MOBILE SYSTEM FOR DETECTING AND DIAGNOSING HEART DISEASES

Miriam Vega, Carlos Vázquez, Javier Naranjo, Arturo Preciado, Alejandro Romero, Carely Heras.
ITESM Campus Toluca
Eduardo Monroy Cárdenas #2000
Toluca, México 50110
{a01050841, carlos.vazquez.hurtado, a01051072, arturo.preciado, a01050889, a1051214}@itesm.mx

ABSTRACT
Heart diseases are a typical cause of death all over the world, providing the user with a novel, low cost, mobile device, capable of warning the user and medical attendant in case of a medical emergency to prevent a critical situation, is the ultimate motivation of this investigation. The main contribution of this work is the design and implementation of an intelligent mobile system for detecting and diagnosing heart diseases.

The proposed system is based on a client / server approach. The user is provided with a 3G Smartphone. The client is continuously monitoring the ECG signal via Bluetooth from a device attached to the user’s body. In the server side, a web based MATLAB server program is performing all the advanced analysis regarding the use of Artificial Neural Networks for detecting and diagnosing heart diseases. If necessary, an alert is generated, otherwise, all the patient records are stored on a database. As a supervision method, ISSEMYM medical staff is attending the server alerts if needed. A collaborative medical diagnosis site has been developed for registered medical users.

KEY WORDS
Automatic diagnosis, Heart disease detection, Mobile technologies

1 Introduction
In today’s world the advances being made in terms of technology are amazing, the things that one day we could only dream about had become real. Every day new things get into our world, new machines capable of doing things only human could, or phones that are able to learn who we are and what we are used to do, so that in the future it can provide us with the best options, taking on account what we like, and what we usually do.

Nevertheless diseases have become more dangerous, all kind of viruses had mutated into enemies we can not kill, examples of this are HIV, Cancer and AH1N1 among others. People live their lives warring that someone is going to discover something new before them, but not only that, people have more stress than ever and worst without the knowledge of what this may cost them. This, the lack of time to prepare a proper meal and the fact that gym is no longer a priority makes us an easy target for some other diseases which had existed for ever.

What we propose to do is a new system able to read the heart signals with the help of the Alive Technologies ECG [1], convert them and send them to mobile device in order for the patient to be monitored through all the heart disease, as well as in the recovery of a surgery. At the moment in which the signal reach the phone, it will analyze the it and give the diagnose. This diagnose is going to a web page with a data base visible, for the doctor and the people with the problem.

We choose to use a commercial ECG from Alive Technologies to offer complete mobility to the system. A blackberry smartphone is the one that is in charge of the health monitoring. The Smartphone is continuously reading the ECG via Bluetooth and logging and uploading information to a central Internet server. As a major contribution, compared to other papers, an intelligent program, running on the server side, is able to detect and diagnose heart diseases. In order to have a robust system, medical personnel verifies the automated diagnosis.

Some studies in the field of health care on a mobile phone have been done, the UCLA made an study in which they propose a diagnostic quality driven architecture for wireless telehealth in mobile platform and body sensor network. They show the advantages of accurate diagnosis inference while preserving diagnostic data features along sensing, preprocessing, feature extraction and diagnosis pipeline. They believe that the diagnosis relevant information of any physiological signal shall be maximally preserved during data flow and is context-dependent [2].

The CSIRO ICT Centre described some of the useful measures that can be derived from ambulatory accelerometer and ECG data, which are useful in assessing the progress of outpatient cardiac rehabilitation. These measures can be used to monitor patient’s exercise activities and physiological status in the free-living environment as well as the performance in the hospital rehabilitation sessions. The described measures made by them, provide a more comprehensive view on the patient’s progress during the rehabilitation program compared to the traditional assessment using only the six minute walk test. They say that there are several usability related issues and problems that may lead to loss of data or otherwise corrupted mea-
surements. The main reliability problem in their study was the incomplete data especially related to ECG measurements [3].

Very high technology chips for monitoring and analyzing Electrocardiography signals are being developed by Iyad Al Khatib and a group of researchers [4, 5]. Such chips provide a dedicated kernel, running analysis in parallel at a very high frequency and with the capability of large data storage.

In normal heart activity electric impulse are generated. This electric charges are the one registered with the ECG, and the position of the electrodes (figure 1).

The electrodes pick up the signal and send it to the ECG which generates a wave that can be read by doctors and interpreted in order to acknowledge what the problem is (figure 2).

1.1 Diseases recognized using this system

When a problem is detected the doctor will prescribe the treatment to follow. What we are doing is teaching the computer to read the signals and decide if a patient is ill, however due to the fact that teaching a computer is not easy, for the moment we are only studying four of the most detected heart diseases, according to a cardiologist from Mexico, which are arrhythmia, left bundle branch block, right bundle branch block and ischemia.

a) Arrhythmia: disorders of the regular rhythmic beating of the heart. They’re common — about 2.2 million Americans are living with atrial fibrillation [6] (one type of rhythm problem). Arrhythmia may occur in a healthy heart and be of minimal consequence. They also may indicate a serious problem and lead a stroke or sudden cardiac death (figure 3).

b) Left bundle branch block: the nerve impulse is blocked or delayed. Patients with LBBB may have left ventricular disease or cardiomyopathy (figure 4).

c) Right bundle branch block: the nerve impulse is conducted slowly or not at all. The right ventricle finally receives the impulse through muscle-to-muscle spread, outside the regular nerve pathway. This method of electrical transmission is slow and results in a delayed contraction of the right ventricle (figure 5).

d) Ischemia: occurs when blood flow to the heart muscle (myocardium) is decreased by a partial or complete blockage of a coronary artery. A sudden, severe blockage may lead to a heart attack (myocardial infarction). Cardiac ischemia may also cause a serious abnormal heart rhythm (arrhythmia), which can cause fainting or even sudden death (figure 6).
2 Development

Figure 7 depicts a typical application of the system. Due to the high risk of the application to give the diagnosis without medical supervision, the web application allows the medical staff to see each patient’s ECG remotely and to have the patient’s medical records. The computer diagnosis is, with all the information collected by the application, verified by human experts and corrected if necessary.

2.1 Client application

The client application that runs on the Smartphone has been developed using J2ME, it is responsible of the acquisition of the information provided by the sensor’s measurements and the communication with the server for further processing of the data. Figure 8 shows the client program running on the Blackberry JDE simulator.

We searched for a device that had all the mention characteristics. We saw that a great advance is being made in term of long distance health care, that is why we use the Alive heart monitor (image 9) which has the following features [7]:

- Bluetooth 100m range
- Real-time transmission to PC or Smartphone
- PDA or access point for storage
- Analysis SD memory card storage option 3 axis accelerometer
- Records ECG, heart rate, activity, body position
- Speed and location tracking using optional GPS

The client’s application in the Smartphone is very simple; it works as a communication bridge and guarantees that the data sent by the Alive Tech ECG device via Bluetooth reaches its destination in the web server using the 3G network. If the ECG signal is monitored the whole time, the battery life will decrease, the 3G network’s reliability would too and the server memory will eventually be full, which is not convenient for the system. If five seconds samples were taken every ten minutes, the disease detection system and the doctors would have enough information to make the diagnosis of state of the patient. Hence the client’s application is activated every ten minutes and sends the five seconds sample to a web server via e-mail.

In the Bluetooth SPP connection, between the ECG device and the Smartphone, the data is transmitted in real time us-
ing a special streaming data format. Data is transmitted in packets terminating in 1 byte checksum. The first segment of the packet is the main header, in which the synchronization bytes and the sequence number of the packet are specified. The values needed for the two synchronization bytes have to be 0x00 and 0xFE respectively, if these two values are present consecutively in the data streaming, then a new packet is starting. The next segment is ECG header that specifies the format and length (in bytes) of the ECG data. This header is followed by the ECG data, the Accelerometer header, the Accelerometer data and the byte checksum. Nevertheless the unique data important for us is the one contained in the main header, ECG header and the ECG data; that is why the client application is focused in these three segments. First, the program must found the synchronization bytes reading each byte of the data streaming. Despite of containing important data like the ECG header, the following nine bytes are discarded because after some test we conclude that the value of the bytes is always the same, and if these value is known, then there is no reason for processing that bytes. According to the test, the following 72 bytes contain the ECG data with format of 8-bit, unsigned and sampled at 300Hz. Therefore, every time a new byte is read, its value is stored in an array which size is enough for keeping the data belonging to the five seconds sample. After the mentioned 72 data bytes, the following bytes are not useful, so the program returns to its initial state and listen for the synchronization bytes. This process is repeated until the five seconds sample is completed (or the array is full) (figure 10).

2.2 Server application

The server application is based on an intelligent system that can recognize heart diseases using pattern recognition from ECG; it was developed using Artificial Neural Networks (ANN) Toolbox from MATLAB.

In order to recognize heart diseases we used MIT-BIH Arrhythmia Database to train the network with information about Normal Heartbeats, LBBB, RBBB, PVC available thanks to physionet [8].

From the time domain ECG signal we extracted 30 features from each heartbeat. The rhythm and the morphology of the heartbeats were obtained, for the rhythm we measured, the distance from the R peak to the previous one and the distance between the same peak to the next one, figure 11.

2.3 Collaborative Web Site

Medical communication is important, we propose the use of a collaborative Joomla base website so medical diagnosis can be done easily. Joomla [9] is an Open Source content management system (CMS), it is an independent, fast and reliable platform.

Our site, called BIOITED, offers secure sessions so medical users can log on into a collaborative session where they can access the medical records, share their diagnosis points of view, leave their comments and review the automated alerts and diagnosis generated from the MATLAB server program. All data is stored using MySQL database and was designed as shown in image 12.
Access is granted to registered users (medical personnel or patients) and can be done via HTTP using a PC, as shown in figure 13, or via wml (or HTML if supported) using a smartphone. It is very useful to have mobile access since an alert can occur anytime and any place. Due to 3G networks wide coverage, it allows our system to be a reliable and feasible.

3 Tests and Results

Initial tests were made with signals taken from the ECG and the MIT physiobank data base.

The signals were taken by connecting three electrodes in specific parts of the chest, this signal was digitalized and sent to a computer where program analyzed them and gave a diagnosis.

We also used a signal taken by a hospital ECG (figure 14) it was used to compare not only the signal taken by us but also to ensure the diagnosis were correct.

The difference between the healthy signal (figure 15) and the one that shows ischemia (figure 16) are recognizable to a cardiologist, and even for a person without any medical experience, even thought, feature extraction is needed analyze it using ANN. Figure 17 shows to patients that agreed to test our system, the first one is a healthy one, while the other had had heart attacks caused by Ischemia.

The fact that the signal is so clear helps both, the computer program and the doctor to analyze it; Dr. Oralia Ortiz told that the signal is as good as one provided by the hospital with the only deficiency that the hospital one can show all the signals while the alive monitor show only two, problem that can be fixed with the use of two heart monitors.

We have also managed to make the connection from the alive heart monitor with the smartphone using Blue-
Tooth which is a great advance into achieving the goal of our project.

4 Conclusion

The Cardiologist, Armando Gonzalez Arroyo at the ISSE-MYM hospital, who is contributing with this project, has great expectations for what this development could lead. That’s why, we conclude, this project is not only important from the academic point of view but from the practical one. Dr. Armando Gonzales says that illness as heart attacks, arrhythmia, blocks, and other could be monitored. He told us that even though real and accurate diagnostic can only be made by a physician in physical presence of the patient, a device such like ours can help in cases where the patient can not be taken to the doctor’s office or when they are in different places at the time. He also told that the device could help to lower the percentage (20%) on silent arrhythmia which is the normal disease with the problem that it do not present any kind of symptoms, only the ECG and nuclear test can find them.

Other heart diseases can only be found in the right moment, meaning when the patient feels the pain, by using our device the doctor will have a constant observation on the patient and can catch the problem at the right moment.

This development can be of great utility for the medical field, we have achieved great thing that makes us different from other, for example the communication with the cell phone, as well as the web page, which has different data base for the physician to be able to see the way the patient develops.

References


