

# Performance improvisation using IOT based sensor network in telemedicine assistance by electrocardiogram signal analysis for diabetes healthcare

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## ABSTRACT

**Introduction and Aim:** People are suffering from chronic diseases like diabetes, which may lead to unanticipated death in many pathetic situations. Therefore, constant follow-up of the essential factors of health turn out to be crucial. The proposed system is an emergency telemedicine healthcare support, which is used for continuous electrocardiogram (ECG) signal monitoring, along with the essential parameters like heartbeat, temperature, etc., which help in diagnosing and make aware on cardiac complications in diabetic patients. Here internet of thing technology helps a lot. This system finds the deviations in the parameters being monitored.

**Materials and Methods:** The ECG signal is processed in the processor to calculate the heartbeat per minute. The parameters of critical components are obtained and processed.

**Results:** The features extracted from the critical components were values of required peaks, which were sent as raw waveform to doctor's device. If any abnormality is detected in the ECG signal, an SMS with a link consisting of patient details are sent to the doctor through GSM modem.

**Conclusion:** It enables the doctors to give appropriate medication and care to the patient on time.

**Keywords:** Cardiac health monitoring; diabetic patients; Internet of Things (IoT); GSM; vital biological parameters.

## INTRODUCTION

A set of evenly scattered and devoted sensors for trailing and saving the patient medical records of the environment and aligning the assembled data at an axial location is known as Wireless Sensor Network (WSN). WSN measures patient's physical conditions like temperature, heartbeat and electrocardiogram (ECG). The sensor network (1) in medical applications can be of various types such as environment-embedded, implanted and wearable.

Environment-embedded systems are placed in the environment, and their applications include monitoring an ill patient completely at home or in hospitals. In a human body, the implantable devices are inserted to monitor the body conditions. The places where the wearable devices (2) are placed are near to the body or on the surface of the human body. Nowadays, using the wireless sensor network along with Internet of Things (IoT) is more challenging.

The combination of sensors and actuators with Internet of Things (IoT) becomes instances of cyber-physical systems, smart medical systems, intelligent transportation, smart home, smart cities and so on. IoT is a computing logic, which describes the physical objects which are able to identify themselves to other devices are being connected to the internet. In IoT the object is now connected to surrounding objects, and database data (3). Hence, the object itself digitally becomes greater than by itself.

IoT devices are used in backward areas to facilitate healthcare monitoring in exigency times. This health observing devices can be the radical devices, which are competent of monitoring specialized parameters. To measure these specific parameters on real time (4) a special sensor can be equipped with living spaces to observe the health of patients.

## MATERIALS AND METHODS

Acquiring the physiological parameters using sensors and uploading these records to cloud are the main aim of the system as per Chhabra, *et al.*, (1). The heart rate of the patient is estimated by the system and sends it to the cloud. Doctor examines the ECG of the patient. Real-time health-related parameters of the patient can be analysed by the doctors, which are not admitted in hospital. Field Programmable Gate Array (FPGA) technology is used by this real-time existing system. This system initializes the programs in FPGA chip (2). This chip is used to integrate all the modules and implements collection, confines, real-time processing and carrying. The FPGA chip is taken as an axial data microprocessor. A structured design is applied on Very High-Speed Integrated Circuit Hardware Description Language (VHDL) by the FGPA chip to collect and translate real-time ECG Signals. It is considered as an acute and adequate healthcare which meets the needs of amplifying human population and medical expenses (3). Abnormalities of health conditions can be disclosed by the system in time and it makes diagnoses

according to the extracted data. By using a wearable observing node, ECG data are accumulated and are communicated precisely to the IoT cloud. All these are done by using Wi-Fi. IoT makes use of open source protocols. Distinct ECG network includes Wi-Fi, Bluetooth, Zigbee and BLE are made known and correlated.

According to Patil *et al.*, this system uses 3 lead electrodes along with a small signal processing block. The technology of Arduino Uno and MATLAB for signal conversion and representation is used (4). It is a cheap, lightweight, portable and provides self-monitoring facility in patient side. Patient's heart conditions in real time can be monitored and diagnosed by the system with an ECG sensor and it can generate alert whenever the deviation is found. A wireless ECG monitoring system is developed which is used for the integration of Bluetooth Low Energy (BLE) technology. A BLE based system comprises a single-chip ECG signal acquisition module, a Bluetooth module and a smart-phone (5). For mobile device platform, Apple's iPhone 4S is selected which is embedded with Bluetooth v4.0, Wi-Fi, and iOS. The monitoring system is able to acquire ECG signals through 2-lead ECG sensor, transmit the ECG data via the Bluetooth, process and display the ECG waveform in a smart-phone. The physical constraints are eliminated by the system, which is imposed by hard-wired link using BLE. As per Stefan *et al.*, it is an application for Android-based mobile devices, which acknowledges computerized arrhythmia detection and real-time ECG monitoring by examining ECG parameters. ECG's data can be refined and appraised which is afforded by pre-recorded files or accomplished live by procuring a shimmer sensor node via Bluetooth (6). Pan-Tompkins algorithm for QRS- detection is stationed on the application. It contains further algorithm blocks to disclose anomalous heartbeats. The Supra ventricular Arrhythmia databases shows that the algorithm disclosed more than 99% of all QRS complexes accurately. Overall sensitivity for abnormal beat detection was 89.5% with a stipulation of 80.6%. This application is handy for downloading and may be used for real-time ECG monitoring on mobile devices.

This proposed system consists of hydrophobic electrodes which provides the waveforms of all morphological without distortion of an ECG signal for dry and water-immersed conditions (7). An electrode is comprised of a mixture of carbon black (CB) powder and poly dimethylsiloxane (PDMS). Various tests were performed for feasibility testing of the CB/PDMS electrodes. One of the tests included evaluation of the electrode to skin contact impedance for a different diameter, thickness and different pressure levels. Performance comparison of

CB/PDMS electrodes to Ag/AgCl hydrogel electrodes was carried out in three different scenarios. A dry surface, water immersion and post water immersion is the three different scenarios. The system continuously monitor the health condition remotely, and gives an alert to the doctor if any parameter is assorted. Healthcare system in a mobile application is a fundamental technology for reducing the cost of living occurred in healthcare as per the studies conducted by Padmashree *et al.*, (8). The main four units are micro-controller, sensor, GSM, Android phone. The body temperature and heartbeat of a patient should be analysed by AWTESA. The heartbeat value and the temperature value are converted from analogue to the digital signal and processed in the micro-controller. This system gives the freedom of mobility to the doctor. Doctor's unit and Patient Unit are the two units present in this. A mobile network with the doctor to send a message using GSM is only needed to transfer the information. AWTESA system is simple and has less number of wires.

In the medical area, wireless devices have become more popular with a wide range of capability. To monitor and gather the data of patient body, six different sensors are used. Mobility is an advantage in this project. The focus of this system is on wireless personal area network technologies, WiMAX, Wi-Fi, ZigBee. The use of WSN's as a key infrastructure enabling unobtrusive, continual, ambulatory health monitoring is demonstrated. Wireless technology is the best solution for mass emergency situations like natural or human-included disasters. The databases of the patient was built up by continuous medical monitoring will be updated easily (9). The system work required is reduced. Wi-MAX technology is based on the IEEE 802.16 standards, which have secured wireless data transmission. This standard is the incorporation of AMC, FEC, QoS framework, and OFDM. RFID is used to have a potential in positioning and hospital staffs. To improve telemedicine services the cellular systems have the great potential by extending the range of healthcare system. The system architecture is consists of medical sensors, a portable personal server, a hospital server and related services (10).

Designing a system that measures blood pressure, pulse rate, the body temperature of the patient is the focus of this project (11). The design and development of the system is dealt by this system. The design consists of different sensors such as blood pressure sensor, temperature sensor, heartbeat sensor and sugar level sensor. All these sensors are interfaced with the micro-controller. With the help of Global System for Mobile communication (GSM), this provides all these measurements to respective doctors. With the help of ADC, this system also

shows how microcontroller in measures the different health conditions of the patient real-time.

To a digital form, these readings are converted. GSM is used for mobile communication in this system. This means that the doctor’s PC receives all the transmitted readings through GSM network. The patient’s health is completely monitored and the respective doctor will be able to access this information (12). For home and ambulance use, the design of the system is kept simple. This device is mainly designed for ambulance. Further, it can be implemented in homes and in rural areas. The efficiency of the proposed system is being demonstrated. This will be more efficient for doctors to check the patient’s health as it gives real-time information regarding the patient’s condition. The use of telemedicine is one of the important concerns to provide the medical services to the patients, living in the rural areas of India (13).

Dynamic wireless sensor network is the principle of the proposed system where the source (patient) is free to move, which gathers all the information from different sensors. The proposed system consists of different blocks such as a controller, heartbeat

sensor, temperature sensor, ECG sensor, LCD display, IoT etc.,

The HTML is used to send a link to the doctor, if any abnormalities occur in the patient body. Here, the controller acts as the heart of the system. The controller used is an Arduino controller that collects all the information from the sensors and processed using Io Talon with GSM.

Here, the sensors are placed on the skin of the patient body. This detects the abnormality and passes the information to the IoT. IoT is a combination of micro-controller and GSM. Hence, the data is uploaded and sends it to the doctor using a link. The link consists of all the information about the patient medical information. So that the doctor can analyse it and take decisions even though the patient is far away from the hospital.

**A. Block diagram**

The process starts by switching off the IoT button before resetting the controller. The resetting process helps to erase previous values. All the sensors have to be kept on the surface of the body.

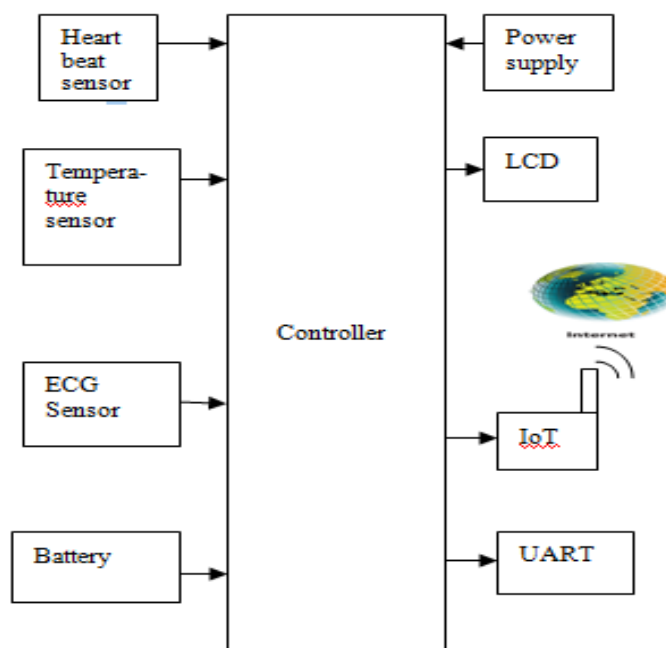


Fig. 1: Proposed block diagram

Now, automatically the temperature sensor starts calculating the temperature of the body. On the LCD display, the temperature will be displayed. The forefinger has to be placed near the LED of the heartbeat sensor in the next step. When the light starts blinking in a proper manner, the red button in the IoT board should be pressed to calculate the heartbeat. The red button is used since the heartbeat sensor is programmed in a while loop condition.

The electrodes of the ECG are placed on the right arm, left arm and the right leg already. This electrode

is very helpful in continuously calculating the ECG rate of the patient. Now, the IoT button has to be switched on, so that the parameters will be uploaded to the server. By using the GSM the message with a link will be sent to the doctor to analyse the parameters. This link is created using HTML. The parameters will be updated into the server automatically by switching on the IoT. These details will be stored permanently and the storage capacity is infinity.

## B. Flow chart

The following chart shows the flow of the whole process carried out in the proposed system.

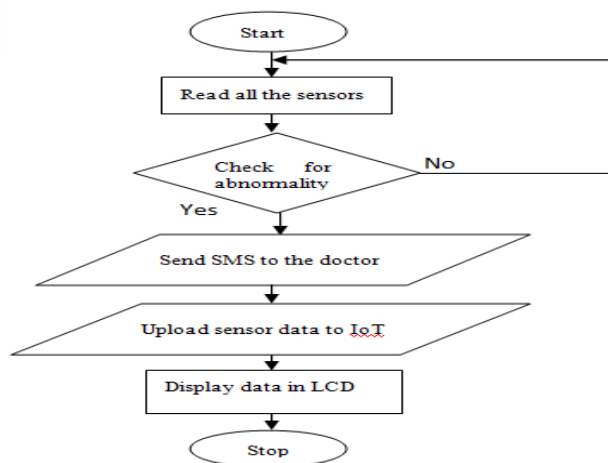


Fig. 2: Flow Chart

### A. Algorithm

1. Start the program.
2. Read all the sensors.
3. Check for abnormality.
4. If any abnormality present then sends a link consisting of sensor data through SMS to the doctor using GSM.
5. Upload all sensor data to IoT.
6. Display the data in LCD display.
7. Stop the program.

## RESULTS AND DISCUSSION

The system circuitry consists of a processor, GSM, IoT, power supply, temperature sensor, heartbeat

sensor, ECG sensor. Connections are given precisely to get the output of all the three parameters.

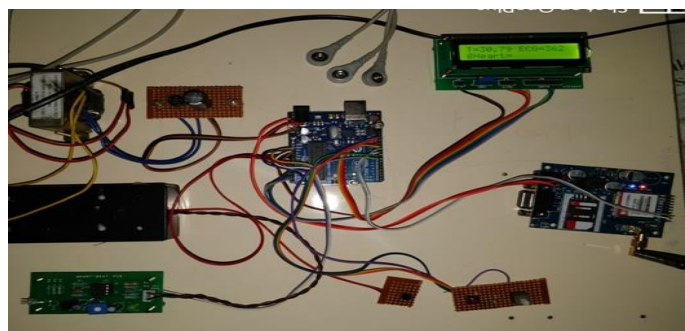


Fig. 3: Portable circuitry to measure the vital parameters

The processor used in this is an Arduino Uno R3 processor which is programmed to calculate the parameters. For uploading the data to the server, IoT is used. The uploading of data to the server starts when the finger is placed near the LED of heartbeat sensor and the ECG sensor is placed on the patient.

This automatically sends the message with a link to the doctor. Hence, doctor analyses the parameters and prescribe the patient even though the patient is not nearby the doctor.



Fig. 4: Heartbeat calculation by placing the finger

The message is received from the kit using GSM. GSM uses SIM 900 with the internet. The message consists of “Please open below link to view patient data” along with a link.

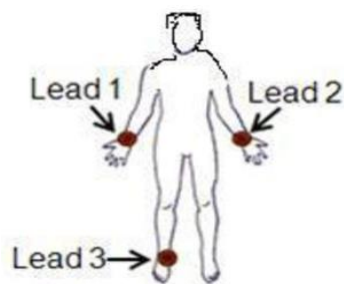


Fig. 5: Position of electrode sensors for ECG measurement

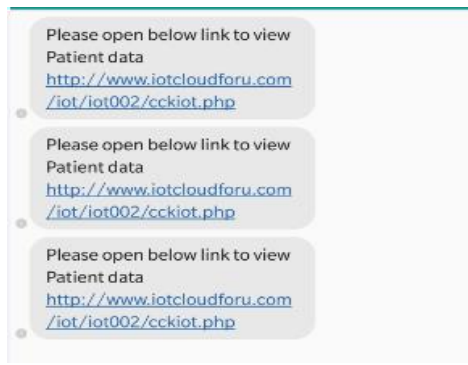


Fig. 6: Message with link received from the kit

The doctor can go through the link, which is in the message, and analyse the parameters present in it. Hence, the doctor can take immediate action before the situation goes out of the hand (9). The received

ECG waveform gives the information about the critical parameters QRS complex and their values instantaneously.

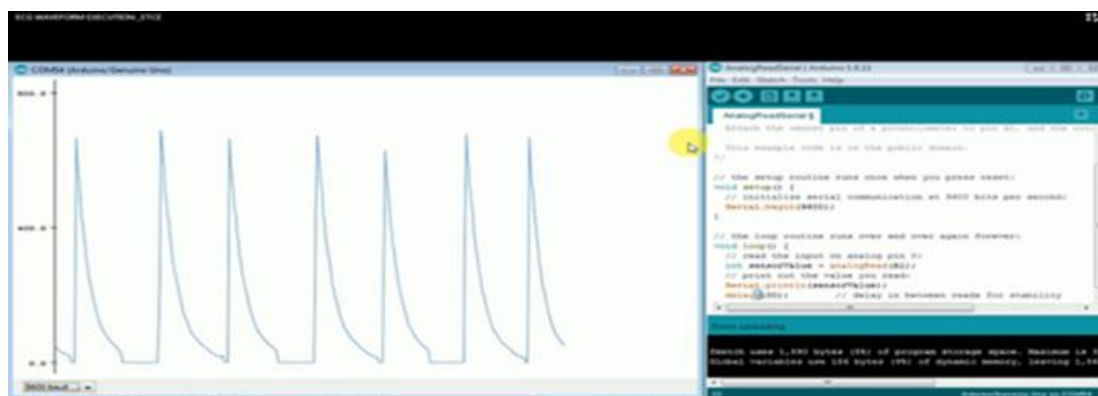


Fig. 7: ECG waveform received at doctors end device

**PERFORMANCE ANALYSIS**

- a. Real-time monitoring system.
- b. Remotely patient’s body parameter can be measured and can be sent to doctors to get emergency support from the doctor.

- c. It will be used in e-hospital.
- d. We monitored 4 different patients by deploying sensors and we got blood pressure and heart beat data and temperature are shown in table below.

Patients	Temperature			Blood pressure			Heartbeat		
	Low	Normal	High	Low	Normal	High	Low	Normal	High
p1	60	90	91	85	125	164	70	80	90
p2	64	90.2	91	80	130	160	72	82	92
p3	67	89	92	82	127	167	74	84	94
p4	65	89.7	92	70	120	170	76	87	97

**CONCLUSION**

The above system implementation gives the information regarding the patient’s health condition at each instant along with the information about blood glucose level and insulin level including other basic parameters. By using appropriate routing algorithms (14), this system helps the doctor to do classification of the disease and send the precautions and prescriptions that has to be followed by the

patient on time. These parameters can be used for analysis and recognition (15) of emergency in diabetes. Diabetic patients (16) are majorly prone to unexpected and sudden heart attacks and other heart related problems. This method of monitoring the ECG of diabetic patients will help doctors in diagnosing (17) heart problems at earlier stage and necessary actions can be taken by instructing from remote place itself.

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