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A Portable Smart Band Implementation for Heart Patients in Critical Conditions

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***Abstract* - In case of an emergency, most of the patients are not in a condition to inform about their condition to the medical centers or their relatives or friends. Looking at the number of deaths due to heart attack is every year worldwide, the lives of heart patients is always risk. Almost 25% of population between age of 25-69 suffer from heart diseases. One of the most useful help for such patients could be monitoring their heart conditions constantly and able to predict the condition of their hearts in near future. We came up with solution for this, is to ensure that immediate help is provided to the patient as soon as possible and at any location possible. To design of a cross-platform heart disease prediction app and sending location of the patient when under duress through the use of smartphone's GPS sensor makes this project very user friendly.**

Keywords: ECG Leads, GPS, Heart attack, Arduino, CVD.

1. INTRODUCTION

Heart disease is No 1 cause of deaths in world killing 17.5 million annually, an estimated of 31% of all deaths worldwide. In 2011, about 326,200 people experience Heart attacks out of -hospitals in the United States. More than 75 % heart attacks occur in low and middle income countries. 80% of Cardio Vascular Disease(CVD) are due to heart attacks. Many of heart attacks are fatal. And 40-75% of all victims die before reaching hospital [2]. Over 50% of all victims wait more than 2 hours before getting help (The British Heart Foundation).

Detecting Heart attack is not enough to save the victims life, but informing to doctor about the situation may help. Victims do not take symptoms very seriously and which leads to critical condition. So we need to inform about this critical situation to relatives and doctors before getting worse. There should be keen observation required for all victims. Observation on victim helps in minute variation on pulse are recorded and proper treatment given.

In this paper we propose a Portable implementation which detects heart attack and also predicts the critical situation in prior with the patient's location. So this model will help people who waiting for help and also survival rates also increases by informing nearby hospitals and relatives. The proposed solution is based on Arduino-mobile communication, which provides guidance in real time and being highly available. The paper explains about the introduction first and the related work which have carried out and proceeds with the proposed model and concludes with the conclusions and future work.

2. CASUSE OF CVD

Coronary artery disease (CAD) is the most common disease in the world. CVD begins with damage to the lining and inner layers of arteries.

Several factors causing [3] CVD are:

- Smoking
- High amounts of cholesterol settled inside arteries
- High Blood Pressure
- Diabetics
- Heart defects when born
- Excess use of alcohol
- Stress

The chemicals in tobacco will deposit on arteries causes heart failure. Cholesterol occurrence on arteries may block the blood flow towards heart and causes pain and in many causes heart failure. This means that other organs, which normally get blood from the heart, do not get enough blood. It does not mean that the heart stops. The medical term for this is myocardial infarction. High blood pressure may strain the heart and leads to heart attack. Other main factor causes heart attack is Abdominal Obesity. The fat accumulates in intra-abdominal layer affects high blood pressure and also causes diabetics, which leads heart failure.

Studies show that healthy choices have resulted in 330 fewer women dying from heart disease per day. Here are a few lifestyle changes you should make:

- Don't Smoke
- Manage your Blood Sugar Level
- Get your Blood Pressure under control
- Lower your cholesterol
- Stay active
- Eat healthy
- Lose weight

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3. RELATED WORK

Many researches working on detecting emergency status of patients in real time with advanced technologies. But among all those technologies and researches there are many drawbacks in observing patients real time constantly. Sharing information of patient to the nearby hospitals during emergency was a problem. Sharing information instantly with all nearby hospitals and emergent people of patient will be very necessary. And also pre-hospital suggestion awareness will help people life fatal heart attack. Predicting the heart critical condition is also very important. Victims health prediction Sharing with doctors help them to monitor even in remotely. Prediction of heart condition can be happening by continuous observation of patient. Today's technology helps to do all these only when the patient is in hospital.

The main problem from the above technology is that they are not detecting and predicting heart condition of patient outside hospital. Their approach is on processing the information got from the patient in emergency cases. The application is going to work on some above dictated papers only when the user of that system is going to initiate that application. New technology is required to overcome this problem in future. A graph of heart attacks in India is rising and which needs a look in serious views. According to medical researchers there will be 25% of Indians going to suffer with heart attack in near of 2020.

In America heart disease become common and near future tis will be very serious issue. So we proposed this project, which overcomes all drawbacks of existing system.

4. PROPOSED SYSTEM

This is the system wearable by patient in wrist as smart band. Smart band consists of ECG sensors which are very accurate to read electrical signal in wrist. No other sensors give accurate as ECG leads. These signals receive from the leads are the processed by the AD8232 amplifier. This amplifier is used to amplify the low electrical pulses to measurable signals. Then these amplified signals are the sent to Arduino (pro mini).

Pro-mini Arduino act as brain of smart band. Signals receive from leads are converted to digital signals. Electrical signals are converted to digital to compare with the threshold values set in the Arduino. Threshold values are manually calculated by all previous record collected from heart patients. Then converted real time signals are compared with threshold values.
If received values are below the threshold values, then they are stored in the Micro SD card in band for prediction purpose.

If received signals crosses the threshold value, then which is considered as detection of heart attack. Based on how much threshold value crossed heart attack condition is recorded. This condition in smart band is called emergency mode. In emergency mode Arduino checks Bluetooth connection and then sends emergency alert signal to the patients mobile. Mobile of Patient will immediately identifies location from app installed. Then this location with alert message app sends to server maintained by technical team. This server searches nearby hospitals in patient's location. After receiving hospital details server sends patients location and emergency message about heart attack. Meanwhile emergent persons of patients also receive the location and condition of patient.

Stored data in Micro SD is used to predict the heart condition and able to predict the danger in prior to attack.

4.1. Programming Language Selection

The application is built using the iconic Framework, which provides front end development capabilities in JavaScript. AngularJS is a framework built on JavaScript and backed by Google, which implements the MVC architecture pattern.
Firebase is a real-time database built on publisher-subscriber architecture [5].
Heroku is a cloud platform as a service. Due to fact that the server is independent of the application and has no decencies to any of the other models, this server can actually be used by other developers to create their own application that need to classifier, thereby open-sourcing our project to application developers.
Python is a high-level, general-purpose, interpreted, dynamic language being widely used in programming. Compared to C++ or Java, its design philosophy emphasizes on better code.

4.2. Frameworks and Libraries

Apache Cordova is a popular mobile application development framework originally created by Nitobi. It enables wrapping up pf CSS, HTML, and JavaScript code depending upon the platform of the device.
Ionic Framework is a complete open-source SDK for hybrid mobile app development [6]. Built on top of AngularJS and Apache Cordova, Ionic provides tools and services for developing hybrid mobile apps using Web technologies like CSS, HTML5, and Sass.

4.2.1. Machine Learning Libraries

- SciKit-Learn:An efficient machine learning library written in Python which is openly accessible and reusable in any context.
- NumPy, SciPy and matlotlib are open source libraries that are internally utilized by SciKit-Learn to provide the machine learning capabilities.

4.2.2. Twilio Programming Messaging Service

Twilio is a service allows developers to programmatically send and receive text messages through web service APIs [7].
The service is billed based on usage, and hence for a proof-of-concept this project demonstrates the sending of alert SMS to a single number which is offered as free trial period

4.2.3. Flask Microframework

Flask is a micro-framework for Python and is distributed under BSD license. It is a micro-framework in the sense that it does not enforce the user to use any particular tools

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or libraries. It has the added advantage of being swift to set up and deploy and works well with dependency management tools.

4.3. HARDWARE

4.3.1. Arduino Pro Mini

The Arduino Pro Mini is a microcontroller board based on ATmega328. It has 14 digital input and output pins, 6 analog inputs. The Arduino is intended for semi - permanent installation in objects or exhibitions [8].

4.3.2. AD8232

The AD8232 is a neat little chip used to measure the electrical activity of the heart [9]. This electrical activity can be charted as an ECG or Electrocardiogram. Electrocardiography is used to help diagnose various heart conditions.

4.3.3. Bluetooth HC-05

HC-05 is a serial port module which allows for transparent wireless serial connection setup. The voltages and the heart attack alert are relayed to the mobile via this module.

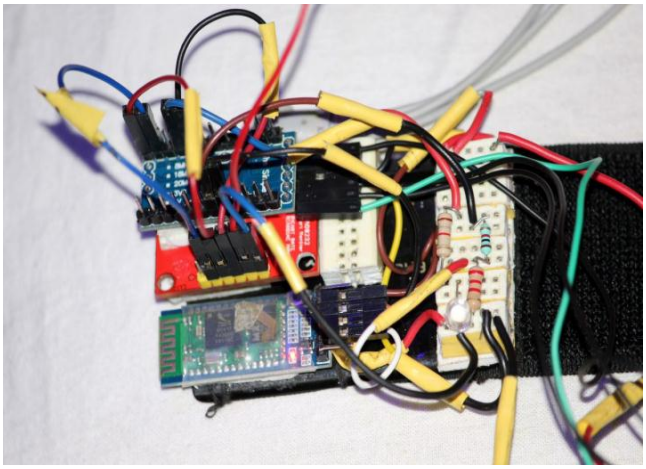

Fig 1.1 Wearable band Hardware

5. TESTING

5.1.1 SOFTWARE TESTING

Software testing is an investigation conducted to provide stakeholders with information about the quality of the product or service under test. Software testing can be stated as the process of validating and verifying that a computer program/application/product:

- Meets the requirement that guided its design and development
- Works as expected
- Can be implemented with same characteristics
- Satisfies the needs of stakeholders

5.1.2. UNIT TESTING OF MAIN MODULES

Table 5.1.2.1 – Test Case for User with Arterial Blockage

Name of the test	Test Case for Arterial Blockage
Test Description	Test classification of an input
Sample Input	Age=59, Gender=Male
Expected Output	1 (Class 1 = Blockage exists)
Actual result/Remarks	As expected.
Passed	Yes

This test case is based on checking Arterial Blockage Existing [1] or not. With the Data sets available[4] collected is tested in SVM model to verify the existence.

Table 5.1.2.2- Test Case for Threshold Exceeding Detection

Name of the test	Test Case for detection
Test Description	Test whether emergency situation is detected
Sample Input	From Leads
Expected Output	"Attack" string
Actual result/Remarks	As expected.
Passed	Yes

This test case in the smart band checking for threshold level reaching or not. During this process the converted leads electrical values are compared with the threshold values. If the signal value reaches threshold, then "Attack" string is generated and informs to smartphone.

Table 5.1.2.3- Test case for Receiving "Attack" and updating Firebase

Name of the test	Test Case for Receiving "Attack" and Updating Firebase
Test Description	Test whether emergency situation is detected
Sample Output	Input from Bluetooth comes as a string "Attack"
Expected Output	Firebase instance alert value set to "1"
Actual result/Remarks	As expected
Passed	Yes

During this test case smartphone checks for string received from band. If the received string contains "Attack", then smartphone updates the firebase instance with 1.
This can be done only when emergency situation of patient.
Firebase instance is "alert" value is setting to "1" is in the server.
Smartphone allows server to set "alert" value to "1".

Table 5.1.2.3- Test case for Fetching Location and send SMS

Name of the test	Test Case for Fetching Location and Sending SMS
Test Description	Test case for Fetching Location and Sending SMS
Sample Input	Event when firebase alert value becomes "1"
Expected Output	Event triggers, firebase alert value reset to "0", Location get fetched and SMS request is sent to server
Actual result/Remarks	As expected
Passed	Yes

In this test case Smartphone fetch the patient's location. Whereas firebase value is then reset to "0" to avoid re-triggering.

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Table 5.1.2.4-Test Case for Server Sending SMS

Name of the test	Test Case for Server sending SMS
Test Description	Test whether the server sends SMS with user Location
Sample Input	A "GET" request on server on endpoint
Expected Output	Server receives "GET" request, and requests Twilio to send SMS through RESET API
Actual result/Remarks	As expected
Passed	Yes

In this test case server search of nearby hospitals and sends emergency message with location to hospitals. And also sends message to emergent people with location.

6.RESULTS SNAPSHOTS

Figure6.1-Server Start-Up(Heroku)

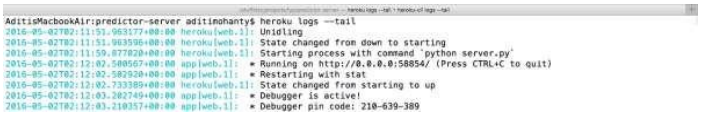


Figure 6.2 Server Classifier Positive Test Case

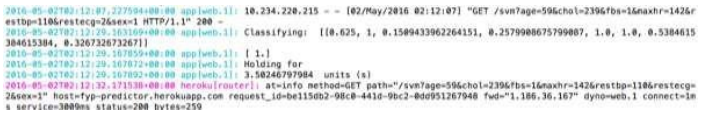


Figure 6.3 SMS Request on Server

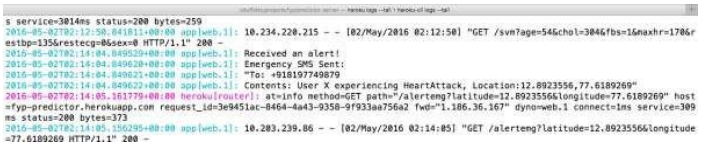


Figure 6.4-Client Test Case

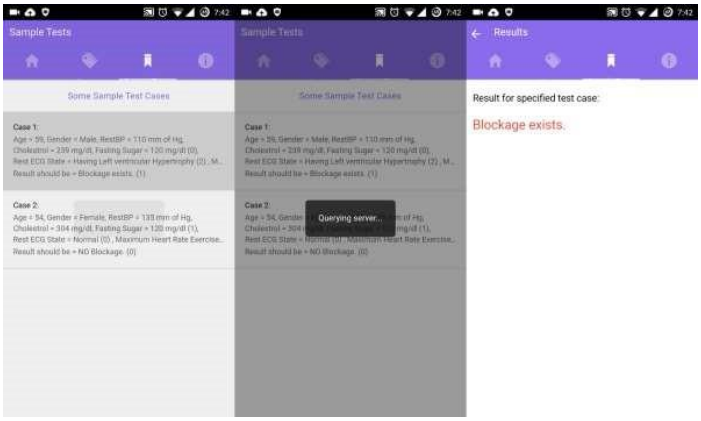


Figure 6.5-Emergency Sequence of Events on Cardia App

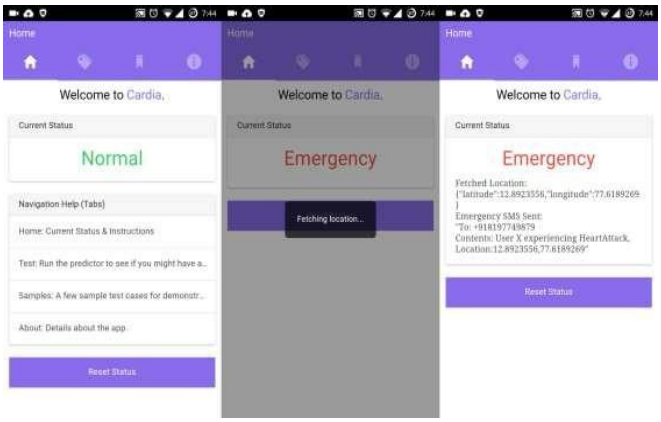
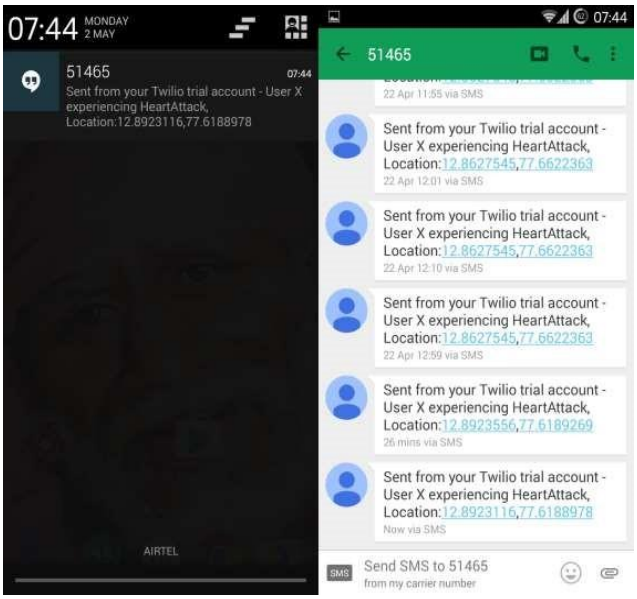


Figure 6.6-SMS Received on Contact's Phone



7.CONCLUSION

The main objective of this project was to build a system for heart patients which is fast and convenient to use. In this project, the wrist-band senses the required data using an ECG device and relays it to the mobile through Bluetooth. If the data reaches a certain maximum threshold value, then an emergency message is sent to the concerned entities along with the current location of the user. The UCI data set is used to build the prediction model and user input is used to predict if in future the user will be at a risk of any heart disease. So with this project both monitoring and prediction is done.

7.1 LIMITATIONS OF THE PROJECT

- As Twilio is a free service, we are able to demonstrate the working of the alert notification by sending an SMS to a single mobile number – this is a proof of concept, as in a fully funded complete product the system can register & send notifications to any number of devices.
- Using, USB to TTL as the power source for the wearable band.
- Current size of the wearable band.
- Integration of the band with an internet component to move towards an IoT-type device.

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7.2 FUTURE ENHANCEMENT

As for implementation of additional features,

- Increase the accuracy of the predictive SVM model by amassing more data.
- Provide automatic detection of ST Wave Abnormalities.
- USB to TTL as the power source for the current device for demonstration purposes will be removed by adding a battery component.
- Designing a dedicated printed circuit board to make a complete wearable band.
- Collection of data through the sensors and storing – can made publicly available to help researchers, with privacy of individuals conserved.

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