ISSN: 2321-7782 (Online)
Volume 2, Issue 12, December 2014
International Journal of Advance Research in Computer Science and Management Studies
Research Article / Survey Paper / Case Study
Available online at: www.ijarcsms.com

Ubiquitous Heart Disease Detection System

Shashank Nigam[1]
Department of Computer Engineering
Fr.C.Rodrigues Institute of Technology
Navi Mumbai – India

Pratik Malkar[2]
Department of Computer Engineering
Fr.C.Rodrigues Institute of Technology
Navi Mumbai – India

Mritunjay Ojha[3]
Department of Computer Engineering
Fr.C.Rodrigues Institute of Technology
Navi Mumbai – India

Abstract: ***The internet of things (IoT) is the new emerging field that focuses on machine to machine communication, gathering data from it analyzing it and creating new models out of it. The IoT principles can be used to make the machine operation ubiquitous even eliminating the need of human intervention for their control. The principle of electronic health and more specifically mobile health can be combined with the principle of IoT, making human health care ubiquitous, by keeping the records of the user's health prescribing medicines, and generating health reports. These principles can be used to make human health an object of internet. The system proposed here makes use of the heart rate sensor to record the heart rate of the individual. Heart being a vital parameter, heart rate can be used to detect various anomalies related to the heart such as bradycardia, tachycardia or even the life threatening arrhythmias. Further the data can be used to guide the individuals during their workout regimes. The users can be notified in case of any emergency along with its close relatives or neighbors and can be also guided to the nearest hospital. The paper studies the mechanism of the implementation of this concept. The paper also studies the different heart diseases that can be mined from the heart rate using artificial neural networks.***

Keywords: Internet of things (IoT), mobile health, tachycardia, bradycardia, arrhythmias, artificial neural network.

I. INTRODUCTION

The paper Ubiquitous Heart disease detection System is based on mapping vital parameter such as heart rate, temperature blood pressure etc. Heart is the center of the circuitry called as the circulation. The primary responsibility of the heart is to pump the blood throughout the body through either systematic circulation or through pulmonary circulation. The project is based on the concept of internet of things. This project is an implementation of the mobile health popularly known as the m-health or e-health. The following sections give an introduction on various related fields

A. Internet of things (IoT)

It can be viewed as the communication among various machines. In a broader prospective IoT involves gathering data from those devices and analyzing it to extract useful data. IoT can be used to analyze the characteristics of these machines and use these information to optimize the machine running, cleaning, and then generating newer models out of it. The devices can then send the data on the cloud that can be further used for analysis and data mining [1]. IoT has devices and the cloud based analysis as the two most essential ingredients of the IoT. The device move the data over the edge gateway, the gateways move the device data over the complex network which is further send to the cloud that can be further used to analyze data through data mining. Each devices in the IoT is given a unique identity and thus in such cases the IPv6 can come as a considerable solution. Apart from the unique identity the devices also require a communication medium and most importantly a sensing medium that can collect the physical parameters of the device or the environment the device is working on [2].

The IoT can be effectively used as the monitoring system to monitor the human health. The IoT can use sensors to record vital parameters of the organs, send this data over the cloud. This data can be further mined so that to detect or diagnose the onset or possibility of any disease, and medium to check our normal and healthy living. IoT can be further used in the future in order to improve commerce, increase leisure and can be even used to save our life.

B. Mobile Health

Mobile health is the term used by the practice of the medicine and public health supported by the mobile devices. MHealth application includes the use of the mobile devices in collecting community and clinical health data and delivering it to the practitioners and patients providing a real-time monitoring of the patient's vital organs and direct provision of the care. This fulfills a variety of objectives such as the access to the healthcare and the health related problems; improved ability to diagnose and track diseases; timelier; and a more accurate public health information. The growing number of health related apps in smart phone makes the concept of mHealth possible [4] [5].

C. Heart rate

Heart rate is the speed of the heartbeat, specifically the number of heart beats per unit time. The heart beat is typically expressed in the form of beats per minute (bpm). The heart rate can vary according to the body's physical needs, including the need to absorb oxygen and excrete carbon dioxide. The normal heart rate ranges from 60-100bpm. Based on the various heart rate found among the individuals the heart rate can be classified as follows [7]:

1. *Bradycardia (Low heart rate):*

   Bradycardia is a slow heart rate defined below 60 bpm, although it is seldom symptomatic until the rate drops below 50bpm. It sometimes results in fatigue, weakness, dizziness, and a very low rates of fainting

2. *Tachycardia (High heart rate):*

   It is fast heart rate defined above 100bpm at rest. It is the case when the heart beat exceeds the normal beating range. This disorder can be dangerous based on the speed and the type of the rhythm.

3. *Arrhythmia:*

   This is the case when the heart is not beating properly. It is the condition where the heart is beating unconditionally faster or slower.

II. Previous Literature Review

The paper Ubiquitous Heart disease detection System is based on the principles of Internet of Things (IoT). IoT consist of the communication of the device using a network interfaced by the gateway and processed in the cloud access points [1]. The following contents give a brief overview of the work being carried out in current and related fields

A. BODY AREA NETWORK

The body area network also called as the wireless body area network (WBAN) [6] [8] or the body sensor network (BSN) is the wireless network of the wearable networks. With the increase in the use of the sensors, in the form of a wearable devices or the use of the sensor embedded smart phones, the use of BAN is on an increase with the development of the technology. The availability of BAN allows continuous health monitoring and send real time updates to the internet. Various sensors can be connected on the clothing or on body implanted under the skin. The values taken from the sensor can be transmitted to the analyzing devices through wired or wireless. Various IEEE standard are available using BAN. BAN depends on the range, interference, network density sensor per network, quick time of transmission in body environment and security or encryption. The hardware requirement of the same depends on the energy efficiency of the devices, the quality of the sensors used and lifetime of

the same. Wireless BAN (WBAN) is a specialization of the BAN used for efficient health monitoring in which the user can move anywhere and need not be present in the hospital for the same. Thus the use of the BAN the concept of mHealth and telemedicine can be efficiently implemented.

B. SENSORS

In our literature survey we came across the different commercially available heart rate sensor. The following text provides a brief overview of the same [5].

1. *Polar wearlink transmitter with Bluetooth:*

This ECG accurate device picks up the heart rate signals and transfers the data into compatible mobile training application. Consisting of the soft textile wrap around the body it provides the full freedom for the user. The device is compatible with Android phones (version 4.3 and above), Symbian phones and IOS.

2. *Jarv Premium Bluetooth 4.0 Smart Heart Rate Monitor:*

This heart rate sensors is designed for the iPhone 4S, iPhone 5, iPad Mini, iPod Nano, and New iPod Touch. Running on the 3rd party iOS application it can be used as the training guide for runner, cyclist and other fitness enthusiasts.

C. Cloud Services

The cloud access point act as the backend of the entire application used for the analysis of the data given to it and providing the necessary feedback based on it. It provides virtualization of the physical structure and makes it available as the software component thereby speeding up the IT operations. High performance, durability and availability are some of the important characteristics of the cloud services. The cloud services can be delivered in one of the following forms

1. Infrastructure as a service (IaaS)
2. Platform as a Service (PaaS)
3. Software as a Service (SaaS)

Using Google App Engine as an effective cloud service provider: Google popularly provides the Google app engine as a free service to most of small scale application. An app engine is the concept where one does not need a product instances or databases to run the application but a bunch of computers provided these services. The Google platform allows the use of the app engine to act as a backend for most of the mobile device application [10] [11].

Google Cloud Endpoints consists of tools, libraries and capabilities that allow you to generate APIs and client libraries from an App Engine application, referred to as an API backend, to simplify client access to data from other applications. Endpoints makes it easier to create a web backend for web clients and mobile clients such as Android or Apple's iOS.

For mobile developers, Endpoints provides a simple way to develop a shared web backend and also provides critical infrastructures, such as OAuth 2.0 authentication, eliminating a great deal of work that would otherwise be needed. Furthermore, because the API backend is an App Engine app, the mobile developer can use all of the services and features available in App Engine, such as Datastore, Google Cloud Storage, Mail, Url Fetch, Task Queues, and so forth. And finally, by using App Engine for the backend, developers are freed from system admin work, load balancing, scaling, and server maintenance.

D. Heart rate variability (HRV)

The heart rate varies with every heartbeat. Heart rate variability is the variation of the beat to beat intervals, also known as the R-R, intervals. Electrocardiogram is the signal originating from the heart. The most distinct feature of the ECG is the QRS complex, which consists of the Q, R and S waves and originates from the electrical activation of the heart ventricles.

The following figure shows the illustration HRV indicates the fluctuation of the heart around an average heart rate. An average heart rate of 60 beats per minute (bpm) does not mean that the interval between successive heartbeats would be exactly 1.0 sec, instead they may fluctuate/vary from 0.5 sec up to 2.0 sec [7] [12].

HRV is affected by aerobic fitness. HRV of a well-conditioned heart is generally large at rest. Other factors that affect HRV are age, genetics, body position, time of day, and health status. During exercise, HRV decreases as heart rate and exercise intensity increase. HRV also decreases during periods of mental stress. HRV is automatically regulated by the automatic nervous system.

The measurement of the HRV is done using different methods which include [7]

1. Time domain analysis
2. HRV triangular index
3. The standard deviation of the heart rate.
4. Geometric methods

E. Data mining algorithms

The changes in the functioning of the body is clearly displayed in most of the cases using the changes in the heart rates the following section gives a brief overview about the proposed algorithm for the mining the heart rate. [13]

1. Neural network design:

A neural network is the set of connected input/output units in which the each connection has a weight associated with it. During the learning phase the algorithm learns by adjustability so as to predict the correct class label of the input. They have high tolerance to the noise in the data and can even classify the pattern that they haven't been trained. They are useful when the relationship between the classes is not known. They can be used for the continuous input of the data and are used for wide range of applications such as the pathological diagnosis, medical diagnosis, handwriting analysis etc. There are different types of the neural network algorithms which include the back propagation, multilayered feed forward. The back propagation performs learning on a multi layered feed forward neural network, which consist of an input layer one or more hidden layer and an output layer.

The neural network topologies are based on the number of input, the number of hidden layer and the required output. The data are usually normalized for the training purpose. The neural networks can be used for both classification and numeric prediction. The neural networks learn iteratively processing the data set of the training tuples, comparing the network's prediction for each tuple with the actual known target value. To compute the net input to the unit each input unit is multiplied by the weight and is summed. The j in a hidden or output layer, the net input Ij, to unit j is as follows

$$Ij = \sum wij * Oj + \Theta \qquad (2.1)$$

Given an input Ij to unit j, then Oj, the output of unit j, is computed as

$$Oj = \frac{1}{1+e^{-Ij}} \qquad (2.2)$$

III. System Design

The system mapping human health to internet maps the human's heart rate to the internet. The system takes the human heart rate from the polar H7 heart rate sensor, and the recorded heart rate is send via Bluetooth to the smart phone system where the bits of data is converted into beats per minute. The data is send at a constant interval of 1seconds. The beats per minutes calculated is send to the cloud server where the data is mined using artificial neural networks. Based on the results of the mining the notifications are sending to the users. The basic block diagram of the system is shown in fig 3.1:

The following contexts give the brief context of the design of different modules involved in the project.

A. SENSOR TO SMART PHONE CONNECTIVITY

The system makes use of the heart rate sensor. The heart rate sensor proposed for the project is the Polar Heart rate sensor (Polar H7) as it is easily available in the market. The device claims to provide an ECG accurate reading of the heart rate measurements which is extremely important for the accuracy of the results to be obtained from the system. The device is compatible with the android devices operating with android version 4.3 or later, as the sensor makes use of the low energy Bluetooth v4.0 there by making the device durable. The android application used in the proposed system acts as an interface for receiving the heart rate readings and calculating the mean heart rate per minutes. The android application proposed for the system is of version 4.3.0 (level 18) or greater. The process of transferring the heart rate to the mobile device can be explained as follows:

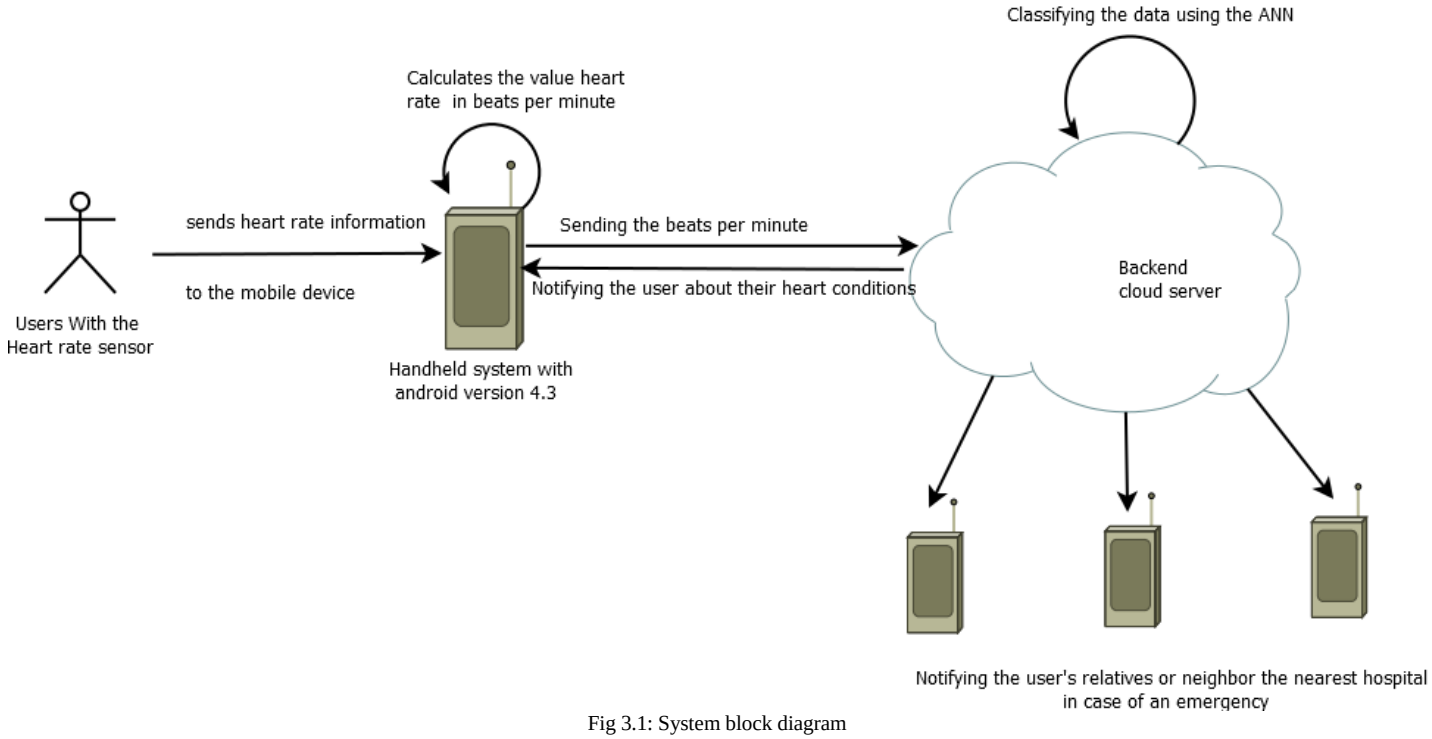

Fig 3.1: System block diagram

The plastic electrode is placed on the chest with the chest detect strap on the skin. The Bluetooth Low Energy starts as the peripheral and advertises to be connectable with a collector (phone or wrist unit). When the collector (the android system proposed) sends the advertisement message, the sensor accepts it and a short paring phase occurs. After this phase the collector enables the heart rate notification of the sensor by writing 0x01 to the client characteristics configuration descriptor (a Bluetooth GATT service). The sensor sends the heart rate as the heart measurement notification. The sensor claims to support all forms of RR readings. The unit for the RR interval is 1/1024 seconds. Once the strap is removed the absence can be detected through the Sensors contact status bit and sends it through the Heart rate measurement notification (a Bluetooth GATT service). The sensor will terminate the connection if the contact is absent for 20-30 seconds. In this mode the sensor losses very low energy (<1 micro ampere) [4]. The heart rate sensor make checks the connection after every 30 seconds and record the average heart rate during that period. If no connection could be detected after the 30 seconds the parameter is updated and the value is updated and the data is re send. Once the heart is calculated and assigned to the heart rate parameter of the Bluetooth and sent to the user's hand held device using the heart rate profile and the heart rate service specification.

B. OPERATION AT THE MOBILE DEVICE

In most of the cases, the android device acts as the server that looks for the advertisement from the peripheral sensors who advertise their connections. Based on the application the android device can act as either the server or the client. While the data is sent using the Bluetooth heart rate profile the collector acts as the GNATT client and the sensor acts as the GNATT server. The

Android device acts server that establishes the BLE connection with the sensors. Once the connection is established through the BLE the data transfer takes place from the heart rate sensor to the mobile device.

In order to use the Bluetooth function it is important to apply the Bluetooth permission to the mobile application. This allows the application to request a connection, establish a connection and transferring the data through the Bluetooth. If the application is needed to initiate the discovery it is important to declare the Bluetooth authentication in the android activity. The devices can be made visible to only Bluetooth LE as well. Once the device application is made ready for the Bluetooth connection it is necessary to ensure that whether the BLE is supported or not. If the BLE is present and not activated then it can be activated through the use of the BLE Adapter. The Bluetooth Adapter is necessary for any and all the Bluetooth activity. As there are only one adapter in the device one's application can interact it using the application. The Bluetooth can be ensured through the use of the isEnable() Function. The Android application can detect the Sensor through the use of startLeScan() method where the devices can be scanned in a specified loop and the scanning can be stopped once the device is found It is important to connect any low energy sensors to connect to the connectGatt() method. The method makes use of three parameter namely, a context (e.g. this), auto Connect (a Boolean specifying whether to automatically connect the BLE device as soon as it is available) and a reference to the Bluetooth GATT service being used. This process returns the GATT server hosted by the BLE device and returns a BluetoothGatt instance that determines the use by the client applications. By using the GATT attributes the heart rate can be either collected in either UNIT 16 or 8. Converting the value to the integer will give the required value of the heart rate. Once the application finishes the task it is important to close the connection through the use of close() function.

C. SETTING UP THE ANDROID APPLICATION BACKEND

The data send or recorded through the android application needs certain processing that can be efficiently achieved through programming the data on the backend. As the android applications work on the devices that have limited memory, limited processing it is important to process the data outside the application frame work that can be incurred with minimum cost required for send the data through the wireless networks. The Google app engine is the most appropriate service for this specification. The Google app engine achieves this by having an end point connectivity or the respective API to connect to the backend application. The android application can communicate with the application through the get and the post methods of the HTTP. For using Google app engine as the backend for the applications it is necessary to have a valid Google app engine product deployed at the appspot. The client application must make use of the java library generated by the backend. An API end point can be created using the maven artifact. Once the API backend has been created the client libraries can be created from the maven artifacts. Annotate the API so that the classes can be created. The client application can make calls to the API during its lifecycle and make use of the backend services.

D. COMMUNICATING WITH THE BACKEND CLOUD

The android devices can communicate with the Google app engine using the Google Cloud Messaging for Android (GCM) which allows an application to send the data to the server. This is a light weight messaging and can message up to 4kb of payload. Using this service on can receive the upstream message from the user data and passes the message straight to the android application for its support and the services to be needed. This requires the android application to be enabled with the GCM Connection services. The GCM connection takes the message from the 3rd party server and sends it to the Client Application enabled with the GCM. For this process the android application has to first register with the application frame work. Which returns a registration ID. The application sends message to the GCM servers. Google enqueues and stores the messages in case the server is offline. When the device is online the messages are send to the server.

E. AT THE SERVER

The backend Google app engine provides an efficient data storage mechanism. The Google app engine stores the data in the hierarchical pattern and makes use of the object oriented data storage. The Google's data storage is based on the Big table's technology. This helps in the traditional data storage to become more dynamic and scalable. The Google app engine makes use of the model view control pattern. In the model view control pattern the model defines the persistent data to be stored, the HTML and the CSS helps to create the look and the feel of the application and the code helps in controlling the data storage and decision making. Thus the controller handles all the data to be stored and manipulated at the app engine data base. The data bases are usually created through the python programming language. The data base will store the basic information about the users which includes his name, age, whether he drinks or not, how often he drinks, whether he smokes or not, how often he smokes, whether he consumes fried foods, how often he consumes fried products, what all does he include in his fried diet, whether he consumes meat and more specifically red meat and in which forms. These information forms the basic details of the user which are to be provided initially while registering with server. Each user will then be provided a unique identity key. The user's heart rate and the GPS location send by the application is stored in the database containing the user id, user heart rate and the user GPS location, and the classification of the heart rate.

F. CLASSIFICATION ALGORITHM

The system proposes the use of the artificial neural network as the general classification algorithm for classification of the human heart rate. This contains simple highly connected processing elements that compute the result according to the dynamic state of response. The basic neural networks consist of three layers. The input layer which communicate with one or more hidden layer which further gives the out through the output layer. In neural networks the back propagation allows the weights to be adjusted accurately such that the training data is accurately classified in the forward propagation. There are number of heart anomalies that can be accurately classified through the use of the artificial neural network. The back propagation is the particularly the algorithm used for the accurate training of the data sets. The algorithm is used to adjust the data weights there by accurately training the data. The back propagation adjust the weight by calculating the derivatives of the output values and back propagating the values thereby adjusting the weights. The sum of the weights are calculated using the sigmoidal function represented as follows where y represents the output of the values 'w' as the weight.

$$y = \frac{1}{1-e^{-w}} . \qquad (3.1)$$

The neural network representing the general classification can be proposed in the following diagram. The input nodes are represented through the i(n)s n>=1, the h(n),s represent the hidden nodes and the o(n)'s represent the output nodes.

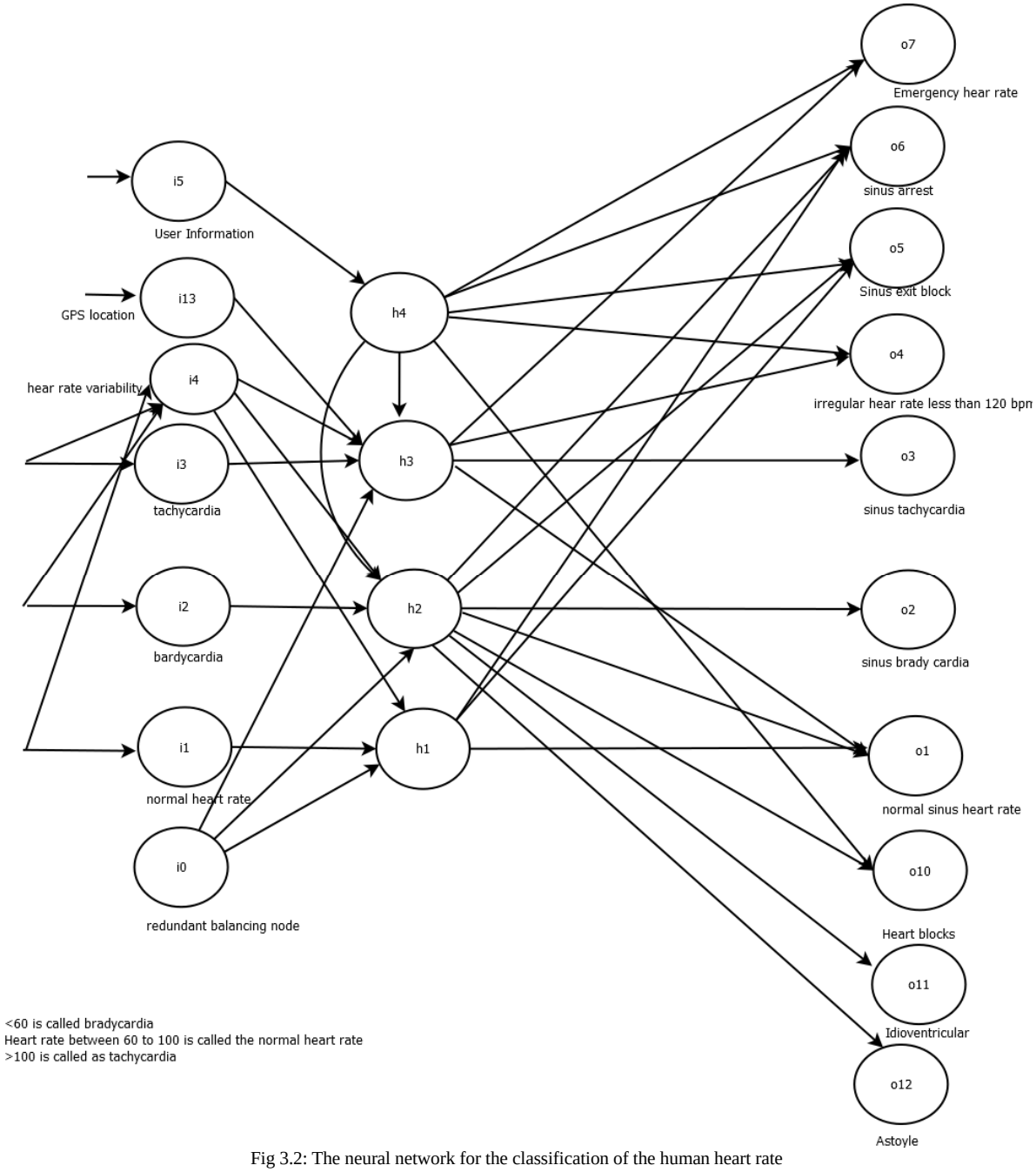

Fig 3.2: The neural network for the classification of the human heart rate

Each of the node have their respective weights assigned to them. Based on the value of the weight at each of the hidden layer the output of the database can be mapped successfully. The neural network proposed here for learning has only one internal hidden layer. The network is first trained on some of the sample input data and with the help of the principles of back propagation, the weights are corrected for each of the input nodes obtained. The following diagram indicates the structure of the neural networks. In the above network the different parameters arte given different weights. These weights are accumulated and at each of the hidden node the values are calculated. The attributes considered are the various parameter affecting the functioning of the heart. For a general classification of the heart rate as normal heart rate, in the neural networks if the bpm is recorded to be in between 60 -100 and the beats does not change drastically that is the current bpm is same or approximately equal to the recorded normal heart rate then the heart rate is classified as the normal heart rate. Accordingly a number of classification can be made on the data sets based on the above neural network. It makes use of the GPS location, user heart rate, and the user profile which includes different parameters such as his age, weight height and other related data. The heart rate greater than 150 beats per minute is considered to be dangerous. In such cases the user is notified about this dangerous situation. The sinus bradycardia can be characterized by regular heart rate less than 60 beats per minutes. Similarly the sinus Tachycardia can be detected if the regular

beats are greater than 100 beats per minute. A chaotic heart rate greater than 100 beats per minutes might result into Multifocal Atrial Tachycardia most common in the elderly people. The variation of the heart rate typically periodic sudden decrease in the heart rate might be a case of the sinus exit block. When the variation increases to a large extent the heart may portray sinus arrest which is a life threatening dysthymia. Heart blockage can be detected based on the heart rate. When there is a variation of the heart rate during the bradycardia, with different levels of variations, different degree of heart blockage can be detected, and the user can be notified similarly. When the heart rate is alarmingly low such as in Idioventricular and Asystole the users nearest relative can be notified accordingly

G. DATAFLOW DIAGRAM:

As per the diagram the user first wears the heart rate sensors. The heart rate sensor then advertises and looks for any available services. On detection of a valid device the sensor and the device undergo a small paring. The user is requested to register his basic information that is further registered in the data base maintained at the server (cloud system in this case). The device establishes a connection with the system. The heart rate sensor sends constant information to the connected device every 1 second. The device sends the user heart rate, and its GPS location to the server. At the server the data is constantly mined using the artificial neural network explained in the above section. The cloud through the use of the Google cloud messaging sends the constant notification to the user regarding the basic heart functioning. In case of any emergency such as arrhythmia or cardiac arrest, the users GPS location is broad casted to the numbers registered by the user.

The following diagram indicates the dataflow of the entire system. The data flow diagram can be indicated as follows

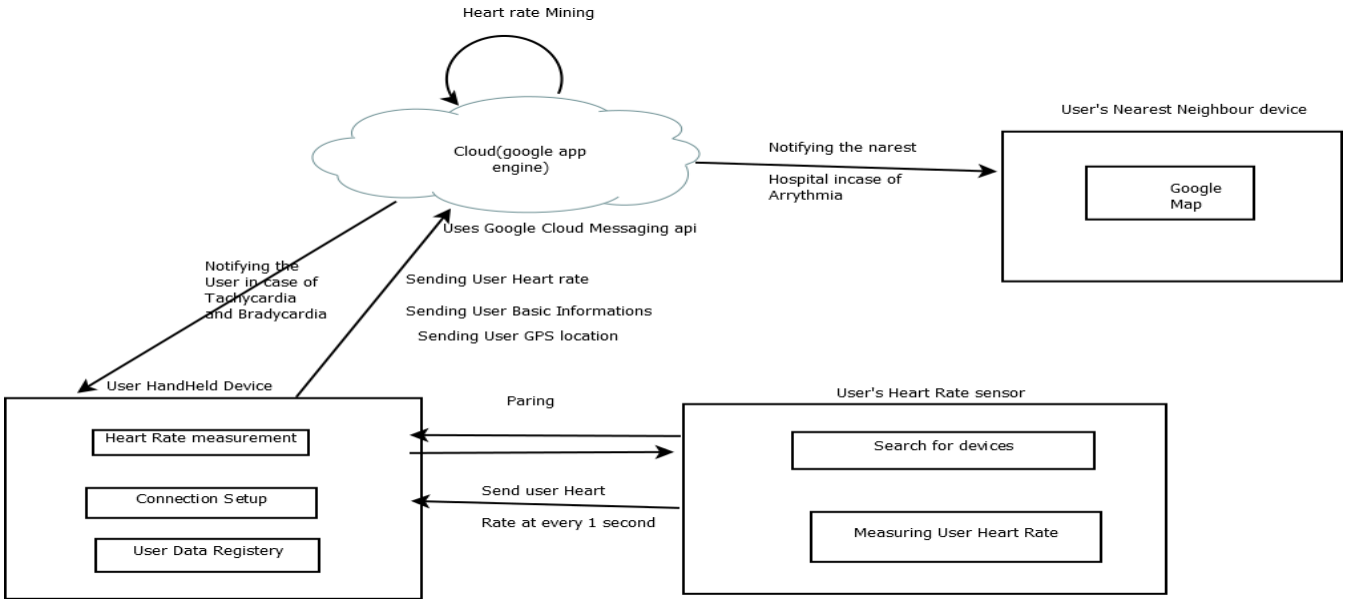

Fig 3.3: Data flow diagram of the entire system

IV. CONCLUSION

This paper proposes the technology for mHealth on the principles of the Internet of Things. The different techniques were studied during the course of this paper. The concept of internet of things works on the principles of the device to device connectivity. The paper shows how the low energy devices can be connected to the portable mobile device (android device). The different Bluetooth low energy services were also studied.

The basic operation of the sensors along with operation of Bluetooth 4.0+ were studied through the course of this paper. The paper also describes the operation of the same. The different services used by the sensor and the mechanism of their connectivity was studied. The android application in order to be compatible with the heart rate sensor requires be at a version of 4.3 or greater. The mechanism of pairing and establishing the connection was studied.

Google app engine can provide a better connectivity to the android application. These application can communicate with the backend cloud access points by creating the respective API and using them as the libraries in the application. The mechanism of communication of the android application with google app engine through the use of the google cloud messaging was studied here.

The Human heart rate can be mined through different algorithms. The artificial neural networking provides a better mechanism of classification and predicting the result based on the training data. The ANN has a large power of learning and can provide association between the unrelated data. For the classification of the human heart rate the artificial neural networks has one hidden layer used for the computation and further classification.

Thus the paper intends to make human health care system ubiquitous. The measurement of the human heart rate and there by an early detection can be made possible. This would further facilitate the human health making it more salubrious and thereby increasing the life expectancies.

ACKNOWLEDGEMENT

We would like to thank our college Fr.C.Rodrigues Institute of technology for providing an opportunity for working on this topic. We would also like to thank out mentor and guide Mr. Mritunjay Ojha for guiding us throughout the process. Lastly we would like to acknowledge the work done by various researchers from the field of android application development, Cardiologist and researchers from cloud computing, which has helped us greatly in the study for this paper.

References

1. Intel, “Internet of Things”, article, June 2014; https://software.intel.com/sites/billboard/article/internet-things-fast-forward-now?cid=sm-FBPAGEIntel%20IoT%202014&utm_source=FBPAGE&utm_medium=social&utm_content=Intel%20Developer%20Zone%20%20IntelDeveloperZone&utm_campaign=smIntel%20IoT%202014&postid=61999264&clientid=1249&linkId=8394702
2. Jayavardhana Gubbi Rajkumar Buyya, Slaven Marusic, Marimuthu Palaniswamia, “Internet of Things (IoT): A Vision, Architectural Elements, and Future Directions”, Department of Electrical and Electronic Engineering, the University of Melbourne, 2012.
3. Berg,”Four types of Internet of Things”, blog, 2 April. 2014; http://blog.bergcloud.com/2014/04/02/four-types-of-iot/
4. WHO, “mHealth. New horizons for health through mobile technologies”, Global observatory for eHealth series, vol. 3, 2011
5. Chang Liua, Qing Zhua, Kenneth A. Holroydb, Elizabeth K. Seng,” Status and trends of mobile-health applications for iOS devices: A developer’s perspective “ , School of EECS, Ohio University, United States b Psychology Department, Ohio University, United States, 6 July 2014.
6. Khalid Abu Al-Saud, Massudi Mahmuddin and Amr Mohamed, “Wireless Body Area Sensor Networks Signal Processing and Communication Framework: Survey on Sensing, Communication Technologies, Delivery and Feedback”, Journal of Computer Science 8 (1): 121-132, 2012
7. ISSN 1549-3636, Department of Computer Science and Engineering, College of Engineering, Qatar University, Qatar Awang Had Salleh Graduate School of Arts and Science, University Utara Malaysia, 06010 UUM Sintok, Kedah, Malaysia
8. American Heart Association, “Heart rate”, Aug 2014; http://www.heart.org/HEARTORG/search/searchResults.jsp?_dyncharset=ISO-8859-1&q=heart+rate
9. Jochen H. Schiller, “Mobile communication”, Pearson Education Limited, ISBN 0 321 12381 6, Second edition, 2003.
10. Bluetooth,”GATT service specification”, Aug 2014; https://developer.bluetooth.org/gatt/services/Pages/ServicesHome.aspx
11. Google Cloud Platform,” Building mobile application with App Engine Backend”, Aug 2014;https://cloud.google.com/developers/articles/how-to-build-mobile-app-with-app-engine-backend-tutorial
12. Google Cloud Platform,” Google Cloud Endpoints”, Aug 2014 https://developers.google.com/appengine/docs/java/endpoints/
13. American Heart Association,” Cardiovascular Circulation”, Aug 2014; http://circ.ahajournals.org/
14. K.Srinivas1 Dr. G. Raghavendra Rao2 and Dr. A.Govardhan3,”Survey on prediction of heart morbidity using data mining techniques”, International Journal of Data mining and knowledge Management Process, vol. 1 no .3, May 2011.
15. Polar,” H7 heart rate sensor”, Aug 2014; http://developer.polar.com/wiki/H6_and_H7_Heart_rate_sensors
16. Retro Meier, “Professional Android 4 Application development”, John Wiley and Sons, Inc., 2014
17. Android Developers, “Bluetooth low Energy and its connectivity”, Sep 2014 http://developer.android.com/guide/topics/connectivity/bluetooth-le.html
18. By Valerie GAY, Peter, ” A Health Monitoring System Using Smart Phones and Wearable Sensors”, International Journal of ARM, vol. 8, no. 2, Faculty of IT, University of Technology Sydney, June 2007.

