

# Advanced Cardiac Health Care Monitoring Using Iot

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**Abstract.** *Recent advances in wearable technology such as smart devices equipped with powerful microprocessors, memory subsystems with various kinds of built-in sensors such as the gyroscope, accelerometer and optical sensors in a single package have opened a new application space. One of the main areas of interest is to monitor patterns of heart rate, heart rate, ECG and PPG especially long-term in the natural environment. In this paper, we assessed cardiac function by using pulse rate, ECG, cardiac output and more. In our body oxygen plays a vital role, the level of the oxygen is especially important to detect a disease. So, oxygen level is also detected. By using sensors the condition of a patient is monitored through wireless communication. Everybody needs some rest to work energetically in a periodic way but due to lack of sleep or oversleep a person is exposed to disease or feeling unhealthy to their routine. When monitoring our health conditions, if a person is identified with a lack of nutrients or reduction of pulse rate, the patient's details will be automatically sent to the doctor and the prescription will be given directly from the doctor. One of the common issues for the cardiac patients is the falls, but rigorously it is difficult to define it. Therefore by this project we also help to find the fall detection. Additionally, in case of any emergency, nearest ambulance is detected and calling using android and Bluetooth. Understanding the importance of sleep, our app is also capable of monitoring sleep. For the elder people it also alarms and indicates the intake of medicines in a regular interval. As a whole all these features are embedded in a mobile application and the login details will be known by the patients, guardian, and the doctor as well as live chats and video chats are initiated to monitor a patient in a better way. Thus, here is our brief version of "Advanced Cardiac Health Care Monitoring Using IoT".*

**Keywords:** ECG, heart rate, oximeter, fall detection, wireless communication, ambulance intimation, sleep monitoring, prescripti

## 1. INTRODUCTION

The responsibilities for the technology are increasing enormously for human beings especially for their health needs. Because of their busy life they don't have time to take care of themselves; this may lead to health issues majorly cardiac issues. In our analysis the major cause for cardiac problems were enormous rate of increase in urbanisation and industrialisation, roughly above 30-50% of heart attack victims are from high stress jobs such as white collar jobs and from the BT/IT sector [1]. From a study one-fourth of the patients

who are admitting to the hospitals for heart-related problems were taxi and truck drivers and traffic police. This proved that air pollution also plays an important role in various kinds of heart related issues.

In our project we improvised the technologies that exist for cardiac issues that help the patients who are in need. To detect the heart rate on ECG is reliable. Therefore, Wearable smart devices that are embedded with memory-subsystems with various types of built-in sensors such as gyroscope, accelerometer and several optical sensors were using for the detection of ECG, PPG. Oxygen plays a vital role in a body, the level of the oxygen is especially important to detect a disease. So, oxygen level is also detected. By using Micro-Electromechanical System (MEMS), Temperature, Vibration sensors the condition of a patient is monitored through wireless communication. Every one of us need some rest in our busy life to lead a healthy life. So, we monitor people's sleep using our app [2]. And also our app helps people to alarm the time for their medicine. When monitoring our health conditions, if a person is identified with a lack of nutrients or some pulse rate the patient details are automatically sent to the doctor and the prescription will be sent directly from the doctor with the help of wireless communication. Additionally, automatically nearest ambulance is detected and called using android and Bluetooth. For the senior citizens of our society it also alarms and indicates the intake of medicines in a regular interval. As a whole all these features are embedded in a mobile application and the login details will be known by the patients, guardian, and the doctor as well as live chats and video chats are initiated to monitor a patient in a better way.

## 2. RELATED WORK

Identification of risk using embedded systems such as ECG patterns has been the subjected for many studies over the past decade. [3][15]From the article using ECG sensors they collect data for the diagnosis of heart problems. It is therefore extremely accurate in predicting cardiac arrest and identifies out coming measures, symptoms of the disease, and its treatment. It mainly focuses on helping the victims to answer several questions: "Based on my condition, what is the best result I can hope to achieve and how do I get there?" They replied to the victims' questions in a variety of ways, including for patients with similar circumstances to and share their experiences communicate with each other. Moreover, this E-Health form was based on submissive communications apart from data's that are simply objective [16]. G. Wolgast developed a smartphone-based system that monitors and detects failure of heart in real time [4]. One advanced heart monitoring system monitors the body with Arduino as a microcontroller part, LP Bluetooth device for connections and the antenna for sending and receiving data depending on the Android™ app made on the smartphone. These studies mainly focus on communication tools to exchange the data's in a much efficient way with small audio to get a clear uninterrupted signal of display and analysis in the system. The writers of the application claim that the system has the ability to transmit sound-free sound to the smartphone device with a higher rate of accuracy and those soft wares improvements were required only in predicting heart failure by looking on the ST category.

Every day, Internet of Things produces health-related systems [5]. Or a large amount of Android™ applications is made on a smartphone[17]. The application of the authors claim that their program has been able to transfer free audio to a smartphone with high rate of accuracy and then only the software has been developed. First thing, we built an integrated IoT embedded system for abnormal cardiac output. [6]Second, we have developed a real-time 24/7 health care monitoring system with a various embedded systems like wearable

Electro Cardio Gram and mobile phones' accelerometers for user as the distinct system for estimate various heart related abnormalities. [7]Third thing, we have built a very low powered bluetooth based signal transmission networks in-between the sensors and the data transfer smartphone. Fourth, we analysed the collected data's using the classification of signal and ML techniques to predict the accuracy.

Normal physical activities of patients, especially heart patient's real time monitoring can be identify by using wireless sensors and smart devices.[8][9] Normal physical activities of patients, especially heart patient's real time monitoring can be identify by using wireless sensors and smart devices. Sensor with low power communication is designed and further developed to collect ECG signal and acceleration of the body using mobile application. [10]Experiments and their verifications were held on countable subjects along with various test cases like walking, bending and also running. We use the accelerometer of the smartphone and GPS system to detect the acceleration of the victim along with his corresponding location information. [11] Real-time analysis is used for monitoring of cardiac activity along with physical activities. Using the analogue filtering chain for conditioning of signal, the smart gadget continuously monitors the measurement of theelectrocardiogram. The communication of the device wirelessly, using Bluetooth method, with a smart mobile system, where a complete verification is performed on the received data's, and decisions are made on the current health of the victim. [12] On various studies, a personalised real-time smart heart monitoring system using smartphones and wireless sensors are made. The main objective of the application is to monitor the health of high risky cardiac victims. [13] The mobile application involves the analysis of various real- time sensors and environmental data's and an automatic alerting of the ambulance service and assigned guardians when a heart victim is in an emergency. It transmits the data's collected from the sensors to a health centre for all-time monitoring by the concerned cardiologist they prefer. This system can also be personalized and can be programmed to monitor the progress of the patient. [14] The app has a program that is used to give proper advices (e.g. prescribing medicine) to the patient. Remote monitoring and remote monitoring have proven to be superior to standard care in following these patients and represent a new level of care. With the widespread availability of smartphones and more people using them for health inquiries, in-app remote care provides a promising digital health solution that promotes alternative adherence testing based on alternatives. [15] It focuses on patient delivery and demonstrates promising results, but also highlights the need to increase the automation of the system to achieve acceptable adherence standards. This program is an automated application-based system that represents the next generation of application-based monitoring and is currently being tested in international research for promising first results.

#### **a. Our Specification**

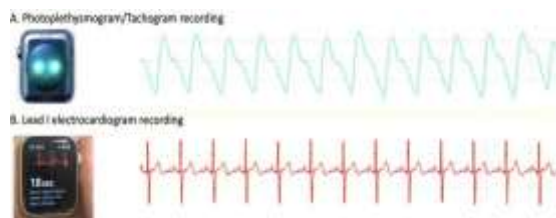
The difference between the above explained project and our project is the improvised app we planned and it also has the ability of live conversation with doctors about the data's that are collected from the various health monitoring sensors via the app. To the best of my knowledge and the researches made in this field our project is the first application for the cardiac patients with all facilities.

### **3. ECG, PPG, AND OXYGEN DETECTION**

#### **a. Functions Of ECG**

ECG, PPG and oxygen detection are useful in the analysis of our health. Therefore in our project we use optical heart rate monitor inside our smart gadget. In the Figure 1: (A) the visual tachogram recording output shows the analysis of the intervals between adjacent R

waves which are measured over a period and other variety of parameters can be calculated from these intervals. Thus, this result can plot the overtime result of the heart rate frequency. ECG is the tiny waves or signals that generated under the skin due to heartbeat is a trace. And then this signal is analysed by our smart gadget to get data about our heartbeat, blood flow and stroke volume, myocardial infraction, rate and disorder in rhythm, pericarditis, electrolyte disturbances, and another pulmonary embolism. Thus, the output recording of the heart's electrical activity from the electrodes of the body surface is given in the Figure1: (B)



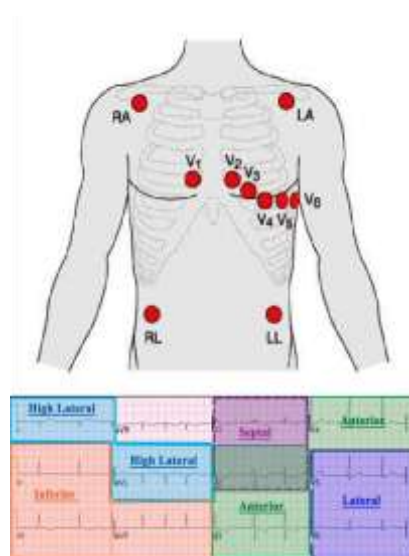
**Figure 1:** A) Tachogram recording; B) Lead I Electrocardiogram recording

**b. Working**

In this way we can collect data's like heart rate, state of conduction and muscles of heart, and heart rhythm and even we can even detect the level of chemicals in the blood flow like potassium, etc., while holding our hands above the device crown just for 30 seconds the smart device can trace the heartbeat it is drawn in red graph in the device after that the device will let us know it is a normal heart beat or an abnormal heart one.

**c. Comparison**

The difference between the normal ECG that is detected in the hospital and by this smart gadget is as follows: the one in the hospital takes 12 leads that are placed in the skin near or around the heart but our device has only one lead that is enough to get the information. The overall anatomy of the heart is plotted in the Figure2: (A) and the diagnosed ECG output of different part of the heart is represented in the Figure2: (B)



**Figure 2:** A) Cardiac Anatomy; B) ECG Diagnosis

**d. PPG**

PPG is an optical based technique used to find mechanical activity of a heart i.e., by measuring blood volume which changes by pulse.

**e. Working**

Using the beams of light and light sensitive sensors in smart gadget developed, we ensure the benefits of detecting the flow of blood in the wrist region made by the peripheral pulse in the heart thus PPG works. In the Figure3, the activity of PPG happens when the reflecting light hits on the body surface. Hereby we can also detect the heartbeat rate. To the peak pulsation in the blood may be interpreted in the R-R interval of the heart and finally they are incorporated using various algorithms to detect the atrial fibrillation.

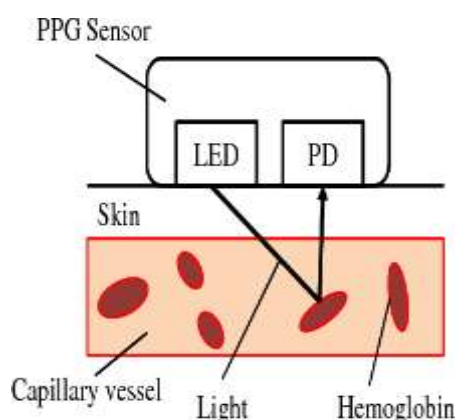


Figure 3: Structure of detecting PPG by receiving the reflected light

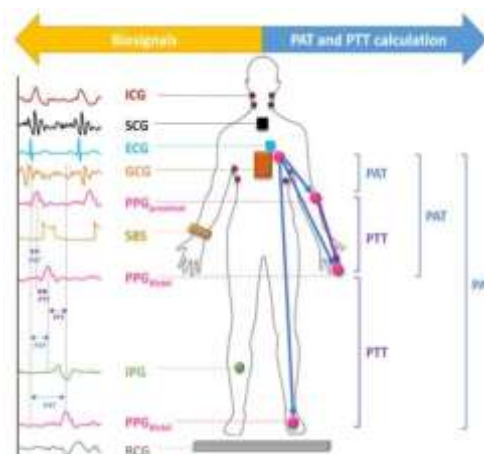


Figure 4: PAT and PTT calculation using bio signals

Along with PPG we can use tachogram which is a device used to analyse speed and distance so that it can plot the time with heartbeat. The analytical output which comes by using the bio signals can be calculated from the Figure 4 which is nothing but the velocity of the pulse wave and the time delay of pressure wave to travel between two arterial sites. And also, with the help of algorithms we can detect irregularity in pulse and thus AF.

### f. Oxygen Level Monitoring

Our bodies process three things: food, fluids, and oxygen. And while we can enjoy more food and fluids, it is the oxygen that actually fuels our body's fuel. Oxygen, through a process called oxidation, converts food and liquid into energy. It is this "oxygen fire" that makes our body tissues, repairs our cells, nourishes our minds, and even soothes our nerves. Not only that, but breathing is a cleansing tool for our body.

Therefore oxygen plays a vital role to all the living organisms. So, in order to measure it, it is done by using mini electronic processor along with small LEDs which is facing a photodiode usually through a fingertip or earlobe of a patients' body. The oxygen level in the blood above 95% saturation is normal but if the saturation levels 92% or less is the indication in abnormal. Therefore, our oxygen level also determines our health condition. In the Figure 5, the oxygen level and the consequences based on it is displayed based on the SpO2 level present in the human body.

SpO2 LEVEL	INDICATION	HEALTH CARE INTERVENTION
Normal in healthy individuals	More than or equal to 95%	No significant intervention needed.
Normal in people with COPD	88% to 92%	Continue with respiratory assessment and monitoring.
Hypoxic	88% to 94%	Assess for underlying respiratory disease and initiate oxygen therapy, especially in COPD patients.
Severely Hypoxic	Less than 88%	Administer supplemental oxygen immediately.

Figure 5: Oxygen level and its consequence

## 4. ALARM, AUTO-AMBULANCE

### a. Alarm Function

Our device helps the elderly people in other ways. Most of the elder people suffer due to lack of memory. Now-a-days though it is common, elder people must take care of themselves. Therefore, in our device we include a feature that alarm or indicate the elder people to remind them for their medicine. It is so much of useful for them.

Initially it allows entering the reminder inputs by the users and allows users to enter the dosage for each reminder. The time and dates for the remainder are stored in the database by using raspberry pi. Some forgets to intake the medicine at proper time and some may even



Figure 6: Medicine intake reminder applicationAuto-Ambulance

forget which medicine so to avoid this problem automatic speech using ESPEAK module is used in Linux OS. This project provides an easy way to remind the date, time, and quantity of dose of the medicine to be intake by the patients by giving an alarm as with speech. Thus, the remainder for the intake of medicine for the elderly people which indicate them is given in the Figure 6

The health condition of the person is being continuously monitored. Once any critical situation occurs, the details about the respective patient are sent to the guardian, doctor and ambulance service.

The location of the patient is also shared along with his details. Therefore, this system helps for immediate of the patient.

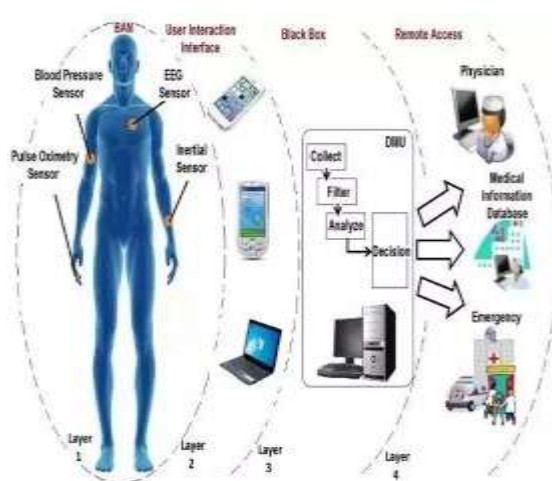


Figure 7: Complete working of automatic ambulance detection method

Thus, in the Figure 7, the working of the automatic ambulance detection is shown.



## 5. FALL DETECTION

Falls are considered as one of the most detrimental events for the aged population. To the lying posture falling can be defined as an unintentional transition. By using gyroscope linear acceleration and the angular velocity can be measured by our project, in which we can determine whether a transition of the patient is intentional or not. More accurate values can be determined from our fall algorithm by using both gyroscope and also the accelerometer posture information. Moreover, in this project, the system used is cost effective and also fast access. The solutions from the existing systems can be classified into two divisions. In which the first division only analyses acceleration to detect falls. Both the body orientation information and the accelerometer are used to detect falls are utilized in the second division. Besides the above mentioned technique for fall detection, complexly inferencing techniques were also used to improve activity based recognition accuracy.

### 5.1 Methodology

#### 5.1.1 Data Collection

Since in our project it measures both angular velocity and the acceleration, we use the T-E-M-P-O method (Technology-Enabled Medical Precision Observation) sensor nodes (3.0) which have triaxial for both accelerometer and a gyroscope as shown in the Figure 8 (A) and its implementation in the human body is shown in the Figure 8 (B).

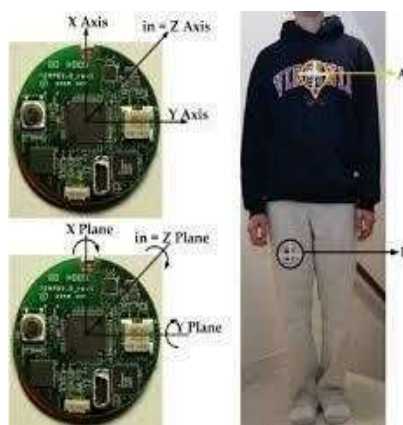
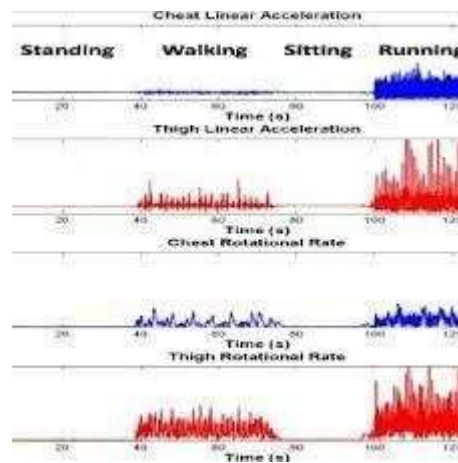


Figure 8: A) The TEMPO with 3.0 sensor node; B) The attachment of the 2 nodes in the body

Moreover all the postures have their own angles between the upper legs and the trunk; hence the sensor nodes were fitted to the chest as Node A and thigh region as Node B as shown in the above figure. To stimulate any kind of falls, ADL or type of fall-like activities four data sets are collected from all parameter with five seconds for each activity of the parameter approximately. In some activities of Activities of Daily Living such as walk, walk on stairs, sit, lay down jump, run and run on stairs, some fall related movements like sudden sit-down or upright sudden sit-down reclined, and some flat surface falls such as fall back, fall forward, fall right or fall left, and also inclined falls such as fall on the stairs. Moreover, in addition to that static posture data's such as bending, standing, sitting, and lying down from a proposed posture recognition algorithm to explore the single subject the data were collected accurately.

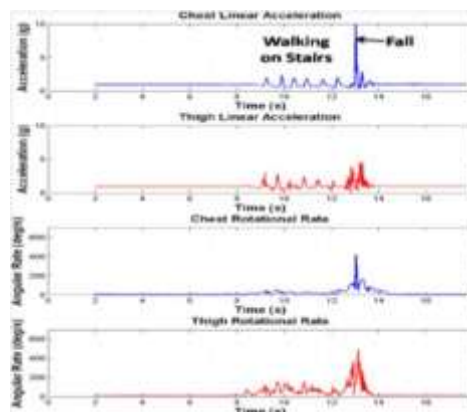




**Figure 9:** The linear acceleration and rotational rate of the trunk and thigh for standing, walking, sitting, and running was detected. Thus, the range of linear acceleration of the heart, trunk, thigh while standing, walking, sitting, and running is shown in the Figure 9.

### 5.2 FALL ON STAIRS

The sign of falls will be in horizontal body orientation, but once these falls occurs on non-horizontal planes it triggers false negative such as with stairs. To detect falls, the trunk inclination changes, but this method triggers the false positives when people bend down quickly. In the Figure 10, the acceleration, and the rotational rate of the chest and thigh in wave form is shown.



**Figure 10:** Acceleration and the rotational rate of chest and thigh

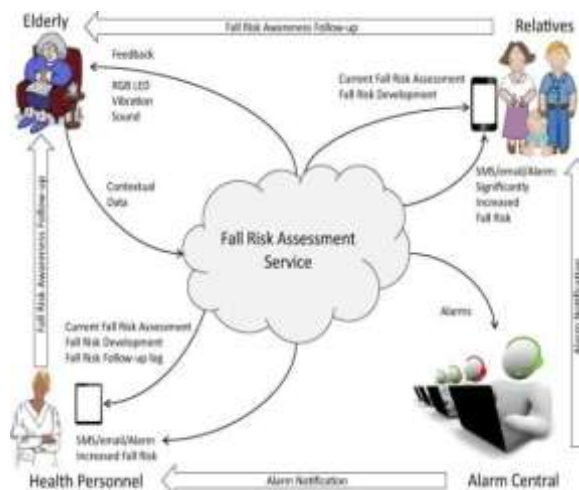


Figure 11: Entire system case study

The entire system of the control and monitoring of the patient by the doctor and the guardian along with the alarm system is shown in the Figure 11.

Falls are the most detrimental events for the aged people. According to [10], more than 30% to 40% of people age 65 years or older people have at least one fall per year. People working in special career such as fire fighting also have a high risk of fall. Hence, reliable fall detection mechanism has given much more importance.

## 6. SLEEP AND MONITORING APP

### a. Sleep Monitoring

We use Smart pyjamas with built-in sensors that can measure heart rate, breathing and posture during sleep. These smart pyjamas use five pieces of fabric on the body that sense the embedded nerves that can be worn or sewn into bedding. The wires from each piece are connected using silver threads inserted with silver wrapped around cotton. The nerves in the fabric of the tissue can receive constant body pressure while lying in bed. Pyjamas can determine how well a person sleeps, and personal information can be shared with their doctor or sleep therapists to help them understand how their sleep patterns can be improved. The outlook of the sleep monitoring kit is shown in the Figure 12 which is attached with the pyjamas.

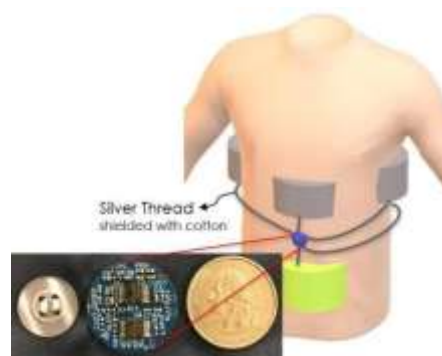


Figure 12: Sleep monitoring kit

The pyjamas can tell the position of the user while sleep, and even if the users' posture may affect the quality of sleep with cannot be achieved by smart watches or rings etc., The vapour which is depositing on the electronic-polymer based films were used for the creation of the smart pyjamas sensors are washable and dries very quickly and also withstand mechanically more demanding on textile manufacturing process.

### b. Prescription App

Our smart live chat application allows patients to chat with their highly qualified and deemed doctors, Pharmacists and Nutritionist anywhere at any time. The patients can also able to upload their medical report or any photographs to enable our pre-identified medical professionals for better understand the patients' health condition. If there is any serious change in patients' health, they have an option of requesting their doctor through this smart app by pressing a button on the doctor's home phone feature or by contacting your doctor via video using our video consultation feature. Our aim is to ensure patients' with safe and

trouble-free health information from the comfort of their own location. Rather than looking for the answer from Google or any other searching websites, you can now contact our professionally qualified health professionals in your own time. In the Figure 13, the overview of the App structure for contacting with the doctors for clarifying the prescription and along other related stuffs.

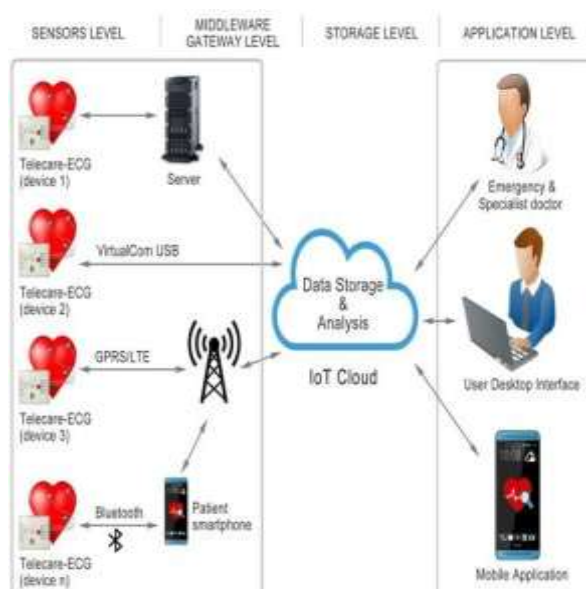


Figure 13: App preview

## 7. RESULT ANALYSIS

When a person is in need to check their health condition they can use this mobile application and their data are collected and stored in a cloud database. After that the report intimation about the normal and the abnormal conditions are received to the person as well as the doctors for their verification through IOT. In case a person forgets to intake a medicine at a regular interval the mobile indicates them with a vibration or some alarms. In the Figure 14, the overall setup of our project is shown, in which the servers, sensors and Bluetooth connection from hardware's is connected to mobile app, desktop, specialised doctors via the cloud database.

Figure 14: Overall setup of the project



## 8. CONCLUSION

Our project is the combination of alertness, intimation, monitoring, suggestions from doctors for our confirmation etc., in the absence of a doctor. Thus we created our project to help elders, common people, and even for the children to maintain their health and also to check their health condition without depending on anyone through the mobile application. The data collected will be sent to the cloud and stored in a database and through IOT it is sent to the doctor for the verification of the body condition. If a person is found abnormal with a serious condition or fainted the ambulance alert is created and calls them immediately even when a person is unable to ping someone for help. The message directly goes to the guardian as well as the doctor. Thus our project is also used in telemedicine.

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