A Real-Time Monitoring System with BSN for Remote Cardiac &Blood Pressure Patients

A Project Submitted in Partial Fulfillment of the Requirements for the Degree of Bachelor in Computer Science & Engineering

by

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Abstract

In several countries, including our own, cardiovascular disease is the most common cause of mortality and morbidity. Myocardial infarction (heart attack) is of particular importance in heart disease as well as time and type of reaction to acute myocardial infarction and these can be a determining factor in patients' outcome. In order to reduce doctor's attendance time and keep patients informed about their condition, this system would be helpful. Internet of Things (IoT) based wireless healthcare monitoring system that can provide real time online information about medical conditions of a patient.Currently most hospitals do not have remote monitoring system. Our propose system is a solution to upgrade existing health monitoring systems in hospitals by providing remote monitoring capability. In addition, thissuggested system is able to generate warning messages to the doctor and patient under critical circumstances.

Approval

The project report "A Real-Time Monitoring System with BSN for Remote Cardiac &Blood Pressure Patients" submitted by Sabbir Ahmed Ayubi, STUDENT_ID: CSE05006471, to the Department of Computer Science & Engineering, has been accepted as satisfactory for the partial fulfillment of the requirements for the degree of Bachelor of Science (B.Sc.) in Computer Science & Engineering and as to its style and contents.

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Declaration

We, hereby, declare that the work presented in this Thesis is the outcome of the investigation performed by us under the supervision of Tarikuzzaman Emon, Senior Lecturer, Department of Computer Science & Engineering, Stamford University Bangladesh, after Dr. MohammadShaharia Bhuiyan, Assistant Professor of the Department of Computer Science & Engineering, Stamford University Bangladesh leaving the university. We also declare that no part of this Project and thereof has been or is being submitted elsewhere for the award of any degree or Diploma.

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Introduction

1 Introduction

1.1 RESEARCH BACKGROUND

Health monitoring systems become a hot topic and important research field today. Research on health monitoring were developed for many applications such as military, homecare unit, hospital, sports training and activity emergency monitoring system. In this paper, we developed the wearable and Real-Time Monitoring System with BSN for Remote Cardiac &Blood Pressure Patients. With the advent of computers, technology is playing an ever-increasing role in society by making jobs easier and faster, providing new medians for communications, and most importantly, increasing quality of life with medical devices. Through the twentieth century, medical devices have helped save lives.

A modernized healthcare system should provide better healthcare services to people at any time and from anywhere in an economic and patient friendly manner. Currently, the healthcare system is undergoing a cultural shift from a traditional approach to a modernized patient centered approach. In the traditional approach the healthcare professionals play the major role. They need to visit the patients for necessary diagnosis and advising. There are two basic problems associated with this approach. Firstly, the healthcare professionals must be on site of the patient all the time and secondly, the patient remains admitted in a hospital, wired to bedside biomedical instruments, for a period of time. In order to solve these two problems, the patient oriented approach has been conceived. In this approach the patients are equipped with knowledge and information to play a more active role in disease diagnosis, and prevention. The key element of this second approach is a reliable and readily available patient monitoring system (PMS) [1].

1.2 RESEARCH MOTIVATION

Blood Pressure (BP) is considered to be a strong indicator of an individual's well-being and one of the most important physiological parameters that reflect the functional status of the cardiovascular system of human beings. There is evidence of a direct relationship between blood pressure and cardiovascular diseases which represents nearly 50% of the world's cause of death by non-communicable diseases. However, BP is also known to be a very unstable parameter and its variability alone is considered by some to be a separate independent risk factor itself. In addition, conventional methods of monitoring BP in clinics or at home are either limited to simple measurement of systolic and diastolic blood pressure at intervals or uncomfortable and unreliable to use over prolonged periods of time. Consequently, the development of a non-invasive and ambulatory system for continuously monitoring BP levels would provide deeper insight and understanding of the underlying mechanisms behind blood pressure variability. More importantly, such device would help predicting the triggering of serious cardiovascular events and making anti-hypertensive therapy decisions [2].

Cardiovascular disease is the most common cause of mortality, morbidity and health costs in our own country Bangladesh and in many other countries. Moreover, according to published reports, with the increase of coronary artery disease, this disease is considered to be the first cause of mortality in developing countries. Myocardial infarction (MI) or its serious form acute myocardial infarction (AMI) is the medical term for a heart attack. Early mortality (within 30 days) associated with a heart attack is 30%, and despite improvements in emergency medical services, more than 50% occur before reaching the hospital. The initial reaction time for people suffering from AMI is important and can be a determining role in their fate. Evidence shows that the rate of illness and death decreased in patients who experienced AMI and received standard treatment in the first two hours. Fortunately, in recent years the treatment of coronary perfusion has developed and so it can reduce damages caused by AMI. By decreasing the interval between the onset of symptoms and administration time of drugs, better results can be achieved. An Australian study shows that if treatment is started up to one hour of onset of symptoms, the mortality rate decreases 45%, and if treatment is started after three hours of symptom onset, the mortality decreases 23%. Another study in the U.S. shows that only 5% of patients received reperfusion therapy within the first hour after the onset of symptoms, and most delayed coming to the emergency department [3].

Cardiovascular disease (CVD) is the single leading cause of global mortality and is projected to remain so. Cardiac arrhythmia is a very common type of CVD and may indicate an increased risk of stroke or sudden cardiac death. The ECG is the most widely adopted clinical tool to diagnose and assess the risk of arrhythmia. ECGs measure and display the electrical activity of the heart from the body surface. During patients' hospital visits, however, arrhythmias may not be detected on standard resting ECG machines, since the condition may not be present at that moment in time [4].

1.3 OBJECTIVES

Increasing rate of chronic diseases in aging population is becoming a serious concern due to lack of sufficient facilities and extremely high cost. The situation is even worse for the people residing in remote areas far from medical facilities as delay in diagnosis and treatment may lead to death. Timely diagnosis and treatment can solve these issues to a great extent. This work aims at creating or extending a suitable model for estimating Remote Cardiac &blood pressure using wireless sensors as explained in chapter (2). Using the developed model, it is expected that calibration of the system is facilitated. Moreover, testing of the model using appropriate computational simulations will take place. Once the model has been simulated, it needs to be incorporated in the wireless, wearable sensor network that acquires the sensors data and estimates arterial blood pressure and heart rate. The pervasive wearable system that interacts with the user will be improved in parallel. Lastly, the clinical assessment of the global system needs to be tested in real patients and the acquired data clinically validated.

1.4 PROBLEM STATEMENT

Cardiovascular disease risk factors:

Cardiovascular risk factors:

There are many risk factors associated with coronary heart disease and stroke. Some risk factors such as family history, ethnicity and age, cannot be changed. Other risk factors that can be treated or changed include tobacco exposure, high blood pressure (hypertension), high cholesterol, obesity, physical inactivity, diabetes, unhealthy diets, and harmful use of alcohol.

Of particular significance in developing countries is the fact that while they are grappling with increasing rates of cardiovascular disease, they still face the scourges of poor nutrition and infectious disease. Nevertheless, with the exception of sub-Saharan Africa, cardiovascular disease is the leading cause of death in the developing world.

You will not necessarily develop cardiovascular disease if you have a risk factor. But the more risk factors you have the greater is the likelihood that you will, unless you take action to modify your risk factors and work to prevent them compromising your heart health.

Modifiable risk factors
Hypertension is the single biggest risk factor for stroke. It also plays a significant role in heart attacks. It can be prevented and successfully treated but only if you have it diagnosed and stick to your recommended management plan.

Abnormal blood lipid levels, that is high total cholesterol, high levels of triglycerides, high levels of low-density lipoprotein or low levels of high-density lipoprotein (HDL) cholesterol all increase the risk of heart disease and stroke. Changing to a healthy diet, exercise and medication can modify your blood lipid profile.

Tobacco use, whether it is smoking or chewing tobacco, increases risks of cardiovascular disease. The risk is especially high if you started smoking when young, smoke heavily or are a woman. Passive smoking is also a risk factor for cardiovascular disease. Stopping tobacco use can reduce your risk of cardiovascular disease significantly, no matter how long you have smoked.

Physical inactivity increases the risk of heart disease and stroke by 50%. Obesity is a major risk for cardiovascular disease and predisposes you to diabetes. Diabetes is a risk factor for cardiovascular disease.

Type2 diabetes a major risk factor for coronary heart disease and stroke. Having diabetes makes you twice as likely as someone who does not to develop cardiovascular disease. If you do not control diabetes then you are more likely to develop cardiovascular disease at an earlier age than other people and it will be more devastating. If you are a pre-menopausal woman, your diabetes cancels out the protective effect of estrogen and your risk of heart disease rises significantly.

A diet high in saturated fat increases the risk of heart disease and stroke. It is estimated to cause about 31% of coronary heart disease and 11% of stroke worldwide.

Being poor, no matter where in the globe, increases your risk of heart disease and stroke. A chronically stressful life, social isolation, anxiety and depression increase the risk of heart disease and stroke.

Having one to two alcohol drinks a day may lead to a 30% reduction in heart disease, but above this level alcohol consumption will damage the heart muscle.

Certain medicines may increase the risk of heart disease such as the contraceptive pill and hormone replacement therapy (HRT).

Left ventricular hypertrophy (LVH) is a risk factor for cardiovascular mortality.

Non-modifiable risk factors

Simply getting old is a risk factor for cardiovascular disease; risk of stroke doubles every decade after age 55.

Your family's history of cardiovascular disease indicates your risk. If a first-degree blood relative has had coronary heart disease or stroke before the age of 55 years (for a male relative) or 65 years (for a female relative) your risk increases.

Your gender is significant: as a man you are at greater risk of heart disease than a pre-menopausal woman. But once past the menopause, a woman's risk is similar to a man's. Risk of stroke is similar for men and women.

Your ethnic origin plays a role. People with African or Asian ancestry are at higher risks of developing cardiovascular disease than other racial groups. [5]

Hypertension and cardiovascular disease

There are at least 970 million people worldwide who have elevated blood pressure (hypertension).

In the developed world, about 330 million people have hypertension, as do around 640 million in the developing world. The World Health Organization rates hypertension as one of the most important causes of premature death worldwide and the problem is growing.81 In 2025 it is estimated there will be 1.56 billion adults living with high blood pressure.

What counts as hypertension?

High blood pressure is defined as a systolic blood pressure at or above 140 mmHg and/or a diastolic blood pressure at or above 90 mmHg. Systolic blood pressure is the maximum pressure in the arteries when the heart contracts. Diastolic blood pressure is the minimum pressure in the arteries between the heart's contractions.

How hypertension impacts on your heart and blood vessels

Hypertension is a risk factor for coronary heart disease and the single most important risk factor for stroke. It causes about 50% of ischaemic strokes and increases the risk of hemorrhagic stroke.

Hypertension stresses your body's blood vessels, causing them to clog or weaken. Hypertension can lead to atherosclerosis and narrowing of the blood vessels making them more likely to block from blood clots or bits of fatty material breaking off from the lining of the blood vessel wall. Damage to the arteries can also create weak places that rupture easily or thin spots that balloon out the artery wall resulting in an aneuvrism.

Elevated blood pressure in people less than 50 years old is associated with an increased cardiovascular risk. As you get older, your systolic blood pressure becomes a more important predictor of the risk of cardiovascular disease.

Although increasing blood pressure is part of aging, a healthy low salt diet, physical activity and maintaining a healthy weight can reduce the risk of this happening.

Dietary salt is a significant factor in raising blood pressure in people with hypertension and in some people with normal blood pressure. If you are already overweight then a high intake of salt increases your risk of cardiovascular disease.

Types of hypertension

The amount of blood pumped by the heart and the size and condition of the arteries determines your blood pressure. However, many other factors can affect blood pressure including the condition of your kidneys and levels of various hormones in the body.

Some people experience essential hypertension, which has no identifiable cause. If you are diagnosed with this its origins may be genetic, or due to your lifestyle including diet, weight and physical inactivity. Secondary hypertension is caused by another condition such as problems with your kidneys, certain medicines and some other medical problems [6].

1.5 METHODOLOGY OF RESEARCH

Heart diseases have become one of the leading causes of human fatalities around the world; for instance, approximately 2.8 million people die each year as a result of being overweight or obese as obesity can lead to adverse metabolic effects on blood pressure and cholesterol which ultimately increases the risks of coronary heart disease, ischemic stroke, diabetes mellitus, and a number of common cancers. According to WHO, it has been estimated that heart disease rate might increase to 23.3% worldwide by the year 2030. The treatment of such chronic diseases requires continuous and long-term monitoring to control threat.

The ubiquitous social connectivity can be used in telemedicine for remote monitoring and offsite diagnoses. It should be noted that over 94%of the world population, that is, 6.8 billion people, are the subscribers of cell phone and about 2.7 billion subscribers are using Internet. Cell phone subscription is increasing rapidly and might reach the level of 8.5 billion by the end of 2016 with 70% of smartphone users from developing countries. In addition, smartphones technology comprises various services such as location tracking, short message service, and access of WLAN/GPRS/3G which provides ubiquitous connectivity. There are extensive studies on use of mobile phones in healthcare and clinical practices illustrating the use of inbuilt applications of smartphones like GPS and location enabled services which offer independent survival of old age patient with fragilities. Existing studies have also highlighted the uses of inbuilt apps in continuous monitoring and maintaining individual records; for instance, in another study, the authors discussed the benefits of existing smartphone health apps considering their credibility for continuous data flow, feasibility, portability, and power consumption. Nevertheless, the discrepancies such as battery consumption, calibration, and generation of false alarms have challenged the capabilities of smartphone apps in the implementation of real-time health monitoring and diagnosis.

An alternative to inbuilt smartphone sensors is wearable sensors that have been used for continuous monitoring, storing, and sending medical data to healthcare givers over distance. Existing studies with wearable sensors offer monitoring in applications like physiological, biochemical, and motion sensing. These sensors have been used in monitoring health indicators and body positions of the patients, as well as in keeping track of sports and other activities. These wearable sensors are becoming promising due to the fact that these sensors are lowcost, easily available, user friendly, accurate, and reliable. Many studies explored the clinical applications of wearable sensors in cardiovascular, neurological, asthma, and hypertension diseases. For instance, developed a system to monitor congestive heart failure in patients, comprising a biosensor in the form of a ring that monitors heart data. Similarly, systems have been designed to monitor respiratory diseases which record acoustic signals by placing a microphone on the neck of the patient while breathing. The framework consisted of a band-pass filter to reduce noise and other distortions in signals which helped to achieve approximately 90% of measurement accuracy. The research work was then extended for detecting apneas using algorithms. Wearable technology is also useful in solving the issues of monitoring in motion artifacts by using multiple sensors integrated on a single chip. Integration of different sensors on same platform (tight fitting in garment) in order to monitor respiratory diseases is another kind of application. These systems are found to be better than spirometry but still require advancements to minimize motion artifacts.

Further, although wearable technology has contributed heavily in the advancement of healthcare monitoring systems, concerns are there that may affect performance of the healthcare monitoring systems. These concerns include (1) failing to use real-time data in the monitoring systems during testing of application, (2) battery issues, (3) security and privacy of the data collected from patients, (4) requirement of medical professional’s recommendations at each step of the development, (5) clinical validation or experts’ acceptability, and (6) user friendliness for the patients and for healthcare professionals. The integration of wearable technologies with mobile networks can offer new potentials of rapid, reliable, and secure information transfer from patients to the doctors [7].

The present study addresses the conclusion of integrating three wearable sensors with modern technology by developing a remote monitoring system for cardiac & blood pressure patients. In this study, we propose a IoT based real-time monitoring system comprising wearable sensor, mobile application, and a web interface to overcome some of the issues, as mentioned in the literature. The wearable sensor has been applied to produce patient's diagnostic information which is then sent to a smartphone wirelessly via Arduino Microcontroller. Further, the gathered data on the smartphone is transferred to a web interface via Wi-Fi/3G.The proposed system has the capacity to create emergency alerts on the basis of predefined values by comparing patient's data to inform the doctor to check the patient.

This study develops a remote monitoring diagnostic framework to detect underlying heart conditions in real-time which helps avoiding potential heart diseases and rehabilitation of the patients recovering from cardiac diseases. The proposed real-time monitoring system is compatible to use various wearable sensors to extract medical information which helps finding out multiple parameters such as Heart Rate, Blood Pressure, and ECG at the same time. These cardiac parameters help early detection of diseases such as arrhythmia, hypotension, hypertension, and hyperthermia through alarming system based on mobile application. Similar to the existing monitoring systems, the developed system architect is three-tire comprising. (1) A patient interface, that is wearable medical sensors, (2) Arduino board with e-Health Sensor Shield and Xbee Shield, and (3) Mobile application and web server. The patient interface is comprised of wearable sensors which extract medical information of the patients and transmit to an Arduino board. Arduino transfers this information to mobile app/web server via Wifi/Bluetooth which processes data to show reports on doctor interface (via mobile application). The details of the system architecture, components, data processing are explained in chapter (3).

Chapter: 2

Literature Review

2Literature Review

Wireless health monitoring system (WHMS) has drawn considerable attentions from the researchcommunity as well as industry during the last decade. Numerous and yearly increasing researchand development efforts have been posted in the literatures. We have limited this effort to include only some of the very recent related works.

Wireless based healthcare system for monitoring the patients with Myocardial infarction (heart attack) disease has been developed and presented in [3]. The system is able to provide medical professional with the ability to be in contact with the patients all the time. This system has been field tested by the authors. The reliability and robustness of the proposed system has been verified by the authors.The experimental results show that the proposed system is able to monitor the physiological dataof patients.

Real time mobile healthcare system for monitoring the elderly patients from indoor or outdoorlocations has been presented in [8]. A bio-signal sensor and a smartphone are the main components of the system. The data collected by the bio-signal sensor are transmitted to an intelligent server via GPRS/UMTS network. The system is able to monitor the mobility, location, and vital signs of the elderly patient from a remote location.

A complete wireless body area network (WBAN) system has been designed in [9]. The proposed system uses medical bands to obtain physiological data from sensor nodes. The author has chosen medical bands in order to reduce the interference between the sensor device and other existing network devices. To increase the operating range multi-hopping technique has been used and a medical gateway wireless board has been used in this regard. This gateway has been used to connect the sensor nodes to a local area network or the Internet. By using Internet, the 2healthcare professionals can access patients' physiological data from anywhere at any time.

Wireless electrocardiogram (ECG) monitoring system based on Bluetooth Low Energy (BLE) technology has been reported in [10]. The system consists of (i) a single-chip ECG signal acquisition module, (ii) a Bluetooth module, and (iii) a smartphone. The system is able to acquire ECG signals through two-lead electrocardiogram (ECG) sensor. The system is also able to transmit the ECG data via the Bluetooth wireless link to a smartphone for further processing and displaying the ECG signals. The results show that the proposed system can be operated for a long period of time due to low power BLE technology.

A system to monitor the blood pressure of a hypertensive patient using mobile technologies has been proposed in [11]. By using the system, a doctor can carefully monitor the patient and can perform diagnosis. The system is implemented on the Java platform and it can reside in a small capacity device. The system is also able to communicate with a server via Internet. The server is used for storing and displaying patient data graphically.

Real time ubiquitous healthcare system for monitoring ECG signals by using mobile devicehas been presented in [12]. By using this system, the user can monitor his ECG signal. Theauthors have presented an algorithm for abnormal heartbeat detection and abnormal heartbeatcheck map

(AHCM). The performance of the proposed system has been evaluated against theMIT-BIH normal arrhythmia database. It has been reported that the system is able to detect at anR-peak with a success rate of 97.8% and it is also able to detect abnormal heartbeat conditionwith a success rate of 78.9%.

A wearable cardiac monitor for continuous and real-time monitoring of user's cardiac condition is introduced in [13]. The proposed device is composed of 3 main components: a disposable electrode, a controller, and personal gateway (e.g., cellular phone, PDA, and smart phone, etc.). The ECG signal is recorded according to the surface Laplacian of the body surface potential. WHAM shows enough feasibility and has advantages as a wearable ambulatory monitoring device in that the hardware is miniaturized enough small to integrate on a small region, thereby no wire leads need. This system is developed to monitor the ECG of the patient if the patient is not mobile. Whereas the proposed system is capable to continuously monitor patients in all states such as mobile or immobile.

In my work we present BSN (Body Sensor Network) based patient monitoring system. The system operation is completed in three main steps as shown in Figure 1. To implement the system, we connect the sensors attached with the patient's body. A real-time monitoring system comprising a wearable sensor, mobile application, and a web interface to overcome some of the issues, as mentioned in the literature. The wearable sensor has been used to generate patient's diagnostic information which is then transferred to a smartphone wirelessly via Bluetooth low energy technology. Further, the collected information on the smartphone is transferred to a web interface via Wi-Fi/3G. The proposed system has the ability to generate emergency alerts on the basis of predefined values by comparing patient's data to inform the doctor if there is a requirement of checkup or investigation.

Chapter: 3

System Architecture: Materials and Methods

3 System Architecture: Materials and Methods

3.1 Materials and Methods

This inquiry expands a remote monitoring diagnostic structure to identify underlying heart and blood pressure conditions in real-timewhich helps avoiding potential heart diseases and rehabilitation of the patients recovering from cardiac diseases. The suggested real-time monitoring system is compatible to use various wearable sensors to extract medical information which helps finding out multiple parameters such as Heart rate, Blood Pressure, and ECG at the same time. For example, these cardiac parameters help early detection of diseases such as arrhythmia, hypotension and hypertension etc. The details of the system architecture, components, data processing are explained as follows.

3.2. System Architecture.

The main architecture of the system can be implemented to obtain various applications. Our system's prototype is implemented as shown in Figure 1 which shows the system architecture with the main interfaces. There are various types of medical sensors can be used by the Arduino Sensor Platform. These sensors are: SPO2, airflow (breathing), body temperature, ECG, glucometer, galvanic skin response, patient position, muscle/electromyography sensor (EMG) etc. The primary goal of this thesis is monitoring blood pressure, ECG and heart rate wirelessly so other medical sensors can be used arbitrarily depending on the future work of the thesis.

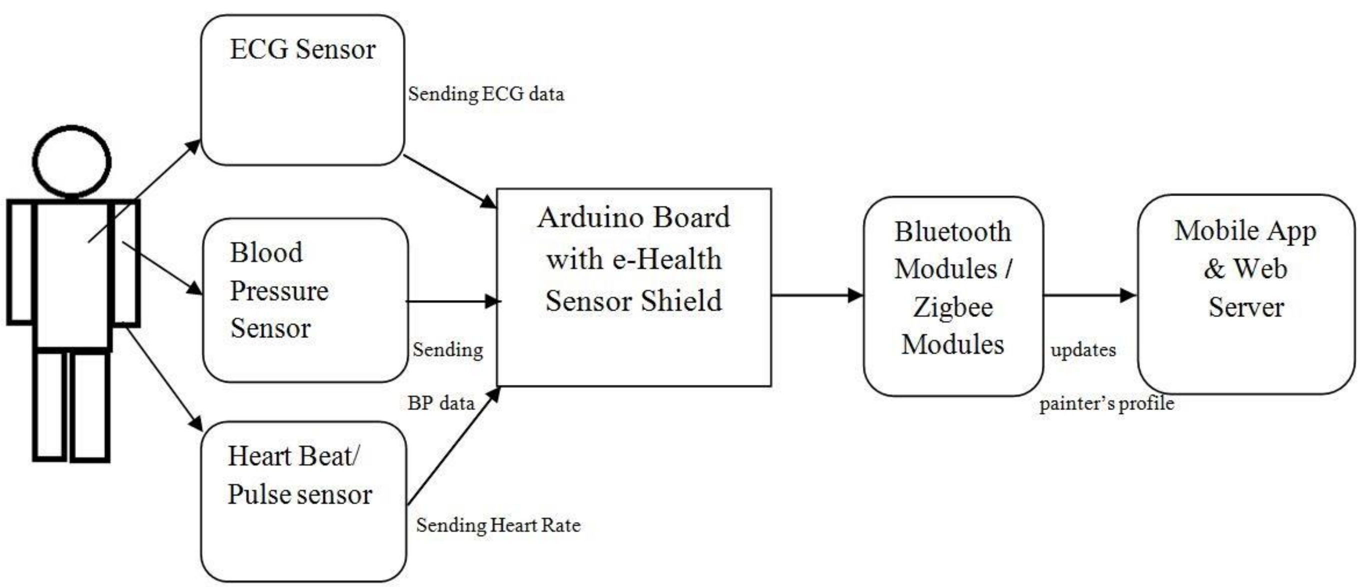

Figure 3.1: System architecture for remote patient monitoring system.Medical Sensors Interfacing with Arduino board

There are three parts in the system architect.

1. A patient interface, that is wearable medical sensors,
2. Arduino board with e-Health Sensor Shield and Xbee Shield, and
3. Mobile application and web server

The first tire of the system is patient's interface which consists of multiple wearable sensors used to collect medical information of the patient. This tire transmits the real-time data from wearable sensors worn by the patient to second tire of the system via sensors. The second tire consists of an Arduino board with e-Health Sensor Shield and ZigBee wireless sensor network used to extract patient's information from wearable sensors. Arduino board using the ZigBee network to transmit the data to the mobile application and web server. The third tire mobile application received the transmitted data and uploads it in the web server to view the data later by the patient and doctor. If any abnormal data received, then the mobile applications notify the doctor by sending a mail and messages.

3.3 e-Health Sensor Platform v2

The e-Health Sensor Platform has been designed byCooking Hacks [14] in order to help researchers, developers and artists to measure biometric sensor data for experimentation, fun and test purposes. This shield provides a cheap and open alternative solution compared with the proprietary and price prohibitive medical market alternatives. However, as the platform does not have medical certifications, it cannot be used to monitor critical patients who need accurate monitoring or those conditions must be accurately measured for an ulterior professional diagnosis.

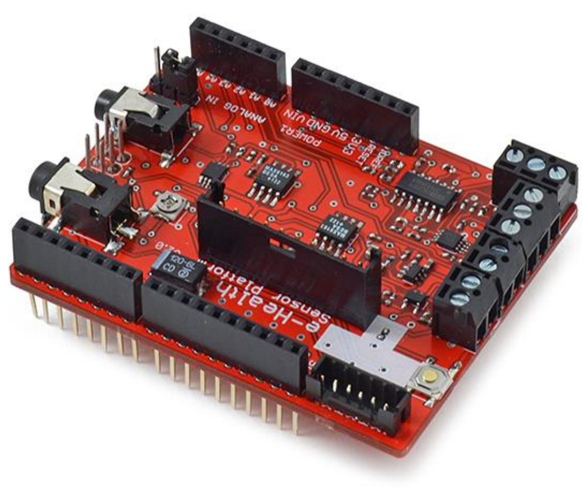

Fig. 3.2 e-Health Sensor Platform

The e-Health Sensor Platform as shown in Figure 2, allows Arduino and Raspberry Pi users to perform biometric and medical applications where body monitoring is needed by using 9 differentsensors. This information can be used to monitor in real time the state of a patient or to get sensitive data in order to be subsequently analyzed for medical diagnosis. The shield has various input and outputs for connecting different medical sensors as described above, also a graphic LCD can be used by the shield. Shield also compatible with all UART devices.

3.4 Electrocardiogram (ECG)

The electrocardiogram (ECG or EKG) is a diagnostic tool that is routinely used to assess the electrical and muscular functions of the heart.

The Electrocardiogram Sensor (ECG) has grown to be one of the most commonly used medical tests in modern medicine. Its utility in the diagnosis of a myriad of cardiac pathologies ranging from myocardial schema and infraction to syncope and palpitations has been invaluable to clinicians. The accuracy of the ECG depends on the condition being tested. A heart problem may not always show up on the ECG. Some heart conditions never produce any specific ECG changes. ECG leads are attached to the body while the patient lies flat on a bed or table.

The electrocardiogram (ECG or EKG) is a noninvasive test that is used to reflect underlying heart conditions by measuring the electrical activity of the heart. By positioning leads (electrical sensing devices) on the body in standardized locations, information about many heart conditions can be learned by looking for characteristic patterns on the EKG

What is measured or can be detected on the ECG?

1. The orientation of the heart (how it is placed) in the chest cavity.
2. Evidence of increased thickness (hypertrophy) of the heart muscle.
3. Evidence of damage to the various parts of the heart muscle.
4. Evidence of the acutely impaired blood flow to the heart muscle.
5. Patterns of abnormal electric activity that may predispose the patient to abnormal cardiac rhythm disturbances.
6. The underlying rate and rhythm mechanism of the heart. [15]

Fig. 3.3 Electrocardiogram (ECG) Sensor attached to e-Health Sensor Platform

The Electrocardiogram (ECG) Sensor as shown in Figure 3 has been designed by Cooking Hacks [14] which is fully compatible with e-Health Sensor Platform. The electrocardiogram has 3 leads these are positive negative and neutral as shown in Figure 3, these leads will be connected to the electrodes and then placed on the patient's body.

3.5 Blood Pressure

Blood pressure is the pressure of the blood in the arteries as it is pumped around the body by heart. When yourheart beats, it contracts and pushes blood through the arteries to the rest of your body. This force creates pressure onthe arteries.Blood pressure is recorded as two numbersthesystolic pressure(as the heart beats) over the diastolic pressure(as the heart relaxes between beats). There are emerging techniques to take blood pressurereadings without the use of artery constriction but suchmethods are not commercially available. Inflating the cuff automatically requires a pump and the development of algorithmsand circuitry to control the pump. Logic must bewritten to determine readings based on the release of pressure in the cuff. For these and several other problems involved building a pressure monitor from the beginning is beyond the scope of the project. The hope was that one ormore existing blood pressure monitors on the market would have a simple interface that would allow programmatic controland access to unit's memory, perhaps via USB cable. Unfortunately, there are no such monitors on the market. The most suitable and feasible solution for building a prototype is to use the Blood Pressure Sensor (Sphygmomanometer)as shown in Figure 4 which designed by Cooking Hacks [14].

Fig. 3.4 Blood Pressure Sensor Interfacing with e-Health Sensor Shield

The Blood Pressure Sensor has been designed for automatic measurements of systolic, diastolic blood pressures with time and date. Sensor has a large LCD screen with LED backlight, also a touch pad key is attached to the blood pressure sensor. 80 measurement results with time and date can be stored in the device memory. Blood Pressure Sensor is designed as fully compatible with Arduino board. Blood Pressure Sensor and communication modules useUART port for transmission of the data each other. The Blood Pressure Sensor only works with e-HealthSensor Shield V2 which designed by Cooking Hacks [14].Blood Pressure Sensor and Arduino interface each other via-Health Sensor Shield, also as mentioned before other typesof medical sensors can be added to the system for expanding the scope of the project.

3.6 Arduino UNO Board

The Arduino as shown in Figure 5 is a micro controller board based on the ATmega328. It has 14 digital input/outputs pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the micro controller; simply connect it to a computer with a USB cable or power it with aAC-to-DC adapter or battery.

Fig. 3.5 Arduino UNO Board

The Arduino enables electronic process in multidisciplinary projects to be more accessible [16]. The Arduino connectors allow to CPU board to be connected a wide variety of interchangeable add-on modules known as shields. XBeeShield enables an XBee module to be connected to the Arduino boards. e-Health Sensor Shield allows medical sensors to be connected to the Arduino board as described previous parts of the paper.

The Arduino Uno has a number of facilities for communicating with a computer, another Arduino, or other microcontrollers. The ATmega328 provides UART TTL (5V) serial communication, which is available on digital pins 0 and 1of the board.

3.7 Arduino micro-controller software

The Arduino IDE is a cross-platform application written in Java. It is derived from the IDE for the Processing programming language and the Wiring project. The Arduino software consists of a standard programming language compilerand the boot-loader which runs on the board. The Arduino hardware can be programmed using a specific programming language which is similar to C++. It makes programming micro-controller much easier. It can transmit data by writing them onto the serial port using a simple serial communication command with need for synchronization,initialization and using interrupts. The Arduino software is free and open-source. It enormously reduces the cost of microcontroller programming.

3.8 Xbee

The Xbee modules supports the unique needs of lowcost, low-power wireless sensor networks. The modules require minimal power, provide reliable delivery of data, operate within the 2.4 Ghz frequency band are compatible with analogue/digital inputs/outputs adapters. The Xbee module as shown in Figure 6 interfaces with a host device through a logic-level asynchronous serial port [17]. ZigBee technology defines three different device types: coordinator, router and end device.

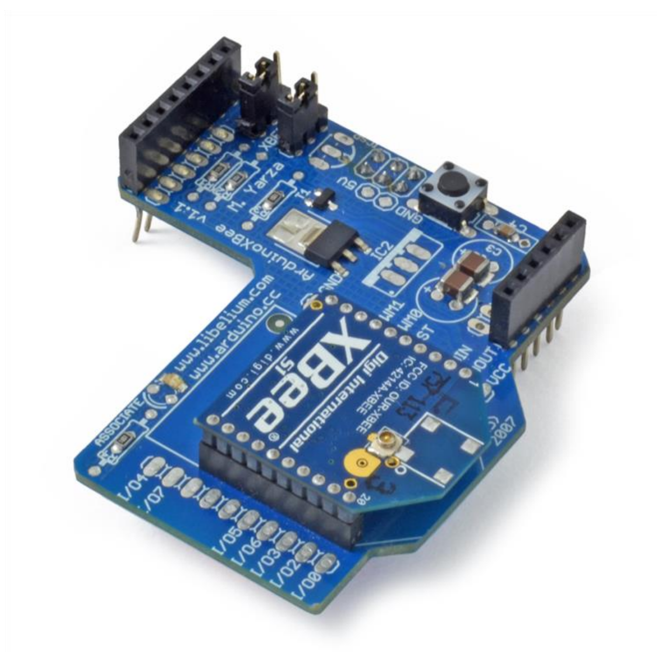

Fig. 3.6 XBee Module attached to XBee Shield

The XBee shield as shown in Figure 6 allows an Arduino board to communicate wirelessly using ZigBee. The module can communicate up to 30 meters indoors.

3.9 Bluetooth

Bluetooth Modules for Arduino as shown in Figure 7 are able to be plugged into the XBee Shield and get a serial communication between the computer and an Arduino board through Bluetooth protocol. Bluetooth module PRO for Arduino supports Serial Port Profile (SPP) to exchange data with other devices. This profile allows to create connections to another device using the same profile (p2p connection). It sends data to specified device. In the development and the implementation of the project, for wirelessly communication between ECG and Blood Pressure Monitor and the management system, Bluetooth modules can be an alternative approach beside the XBee Modules.

Fig. 3.7 Bluetooth Modules for Arduino plugged into the XBee Shield.

3.10 GPRS/GSM

The GSM Quad Band Module for Arduino (SIM900)offers GPRS/GSM connection to Arduino board. The data can send by SMS, make calls or create TCP and UDP socketsin order to send the information to the Internet. HTTP and FTP protocols are also available in order to send the information to the cloud directly from Arduino.

The GPRS module SIM900 as shown in Figure 8 also can be another alternative solution for wireless communication of the system.

Fig 3.8 SIM900 GPRS/GSM Quadband Module for Arduino

Chapter: 4

Implementation

4 Implementation

4.1 Required Hardware

To implement a prototype of this proposed system we need some hardware.

4.1.1 Arduino Uno [18]

Arduino Uno is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. You can tinker with your UNO without worring too much about doing something wrong, worst case scenario you can replace the chip for a few dollars and start over again.

"Uno" means one in Italian and was chosen to mark the release of Arduino Software (IDE) 1.0. The Uno board and version 1.0 of Arduino Software (IDE) were the reference versions of Arduino, now evolved to newer releases. The Uno board is the first in a series of USB Arduino boards, and the reference model for the Arduino platform; for an extensive list of current, past or outdated boards see the Arduino index of boards.

Fig 4.1: Arduino Uno R3

Power

The Arduino Uno can be powered via the USB connection or with an external power supply. The power source is selected automatically.

External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the Gnd and Vin pin headers of the POWER connector.

The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts.

The power pins are as follows:

VIN. The input voltage to the Arduino board when it's using an external power source (as opposed to 5 volts from the USB connection or other regulated power source). You can supply voltage through this pin, or, if supplying voltage via the power jack, access it through this pin.

5V. This pin outputs a regulated 5V from the regulator on the board. The board can be supplied with power either from the DC power jack (7 - 12V), the USB connector (5V), or the VIN pin of the board (7-12V). Supplying voltage via the 5V or 3.3V pins bypasses the regulator, and can damage your board. We don't advise it.

3V3. A 3.3-volt supply generated by the on-board regulator. Maximum current draw is 50 mA.

GND. Ground pins.

IOREF. This pin on the Arduino board provides the voltage reference with which the microcontroller operates. A properly configured shield can read the IOREF pin voltage and select the appropriate power source or enable voltage translators on the outputs for working with the 5V or 3.3V.

Memory

The ATmega328 has 32 KB (with 0.5 KB used for the bootloader). It also has 2 KB of SRAM and 1 KB of EEPROM (which can be read and written with the EEPROM library).

Input and Output

Each of the 14 digital pins on the Uno can be used as an input or output, using pinMode(), digitalWrite(), and digitalRead() functions. They operate at 5 volts. Each pin can provide or receive a maximum of 40 mA and has an internal pull-up resistor (disconnected by default) of 20-50 kOhms. In addition, some pins have specialized functions:

Serial: 0 (RX) and 1 (TX). Used to receive (RX) and transmit (TX) TTL serial data. These pins are connected to the corresponding pins of the ATmega8U2 USB-to-TTL Serial chip.

External Interrupts: 2 and 3. These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value. See the attachInterrupt() function for details.

PWM: 3, 5, 6, 9, 10, and 11. Provide 8-bit PWM output with the analogWrite() function.

SPI: 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK). These pins support SPI communication using the SPI library.

LED: 13. There is a built-in LED connected to digital pin 13. When the pin is HIGH value, the LED is on, when the pin is LOW, it's off. The Uno has 6 analog inputs, labeled A0 through A5, each of which provide 10 bits of resolution (i.e. 1024 different values). By default they measure from ground to 5 volts, though is it possible to change the upper end of their range using the AREF pin and the analogReference() function. Additionally, some pins have specialized functionality:

TWI: A4 or SDA pin and A5 or SCL pin. Support TWI communication using the Wire library. There are a couple of other pins on the board:

AREF. Reference voltage for the analog inputs. Used with analogReference().

Reset. Bring this line LOW to reset the microcontroller. Typically used to add a reset button to shields which block the one on the board.

Communication

The Arduino Uno has a number of facilities for communicating with a computer, another Arduino, or other microcontrollers. The ATmega328 provides UART TTL (5V) serial communication, which is available on digital pins 0 (RX) and 1 (TX). An ATmega16U2 on the board channels this serial communication over USB and appears as a virtual com port to software on the computer. The '16U2 firmware uses the standard USB COM drivers, and no external driver is needed. However, on Windows, a.inf file is required. The Arduino software includes a serial monitor which allows simple textual data to be sent to and from the Arduino board. The RX and TX LEDs on the board will flash when data is being transmitted via the USB-to-serial chip and USB connection to the computer (but not for serial communication on pins 0 and 1).

A SoftwareSerial library allows for serial communication on any of the Uno's digital pins.

The ATmega328 also supports I2C (TWI) and SPI communication. The Arduino software includes a Wire library to simplify use of the I2C bus; For SPI communication, use the SPI library.

Programming

The Arduino Uno can be programmed with the Arduino software (download). Select "Arduino Uno from the Tools > Board menu (according to the microcontroller on your board

The ATmega328 on the Arduino Uno comes preburned with a bootloader that allows you to upload new code to it without the use of an external hardware programmer. It communicates using the original STK500 protocol.

You can also bypass the bootloader and program the microcontroller through the ICSP (In-Circuit Serial Programming) header using Arduino ISP or similar.

The ATmega16U2 (or 8U2 in the rev1 and rev2 boards) firmware source code is available. The ATmega16U2/8U2 is loaded with a DFU bootloader, which can be activated by:

On Rev1 boards: connecting the solder jumper on the back of the board (near the map of Italy) and then resetting the 8U2.

On Rev2 or later boards: there is a resistor that pulling the 8U2/16U2 HWB line to ground, making it easier to put into DFU mode.

You can then use Atmel's FLIP software (Windows) or the DFU programmer (Mac OS X and Linux) to load a new firmware. Or you can use the ISP header with an external programmer (overwriting the DFU bootloader).

Automatic (Software) Reset

Rather than requiring a physical press of the reset button before an upload, the Arduino Uno is designed in a way that allows it to be reset by software running on a connected computer. One of the hardware flow control lines (DTR) of the ATmega8U2/16U2 is connected to the reset line of the ATmega328 via a 100 nanofarad capacitor. When this line is asserted (taken low), the reset line drops long enough to reset the chip. The Arduino software uses this capability to allow you to upload code by simply pressing the upload button in the Arduino environment. This means that the bootloader can have a shorter timeout, as the lowering of DTR can be well-coordinated with the start of the upload.

This setup has other implications. When the Uno is connected to either a computer running Mac OS X or Linux, it resets each time a connection is made to it from software (via USB). For the following half-second or so, the bootloader is running on the Uno. While it is programmed to ignore malformed data (i.e. anything besides an upload of new code), it will intercept the first few bytes of data sent to the board after a connection is opened. If a sketch running on the board receives one-time configuration or other data when it first starts, make sure that the software with which it communicates waits a second after opening the connection and before sending this data.

The Uno contains a trace that can be cut to disable the auto-reset. The pads on either side of the trace can be soldered together to re-enable it. It's labeled "RESET-EN". You may also be able to disable the auto-reset by connecting a 110-ohm resistor from 5V to the reset line.

USB Overcurrent Protection

The Arduino Uno has a resettable polyfused that protects your computer's USB ports from shorts and overcurrent. Although most computers provide their own internal protection, the fuse provides an extra layer of protection. If more than 500 mA is applied to the USB port, the fuse will automatically break the connection until the short or overload is removed.

Physical Characteristics

The maximum length and width of the Uno PCB are 2.7 and 2.1 inches respectively, with the USB connector and power jack extending beyond the former dimension. Four screw holes allow the board to be attached to a surface or case. Note that the distance between digital pins 7 and 8 is 160 mil (0.16"), not an even multiple of the 100 mil spacing of the other pins.

4.1.2 HC-05 Bluetooth device

HC-05 module is easy to use Bluetooth SPP (Serial Port Protocol) module, designed for transparent wireless serial connection setup. Serial port Bluetooth module is fully qualified Bluetooth V2.0 + EDR (Enhanced Data Rate) 3Mbps Modulation with complete 2.4GHz radio transceiver and baseband. It uses CSR Blue core 04-External single chip Bluetooth system with CMOS technology and with AFH (Adaptive Frequency Hopping Feature). It has the footprint as small as 12.7mmx27mm [19].

Fig 4.2: HC-05

HC-05 PinOut (Right):

- KEY: If brought HIGH **before** power is applied, forces AT Command Setup Mode. LED blinks slowly (2 seconds)
- VCC: +5 Power
- GND: System / Arduino Ground
- TXD: Transmit Serial Data from HC-05 to Arduino Serial Receive. NOTE: 3.3V HIGH level: OK for Arduino
- RXD: Receive Serial Data from Arduino Serial Transmit
- STATE: Tells if connected or not.

Software Features

- Default Baud rate: 38400, Data bits:8, Stop bit:1, Parity: No parity, Data control: has. Supported baud rate: 9600, 19200, 38400 57600, 15200, 230400, 460800.
- Given a rising pulse in PIO0, device will be disconnected.
- Status instruction port PIO1: low-disconnected, high-connected.
- Auto-connect to the last device on power as default. Permit pairing device to connect as default.
- Auto-pairing PINCODE: ”0000” as default.
- PIO10 and PIO11 can be connected to red and blue led separately. When master and slave are paired, red and blue led blinks 1time/2s in interval, while disconnected only blue led blinks 2times/s.

- Auto-reconnect in 30 min when disconnected as a result of beyond the range of connection

4.1.3 PULSE SENSOR AMPED [20]

Description-

Pulse Sensor Amped is a greatly improved version of the original Pulse Sensor, a plug-and-play heart-rate sensor for Arduino and Arduino compatibles. It can be used by students, artists, athletes, makers, and game & mobile developers who want to easily incorporate live heart-rate data into their projects.

Pulse Sensor Amped adds amplification and noise cancellation circuitry to the hardware. It's noticeably faster and easier to get reliable pulse readings. Pulse Sensor Amped works with either a 3V or 5V Arduino.

The kit includes:

- .A 24-inch Color-Coded Cable, with a standard male header connectors. Plug it straight into an Arduino or a Breadboard. No soldering is required.
- An Ear Clip, perfectly sized to the sensor. It can be hot-glued or epoxied to the back of the sensor to get reading from an ear lobe.
- Parts to make a handy Velcro finger strap. This is another great way to get heart-rate data.
- 4 Transparent Stickers, to insulate the front of the Pulse Sensor from oily fingers and sweaty earlobes.
- The Pulse Sensor has 3 holes around the outside edge which make it easy to sew it into almost anything.

Open Hardware

Pulse Sensor is an open source hardware project by Joel Murphy and Yury Gitman.Pulse Sensor is made with Design Spark, free circuit schematic and PCB layout editor.

Stats: Diameter = 0.625" (~16mm)

Overall thickness = 0.125" (~3mm)

Cable length = 24" (~609mm)

Voltage = 3V to 5V

Current consumption = ~4mA at 5V

4.2 Assembly

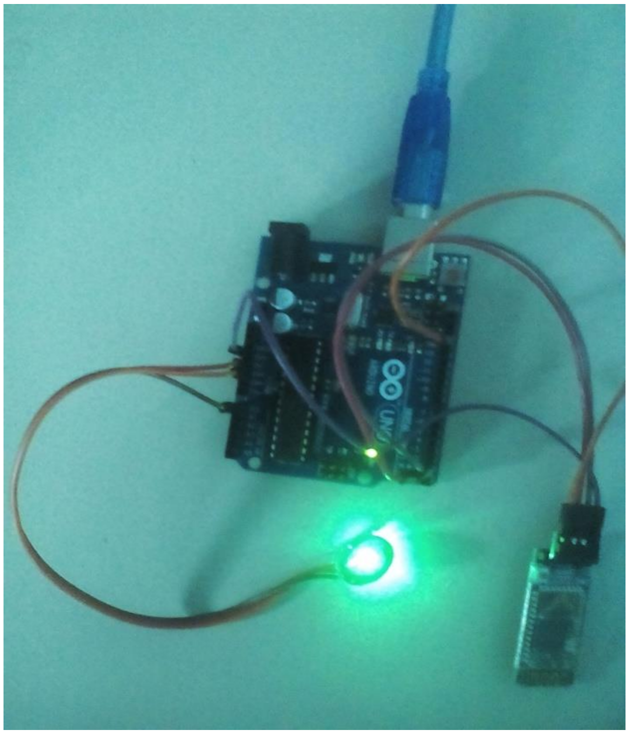

Fig 4.3: Assembly of Hardware

Take all the hardware's connected with Jumper wires and those wires are used for making connections between items and Arduino's header pins.

4.3 Logic & Code

For this system I use Arduino Uno as a micro controller. I implemented my logic and code in Arduino. So all the code are given below.

4.3.1 *Code*

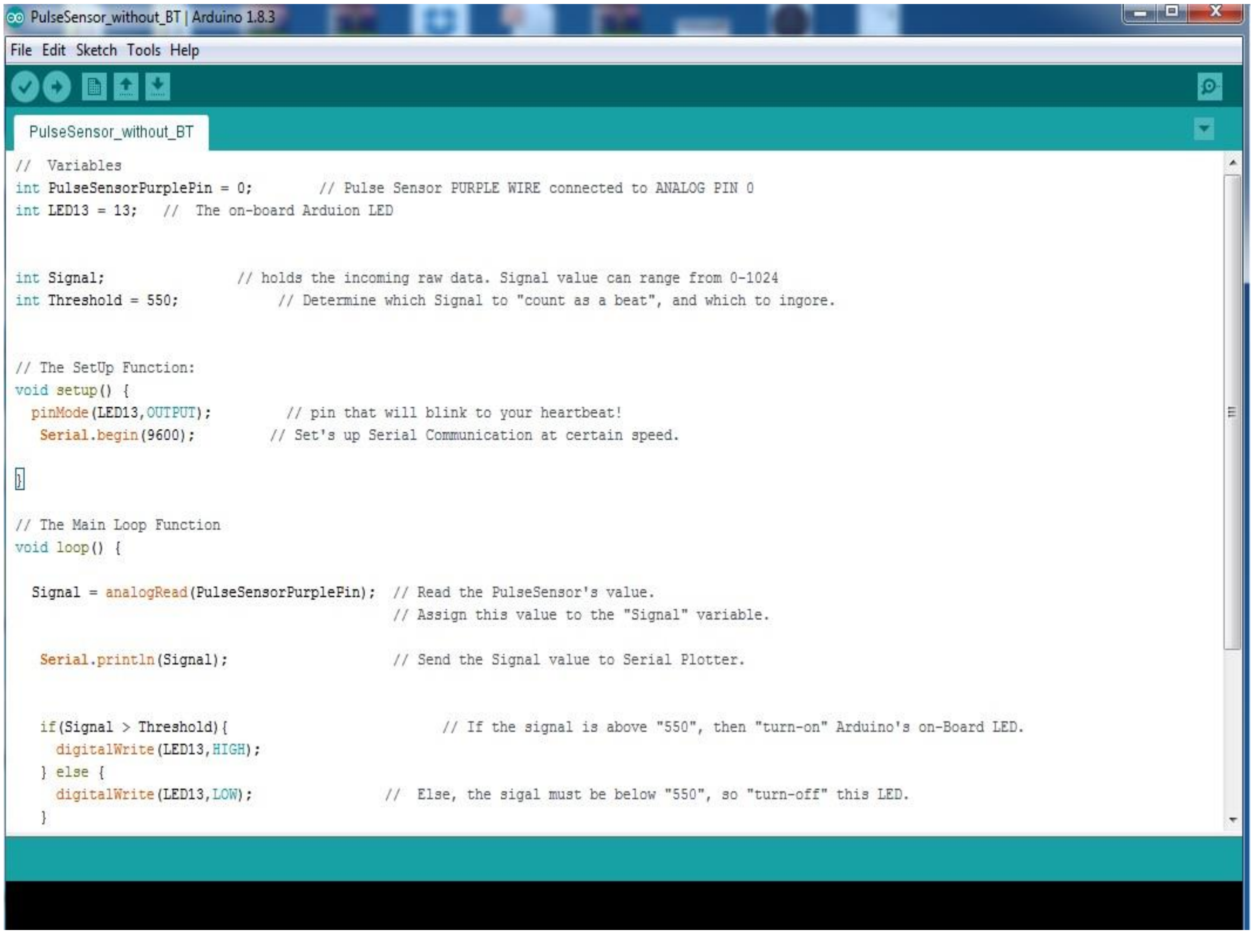

Fig 4.4: Pulse Sensor Code for serial monitor

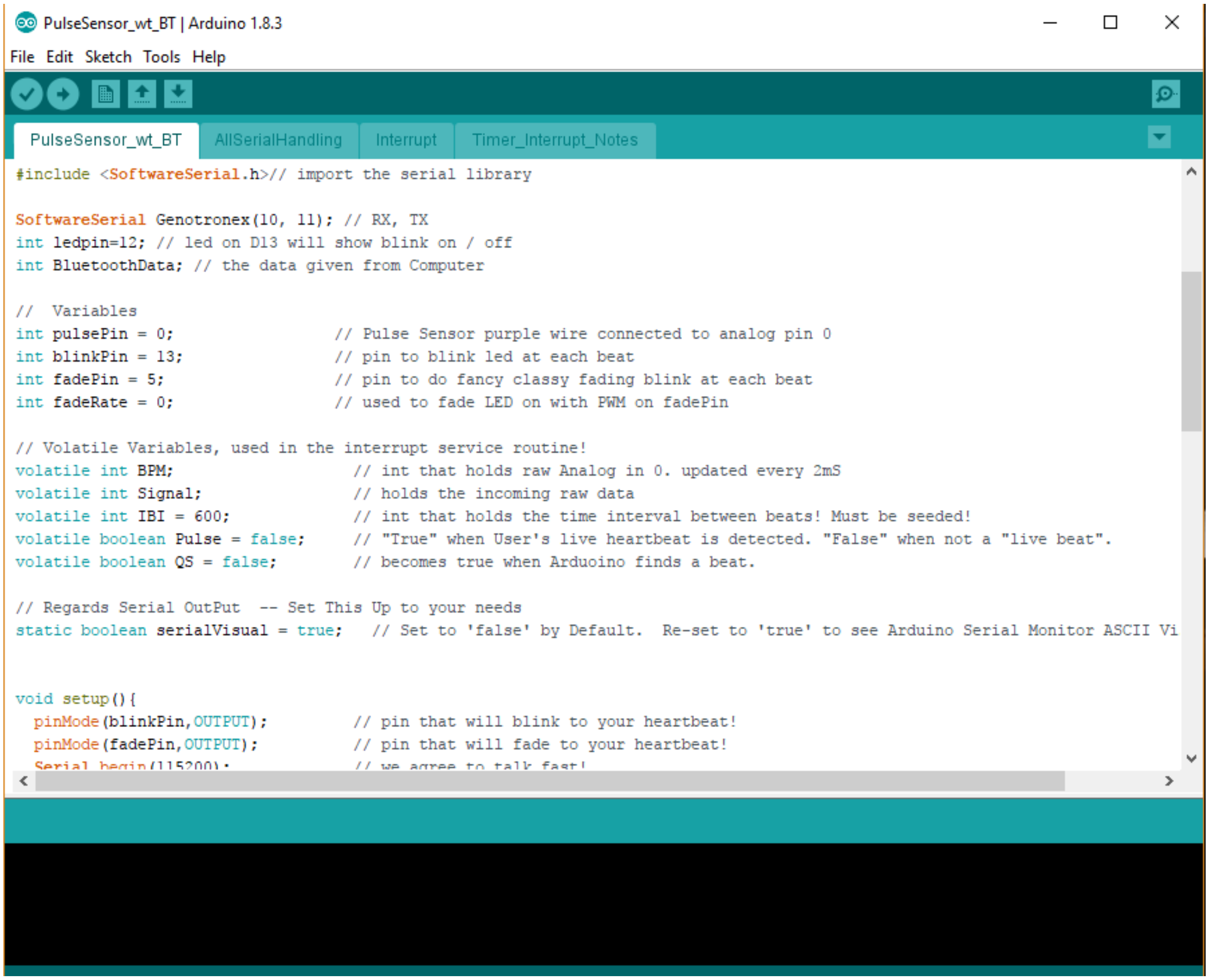

Fig 4.5: Pulse Sensor Code for Bluetooth Terminal

4.3.2*Project Simulation*

After uploading the code, the results are shown in the serial monitor in the Arduino IDE. The result is given below.

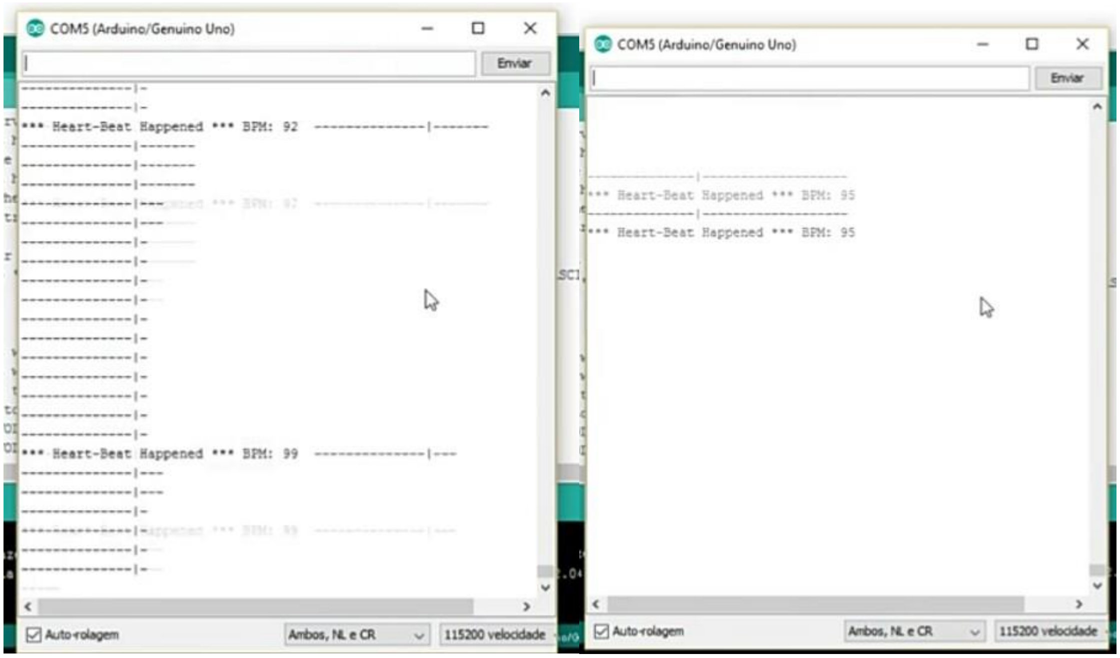

Fig 4.6: Heart Rate shown in the serial monitor.

For pulse remote monitoring in the android mobile we need a mobile application named Bluetooth Terminal. We can download the app from Google Play Store [21]. First, we should connect the Bluetooth Terminal with HC-05 Bluetooth device. After uploading the code shown in Fig 4.5, Android mobile application Bluetooth Terminal shows the results in the display. The result is given below

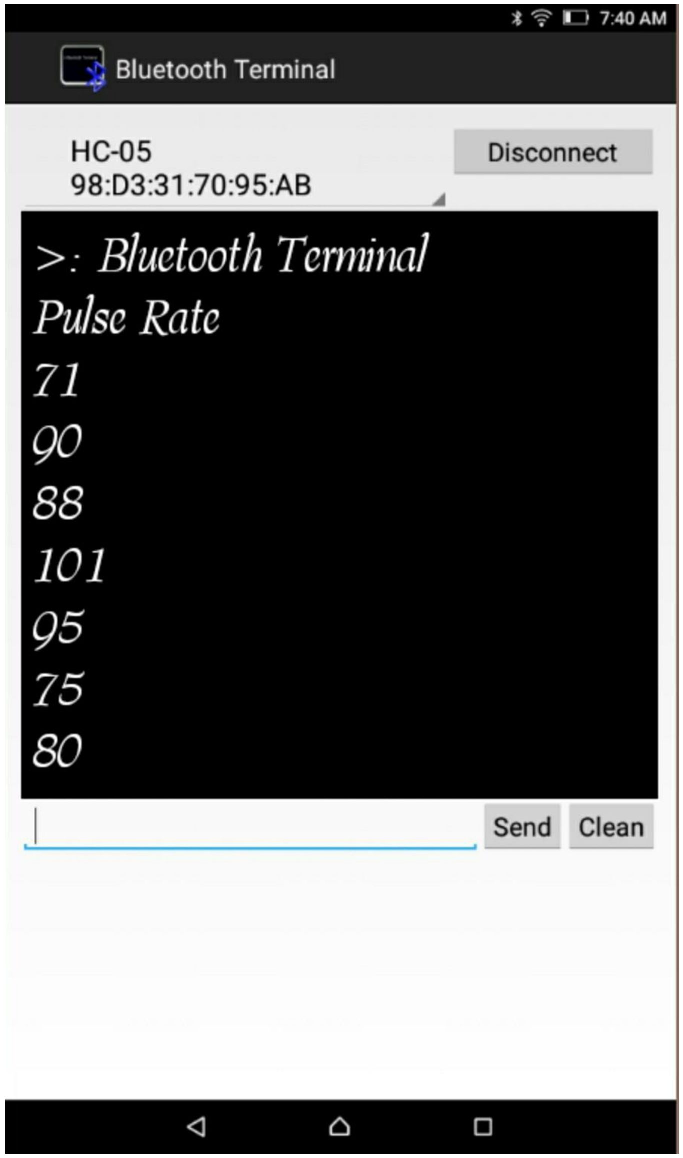

Fig 4.7: Heart Rate shown in the Bluetooth Terminal.

4.4 Chapter Summary

In this chapter I have discussed how I implemented my thesis and how did it work. I also showed the entire simulation combined with android application and hardware with diagram.

Chapter: 5

Conclusion

5. Conclusion

This thesis is about a real-time monitoring system for remote patients using wireless technology. The Arduino Sensor Platform based on the Internet of Things can be used in hospitals; currently most hospitals use ECG for monitoring heart patients but do not have remote monitoring system. This propose system is a solution to upgrade existing health monitoring systems in hospitals by providing remote monitoring capability. In this thesis not only solve the problem of patient's concern of the accuracy of their Blood Pressure Heart rate and ECG monitors, but also set up a health management platform using Arduino board. This new system is easy to find patient's Blood pressure, Heart Rate and ECG in the same time. Because the primary goal of this thesis is to design a new system, I do not focus my time on implementing complete system. With this prototype system, we can monitor our BP, ECG and HR. I am confident that all of my ideas are possible given the current technology. By the using of the modern communication facilities, this system provides patients with convenient medical channels, and largely improves their medical treatment experience; and this will make great contribution to the development of medical technology and the raising people's health level.

BIBLIOGRAPHY

References

[1] Amna Abdullah, Asma Ismael, Aisha Rashid, Ali Abou-ElNour, and Mohammed Tarique, “REAL TIME WIRELESS HEALTH MONITORING APPLICATION USING MOBILE DEVICES” International Journal of Computer Networks & Communications (IJCNC) Vol.7, No.3, May 2015 https://www.researchgate.net/publication/279225152_Real_Time_Wireless_Health_Monitoring_Application_Using_Mobile_Devices

[2] Pedro Manuel, Pinto da Silva, “A pervasive system for real-time blood pressure Monitoring”https://paginas.fe.up.pt/~ee08234/dissertacao/files/pdi.pdf

[3] Mahshid Zomorodi Rad, Saeed Rahati Ghuchani, Kambiz Bahaadinbeigy and Mohammad Mahdi Khalilzadeh, doi: 10.5455/aim.2015.23.151-154 ACTA INFORM MED. 2015 JUN 23(3): 151-154 Received: 11 March 2015 • Accepted: 14 May 2015https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4499298/

[4] Joseph J. Oresko, Student Member, IEEE, Zhanpeng Jin, Student Member, IEEE, Jun Cheng, Shimeng Huang, Yuwen Sun, Heather Duschl, and Allen C. Cheng, Member, IEEE, “A Wearable Smartphone-Based Platform for Real-Time Cardiovascular Disease Detection Via Electrocardiogram Processing” IEEE TRANSACTIONS ON INFORMATION TECHNOLOGY IN BIOMEDICINE, VOL. 14, NO. 3, MAY 2010

[5]Cardiovascular disease risk factorswww.world-heart-federation.org/cardiovascular-health/cardiovascular-disease-risk-factors/[Nov. 09, 2016].

[6]Hypertension and cardiovascular disease www.world-heart-federation.org/cardiovascular-health/cardiovascular-disease-risk-factors/hypertension/[Nov. 09, 2016].

[7]Priyanka Kakria, N. K. Tripathi, and Peerapong Kitipawang, **“**A Real-Time Health Monitoring System for Remote Cardiac Patients Using Smartphone and Wearable Sensors**”** **,**International Journal of Telemedicine and Applications Volume 2015 (2015), Article ID 373474, 11 pages http://dx.doi.org/10.1155/2015/373474

[8] Bourouis, A., Feham, M., and Bouchachia, A.(2011), “ Ubiquitous Mobile Health Monitoring System for Elderly (UMHMSE)”, International Journal of Computer Science and Information Technology, Vol.2, No. 3, June, pp. 74-82

[9] Yuce, M. R.(2010)” Implementation of wireless body area networks for healthcare systems”, Sensor and Actuators A:Physical, Vol. 162, No. 1, July, pp. 116-129

[10] Bin Yu ; Lisheng Xu ; Yongxu Li(2012) “Bluetooth Low Energy (BLE) based mobile

electrocardiogram monitoring system”, In the proceedings of International Conference on Information and Automation, June 6-8, 2012, Shenyang, pp. 763-767

[11] Ospino, M.R. ; Ariza, L.C. ; Rojas, J.G., (2012), ”Mobile system for monitoring measurements inhypertensive patients”, In the proceedings of the IEEE Colombian Communication conference, May16-18, CA, pp. 1-6

[12] Yun-Hong Noh ; Jiunn Huei Yap ; and Do-Un Jeong(2013) “Implementation of the Abnormal ECG Monitoring System Using Heartbeat Check Map Technique”, In the proceedings of International Conference on IT Convergence and Security, December 16-18, 2013, Macao, pp. 1-4

[13]K. Shin, H. T. Hwang, H. Y. Kim, J. P. Kim, H. S. Yeo, and W. Han, “WHAM: A novel, wearable heart activity monitor based on Laplacian potential mapping,” 27th Annual Conference, IEEE. Engg. In Med and Biology, Shanghai, China, pp. 7361-7364. September 1-4, 2005.

[14] The open hardware division of Libelium”, www.cooking-hacks.com

[15] **Daniel Lee Kulick, MD, FACC, FSCAI.Electrocardiogram (ECG or EKG), http://www.medicinenet.com/electrocardiogram_ecg_or_ekg/article.htm** ***8/31/2016*** **[26/3/2017]**

[16] “Arduino,“Hardware and Software”, [Online].Available:www.arduino.cc

[17] XBee “ZigBee Technology”, [Online]. Available: http://www.zigbee.org/

[18]Arduino Uno "Arduino Uno", [Online]. Available:https://store.arduino.cc/usa/arduino-uno-rev3

[19] HC-05 Bluetooth, “HC05 Bluetooth,” [Online]. Available: https://arduino-info.wikispaces.com/BlueTooth-HC05-HC06-Modules-How-To

[20] Pulse Sensor, Joel Murphy and Yury Gitman. www.pulsesensor.com

[21] Bluetooth Terminal, “Bluetooth Terminal”, [Online]. Available:https://play.google.com/store/apps/details?id=ptah.apps.bluetoothterminal