Engineering, Technology and Techniques

**BRAZILIAN ARCHIVES OF
BIOLOGY AND TECHNOLOGY**

A N   I N T E R N A T I O N A L   J O U R N A L

Smart Health Surveillance with Automated Database Using Android Mobile Device

Anitha Karthi[1]*, Rajkamal Rajendran[2], Poomanirajan Mathiarasan[1].
[1]Rajalakshmi Institute of Technology - Electrical and Electronics Engineering, Chennai, Tamil Nadu, India.
[2]Madanapalle Institute of Technology and Science - Electrical and Electronics Engineering, Andhra Pradesh, India.

ABSTRACT

Smart Health Surveillance system is to measure and display the Electrocardiogram (ECG) and temperature of patient's body continuously and also to communicate to the doctor. The system measures ECG using infrared sensor and the temperatures at oral and wrist of the patient using temperature sensors. Microcontroller, receives the data from the sensors, displays the same and communicates to the web server automatically. In the existing system, patient's vital parameters are obtained and the obtained values are entered into database and then uploaded into a web-based server manually. The existing system has no alert signal, during abnormal condition to the surrounding and to the doctor. The proposed system consists of a visualization module of the server program, which graphically displays the recorded biomedical signals on android mobile devices used by doctors at the receiver end. It also gives a buzzer or an alarm in case of abnormal condition of the patient.

Key words: Android mobile device, Health Surveillance, PIC microcontroller, Wireless sensor network

*Author for correspondence:

INTRODUCTION

Smart health monitoring system is a vital topic and an important research field today. The new research is emphasizing on improving the quality and healthy life by designing and fabricating sensors which are either in direct contact with the human body (invasive) or indirect (non-invasive). One of the most promising applications of information technology is in healthcare management. Healthcare is moving from a reactive approach to a proactive approach characterized by early detection, prevention, and long-term management of health conditions. The monitoring system allows an individual to closely monitor their changes in vital signs and provide feedback, which helps to maintain an optimal health status. There is an extensive interest in using wireless technologies in-patient monitoring in various environments including hospitals and nursing homes. Due to wireless technology, it provides better treatments to patients though they are physically not present in hospital. This system is more useful for elderly people as they are more prone to chronic diseases and need continuous health monitoring. There are different products developed which supports the wireless health monitoring system and provide real time health condition of patient to doctor immediately.

The patient monitoring module is available which transmits the acquired vital signs through a wireless communication module to multiple personal computers[1]. There is also system with visualization mechanism that allows the doctor at hospital to monitor multiple patients in real time with long term monitoring data acquired from multiple sensors and works with standardized protocols such as IEEE 1451 and ISO IEEE 11073 for transmitting the acquired sensor data[2]. Wireless patient monitoring system is available that could allow patients to be mobile in their environment and the system with a pulse oximeter to measure blood oxygen concentration and the patient's pulse, as well as a temperature sensor to keep track of the patient's temperature[3]. Alert systems in terms of Simple Message System (SMS) and email to the doctors about the physiological parameters of the patients are existing[4]. Wireless architecture for human health monitoring system using the two sensors, temperature and pulse heart rate are available. These sensors output are interfaced with PIC microcontroller and data is transmitted to the node wirelessly using zigbee which pass the data to a Personal Computer[5]. Real-time monitoring and alarming system for patient health, especially for patients suffering from diseases during their normal life with an embedded microcontroller connected to a set of medical sensors and a wireless communication module is available, where the systems have ability to process real-time signals generated from biosensors and transmit the measured signals through the patient's phone to the medical center's server[6].

System is also present to focus on the measurement and monitoring various biological parameters of patient's body like heart rate, oxygen saturation level in blood and temperature using a web server and android application, where doctor can continuously monitor the patient's condition in terms of data on his smart phone using an Android application[8]. Patient monitoring system is available to monitor the patient's vital parameters such as ECG, heart rate, SpO_2, pulse rate and temperature and values are entered into a database and are uploaded into a web-based server manually[9]. The system using a set of collected vital signs (blood pressure, heart rate, oxygen saturation, and pulse rate, temperature and blood glucose level) from 30 hospitalized older adults with an overall accuracy of 98% is existing[11]. System that sends an automated SMS to the pre-configured Doctor's mobile number using a standard GSM module interfaced to the ARM microcontroller if a particular patient's health parameter falls below the

threshold value is available[12]. Zigbee based sensor network for patient monitoring performance is analyzed through simulations[13].

The characterization of cyber physical systems for healthcare applications is based on a comprehensive taxonomy involving eight different perspectives such as application, architecture, sensing, data management, computation, communication, security, and control/actuation for utilizing wireless sensor networks (WSN) or Cloud Computing[14].The systems are available for Real-time ECG monitoring and arrhythmia detection using Android-based mobile devices but with the application available to only download[15]. System for tele-monitoring of patients, where the sensor data is relayed to the server using a smart device or a base station in close proximity is also available. The doctors and caregivers monitor the patient in real time through the data received through the server with such a type of system[16]. There is also system that uses a wireless sensor network to observe the after effects of medicine on patient suffering from chronic heart diseases in their home with the help of remote monitoring system and it eradicates the dependency on PC by using Wireless sensor networks[17].

Wireless sensor network for health monitoring system by using ZigBee module and it is concluded that Programmable Interface Controller has been the low cost implementation used for recording and transmitting the bio-medical signals by wireless technology and very useful to the remote patients[18]. IP-enable internet and the visualization module[19] of the server program graphically demonstrate the recorded biomedical signals on android mobile using Machine to Machine devices is available. The tele medical systems focuses on the measurement of health care parameters based on two different designs of a Body Area Network connected to Android Smartphone[7, 10]. A real time heart monitoring system using android smart phone is also available[20].

It is true that costly and sophisticated medical instruments provide very satisfactory service to patients regarding the medical diagnosis and treatment point of view. Again, the fact that people from developing countries, sometimes have little access to such costly medical equipments for their proper treatment due to socio-economic structure of their countries, is also undeniable. Hence, design and development of low- cost instruments using modern technology is to be given a great concern to facilitate the access of every patient to have satisfactory medical service.

In this concern, this paper is to design a microcontroller based automatic health monitoring system. Another advantage of this proposed system is, 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. Thus, for any critical situation, the nurses or doctors to be present near the patient to check the person's health at that moment. This may be a strain for the doctors who have to take care of a numerous patients in the hospital. In order to keep in track of critical health conditions, this automatic health surveillance is used. To send the tracked signals and data of patient ECG and temperature to doctor's android mobile and in case of emergency an alarming signal to the doctor's android mobiles, GSM is used. The comparison of different health monitoring system with the proposed system is given in Table 1.

Table 1. Comparison of Different Health Monitoring System with the Proposed System

Reference Papers	Wireless system	SMS facility	Alert system	Automated system	Waveform signal display in android device
[3]	Available	Not Available	Not Available	Available	Not Available
[8]	Available	Not Available	Not Available	Not Available	Not Available
[9]	Available	Available	Not Available	Not Available	Available
Proposed System	Available	Available	Available	Available	Available

SYSTEM DESCRIPTION

The system consists of input, control, output and power supply units. Fig.1. shows the block diagram of the proposed system. The Infrared (IR) sensor is placed in the fingertip of the patient. It detects the blood flow rate of the human body. From the blood flow rate, the heart rate of the patient is detected in terms of Beats per Minute (BPM). LM35 is placed in the oral and wrist of the patient. It senses the patient's temperature at both places. The sensed values of Heart rate and the Temperature are fed to the controller unit. The PIC controller receives the value of heart rate and temperature continuously from the input unit. The PIC controller is programmed using Code Composer Studio (CCS) compiler. The received data is the input to the PIC programmer. The PIC programmer compares the input value with the predetermined value and sends the condition (normal or abnormal) and the value of temperature and heart rate to the output unit. The output unit consists of Liquid Crystal Display (LCD), Alarm, Global System for Mobile Communication (GSM) and the Android Mobile device. The value of temperature and heart rate is displayed in the LCD with the condition as either Normal or Abnormal. Through GSM, data and signals of the patient are sent to the doctor's Android mobile. The Android mobile receives the message and the waveform is viewed in the Health care application. In case of an abnormal condition, the buzzer raises an alarm. Alarm acts an alert signal to the caregivers and to doctor.
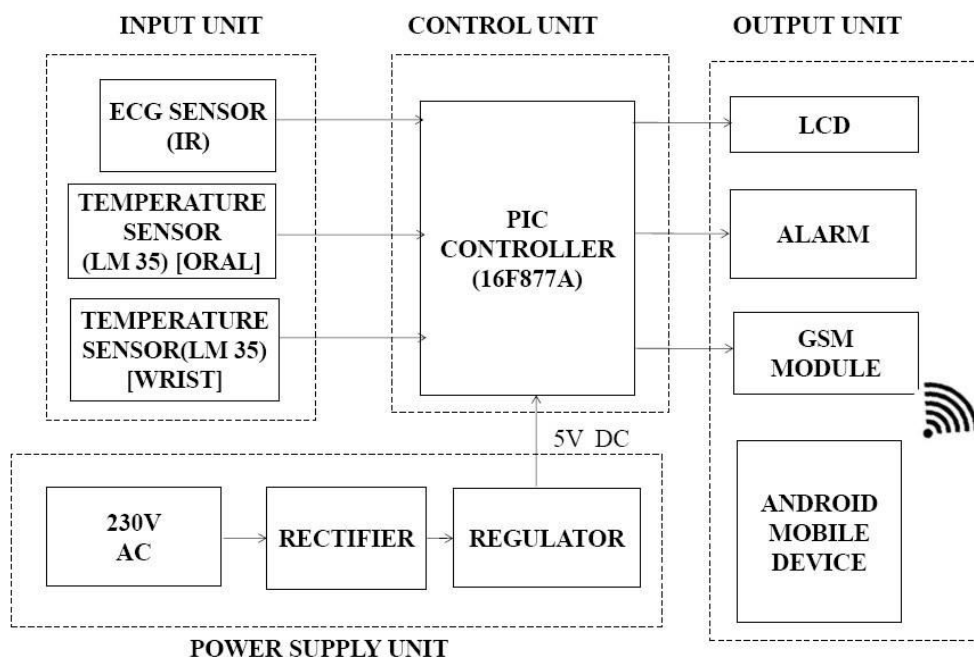
Fig.1. Block Diagram of Smart Health Surveillance system

The proposed technique of sending the data from patient end to doctor's end for one time is depicted in the flowchart, shown in Fig.2.
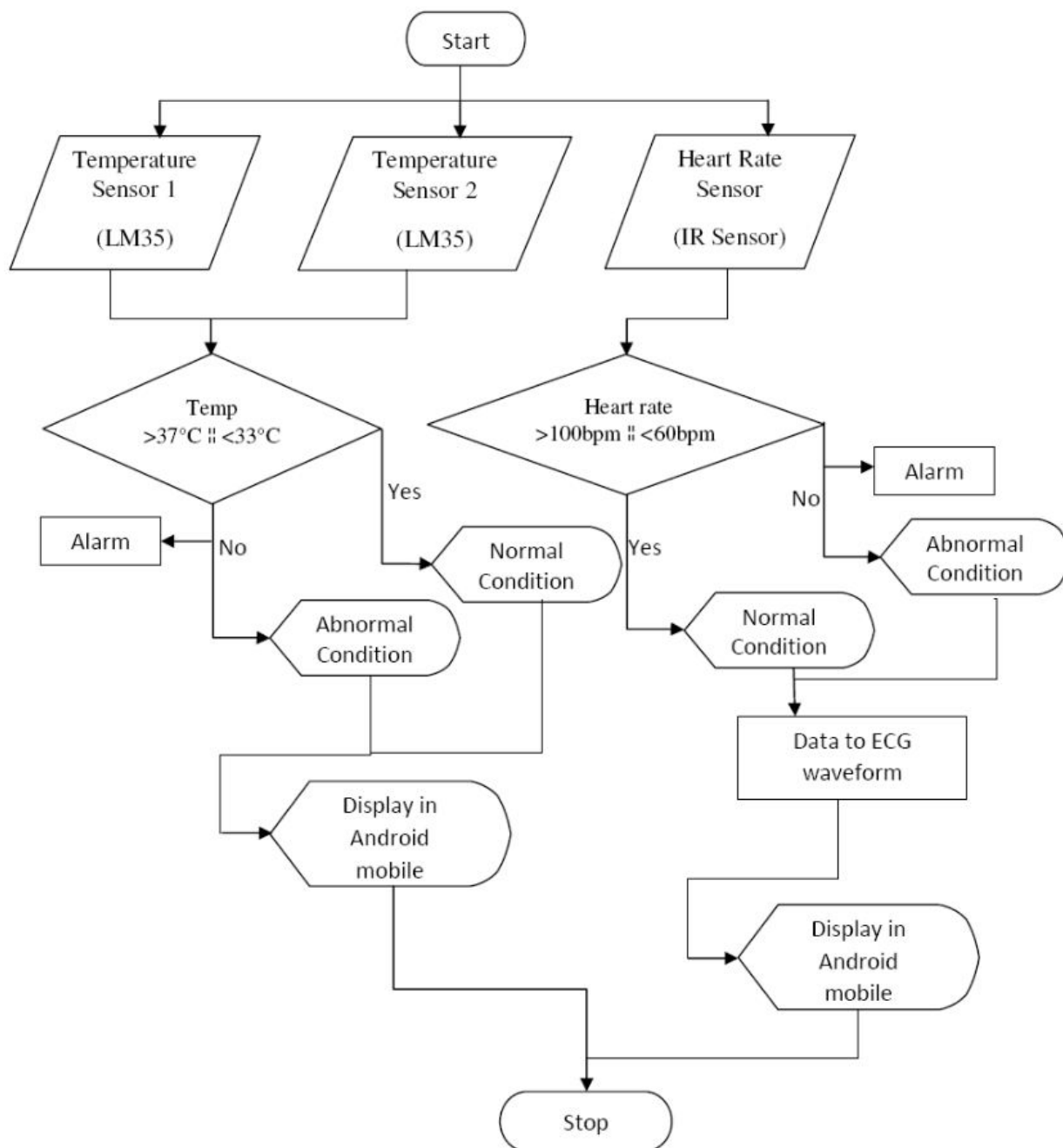

Fig.2. Flowchart for one time end to end data

IR Sensor

IR sensor demonstrates a technique to measure the heart rate by sensing the change in blood volume in a finger artery while the heart is pumping the blood. It consists of an infrared Light Emitting Diode that transmits an IR signal through the fingertip of the patient, the blood cells reflect a part of it, and a photo diode sensor detects the reflected signal. The changing blood volume with heartbeat results in a train of pulses at the output of the photo diode. Microcontroller (PIC 16F877A) cannot detect the train of pulses at the output of the photo diode as its magnitude is small. A two-stage high gain, active low pass filter using two Operational Amplifiers is used to filter and amplify the signal to appropriate voltage level so that a microcontroller can count the pulses. The sensor unit consists of an infrared light emitting diode and a photodiode, placed side by side. The Infrared diode transmits an infrared light into the fingertip, placed over the sensor unit and the photodiode senses the portion of the light that is reflected back. The intensity of reflected light depends upon the blood volume inside the fingertip. Therefore, each heartbeat slightly alters the amount of reflected infrared light is detected by the photodiode. With a proper signal conditioning, this little change in the amplitude of the reflected light is converted into a pulse. The pulses are counted by the microcontroller to determine the heartbeat.

Temperature sensor [LM35]

The LM35 is an integrated circuit sensor used to measure the patient's body temperature. LM35 is a precision Integrated Circuit temperature sensor with its output proportional to the temperature (in °C). The sensor circuitry is sealed and therefore it is not subjected to oxidation and other processes. With LM35, temperature can be measured more accurately than using a thermistor. It also possesses low self-heating and does not cause more than 0.1°C temperature rise in still air. The operating temperature range is from -55°C to 150°C. The output voltage varies by 10mV in response to every °C rise/fall in ambient temperature, *i.e.,* its scale factor is 0.01V/°C. The sensors are placed in the oral and wrist of the patient and the sensed values is fed to the PIC microcontroller. The temperature value between 33 and 37 °C is the normal body temperature. When the temperature value is reduced less than33 or increased above 37 ° C, it is an abnormal condition.

SIMULATION CIRCUIT

Fig.3. shows the simulation circuit of an automated system in Proteus 7.2 for smart health surveillance for patients.
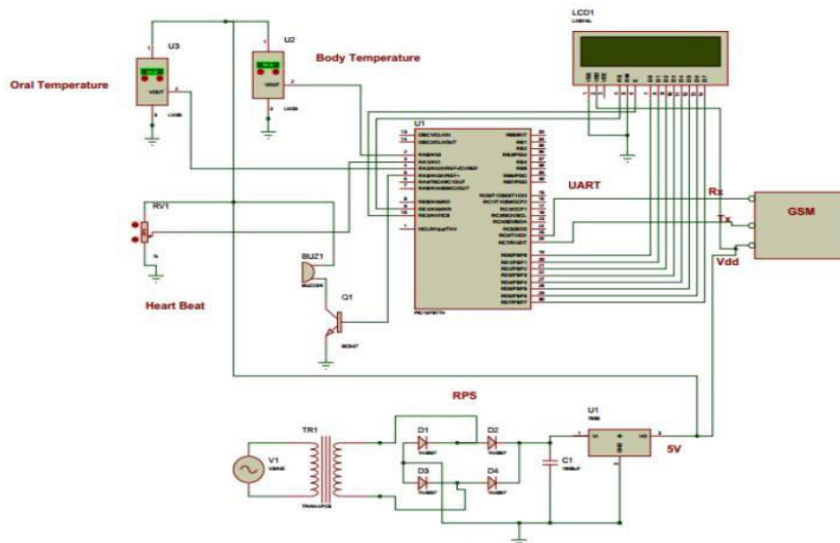
Fig.3. Simulation Circuit of Smart Health Surveillance system

Here both the temperature (oral and body) is sensed by temperature sensor, LM35 and Heart rate is sensed by IR sensor and the output of it is connected to microcontroller. The microcontroller handles the value is given as output to LCD and it shows the value of sensed values. The GSM is also connected to the microcontroller and the sensed values will be sent to the doctor's android mobile device through GSM.

LM35 is a temperature sensor, RV1 is a variable resistor, PIC16F877A is a PIC controller, and LCD is the display. The Temperature sensor's (LM-35) pin-1 is connected to the supply of 5V. The pin-3 is connected to the ground. The output pin-2 gives the sensed temperature output. The sensed analog temperature is fed to the PIC controller pin-2. The ECG Sensor [IR sensor] is replaced by the variable resistor since the sensor element is not available in the Proteus software. The pin-1 is connected to the supply of 5V. The pin-3 is connected to the ground. The output pin-2 gives the variable resistance output. The output is fed to the PIC controller pin-3.

The PIC controller 16F877A, pin-2 receives input from the temperature sensor and pin-3 receives input from the variable resistor. Pin 19-22 and 27-30 are connected to the Light Emitting Diode (LED) display. The pin-4 register select (RS) of the LED display is connected to the pin-9 of the micro controller. The pin-5 read/write (RW) of the LED display is always connected to the ground. The pin-6 enable (E) of the LED display is connected to the pin-10 of the PIC controller. The patient temperature is given as input to the LM35 (Temperature sensor) and the patient Heart rate is given as input to the variable resistor. The input value is processed in PIC controller, which is programmed in CCS compiler. The LED will display the reading of the temperature both oral and body temperature and also the heart rate value and displays whether it is normal or abnormal.

HARDWARE IMPLEMENTATION

Fig.4. shows hardware implementation of an automated system for patient health surveillance.
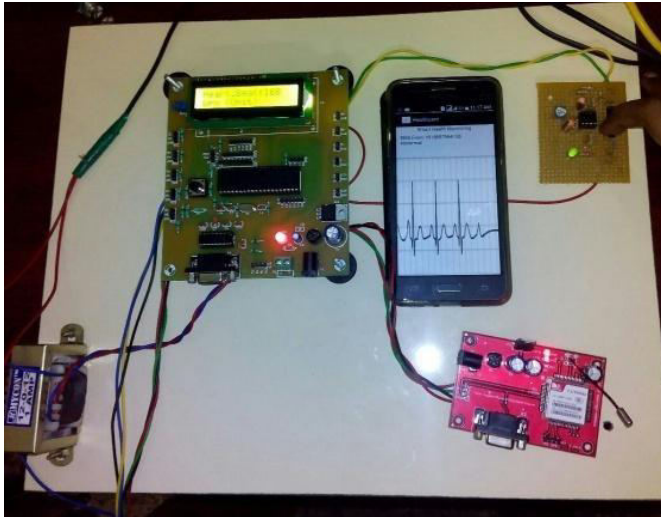
Fig.4. Hardware Implementation

A 5V supply is given to the PIC m i c r o controller, buzzer, GSM and for the sensors. The 230V AC is given to step down transformer, which steps down to 5V and gives input, to the PIC microcontroller. The Temperature sensor of both the oral and body sensor is connected to the pin 1and 2 of port A of PIC controller. The IR sensor is connected to the pin 3 of port A of PIC controller. The GSM is connected to port C (pin 25 and 26) of PIC microcontroller. LCD is in-built. The Buzzer is connected to the port D pin 2 of PIC controller. The Temperature sensor is connected to the patient and also the IR sensor both sense the value and give it to PIC microcontroller.

Table 2. Specification of the proposed System

Module	Type	Specification
Heart rate sensor	IR sensor	3.5V , Infrared, LED
Temperature sensor	LM35	-55º to -150º c
Android mobile	Connectivity OS	Wireless
Alarm/Buzzer	Electro mechanical	3-20 V DC

RESULTS AND DISCUSSIONS

The patient's heart rate, temperature values and the signal are sent automatically to the Doctor's android mobile device. The condition and data are also displayed in the LCD. In case of any abnormal condition, it also raises an alarming signal during any abnormal condition. The normal temperature value is 33-37°C and the normal heart rate is 60-100 bpm. If any of the values goes down or high, the abnormal condition will be detected and the message is sent to Doctor's android mobile device and the alarm will be raised. In case of normal condition also LCD displays the values and the Doctor can check the signal and values often in his android mobile device. Fig.5. shows the normal temperature of a patient.
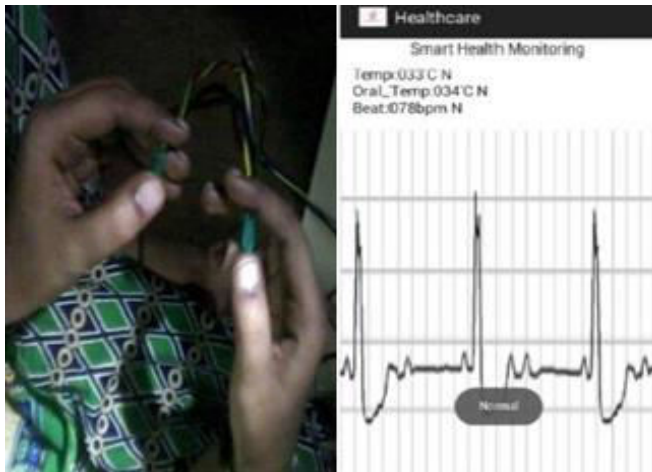
Fig .5. Normal Temperature Output

The temperature sensor is connected to the patient's body. The temperature value is sensed it is displayed as normal in LCD and the corresponding value of temperature along with heart rate is sent to doctor's android mobile application Health care. If the temperature output of patient is, abnormal such condition along with its value displayed and the alert message sent to doctor and the alarm is raised as shown inFig.6.

Fig .6 Abnormal Temperature Output

Fig.7. shows the normal heart rate output of the patient. The heart rate is normal which is displayed in LCD display and the corresponding output waveform is displayed in doctor's android mobile device in Healthcare application.
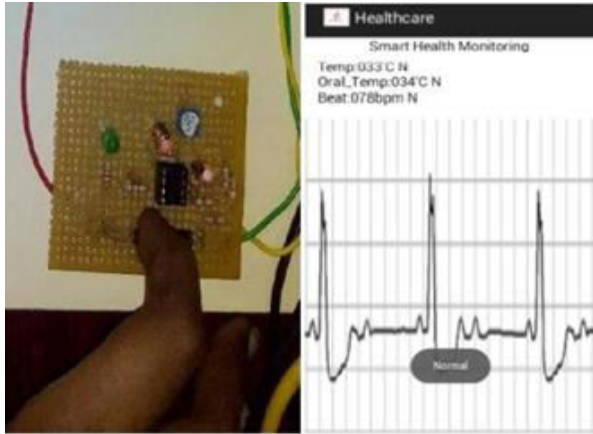
Fig .7 Normal Heart Rate Output

Fig. 8. shows the resultant waveform for the heart beat abnormality with the value in the android mobile.

Fig .8 Abnormal Heart Rate Output

Smart Health surveillance using mobile device

In Table 3, the proposed work is interpreted with respect to other works.

Table 3. Interpretation of Proposed System with respect to Reference papers

Ref. paper	Measuring Quantity	Sensors	Controller	Communication device	Device	Network	Software	Monitoring	No. of Patients	Alert system
Proposed System	ECG, Heart Rate, Pulse Rate, Temperature	Infrared sensor, Temperature Sensor	PIC 16F877A	GSM	Android Smart Phone [monitoring end]	Internet	Data to Waveform Application	Numerical values and waveform	Single	Alarm, SMS, Value with status
1-	ECG & Heart Rate, SpO₂ , non-invasive BP,body temperature	clamp type sensors, Pulse oximeter, occlusion cuff thermistor	PIC 18F4550	GSM	PC[monitoring end]	-	Microsoft Visual Basic-Front end	Numerical Values	Single	-
2-	ECG	ECG sensors, Bio sensors	-	Zigbee	Smart Phone [monitoring end]	Internet	3 D views Real-time Data Visualization	Analytics-based Decision Support	Multiple	Colour change
3-	pulse rate, temperature, blood oxygen concentration	Thermistor, Pulse oximeter	Arduino Fio	XBee	PC[monitoring end]	Virtual Interface	Lab view GUI	Numerical values and waveforms.	Three	Alarm
4-	ECG, heart rate, temperature.	ECG sensor, heart rate sensor, body temperature sensor	ATmega32	Blue tooth	Android Smart Phone [Receiving end] PC[monitoring end]	Internet-Web server	GUI	Waveforms	Single	SMS, E-mail, Buzzer
5-	Heart rate, temperature.	Pulse heart rate sensor, Temperature Sensor	PIC 18F46J50	Zigbee	PC[monitoring end]		Visual Basic	Numerical values	Five	-
6-	Heart beat rate, Breathing rate , Blood pressure , Temperature, ECG	Bio sensors	Micro controller	Blue tooth	Android Smart Phone [Receiving end and monitoring end]	Internet-Web server	GUI built on PHP	Numerical values and waveforms	Single	SMS, Call
7,10-	ECG, heart rate, heart rate variability, plethysmography	Bio sensors	Embedded Controller	Zigbee Blue tooth	Android Smart Phone [Receiving end and monitoring end]	-	-	Measuring, analysing and visualizing medical parameters	Single	Message
8-	SPO₂, Heart Rate, temperature.	Pulse oximeter, Temperature sensor	MSP430	Blue tooth	Android Smart Phone [Receiving end and monitoring end]	Internet - Web server	-	Numerical values, Collection in graphs	Single	-
9-	ECG, Heart Rate, Pulse Rate, Temperature, Sp0₂	PPM sensor LM35 sensor	PIC 16F887A	Blue tooth GSM	Android Smart Phone PC [monitoring end]	-	JAVA	Waveform	Single	SMS
11-	ECG, Heart Rate, Pulse Rate, Temperature, Sp0₂	Bio sensors	-	Blue tooth WiFi	Android Smart Phone PC [monitoring end]	Internet - Web server	GUI	Numerical Values	Single	-
12-	ECG, Heart Rate, Pulse Rate, Temperature	ECG Sensor, Heart sensor, Temperature Sensor,	ARM processor	Zigbee GSM	PC[monitoring end]	-	GUI using Visual studio	Numerical Values	Single	-
13-	Blood flow, ECG, respiratory rate, BP, Body temperature	Bio sensors	-	Zigbee	-	-	ns2.34 simulator tool	Packet Delivery Ratio simulated values	Single	-

15-	ECG	ECG sensor	-	Blue tooth	Android Smart Phone [monitoring end]	-	-	Automated arrhythmia detection by analyzing ECG parameters	Single	-
16-	Body Parameters	Bio sensors	-	-	Smart Phone [monitoring end]	Internet - Web server	-	tele-monitoring-all parameters	Multiple	-
17-	ECG	ECG sensor	PIC 18LF4620	Zigbee CC2500 module	PC[monitoring end]	Internet	ECG Visualisation software - JSP	Numerical values and waveform	Single	-
18-	Body temperature, pH level, Heart beat rate, Oxygen saturation level and ECG	Temperature Sensor, Heart Beat Sensor, Pulse Oximeter, pH Level Sensor, ECG Sensor	PIC 16F877A	Zigbee	PC[monitoring end]	-	-	Numerical Values	Single	-
20-	ECG	ECG sensor	Micro controller	Blue tooth	Android Smart Phone [monitoring end]	-	-	-	Multiple	-

CONCLUSION AND FUTURE SCOPE

The design and implementation of a smart health surveillance system is presented in this paper. The system acquires the patient's vital parameters such as heart rate value and temperature of the body at important positions. The system displays the patient's real-time data and these values are entered into the database automatically and communicated to the doctor's Android based smart phone using GSM module, which is not available in the existing systems. The system is tested with the patients and the results are obtained. The results obtained are very promising and the detection of P Q and R of ECG signal is highly possible. The system facilitates the patients by eliminating the use of invasive instruments or using PC or laptop to see the biological data. The system is applicable for people above 10 years of age and there is possibility of enhancement of system for kids. Further the system can be extended to the service of the Doctor's abroad to diagnose chronic diseases.

REFERENCES

1- AbhishekEkhare and Uttam Chaskar. Design and Development of Multi parameter Patient Monitoring System with Wireless Communication to PC: International Conference on Control, Instrumentation, Communication and Computational Technologies (ICCICCT). 2014; pp.21-25.
2- Alex Page, Tolga Soyata, Jean-Philippe Couderc, Mehmet Aktas, Burak Kantarci and Silvana   Andreescu, Visualization of Health Monitoring Data Acquired from Distributed Sensorsfor Multiple Pati ents, IEEE Global Communications Conference (GLOBECOM). 2015; pp: $1-7$.
3- Alexsis Bell, Paul Rogers, Chris Farnell, Brett Sparkman and Scott C.Smith. Wireless Patient Monitoring System, Health Innovation and Point of Care Technology Conference Seattle, Washington USA. 2014; pp.149-152.
4- Baviskar Rahul Nandkishor, AparnaShinde and Malathi P. Android Smartphone Based V Body Area Network for Monitoring and Evaluation of Medical Parameters, First International conference on Networks & Soft Computing. 2014; pp.284-288.
5- Kalpana.P.M. Design and Development Of PIC Microcontroller based Wireless Architecture for Human Health Monitoring, International Journal of Innovative Research in Science, Engineering and Technology.2014; Vol.4, pp.234-240.

Smart Health surveillance using mobile device

6- Kasim M. Al-Aubidy; Ahmad M. Derbas; Abdullah W. Al-Mutairi, Real- time patient health monitoring alarming using wireless-sensor-network, 13th International Multi-Conference on Systems, Signals & Devices (SSD). 2016; pp: 416 - 423

7- M. Wagner, B. Kuch, C. Cabrera, P. Enoksson, A. Sieber. Android based body area network for the evaluation of medical parameters, International workshop on intelligent solutions in embedded system. 2012; pp. 33-38.

8- Maradugu Anil Kumar and RaviSekhar Y. Android Based Health Care Monitoring System, IEEE Sponsored 2nd International Conference on Innovations in Information Embedded and Communication Systems(ICIIECS), 2015; pp.1-5.

9- Mathan Kumar K and Venkatesan R.S. A Design Approach To Smart Health Monitoring Using Android Mobiles, IEEE International Conference on Advanced Communication Control and Computing Technologies (ICACCCT).2014; pp.1740.

10- MathiasWager, Benjamin, CarlosCabrera, Peter Enoksson and Arne Sieber. Android based body area Network for evalution of medical parameters, Intelligent Solutions in Embedded Systems (WISES). 2012; pp. 33-38.

11- MirzaMansoorBaig, Hamid GholamHosseini, Martin J.Connolly and GhodsiKashfi. A Wirelesss Patient Monitoring System For Hospitalized Older Adults: Acceptability, Reliability and Accuracy Evaluation, Biomedical and Health Informatics (BHI), IEEE-EMBS International Conference. 2014; pp.330-333.

12- 8PurnimaPuneet Singh. Zigbee and GSM Based Patient Health Monitoring System, International Conference on Electronics and Communication System (lCECS). 2014; pp.1-5.

13- Rinki Sharma, Shreyas K Gupta, Suhas K.K and SrikanthKashyap G. Performance Analysis of Zigbee based Wireless Sensor Network for Remote Patient Monitoring, Fourth International Conference on Communication Systems and Network Technologies. 2014; pp.58-62.

14- S. A. Haque, S. M. Aziz, & M. Rahman, Review of CyberPhysical System in Healthcare, Intr. Journal of Distributed Sensor Networks. 2014; Article ID:217415, 20 pages.

15- S. Gradl, P. Kugler, C. Lohmuller, & B. Eskofier, Real-time ECG monitoring and arrhythmia detection using Android-based mobile devices, Annual IEEE Intr. Conf. on Engineering in Medicine and Biology Society. 2012; pp: 2452-2455.

16- S. Mukherjee, K. Dolui, & S. K. Datta, Patient health management system using e-health monitoring architecture, IEEE International Conference on Advance Computing (IACC). 2014; pp: 400 – 405.

17- S. Prakash, & V. Venkatesh, "Real time monitoring of ECG signal using PIC and web server", International Journal of Engineering and Technology (IJET).2013; Vol.5, No.2, pp.1047-1053.

18- Sakuntala S and RamyaDharshini R. Remote Health Monitoring System Using PIC Microcontroller, International Journal of Emerging Technology in Computer Science & Electronics (IJETCSE).2015; Vol. 13, pp.209-214.

19- Sang-Joong Jung, Ristro Myllyla, and Wan-Young Chung. Wireless Machine-to-Machine Healthcare Solution Using Android Mobile Devices in Global Networks, IEEE Sensors. 2013; Vol. 13, no.5, pp.1419- 1424,

20- R. Issac, M. Ajaynath, CUEDETA. A real time heart monitoring system using android smart phone, IEEE. 2012; pp. 47-52.

Erratum

In Article "Smart Health Surveillance with Automated Database Using Android Mobile Device", with the number of DOI: http://dx.doi.org/10.1590/1678-4324-2017160723, published in journal Brazilian Archives of Biology and Technology, vol. 60, the 01 page.

That read:
"http://dx.doi.org/10.190/1678-4324-2017160723"

Read:
"http://dx.doi.org/10.1590/1678-4324-2017160723"