Advanced Wireless Telemedicine application using Embedded Sensor and Android OS

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ABSTRACT

Many patients who have undergone major surgeries/therapies require continuous monitoring of their health parameters such as body temperature, pulse rate etc. Hence usually they are advised to remain in the hospitals for months, which is not affordable. We are therefore suggesting a system which could monitor the health continuously and remotely and also alert the doctor when any of the parameter varies beyond the safe level.

Keywords: telemedicine, wireless, embedded sensors, android

1. INTRODUCTION

Advances in devices and systems enabled with wireless communication have a substantialimpact in the field of healthcare. Monitoring patient's health status anytime and anywhere without limiting the patient's movement as a consequence of being tied down through cables to the monitoring equipment is an important application. Through the reduction in the size of sensors and the use of wireless interface to transmit the data recorded by the sensors, health care monitoring can be stretched beyond the hospital boundaries. This is considered to be a fundamental technology for integration ofuniversal healthcare systems in mobile application with the capacity of reducing the expenses incurred in health care. This is because the physician is able to monitor the patient's advancement or deterioration in health withouthaving to spend on the cost of hospitalization.

The incorporation of wireless communication into medical applications has immense benefits. With wireless technology, the patients can be monitoredfrom a remote location and this is efficient to a certain extent. This would also enable smart monitoring of multiple patients simultaneously. When an alarming condition occurs in a patient, the doctor in charge could be notified to take appropriate action.

There are a few health monitoring systems such as the one using RFID technology, where patient's health parameters are transmitted to the concerned doctor's system. The major drawback of this system is that the patient and the doctor must be under one roof and requires a central server, which is a very expensive affair, the other one uses Bluetooth, where patient's health parameters are continuously transmitted via Bluetooth. Whenever the doctor wants to know his health condition he has to bring his phone/Bluetooth display device in the patient's Bluetooth range (which is less than 50 meters). Both of the above mentioned systems does not give the freedom of mobility to the doctor, and are too expensive to adopt.

Telemedicine technology in hospitals is quickly evolving. The prospective is to have a completely monitored hospital network, where each patient is constantly monitored via GSM technology.

The system consists of four units.

- **Micro-controller:** Central processing system which is responsible for all controlling and processing operation.
- **Sensor:** Capture bio-medical signal like heart beat and body temperature.
- **GSM**: Transfer data.
- **Android phone**: Display all parameters of patient's for Doctor.

Advanced Wireless Telemedicine application using Embedded Sensor and Android OS(AWTESA)system enables doctors to monitor patient body temperature and heart rate fromhospital. All these measurements are transferred to an android phone via GSM module. Android application displays all the acquired bio-signal parameter.

The message is sent to android phone in two mode function.

- Regular updates
- Abnormalities condition

The AWTESA continuously monitors the patient's health condition, if any variations occurs (in below or above to the normal range) i.e. heart beat rate is below 60 or above 90 and body temperature is below 25^0C and above 38^0C, immediately an emergency message is sent to doctor's phone and

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the regulating steps taken by him is given high importance which is the need of the hour and forms the unique module of the developed system. AWTESA system even facilitates to send messageto more than one doctor or nurse, in case the first doctor fails to respond urgently.

1.1 Literature Survey

1.1.1 Heart beat sensor and body temperature sensors.

A wearable health monitoring system called "button system" is attached over the chest for monitoring electro cardio gram (ECG), heart rate; temperature and another type of accelerometric sensors acquire sufficient accuracy of the heart rate with accuracy comparable to the classical ECG devices. It is measured that data while sleeping (for about 6 hours) with a large capacity battery (2000 MAh) instead of Li-ion battery. Heart rate variability (HRV) was then used as a quantitative marker of automatic nervous system activity, and the temporal variation of HRV was estimated. [9].

The effective way for hypertensive patients to prevent cardiovascular problems and precisely regulate anti-hypertension cures. Blood pressure can be measured by conventional cuff-based sphygmomanometer or invasive instruments in non continuous mode. In this paper propose the microcontroller based continuous non invasive cuff less blood pressure measurement system with an alarm circuit for healthcare monitoring system. Light signal is used in sensor network section of this embedded system as light does not have any harmful effect on human body. Pulse rate calculation and body temperature determination is also embedded in this system using sensor network. Accuracy of the system is found in acceptance range by comparing the results with the existing conventional systems. If BP reading, heart rate or body temperature exceeds the standard range for any patient, the system is able to notify using an alarming circuit. The whole system is controlled by microcontroller ATMEGA8L[3].

Nano sensor was placed in the mobile phones which contain in build highly sensitive TI MSP430 family microcontroller and zigbee used to transmit the health care data. The Nano sensor used to detect the minute variations in the human body without need various types of sensor. The hospital management continuously monitor the patient health condition if any variations occurs in below or above to the normal range immediately making call to the patient home and also call the ambulance. The location of the person detected by using the GPRS tracking system.[1]

1.1.2 Health Monitoring using Wireless Sensor Networks (WSN), Adhoc, GSM, Zigbee technologies:

Using a Wireless and remote patient monitoring system and regulating the conditionby means ofthe collected data together with GSM technology which is used to monitor various parameters of a patient in Intensive Care Unit from a remote location and also adjust the medicine dosage accordingly is provided. Doctors will be able to monitor patient parameters such as his body temperature, blood pressure and heart rate in distant areas of hospital as well as when he is out of the premises. As a response to the message received by the doctor, the system also provides a feedback to control the dosage of medicine to the patient as guided by the doctor remotely. Mobile phones are used to communicate the values of measured parameters using Simple Messaging Service(SMS) to clinicians for further analysis or diagnosis.[4]

Approaches are provided to use mobile communication devices as the router of health information. This has been adopted so that the doctors can take decisions and provide a better health care support to their users. This paper discusses in detail the specification of a reasonable health monitoring system, where its components are characterized by assistant agents running in mobile devices and using a low cost wireless communication protocol (SMS) to exchange knowledge with a central root. Communication protocol requirements and agent reasoning, based on a production system, are shown in detail along with a description of few results from practicaltests.

A wireless electro cardio graph technology (WECG) which works on 2.5 GHz frequency band has been designed and implemented. Using WECG technology the doctor and nurses have the capacity to monitor the patients adaptably and reply from a remote location. A test of read analysis for wireless ECG system to monitorthe heart pulses has been conducted by the authors. The results have been depicted as follows: for indoor environments read up to the distance of more than 50 m was achieved. In the outdoor environment operating at the Line of Sight (LoS), it was found that the principal unit and local ECG sensor unit could communicate for a distance longer than 250 m.

Practical application of this unit are applicable to a number medical cases, including treating the heart related ailments, initial medical

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treatment required at the disaster stricken areas such as earthquake, tsunami, any road accident etc., and other remote medical monitoring in health care centres, or intensive care units at the hospital.[5]

There are several kinds of wireless communication technology which can be used for achieving the required solution. The system developed combines the short-range wireless communication technology Zigbee and the long-range wireless communication technology GPRS to monitor human health.

Adhoc sensor network based solution technique is intended specifically for remote rural areas where the infrastructural facilities such as the internet, GSM/GPRS etc are not available.[9]

Smart homes contain in house medical monitoring technology which overcomesthe constraints of being fixed under cables at one place. Another advantage of this is that, medical tests can be carried out under the user's home environment as well as preventingthe stress and anxiety on userwhich could otherwise influence the accuracy of results using the test data. This reduces the possibility of misdiagnosis on the patient thus relieving the pressure on the hospital and promotes the development of low-cost medical care. Medical monitoring technology of smart home uses theZigBee short-range wireless communication technology ther eby achieving continuous, real-time and dynamic detection of the human medical parameters, including electro cardio graph (ECG), oxygen saturation and blood pressure. [8]

Telemedicine is an inter-disciplinary technology where the combination of electronic information with communication system is used to deliver health, medical information and services over large and small distances.Advances in acute care and cardiac surgery have resulted in decrease in the number of deaths due to cardiovascular diseases over the past two decades. A large population of patients who have survived heart attack have been produced due to such a development. To initiate the treatment in the critical duration the patients need to be monitored continuously. The existing methods of monitoring are basically conventional and they achieve offline analysis of health parameters thereby restrictingthe mobility of patients within a certain geographical area such as a hospital or a room.Hence the authors propose to enhance the Tele-Health system by providing flexibility of movement to the patient as well as the doctor enabling them to be independent so as to return to their regular work schedule, hence improving their psychological wellbeing [18].

The proposed system achieves this by detecting the changes in heart rate and blood pressure of the patient in advance and sending an alert SMS to the doctor through Global System for Mobile(GSM) Modem thereby gaining immediate medical attention and hence reducing the critical situation of the patient.

Smart mobile e-health monitoring system has been describes which is based on defining a three level intelligent framework that share and analyze patient's data. Techniques for integrating the physical layer components' characteristics with the application layer has been discussed [10][11].

Another Research paper investigates the probability of WSN to wirelessly collect, send and
process multiple parameters of multiple patient s simultaneouslyand in real-time reliably. This is achieved by identifying each patientusing a unique identification
andalso employing a time scheduling scheme during data transmission. This research work is tested on various health parameters for up to six patients concurrently [2].

A health monitoring system is proposed which is
based on defining a three level intelligent fram ework that share and analyse patient's data for achieving the main aim which is a smart, mobile and dependable health care system. This approach is stated to be a decentralized approach; at each level, data is analysed and decisions are made to provide the doctor with the crucial feedback of his/her patient’s health condition. The system also facilitates temporary advice, recommendations and response to any emergency situation that may happen anytime at any place and any time.

Another system is proposed where wireless health monitoring is described with the initial emphasis on measuring the electrical activity of the heart. One application of such a device would be in the monitoring of the electro cardio gram (ECG) activity in sleep apnea patients. Two types of wireless heart monitors are considered in this system one for indoor use and other for outdoor use. The prototype is composed of three parts: microprocessor, sensor, and radio. The Microprocessor is the central control unit of the entire system. Sensors are used to measure the patient’s health indicators and convert that information to electrical data. The Radio is used to transmit

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the data that has been processed by the control unit[13].

A Remote health monitoring system is proposed by authors in [14] is used to collect and transfer bio-signal data from the patient to an associated healthcare centre. In this system, a method using the combination of ZigBee and GPRS is presented. These two wireless technologies are integrated to support continuous bio-signal monitoring in presence of patient mobility. Remote data transmission through GPRS and short range data transmission through ZigBee is proposed. All data output from medical devices are transferred within a group of wireless personal area network (WPAN) to GPRS gateway. The gateway then transmits bio-signal data to healthcare center for further analysis. In order to communicate with different medical devices, the wireless data transmission strategies adopt both RS232 and USB as interface[14].

There exists a system where heart rate variations are tracked using an RF Doppler signal as proposed by authors in [14]. The system works by applying a reassigned joint time-frequency transform (RJTFT). In time-frequency analysis, RJTFT improves the readability of the heart rate on a spectrogram and the heart rate is continuously tracked with it. A heartbeat signal was acquired to verify the result from a stationary human subject using a Doppler radar unit. The sensor operating at 2.45 GHz was located a distance of 0.5 m from the subject. Using the RJTFT, the heart rate was clearly extracted, thereby improved the readability. A reference heart rate was measured by a Photo Plethy Smography (PPG) device and compared with the heart rate tracked by the RJTFT [14].

The authors in paper[15] present a prototype machine-to-machine (M2M) healthcare solution that combines mobile and IPv6 techniques in a wireless sensor network to monitor the health condition of patients. An attempt is made to provide a wide range of effective and convenient healthcare services. The system consists of a low-power embedded wearable sensor which measures the health parameters dynamically, and is connected, over low-power wireless personal area network (6LoWPAN), to the M2M node for wireless transmission through the internet or external IP-enabled networks via the M2M gateway. A visualization module of the server program graphically displays the recorded biomedical signals on Android mobile devices used by patients and doctors at the end of the networks in real-time. Our approach for a global M2M healthcare solution is managed to process the large amount of biomedical signals through the extended network combining IPv6 technique and mobile technology for daily lifestyle to users appropriately[15].

The major conclusions laid by various researchers are listed below:

1) Many remote monitoring systems have been designed and experimented by using GSM-SMS which normally involved the use of GSM modem for carrying sensing and control of devices in the system by users having cellular coverage. It is popular because of its unparallel availability and modest security at the affordable price.

2) Numerous systems have been developed using Wireless Sensor Networks which consists of several sensor nodes in proximity and having data transmission and reception capability between nodes and central base station for wide range of applications. Though initial deployment cost may be high, the operational cost of data communication within the system is negligible.
3) The development and deployment cost of wireless sensor networks is very high due to need of motes, sensors, radio transceivers, etc. spread over a large area.
4) It is difficult to upgrade existing conventional control systems with remote control capabilities.
5) The GSM modem used in cellular based remote monitoring system increases the cost of the system.
6) The long term operational cost of Internet and cellular monitoring systems is relatively high due to usage charges incurred in each message transaction.

1.2 Motivation

In today's world it is said that, world is shrinking day by day. It is due to the fact that people from different parts of the world are able to communicate easily with each other within fractions of seconds. All these advantages are possible due to the advances in digital communication techniques. With the advent of wireless technology the use of wireless networks has increased drastically over the years. In today's world of technological advancements communication and control is necessary in any part of the world.

In existing system continuously monitor the vital parameters such as temperature, pressure and pulse from a distant location. In a hospital either the nurse or the doctor has to move physically from one person to another for health check, which may not be possible to monitor their conditions continuously.

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Thus any critical situations cannot be found easily unless the nurse or doctor checks the person's health at that moment. This may be a strain for the doctors who have to take care of a lot number of people in the hospital.
In order to keep in track of critical health conditions, a real time health monitoring system of patient based on GSM, and SMS is designed and developed in AWTESA project.
AWTESA heart beat IR based sensor would help them to keep track on heartbeat counts of a patient and check for any abnormalities. If any varied change takes place it is notified and send message to android phone via GSM. The android application helps in notification to take an appropriate action at an instance of a time. This would save patients from the future health problem which would arise.

1.3 Scope

AWTESA aims at constructing a biomedical signal acquisition system that captures multiple bio medical signals and transfer the data to a recording and monitoring unit like an Android phone.
AWTESA monitor patient's heartbeat and temperature continuously from centralized location setup in emergency ward i.e. ICU in hospital .Android application used by doctor can monitor patient health condition.

1.4 Objectives

- AWTESA should be designed to analyze the patient's heartbeat and the body temperature.
- The analog value from the heart beat sensor and the body temperature sensor should be converted to digital signal and sent to Micro-controller.
- Messages will be sent to the android phone via GSM.

1.5 Problem statement

To develop a wireless communication system which can monitor patient's bio-medical measures i.e., heartbeat and body temperature and transmit data to the doctor or to keep track of patient's health condition.

1.6 Methodology

- The heartbeat and body temperature taken from the patient.
- The read data (heartbeat and temperature) is sent to the programmed micro-controller.
- Micro-controller will converts received data into a digital signal and sends the data via GSM technology.
- The received message is displayed on an android phone.

2. SPECIFICATION ANDREQUIREMENTS

2.1. Product Perspective

AWTESA patient can be monitored continuously by counting the heart beat pulse and the body temperature. The AWTESA sends message to android phone by using UART protocol.

2.2 Product Functions

The primary function of AWTESA is to send heart pulse and body temperature to android phone. The android phone continuously displays messages received from GSM and also it uploads new patient details such as name, patient ID and disease.

2.3 Constraints

- AWTESA limited to network coverage area.
- Android phone should not be switched off.
- Mobile must be android and compatible with GSM 03 model
- SIM should be GSM not the CDMA.
- GSM SIM's should be active and capable to send message.
- Android application (MESSAGE healthcare) should be installed.

3.DESIGN

3.1 High Level Design

3.1.1 General Constraints

- AWTESA works only in the network coverage area.
- If there are any variations in room temperature abnormality measurements are sent to android phone.
- Hardware module works only for GSM SIM.

3.1.3 Structure Chart diagram

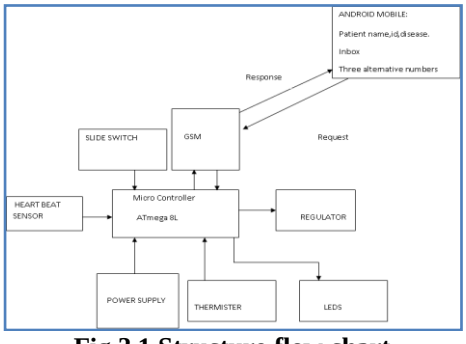

Fig 3.1 Structure flow chart

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1. **IR based heartbeat sensor**: The variation in light intensity produced by LED taken as one pulse reading.
2. **Thermister:** LM-35 is used for temperature sensor and sensor measures body temperature transmits to a micro controller.
3. **Micro controller:** The bio-medical signals are taken as input to micro-controller. It converts analog signal to digital signal and check abnormality condition, sends AT+CMGS commands to GSM.
4. **Power supply:** Sends power of 5V to a micro-controller, GSM and sensor.
5. **Slide switch:** Used to set the two mode i.e., abnormal and every minute mode.
6. **LEDS:** LEDs are used for indicating operation status of the AWTESA module. AWTESA uses four LEDs.
    - Heart pulse Green LED: For counting pulse rate.
    - Heart beat status LED: After sending message GREEN LED will be set to on.

SMS sending indication LED: used forindicating message sending status, after delivery of the message RED LED will be set to on.

7. **Temperature Status LED**: After sending message GREEN LED will be set to on
8. **GSM:** Send message to android phone.
9. **Android phone:** Receives messages from GSM and stores in INBOX. The AWTESA user can enter patient details and store phone database and further emergency message can be sent to three alternative valid numbers with patient name, id and emergency message.

3.2 DETAILED DESIGN

3.2.1 Working of hardware module:

Step 1: All ports are initialized and take pulse rate and body temperature from the patient.
Step 2: Generate the pulse and body temperature.
Step 3: Check for the slide switch set or reset.
Step 4: If switch is set to one abnormality condition mode will be activated
Step 5: If switch is reset every one minute mode is activated.
Step 6: For every minute condition check for number of seconds and increment the pulse count.
Step 7: If minute exceeds 60 second store the pulse and body temperature.
Step 8: If minute does not exceeds switch back to step 2.
Step 9: Check for the pulse rate below 60 and above 90 send message with pulse rate. Similarly for body temperature below 28 and above 35 send message with body temperature.
Step 10: If condition is fails send emergency message to the android phone.
Step 11: Store all received messages in INBOX.

3.2.2 Working of patient detail entry module:

Step 1: Enter details of patient name, patient Id and disease.
Step 2: Enter the patient Id.
Step 3: If patient id is present display all stored details.
Step 4: If patient Id is not present display the error messages.
Step 5: Enter three numbers
Step 6: Send message containing patient id, name and emergency message.

3. IMPLEMENTATION

The aim of this work is to implement a GSM based patient health monitoring system. This system is advantageous in the following ways. a) It is a compact system which gives the freedom of mobility to Doctor; b) Economical c) Wireless so that the distance between doctor and patient does not make any difference. This system consists of two units namely: (i) Doctor's Unit (DU), which is the android cell phone of doctor and also incorporates the facility of informing a family member in the absence of doctor and (ii) Patient Unit (PU), which consists of sensors and interface to measure his body temperature and pulse rate. An Atmega microprocessor is used to fetch the data from the sensors and store it in its memory, which is sent to android phone through SMS using GSM modem. When any of the health parameters go beyond the safety range, a message is sent to the doctor which contains the health parameters.

AWTESA approach involves taking the heart beat pulses from heart beat sensor and send an analog signal to the micro controller then it will convert it into a digital signal. After converting it will check the abnormality of human heart and temperature, it will send an SMS to the Android application via GSM module.

4.1 Platform Details

4.1.1 Android Programming

In AWTESA Android SDK has been used which has been integrated with Eclipse IDE built by Oracle corporation. The Android SDK is open source tool, It is freely available on the developer

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website. The Eclipse program has become the most popular IDE for Android application development. Android developer site has powerful plug-in for facilitating Android development.Android applications are written in java programming language, developers are already familiar with many of the packages provided as part of android SDK, such as java.net.Android development tools (ADT) plug-in for eclipse. Android application provides automated builds and application deployment to android emulators and handsets.

4.1.2 Code Vision AVR Cross Compiler

IDE has built in AVR Chip In-System Programmer Software that enables to automatically transfer of the program to the Microcontroller chip after successful compilation/assembly. The In-System Programmer Software is designed to work in conjunction with the Atmel/Mega8L programmers/development boards.

The IDE has a built in terminal which is used for serial communication and debugging embedded systems.

The code vision AVR C Compiler has some libraries for :

- Alphanumeric LCD modules
- National Semiconductor LM75 Temperature Sensor
- Real time Clocks
- Maxim/Dallas Semiconductor 1 wire protocol
- Power Management
- Delays
- Gray Code Conversion
- AVR Studio Programmer

AVR Studio is an IDE for writing and debugging AVR applications in Windows XP/NT/Vista environments. AVR Studio provides a project management tool, source file editor, Simulator, Assembler, and front-end for C/C++ programming, Emulation and on-chip debugging.

AVR supports the complete range of ATMEL AVR tools. GUI plug-ins and other modules can be written and hooked to the system.

4.1.3 Embedded C

Embedded C contains essential information for anyone developing embedded systems such as Micro controllers, real-time control systems, mobile devices, PDAs and similar applications. The design of module is intended to provide an excellent working knowledge of C language and its applications tool serious real-time or embedded systems. BSI and ANSI X3J11 standards bodies that produce the standard for C. We focus on the needs of day today users the language with emphasis being on practical use and delivery of reliable software.

4.1.4 GSM

Reading a SMS from the Inbox:

To read the first SMS from the inbox send the command AT+CMGL=1 followed by \r\n. The modem will reply with the text of first SMS in the inbox along with sender's mobile number and date and time.

To read a second SMS from the inbox send a command AT+CMGL=2 followed by the same thing as said above and so on.

Sending SMS from SIM300:

To send SMS from SIM300 send the command AT+CMGS=7353056876; followed by \r\n and then the message text and then the ascii code of Ctrl^Z character which is 0x1A.

Ex: To send "Hello" to 7353056876 mobile numbers

AT+CMGS=7353056876; followed by \r\n

Hello

To read all SMS from the inbox send command AT+CMGL=ALL; followed by \r\n. The modem will reply with text, sender's number, timestamp of the all messages in inbox.

4. RESULT ANALYSIS

The patient's reading of heart-beat and body temperature is taken for the 3 hours. At x –axis the time slot taken for each 15 minute interval and at y-axis the heartbeat rate is plotted for heartbeat graph. In the following graph fig 5.15 shows that variations of heartbeat. In the fig 5.16 at x-axis the time slot for 15 minute is taken and at y-axis the body temperature in degree celsius is taken. The patient's body temperature varies at every 15 minute.

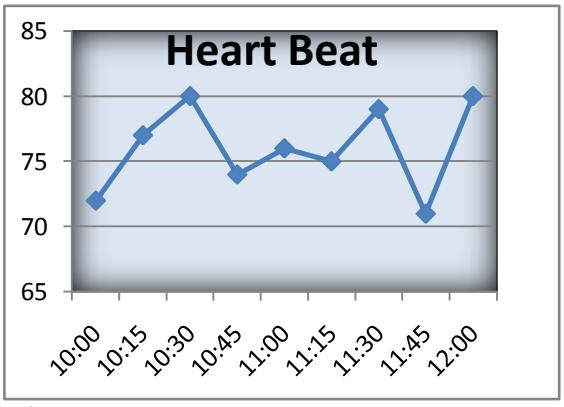

Fig 5.9 Graph for Heartbeat

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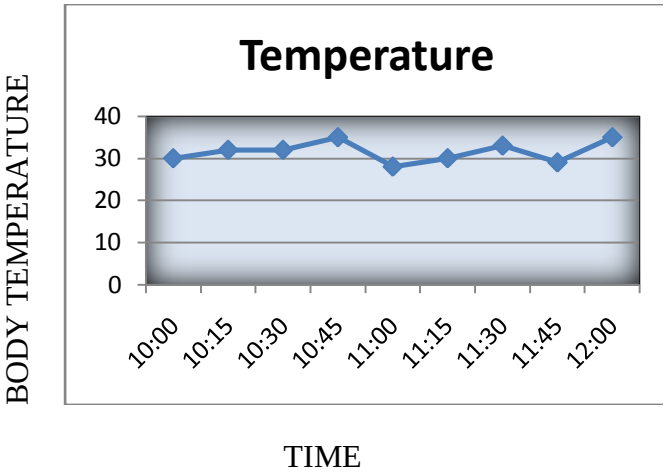

Fig 5.10 Graph for Temperature

5. CONCLUSION

6.1 Summary

Most of the conventional patient health monitoring systems are wired and requires a PC to process the data further and then sends an alert to a doctor. Also they are not suitable for long distance usage as they use zigbee or Bluetooth technology which is limited to a short range. AWTESA system is simple, has fewer wires, all it needs is a mobile network to send message to the doctor which has a wide range for communication.

AWTESAproject is designed to analyze the patient's heartbeat and the body temperature. The analog value from the heart beat sensor and the body temperature sensor is converted to digital signal and sent to Micro-controller. Messages are sent to the android phone of Doctor for analysis using GSM technology.

AWTESA project works on two modes: abnormal condition mode and normal mode.

1. Abnormal condition: In this condition if the pulse rate below 60 and above 90 for one minute interval, similarly for body temperature below 25^0C and above 38^0C sends emergency message to android phone.
2. Normal mode: At every one minute interval updated pulse count and body temperature data are sent to android phone.

6.2 Limitations

The limitations of the product are not negative aspects to the work done. Some important limitations as follows:

- AWTESA hardware system must be setup in Centralized location.
- AWTESA data transmission limited to network converge area.
- Mobile phone should run on Android OS.

6.3 Future Enhancements

AWTESA can interface different health parameters such as Blood pressure monitoring system, Blood sugar level monitoring system, and any compact health parameter measuring system can be interfaced with this, if programmed properly. And we can also add many features to it.

Though the system is economic and affordable by common man, Sensors used here are connected to the microcontroller through wires, and the microcontroller used is of big size, these limitations can be overcome if advanced technologies as such in smart phones are used so as to make the whole patient to look like a simple cell phone, industrial level development is a need.

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