CORONARY HEART DISEASE (CAD) MONITORING SYSTEM BASED ON WIRELESS SENSORS

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ABSTRACT—An intelligent cardiac auscultation is the process of monitoring the heart beat signals variations of a patient monitoring system for monitoring the patients’ health condition automatically through sensors based connected networks in Internet of Things (IoT). The critical condition of a patient is detected by processing sensors data and instantly provides push notification to doctors. In our proposed system, coronary heart disease monitoring based on wireless sensors are used to monitor without any human intervention for cardiac patients using piezoelectric sensors which is used to measure artery thickness by the flow of blood vessels and extract the waveform. The waveforms can be classified as normal and abnormal. These abnormal waveform is sent to mobile app where the data is received and plots the signal curves. The mobile app acts as the display device and uploads the data into the cloud platform for further analysis and an intimation is sent to the cardiologist. The authorized Cardiologist can access the datasets and results from the cloud.

Keywords--Internet of things (IoT), piezoelectric sensors, mobile application, Cardiologist

1. INTRODUCTION

Coronary heart disease occurs when the coronary arteries get narrower and reduce the blood flow to the heart. It is the usual underlying cause of a heart attack. Coronary heart disease is associated with age and is a lifelong condition that affects many people. Coronary arteries are small pipes that supply blood to your heart. The arteries get narrower when fatty material gradually builds up inside and clogs them. The Fat deposits is generally not harmful but if it narrows the arteries too much, that there is no deliver of enough blood to your heart. The effect of this is pain and discomfort. It needs to be treated. The narrowing of artery can develop a crack on the surface, exposing the contents of the plaque to the blood. Blood cells may seal the gap in the surface with a blood clot. The blood clot partially or completely blocks the artery. A heart attack can occur when a blood clot completely blocks the flow of blood and reduces blood flow to the heart muscle.
Fig. 1: represents the coronary artery disease in detail

To provide a solution for the above issues this research presents the implementation of coronary heart disease monitoring system based on wireless sensors. Several sensors are used in detecting heart beat and abnormal variations. In this related work, the popularity of Internet of Things is increasing day by day in the area of remote monitoring system of patient. Monitoring system is based on monitoring the patients’ heart beat automatically through sensors based connected networks. The system can able to detect the critical condition of a patient by processing sensors data and instantly provides notification to doctors. The doctor can monitor the patient at the place where ever he is. The patient is monitored with the sensors and the sensed data is send to the server through the wifi. So it is easy for the doctor to monitor the patient through the web server. In the server the patient body temperature, heartbeat can be sensed time to time and get updated through wifi. So the doctor can monitor the patient every time he wants. If the heart beat is high the notification is sent to the doctor using GSM.

Fig. 2: represents the coronary artery vessels with fat deposit

The main objective of proposed system is monitoring coronary heart disease for a cardiac patient, data acquisition is used to detect the abnormal waveform, mobile app development is used to store waveform display and review of historical display, data retrieval and alert mechanism is used to intimate the cardiologist. This project falls under the category of embedded systems with IoT. The major solution to be worked here using the piezoelectric sensor is used to monitor the artery thickness and the abnormal
variations are sent to the mobile application were continuous monitoring takes place and alert is given to the cardiologist.

2. LITERATURE REVIEW

The purpose of a literature review is to survey the critical points of current knowledge including substantive findings as well as theoretical and methodological contributions to a particular topic. It enables to view the existing works in the topic of interest and also throws light upon the tried and failed methodologies in the available systems.

A multimodality quantitative assessments of myocardial perfusion using dynamic contrast enhanced magnetic resonance and 15O-labelled water positron emission tomography imaging from G.Papanastasiou et al (2018) [6], have dealt with Kinetic modeling of myocardial perfusion imaging data and can improve the diagnosis and clinical assessment of coronary artery disease (CAD). The algorithm used here is hilbert marginal spectrum. The performance measures obtained was between(r=0.83-0.92).The accuracy obtained was 64%. Issue here is that the Positron emission tomography (PET) imaging can find comparative performance but results produced by PET cannot be accurate.

A maximum velocity estimation in coronary arteries using 3D tracking doppler from Stefano Fiorentini et al (2018) [16], commercial ultrasound system was locally modified to perform trans-thoracic, 3D high frame-rate imaging of the coronary arteries. Results from simulation also show that 3D tracking doppler performance is acceptable up to 10 cm depth and 75° beam-to-flow angle. The algorithm used here is K means. The accuracy obtained was 64%. Results from simulations based on realistic coronary flow data suggest that the method can improve the accuracy of maximum velocity measurements in patients. Issue in this paper is that thickness of Blood measurement cannot be made by fat deposit in blood as only amount of blood flow to test through ultrasound high frequency sound waves is measured.

An automatic side branch ostium detection and main vascular segmentation in intravascular optical coherence Tomography Images from Yihui Cao et al(2018) [19], proposes a fully automatic method for side branch ostium detection and main vascular segmentation. The evaluated performance of the presented method by comparing the manual and automatic detection and measurement results. The average ostial distance error (ODE) was 0.22mm, and the DSC of main vascular segmentation was 0.96. The algorithm used here Tompkins.and the accuracy obtained is 71%. In conclusion, the qualitative and quantitative validation indicated that the presented. Issue of this paper is Detection and Segmentation is a time consuming process.

A automatic calcium scoring in low-dose chest CT using deep neural networks with dilated convolutions from Nikolas Lessmann et al (2018) [13], proposes a method for automatic detection of coronary artery, thoracic aorta, and cardiac valve calcifications in low-dose chest CT using two consecutive convolutional neural networks. The method was trained and evaluated on 1744 CT scans from the National Lung Screening Trial. Linearly weighted kappa coefficients for risk category assignment based on per subject coronary artery calcium were 0.91 and 0.90 for soft and sharp filter reconstructions, respectively. The algorithm used here is Naive Bayes and obtained an accuracy of 75%. The results demonstrate that the present method enables reliable automatic cardiovascular risk assessment in all low-dose chest CT scans. The issue of this paper result is not well suited for coronary artery calcification (CAC) automatic cardiovascular risk assessment is not that accurate.

3. SYSTEM ARCHITECTURE

The system architecture of the the proposed system is given in the figure 3. The concept design of monitoring system is shown where the acquisition module consist of a arduino board, piezoelectric sensor, temperature and humidity sensor along bluetooth 4.0 which is used to transmits the data to the
mobile phone which also embedded with bluetooth 4.0 also. The capabilities of widespread use and low energy of Bluetooth 4.0 improve the compatibility and decrease the power consumption of this system. Subsequently, the Android cell phone receives the heart sound data and plots the signal curves in real-time. The mobile app acts as the display device and can upload data to a cloud platform for further analysis. The cloud platform integrates the data for concentrated processing and storage. Consequently, the authorized cardiologist can get access to the cloud platform to get the data set and results via any peripheral devices which are equipped with specific software. Moreover, the users can obtain the diagnose results.

![System Architecture](image)

**Fig. 3: represents the System Architecture**

4. FUNCTIONAL ARCHITECTURE

The Functional architecture consist of three main modules

**Data Acquisition** is used to detect the abnormal waveform

**Mobile app development** is used to store waveform display and review of historical display

**Data Retrieval and Alert Mechanism** is used to intimate the cardiologist
A. DATA ACQUISITION

Data acquisition (DAQ) is the process of measuring an electrical or physical phenomenon such as voltage, current, temperature, pressure, or sound with a computer. A DAQ system consists of sensors, DAQ measurement hardware, and a computer with programmable software. The ability of a data acquisition system to measure different phenomena depends on the transducers to convert the physical phenomena into signals measurable by the data acquisition hardware. There are specific transducers for many different applications, such as measuring temperature, pressure, or fluid flow. A transformer is used to convert the 230 volts and distribute it to DOT board, arduino, sensors using bridge rectifiers and filters. Arduino is an open-source electronics platform that is easy-to-use hardware and software. Arduino boards are able to read inputs i.e. light on a sensor, a finger on a button and turns it into output i.e by activating a motor, turning on an LED, publishing something online. Piezoelectric sensor has multiple proprieties that change in a definite way due to stress, temperature etc. These sensors measure the artery thickness and the abnormal parameters are detected. The temperature and humidity sensors are used to monitor the general parameter conditions. Piezoelectric and temperature/humidity sensors are embedded with the arduino in the acquisition model used as a wearable band in the left hand in radial artery where the blood flow is detected. Periodic expansion and contraction of the artery by generating a mechanical signal which is transmitted through hypodermic tissue to the skin layer. With the help of arduino an analog to digital conversion of the signal is obtained. These abnormal waveforms can be visualized in the mobile application.

Fig. 4: Functional Architecture
B. 4.2 MOBILE APP DEVELOPMENT

PHP is the language which is the most popular one in today’s time because of its server side scripting nature. The PHP language is used for creating dynamic web applications on user demands. Developers find it easy to work on PHP platform which gives them a lot of options for creating web applications according to their choice of programming language. Developing an app using PHP is a cost-effective method which provides a free, open source technology for developing various applications in a simple manner. PHP has the ability to provide a platform that makes a developer create an app, test an app and finally deployment of a mobile app. The server side scripting is used for command line scripting and for coding applications. PHP primarily is a coding language used for creating dynamic websites. MYSQL is used as a database at the webservers and PHP is used to fetch data from the database. Our application will communicate with the PHP page with necessary parameters and PHP will contact MYSQL database and will fetch the result and return the results.

MySQL database can be created easily using simple scripts. The `CREATE DATABASE` once created. It creates some tables in the database. When the database and tables are created. Now its time to insert some data into the tables. PHP is also used to fetch the record from the mysql database once it is created. In order to fetch the data some information needs to be passed to PHP page regarding what data has to be fetched.

The first method to pass information is through GET method in which `$_GET` command is used. The variables are passed in the url and the record is fetched. The second method is to use POST method. The only change in the above script is to replace `$_GET` with `$_POST`. In Post method, the variables are not passed through URL.

a. Android - Connecting MYSQL - Connecting Via Get Method

There are two ways to connect to MYSQL via PHP page. The first one is called Get method. We will use `HttpGet` and `HttpClient` class to connect. After that we need to call `execute` method of `HttpClient` class and receive it in a `HttpResponse` object. After that we need to open streams to receive the data.

b. Android - Connecting MYSQL - Connecting Via Post Method

In the Post method, the `URLencoder.URLConnection` class will be used. The urlencoder will encode the information of the passing variables. The last thing you need to do is to write this data to the link. After writing, we need to open stream to receive the responded data.

Now run the PHPMYSQL application. assume that it is connected to the actual Android Mobile device with your computer. To run the app from Android studio, open one of your project's activity files and
click Run Eclipse Run Icon icon from the tool bar. Before starting the application, Android studio will display following window to select an option where you want to run your Android application. Select the mobile device as an option and then check your mobile device which will display following screen. Now just type in your username and password. Now press the Get button and wait a few seconds and response will be downloaded and will be shown. The mobile application consists of dashboard consisting readings artery thickness and other parameter conditions such as Glucose, temperature, humidity, date, time. Charts column consist of ECG graph, temperature graph, humidity graph, glucose graph and artery thickness graph.

C. DATA RETRIEVAL AND ALERT MECHANISM

Cloud storage involves storing data on hardware in a remote physical location, which can be accessed from any device via the internet. Clients send files to a data server maintained by a cloud provider instead of storing it on their own hard drives. File upload feature easily uploads your data to the cloud for quick sharing and secure, organized storage. With file hosting, we can upload files, and securely store them in the cloud, using your choice of cloud storage provider. Once uploaded, data is searchable, can be organized in a collection, and 100% secure with encryption and password protection.

The mobile application acts as the display device and has the capability to upload data to a cloud platform for further analysis. The cloud platform integrates the data for concentrated processing and storage. Reports section consists of the files that can be retrieved from the cloud whenever required. Consequently, the authorized cardiologist can get access to the cloud platform to get the dataset and results via any peripheral devices which are equipped with specific software. Moreover, the users can obtain the diagnose results.

5. RESULTS AND ANALYSIS

The mobile application consists of dashboard consisting readings artery thickness and other parameter conditions such as Glucose, temperature, humidity, date, time. This was a non-clinical study performed on healthy subjects without any harming procedure. Therefore, ethical approval was not sought for execution of this study. The artery thickness of the subject is obtained with the help of the Arduino UNO and Arduino IDE by placing the piezoelectric at the thumb and fixing it with tape. The ECG waveforms were attained it is time consuming for cardiologist.

Gaussian kernel-based SVM classification was applied dataset consists of long term ECG recordings, in healthy subjects. The continuous ECG signals were obtained. The ECG signal is time interval is obtained using QRS Detection interval.

\[ QRS = \frac{QT}{c} \]

where \( c \) is the number of cardiac cycles

Then precision and recall is was used to find the accuracy. When tested with samples of healthy subjects the precision was significantly higher.

\[ \text{Recall} = \frac{TP}{TP + FN} \]

\[ \text{Precision} = \frac{TP}{TP + FP} \]

where \( TP, FP, \) and \( FN \) are the true positive, false positive, and false negative classification results for the healthy samples. More specifically, Recall shows the percentage of the ground truth that was retrieved and Precision represents the percentage of were relevant.

\[ \text{Accuracy} = \frac{TP + TN}{TP + FP + FN + TN} \]
By checking with number of healthy samples the accuracy we can obtain is 85%.

![Accuracy in Percentage](image)

**Fig. 6: represents the accuracy graph**

### 6. CONCLUSION AND FUTURE WORK

The issues in the existing system where only monitoring the heartbeat of the patient using heartbeat sensors. These sensors were used to monitor the patients general conditions. Cardiac remote monitoring was a difficult task for different cardiac disease such as coronary heart disease. Several attempts were made using different sensors such as ECG Sensors for cardiac monitoring which was cost effective. ECG sensors is a heart rate monitor which is used to measure the electrical activity of the heart. Hence in order to overcome the issues the proposed system will use the piezoelectric sensors which is less cost effective to monitor the artery thickness of coronary heart disease using Internet of Things. It can be extended further to expect that health care system will be further aimed to implement for different cardiac disease conditions.

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