ISSN: 2321-7782 (Online)
Volume 1, Issue 7, December 2013
International Journal of Advance Research in Computer Science and Management Studies
Research Paper
Available online at: www.ijarcsms.com

A Concurrent Cardiac Monitoring and Assessment System

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Abstract: Now-a-days cardio vascular diseases are a credible threat to almost everyone. The reasons for it can be many, from the current lifestyle of people all around the world to the hereditary or genetic problems. Nevertheless the need of a proper care and medication has been felt to the people who are victims of such illness. With that in mind we are planning to enable such victims to carrying out with their daily tasks without being too overwhelmed by worrying about their condition, through our project. We've seen through various researches that most of the deaths caused by these diseases are due to untimely treatment or lateness of help through emergency medical services. In this project we are planning to develop portable ECG monitoring systems wirelessly connected to a server and a classification algorithm that will calculate the probability of cardiac failure risk, according to collected data. The system incorporates various algorithms that will give a probability of heart related risks, and alert the patient and other personnel if the condition requires it.

Keywords: Cardiac, Assessment, Monitoring, Heart-Rate, Android, Smartphone, Naïve Bayes Classification.

I. INTRODUCTION

Heart rate is an important and crucial aspect when it comes to monitoring health and conditions of human body. Now-a-days telemedicine is an important factor especially in outdoor activities like gymnasium, sports fields, military bases, remote villages or rural areas. The applications are numerous and are currently implemented and used in various parts in the world. Heart rate monitoring is done through ECG (Electrocardiogram) signals of the patient; these signals are acquired by special sensors that are attached to person's body. This enables the device connected to the sensors to monitor the heart's rate. The user/patient using the system will have heart rate monitor strapped to the chest, the monitor will then pair with the smartphone and send the collected data to the smartphone.[1] The smartphone will accept this data from the sensor and send the current temperature, heart rate and speed of the person to the server. The server will then assimilate this data, using algorithms analyze it and send appropriate alerts if required to the respective personnel. [1] Thus the proposed system is designed keeping in mind the freedom from wire-strapped heavy, machines for ECG monitoring and gives user the ability to carry on with his/her daily chores and not worry about the complexity of health condition.

II. ELECTROCARDIOGRAM

ECG reads the person's heart rate by acquiring heart activity over a period of time. This is achieved by placing electrodes on the chest over the portion where the heart is located which is usually on the left side of the chest. These signals are plotted on a graph x-axis specifying time in seconds and y-axis specifying heart activity, in millivolts. [2] Figure given below describes how a typical ECG signal is plotted on a graph. The crests and trough show the activity and inactivity of the heart through millivolts on Y-axis, against the time on X-axis.

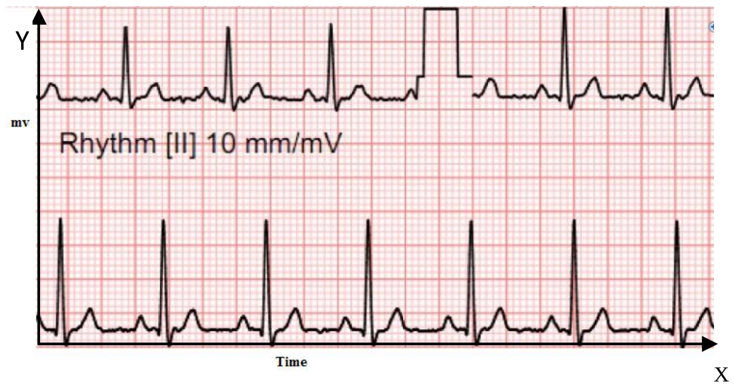

Figure 1. Typical ECG waveform example.

III. REQUIREMENT

A. *Hardware Specification*

ECG sensor attached to the chest collects the ECG signal from the body and transmits it to smartphone using Bluetooth technology. The hardware sensor used for this is manufactured by Zephyr^{TM}, HxM Bluetooth heart rate monitor. We will be using an Android operating system based smartphone, which will be paired with the wireless heart rate monitor through Bluetooth. The system will also require a server to analyse the data, thus acquired and should have access to GSM facilities. The proposed system will have the ability to call caretaker or doctor if situation requires.

B. *Software Specification*

Planned software platform used for mobile application is Android 4.4 Kit Kat Operating System from Google. We are planning to deploy the first prototype on open-source android platform and later depending on success of the application; we will expand to other platforms such as iOS and Windows 8. [1] We are using Eclipse Juno IDE for mobile application development and NetBeans Java IDE for server end development.

IV. SYSTEM ARCHITECTURE

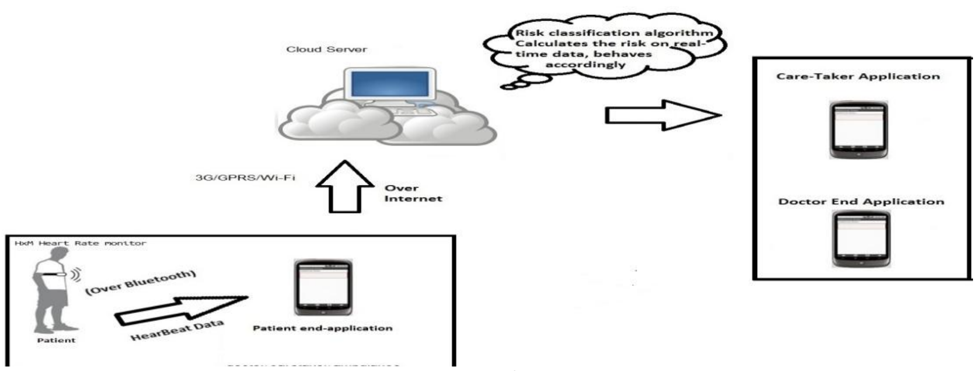

Figure 2. Architecture of CHMAS

The above image depicts the architecture of the Concurrent Cardiac Monitoring & Assessment System. The entire process initiates from the patient side. The device is placed on the body of the patient. The cardiac analysis are sent to the smartphone with the help of Bluetooth synchronization. This data is further passed on to the server computer via internet (3G/GPRS/Wi-Fi). The server calculates the risk factor of the patient with the help of the Naive-Bayes Algorithm. In this algorithm the system is fed with training sets. It uses this as a benchmark to flag an alert message. [6] It is provided with 4 parameters, namely heart rate, temperature, speed and position. It takes the first 3 parameters viz. heart rate, temperature, speed and compares these values with the its database set. It determines the values closest to these benchmark values to predict the risk factor. If there is any unusual cardiac activity then an alert message is sent to the caretaker/doctor of the patient. Along with this information some additional information regarding the current location of the patient is also sent. Hence, the doctor/caretaker can take necessary actions immediately.

A. Electrocardiogram Module

Figure 3. Zephyr™ Bluetooth HxM Heart Rate Monitor.

The proposed module for acquiring ECG signals is provided by Zephyr™ Technology. It's a portable Bluetooth enabled wireless heart rate monitor called HxM Heart Rate monitor. The Bluetooth HxM Heart Rate Monitor system consists of a Bluetooth HRM device, and Zephyr™ Smart Fabric sensor strap. [4] The device contains an internal accelerometer and provides algorithm-derived speed, distance and stride count data. [4] An SDK document describing communications protocols and data packet contents is available free on return of a signed EULA agreement. [4]

Features of these modules are:

- Uses Bluetooth to provide heart rate, RR Interval, speed & distance to your Android and Windows Phone 8 devices
- Machine Washable strap that offers both comfort and accuracy
- Long transmission range (~10m)
- Water Resistant up to 1m [4]

Measurements:

- Heart Rate
- R-R Interval
- Speed
- Distance [4]

Specifications:

- HR Range: 25 – 240 BPM
- Battery Type: Rechargeable Lithium Polymer
- Battery Life: 26 Hours per charge
- Transmit Range: 10m
- Frequency: 2.4 – 2.4835GHz [4]

Operating Limits:

- Temperature: -10 – 50°C
- Humidity: 5 – 95% [4]

B. Risk calculation formula

We are planning to use a classifier algorithm for assessment of heart rate namely, Naïve Bayes algorithm to predict the probability of heart risk or stress in any given environment based on the readings obtained. [3] The naïve Bayes algorithm is based on Bayesian theorem. [5] Parameter estimation for naïve Bayes models uses the method of maximum likelihood. The main advantage of using these algorithms is it requires a small amount of data set to estimate the parameters.

Rec	Age	Income	Student	Credit rating	Buys computer
R1	<=30	High	No	Fair	No
R2	<=30	High	No	Excellent	No
R3	31…40	High	No	Fair	Yes
R4	>40	Medium	No	Fair	Yes
R5	>40	Low	Yes	Fair	Yes
R6	>40	Low	Yes	Excellent	No
R7	31…40	Low	Yes	Excellent	Yes
R8	<=30	Medium	No	Fair	No
R9	<=30	Low	Yes	Fair	Yes
R10	>40	Medium	Yes	Fair	Yes
R11	<=30	Medium	Yes	Excellent	Yes
R12	31…40	Medium	No	Excellent	Yes
R13	31…40	High	Yes	Fair	Yes
R14	>40	Medium	No	Excellent	No

Table 1. Training Set

X = (age= youth, income = medium, student = yes, credit rating = fair)

A person belonging to tuple X will buy a computer?

Derivation:

D: Set of tuples

- Each Tuple is an ‘n’ dimensional attribute vector
- X : (x1,x2,x3,…. xn)

Let there be ‘m’ Classes: C1,C2,C3…Cm

Naïve Bayes classifier predicts X belongs to Class Ci iff

- P (Ci/X) > P(Cj/X) for 1<= j <= m , j <> i

Maximum Posteriori Hypothesis

- P(Ci/X) = P(X/Ci) P(Ci) / P(X)
- Maximize P(X/Ci) P(Ci) as P(X) is constant

With many attributes, it is computationally expensive to evaluate P(X/Ci).

Naïve Assumption of “class conditional independence”

$$P(X/.Ci) = \prod_{k=1}^{n} P(x_k / Ci)$$

P(X/Ci) = P(x1/Ci) * P(x2/Ci) *…* P(xn/ Ci)

Theory applied on previous example:

P(C1) = P(buys_computer = yes) = 9/14 =0.643

P(C2) = P(buys_computer = no) = 5/14= 0.357

P(age=youth /buys_computer = yes) = 2/9 =0.222

P(age=youth /buys_computer = no) = 3/5 =0.600

P(income=medium /buys_computer = yes) = 4/9 =0.444

P(income=medium /buys_computer = no) = 2/5 =0.400

P(student=yes /buys_computer = yes) = 6/9 =0.667

P(student=yes/buys_computer = no) = 1/5 =0.200

P(credit rating=fair /buys_computer = yes) = 6/9 =0.667

P(credit rating=fair /buys_computer = no) = 2/5 =0.400

P(X/Buys a computer = yes) = P(age=youth /buys_computer = yes) * P(income=medium /buys_computer = yes) * P(student=yes /buys_computer = yes) * P(credit rating=fair /buys_computer = yes) = 0.222 * 0.444 * 0.667 * 0.667 = 0.044

P(X/Buys a computer = No) = 0.600 * 0.400 * 0.200 *0.400 = 0.019

Find class Ci that Maximizes P(X/Ci) * P(Ci)

=>P(X/Buys a computer = yes) * P(buys_computer = yes) = 0.028

=>P(X/Buys a computer = No) * P(buys_computer = no) = 0.007

Prediction: Buys a computer for Tuple X. [5]

V. CHALLENGES

When designing this system, the following constraints have been assumed:

•**Modularity and expandability constraints:** the system must be modular in design. Both hardware and software should be divided into small components or modules to ensure easy scalability for further feature expansions. Modules must be produced independently from each other, so that changes or the crash of one module cannot affect the others.

•**Economic constraint:** We should take into account performance to cost ratio so as to design a cost-effective solution.

•**Power constraint:** The system should work on minimum power usage. Low power consumption devices should be used to ensure that power usage is at lowest.

•**User constraint:** The device should be user friendly. It should not become a burden for the user over time. It should be as compact as possible. It should be sturdy and should be built for rough use.

VI. CONCLUSION

In this research article, we plan to take care of the short-comings that were present in the previous models. Not only we plan to make cardiac monitoring User-friendly but also make it much more efficient. Some of the features such as the latest position locator have been added into the system to make it time efficient. The false alerts which were encountered in the previous models have been minimized. This can be achieved with the help of Naïve-Bayes Algorithm. We plan to apply

Bluetooth synchronization and android technology together to create a useful application. Multiple smartphones can interact at the same time. Instant help can be provided to the concerned victims hence this application is turning out to be a life-saving one.

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