization

This research characterized an indoor scenario where a patient is confined in an intensive or superficial care unit. An authorized person is remotely monitoring the patient's health condition. We consider the transmission of ECG data, which particularly focus on heart rate variability. The proposed patch is connected to the ECG data sensing network. The signal is modulated in the LED and sent to the respective receiver.

Finding of Characterization

The other method used to achieve this improved Remote monitoring system for patients are;

1. Firstly, the remote monitoring system was characterized in order to pinpoint the weakness of the existing system below.

This existing system presents an internet-based tele-monitoring system, which has been developed as an instance of the general client-server architecture presented in Figure 1**.**

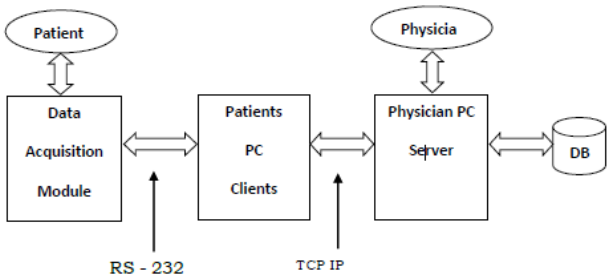

Fig 1 *General Diagram of an Internet-Base telemedical system*

The data acquisition subsystem was designed taking into consideration the requirements of a nonclinical situation. The DAM was implemented as a battery operated device. The removes of unwanted frequencies in this case requires three filters. A low-pass filter is implemented cascaded the signals from the gain amplifier with frequency higher than 100Hz A notch filter or band reject filter is used to reduce 60 Hz noise. A 60 Hz notch filter circuit was implemented using TL082 IC. Finally, a high-pass filter is used to allow the signal that has frequency above 10Hz. It should be noted that a band-pass filter was not used because the pass-band was large, and it is recommended cascaded high-pass, low-pass filters be used in this case. The digital section comprises the data conversion section and the control unit. A/D converter was employed.

Proposed System Design

The main objective is to design a Patient Monitoring System with two-way communication i.e. not only the patient's data will be sent to the doctor through SMS and email on emergencies, but also the doctor can send required suggestions to the patient or guardians through SMS or Call or Emails. And Patient or guardian can able to track patient's location at any point in time through Google Maps which would enable to send medical services in case of an emergency for non-bed ridden patients.

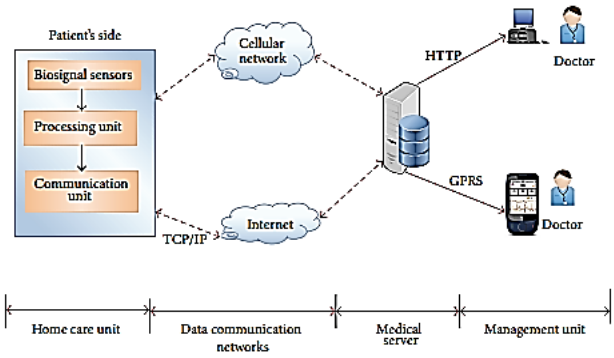

Fig 2: *The architecture of proposed system*

GSM/ GPRS

GSM/GPRS module is used to establish communication between a computer and a GSM-GPRS system. Global System for Mobile communication (GSM) is an architecture used for mobile communication in most of the countries. Global Packet Radio Service (GPRS) is an extension of GSM that enables higher data transmission rate. GSM/GPRS module consists of a GSM/GPRS modem assembled together with power supply circuit and communication interfaces (like RS-232, USB etc.) for a computer. GSM/GPRS MODEM is a class of wireless MODEM devices that are designed for communication of a computer with the GSM and GPRS network. It requires a SIM (Subscriber Identity Module) card just like mobile phones to activate communication with the network. Also, they have IMEI (International Mobile Equipment Identity) number similar to mobile phones for their identification. A GSM/GPRS MODEM can perform the following operations:

1. Receive, send or delete SMS messages in a SIM.
2. Read, add, search phone book entries of the SIM.
3. Make, Receive, or reject a voice call.

The MODEM needs AT commands, for interacting with processor or controller, which are communicated through serial communication. These commands are sent by the controller/processor. Different AT commands supported by the MODEM can be sent by the processor/controller/computer to interact with the GSM and GPRS cellular network.

2. Secondly, new model mathematical techniques was be developed and algorithm was be simulated using Matlab Simulink.

III. DEVELOPMENT OF MODEL FOR THE SYSTEM

Mathematical Equations

This system can be best described in mathematical terms, as there might be a certain amount of confusion at the initial modules of the system architecture. Let 'S' be the system which processes the ECG signals, analyzing the features present in then, does the Cardio Vascular disease detection and sends the alert to the doctor.

S = { s, e, X, Y, fkey, DD, NDD, X-prob | Øs , Success, Failure }

Where, s : first state / initial stat

e: end state/ final state

X: set of input

Y: set of output

fkey: Functions that detect the Cardio-Vascular disease

DD: Deterministic Data

NDD: Non-Deterministic Data

X-prob | Øs: Type of problem

Success: state of achieving the desired goal

Failure: state of failing to achieve the goal.

Algorithm

The ***Pan–Tompkins algorithm*** is commonly used to detect QRS complexes in electrocardiographic signals (ECG). The QRS complex represents the ventricular depolarization and the main spike visible in an ECG signal. This feature makes it particularly suitable for measuring heart rate, the first way to assess the heart health state. With Pan-tompkins, we can generate embedded applications for virtually derivative and it reported that the 99.3 percent of QRS complexes was correctly detected.

Algorithm: Pan-Tomkins

0: Initial: ECG Signal
1: **Procedure** PAN TOMKINS (Noisy ECG)
2: Stage 1 = High pass Filter (Noisy ECG)
3: Stage 2 = Low pass Filter (Stage 1)
4: Stage 3 = Differentiator (Stage 2)
5: Stage 4 = Stage 3 * Stage 3
6: Stage 5 = Integrate (Stage 4)
7: Plot Signal.PQRST(Stage 5);
8: Calculate Signal.RR interval;
9: **End Procedure**
10: procedure DECISION MAKER (Extracted RR interval)
11: if Data <HardThreshold then
12: Decide the patient is abnormal;
13: Transmit the data;
14: Store the data samples in the local storage;
15: **Else**
16: Decide the patient is normal;
17: Transmit the data;
18: Store the data samples in the local storage;
19: **end if**
20: **end procedure**

This algorithm is also called as QRS detection algorithm. We are using this algorithm to calculate the heart rate. Heart rate (in beats/second) can be calculated by the following formula:

Rate = 60 * sampling rate / (RR interval)

Work Flow Chart of the Existing System Design

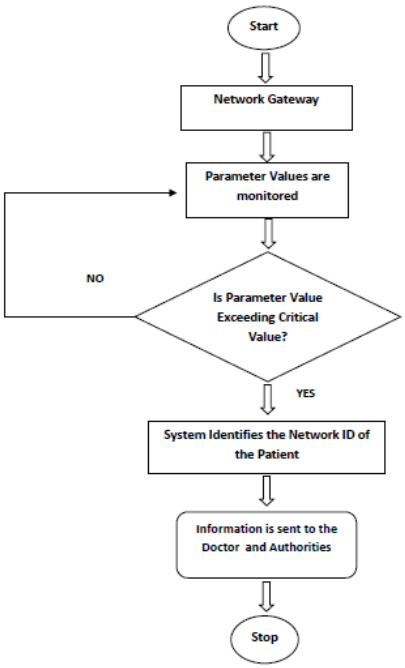

Fig 3: *Flow chart of Existing system*

Work Flow Chart of the Proposed System Design.

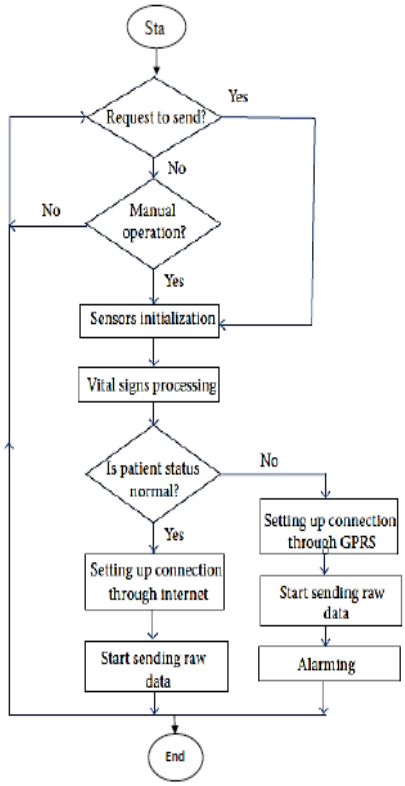

Fig 4: *Flow chart of proposed system*

3. Finally, to develop a virtual environment that will be used to implement objective ii, iii and to test the whole system and validate it with existing systems.

Development of Simulink Model/ Circuit Diagram

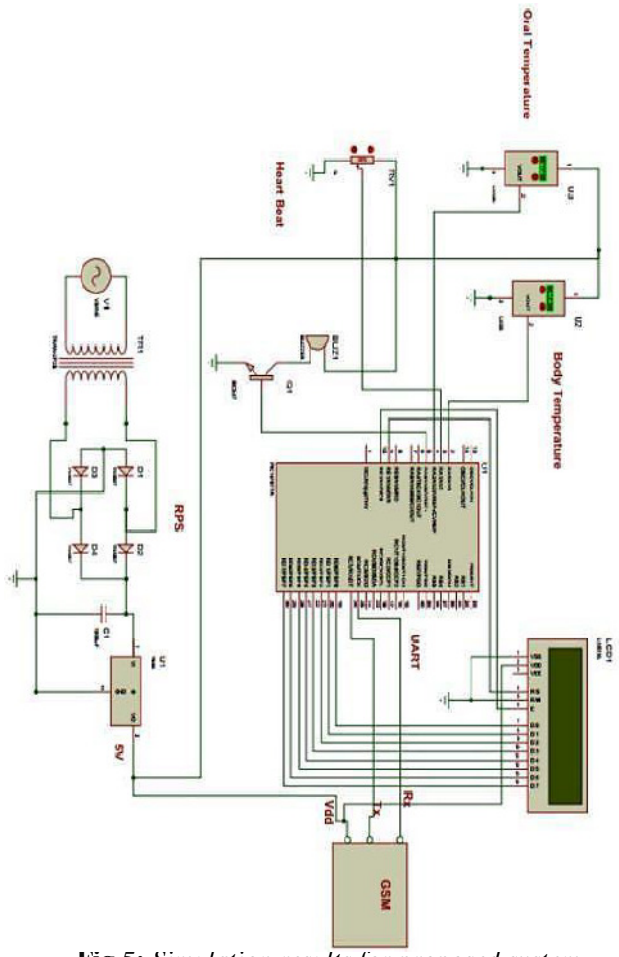

Fig 5: *Simulation results for proposed system*

The circuit diagram of the proposed system is implemented by using Matlab software. The heart beat sensors records the heart beat rate of the patient. The threshold value set to the heart beat sensor is 90bpm. If the measured value is above the threshold value, the information will be sent to the hospital by using Mobile phone.

In above circuit diagram temperature sensor can be located at remote location and you can connect more than one sensor like light sensor, motion sensor, pressure sensor according to requirement

of your project. LCD is use optional. GSM module is used to send SMS to any mobile number. you can also use other wireless communication source like Bluetooth if distance is not more than 5 meter. This project has many applications in remote monitoring systems. You can change it with ease according to your specifications.

The program for the proposed system is writing in the MatLab environment which can be seen in the Appendix 1

IV. RESULTS AND DISCUSSION

The devices sense the data from the patient's body and send them to the local system through the wireless sensor devices. Mobile application is designed for the benefit of doctors and patients. The health status of the patient is updated in the application for every 60 seconds after the update in the server. The data collected from the IoT devices to the system is huge and the information only for last three days can be viewed in mobile application.

All parameters for the last three days can be viewed through the mobile application anywhere any time. To evaluate the PHMS, sample data is collected to monitor the patient health. Sample data on blood pressure, temperature and pulse rate are collected from ten patients are given in Table.2, Table.3 and Table.4.

Table 2: Blood Pressure Data for 5 Patients

Patient ID	Age	Gender	Day 1		Day 2		Day 3	
			Min/ Max (mmHg)	Status	Min/ Max (mmHg)	Status	Min/ Max (mmHg)	Status
P0001	18	Male	80/120	Normal	85/150	Abnormal	85/110	Normal
P0002	24	Male	80/125	Normal	90/150	Abnormal	80/120	Normal
P0003	35	Male	80/135	Normal	90/130	Normal	90/150	Abnormal
P0004	68	Female	85/133	Normal	82/120	Normal	85/130	Normal
P0005	45	Female	75/133	abnormal	90/130	Normal	80/150	Abnormal

Table 3: Temperature Data for 5 Patients

Patient ID	Day 1		Day 2		Day 3	
	Current Temperature	Status	Current Temperature	Status	Current Temperature	Status
P0001	96.8° F	Normal	105.1° F	Abnormal	98° F	Normal
P0002	92.6° F	Normal	97.5° F	Normal	98° F	Normal
P0003	102.6° F	Abnormal	94.3° F	Normal	106.3° F	Abnormal
P0004	95.8° F	Normal	114.2° F	Abnormal	100.2° F	Normal
P0005	101.5° F	Abnormal	96.2° F	Normal	100° F	Abnormal

Table 4: Heartbeat Rate Data for 5 Patients

Patient ID	Day 1		Day 2		Day 3	
	Pulse Rate (bpm)	Status	Pulse Rate (bpm)	Status	Pulse Rate (bpm)	Status
P0001	72° F	Normal	106° F	Abnormal	107° F	Abnormal
P0002	87° F	Normal	83° F	Normal	82° F	Normal
P0003	105° F	Abnormal	74° F	Normal	109.3° F	Abnormal
P0004	90° F	Normal	109° F	Abnormal	86° F	Normal
P0005	103° F	Abnormal	94° F	Normal	78° F	Normal

V. CONCLUSION AND RECOMMENDATION

The Novel idea behind the remote monitoring of Patients and Health line is to Provides quality service to one and all. The remote patient monitoring system was researched, designed and presented around the concept of Internet of things. Personal physiological data from the patient is collected that simulates fall detection and the heartbeat. The readings are collected in a simple local database and the doctor or Healthcare giver can easily access the patient's information at anywhere with the help of GSM-GPRS. The data can also be used in research on medical issues affecting the elderly or chronically ill. This current designed system provides low complexity, low power consumptions and highly portable for health care monitoring of patient's and it can eliminates the need of utilization of expensive facilities. Remote monitoring of the patients using GSM/ 3G/4G Technologies can enhanced to detect and collect data of several anomalies for monitoring purpose such as Brain signal monitoring, Tumor detection, home ultral-sound etc.

In future, we can develop a big data base of all the patients of any hospital and these health parameters can be monitored continuously, and also the information is uploaded to the hospital server. These servers keep the information of the patients in the data base, and doctors can have the access of patient's history, when any further consultancy happens with the doctor.

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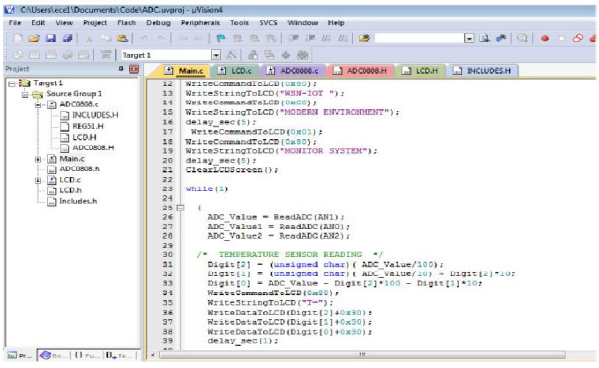
Appendix 1



Pan-Tompkins Program for proposed system