Heart Rate and ECG signal monitoring using Wireless Sensor Network.

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Abstract

Our World Today has witnessed an abrupt development in different fields of life. One of these fields is Health section which it's considered the care of this field one of important aspects of the developed countries. The invention of wireless technology and smart phones facilitated monitoring of patients remotely and made the emergency room's staff to take care of more patients in less time and effort. In this paper it's proposed to design and simulate of ECG and heart rate model using wireless sensor network. This system was implemented to be able to measure a biological aspects of a patient's health like heart rate measuring , Electrocardiograph ECG, Blood pressure etc. The benefit of this system is to overcome the problem of large instruments located in ER and replaced by and small devices with low cost, also to keep track and check even though medical staff arenot in the emergency room by an alert in smart phone using an available and simple app e.g. "Remote XY" and GUI as an interface with processing unit. This system has been built using small sensor nodes that are attached to the patient's body are ECG sensor (AD8232) and 3-lead Electrocardiogram (ECG), Heart beat sensor (KY-039), Bluetooth sensor connection and a user friendly graphical user interface (GUI) on smartphone. The cases study have been checked, the results showed near accurate measurements of heart rate and clear graphs of ECG.

Keywords: Wireless sensor network; Bluetooth sensor; Heart beat sensor; ECG sensor.

1. Introduction

The speedy progress of wireless communication and embedded micro-sensing. Additionally, Micro- electromechanical system (MEMS) technologies have created wireless device network attainable. Such that setting might have several cheap wireless nodes, every capable of aggregation, storage and process environmental data, and human activity with neighboring nodes [1]. Wireless sensor networks encompass distributed, wirelessly enabled embedded devices capable of using a spread of electronic sensors. Every node in an

exceedingly wireless detector network is supplied with one or a lot of sensors additionally to a Microcontroller, wireless transceiver, and energy supply . The microcontroller functions with the electronic sensors yet because the transceiver to make an economic system for relaying tiny amounts of vital information with least power consumption . Wireless sensor networks have several benefits over ancient sensing technology. The primary most notable feature is their value. The comparatively low value of the sensors permits for a few nodes to be broken or lost while not compromising the system, in contrast to larger, additional centralized sensors. Another advantage of wireless sensor networks hold over traditional wireless sensing technology lies in the mesh networking scheme they employ. Due to the nature of (Radio frequency) RF communication, transmitting data from one point to another using a mesh network takes less energy than transmitting directly between the two points. Utilizing node value advantage and mesh networking, organizations will deploy a lot of senses elements employing a wireless sensor network. This decreases the signal/noise of the system, increasing the number of usable information. For all these reasons and more, wireless sensor networks offer many possibilities previously unavailable with traditional sensor technology [2].

2. Related Work

Some health applications for sensor element networks are providing interfaces for the disabled; integrated patient observation; diagnostics; drug administration in hospitals; telemonitoring of human physiological data; and pursuit and monitoring doctors and patients within a hospital [3]. This section of the paper highlights on current and previous study of wireless communications in healthcare domain. Authors in ref. [4] proposed an efficient approach to monitor the illness of the patient during the checkup condition. These medical sensors will sense the condition of patient's body and send a message via Global System Mobile device to concern person or doctors. These data is communicated via ZigBee wireless device. Authors in ref [5] designed and implemented a low cost portable single channel ECG monitoring system using smartphone having android operating system and Arduino. This study aims to develop a low cost ECG monitoring system, which is real-time, affordable, portable and user-friendly. The researchers in ref [6] studied the application of internet of things IoT in health care domain. The system is proposed to monitor the ECG of the distant patient. This system comprises of Raspberry Pi, Arduino Uno, ECG Sensor and IoT Cloud for storing and plotting ECG data in real time.

3. Heart Rate Variability (HRV)

HRV expresses the natural variation of Inter-Beat Interval IBI values from beat to beat. Which IBI is the time interval between individual beats of the heart, measured in milliseconds (ms). Figure 1 shows a prototypical heartbeat. This is known as the QRS complex, with each letter corresponding to a different part of the heart's action. The important thing to note is that the "R" of the complex is the area from which the values for analysis are taken. When we have several heartbeats next to each other, then the distance (milliseconds) between each "R" is defined as the "RR interval" see Figure 2 [7]

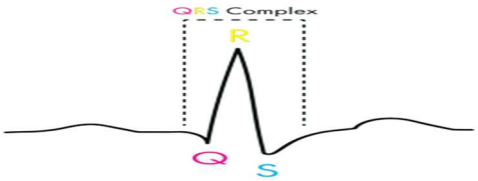

Figure 1: prototypical heartbeat

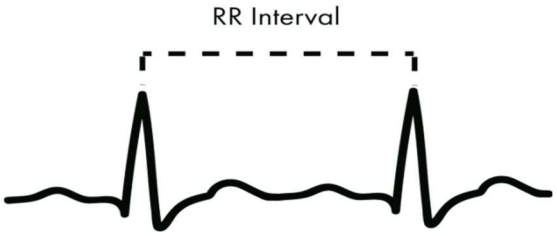

Figure 2: RR interval

4. Design and Implementation of Heart Rate and ECG Monitoring System

4.1. System Architecture

An architecture of a wireless sensor network system consists of six parts simply, See Figure 3.These parts are, Bluetooth Module (HC-06), Heartbeat sensor (KY-039), ECG sensor (AD8232), a Microcontroller (Arduino Uno), smartphone (Android) and a laptop. Wireless communication standard (Bluetooth) is used between a Microcontroller and a base station (smartphone). Software runs over wireless module that reads the received signal from the sensor and sends it to the base station during this process. Measurement results are observed with graphical user interface (GUI) in smartphone, and at the laptop simultaneously, the signal from sensors is received by universal serial bus (USB) cable which is connected to Arduino Uno. Before working on sensors first it's made test to ensure these devices are operating using Arduino and Bluetooth to turn on/off an LED light and A.C lamp wirelessly using mobile software's (Bluetooth SPP, Bluetooth Terminal and Remote XY) and a relay as a switch, perform that the

wireless connection is working. After that it's used ensors and plot the output signals in (GUI).

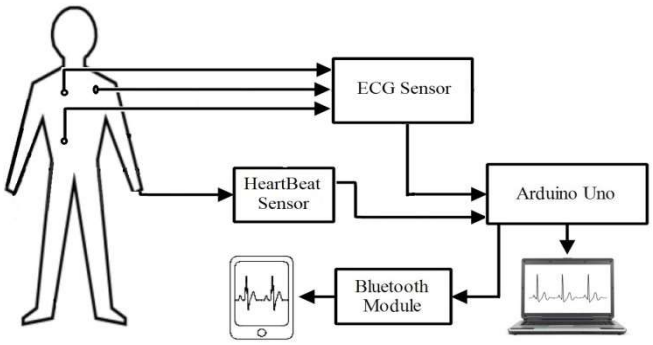

Figure 3. System Architecture

4.2. HC-06 Bluetooth Module

HC- 06 Bluetooth module is a compatible device with Arduino. It is an easy to use Bluetooth serial port protocol module, designed for wireless serial connection setup. Serial port Bluetooth module is capable of 3 Mbps. Modulation with 2.4 GHz radio transceiver and uses Complementary Metal Oxide Semiconductor (CMOS) technology and with Adaptive Frequency Hopping (AFH) feature. See Figure 4. Bluetooth connection pins to the Arduino is shown in table 1 [8].

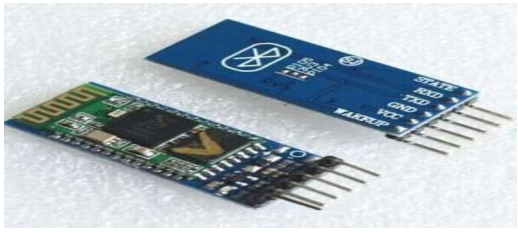

Figure 4: Bluetooth module HC-06.

Table 1:HC-06 Bluetooth Connection to the Arduino.

Sensor Pin	Arduino Pin
GND	GND
VCC	5V
TX	0(RX)
RX	1(TX)

4.3. Microcontroller Unit (Arduino UNO)

Arduino is an open source production platform that is enabled to design circuits easily. Programming language of Arduino is similar to C language.

There are several types of Arduino boards exist which can be chosen to the requirements of the project, and also plenty of modules are available to extend the usage. One of the Arduino boards is Arduino Uno, which has Atmega 328 Microcontroller and contains both analog and digital inputs, outputs input/output pins. Implementation of the circuit with using these pins and Microcontroller is programmed via computer. After that, reading and writing analog and digital data is possible [9].

4.4. ECG Sensor (AD8232)

The AD8232 sensor shown in Figure 5 is a neat little chip used to measure the electrical activity of the heart. This electrical activity can be charted as an Electrocardiogram. The AD8232 has nine pins, and it's connected five of the nine pins to the Arduino. The five pins used are shown in Table 2 [10].

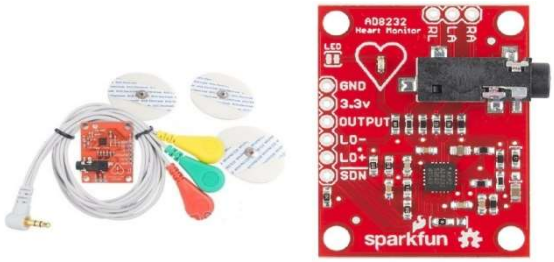

Figure 5: ECG sensor AD8232

Table 2: AD8232 ECG sensor connection to the Arduino

Sensor Pin	Pin Function	Arduino Pin
GND	Ground	GND
3.3v	3.3v Power Supply	3.3v
OUTPUT	Output Signal	A1
LO-	Leads-off Detect -	11
LO+	Leads-off Detect +	10
SDN	Shutdown	Not used

4.5. Heartbeat sensor (KY-039)

KY-039 is heartbeat Sensor Module uses bright infrared (IR), Light Emitting Diode (LED), and a phototransistor to detect the pulse of the finger. The crystal rectifier is connected on the sunshine aspect of the finger, and also the photo transistor on the opposite aspect, photo transistor will acquire the flux emitted, once the force per unit area pulse by the finger once the resistance of the photo transistor is slightly modified. In this paper it's used KY-039 as heart rate sensor, actually the sensor is telling how much infrared light sensor receives, the higher value, the less infrared light. In addition it's described how this signal is converted into a heart rate like 66 beats per minute (BPM). See figure 6. The KY-039 sensor has three pins, and the connection to the Arduino is shown in table 3 [11].

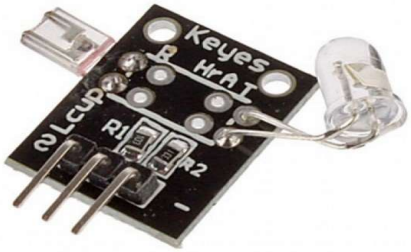

Figure 6: Heartbeat sensor KY-039

Table 3: KY-039 Heartbeat sensor Connection to the Arduino.

Sensor Pin	Pin Function	Arduino Pin
S	Output Signal	A0
+	5 v Power Supply	5 v
-	Ground	GND

4.6. Remote XY

The Remote XY is an easy way to make and use a mobile graphical user interface for controller boards to control via smartphone or tablet. The system includes Editor of mobile graphical for controller boards, located on the site remotexy.com, and Mobile app RemoteXY that permits attaching to the management and control it via graphical interface. [12].

5. Experimental Measurements and Results

In this part the implemented circuit was used in breadboard see Figure 7. This system can work together with the laptop and smartphone, or individually by using only smartphone or laptop. In a computer data of the ECG signal and heart rate are received by USB cable which are connected to Arduino Uno, and in Android phone they are received by Bluetooth module. The design of the ECG signal and heart rate monitoring system is shown in Figure 8.

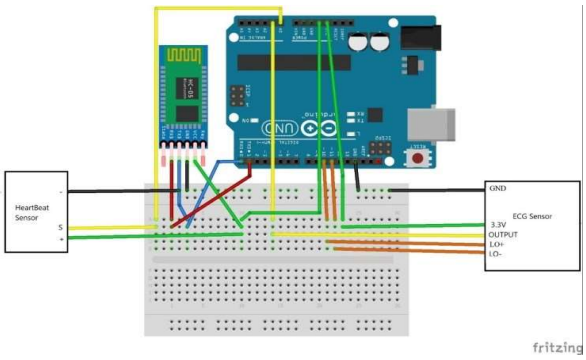

Figure 7: Circuit diagram for heartbeat and ECG monitoring system.

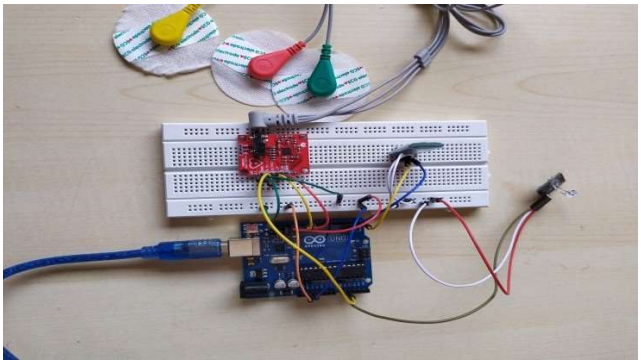

Figure 8:Heartbeat and ECG monitoring system design

The ECG signal and the heartbeat of a tested patient monitoring from a computer are shown in Figure 9 and Figure 10. In addition, The ECG signal and the heartbeat of a tested patients monitoring from a smartphone using Bluetooth are show in Figure 11.

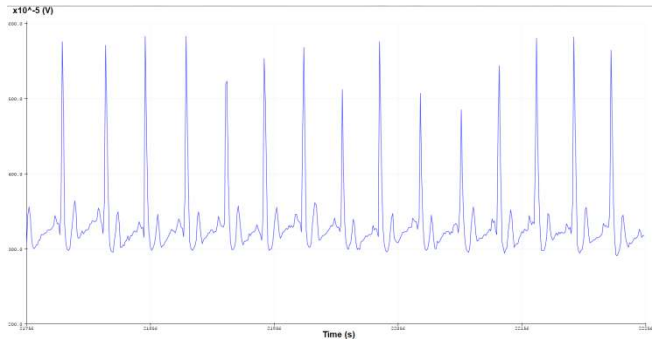

Figure 9. ECG signal from patient on a computer screen.

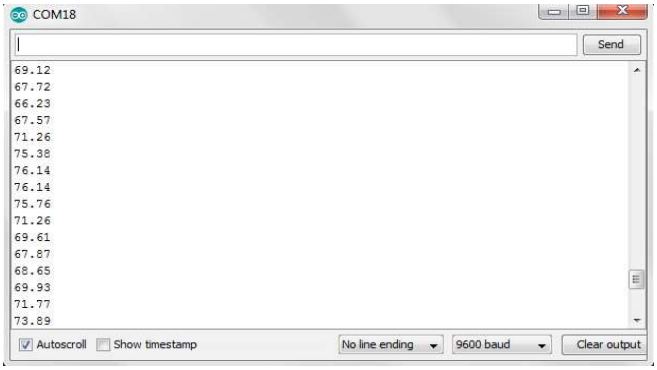

Figure 10: Heart rate (Bpm) from a patient on a serial monitor of Arduino

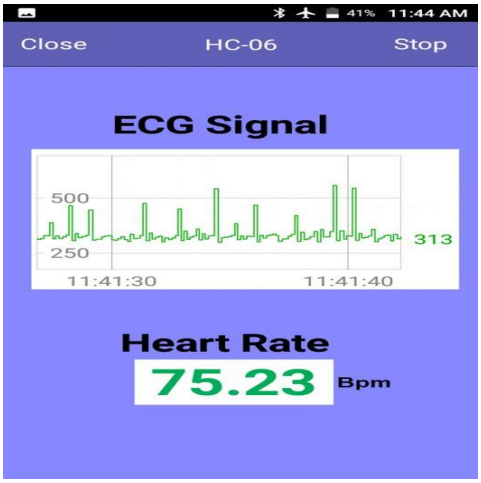

Figure 11: ECG signal and Heart rate for a patient on a smartphone.

From the obtained results through the laptop, it's noted that the ECG signal is close to the ideal results with a slight difference, considering that the used sensors are dedicated to test only and not intended for use in hospitals. But they can be used as monitoring for early warnings, since the RR interval is good indicator to decide that the patient normal or abnormal. The amplitude of the ECG signal is not equal in each pulse in both smartphone and laptop signals, and the RR interval is variable and not fixed in the smartphone signal. It's noted that the planning signal in the smartphone is distorted and difficult to read and may be due to several reasons, the sampling rate cannot be changed in remote-xy application, so its value does not set, when you send a signal via Bluetooth, you may have experienced noise as it passes through the air.

6. Conclusion

The main aim of this research is implementing a low cost heart rate and ECG monitoring system which has been fulfilled. The Wireless Health Monitoring System is capable of monitoring patient's health parameters in real time. The use of wireless technologies, increases functionality of the whole system, by sending information about any irregularities of patient's health. The only requirement that a supervising person must meet is to have an already installed application on smartphone with Bluetooth support. According to the new approach for ECG analysis on sensor nodes, it could be reduced the data packet overload and save power consumption in wireless sensor network. The cost of this system is inexpensive and practical solution for under developed and developing countries and it's an excellent choice for doctors and cardiac patients in developing countries. There are many advantages of using Bluetooth like low-power consumption, low-cost, flexibility, hardware usability and more. The ECG signal

was noisy due to the power line interference because of wires and system equipment's, also the Remote XY app cannot adjust the sampling rate.

7. Recommendation

This research is aimed to be developed by extending work with different communication networks such wi-fi and i- cloud, and use other types of wirless sensors like Wi-Fi and ZigBee. In addition by looking for an improved app instead of RemoteXY can enhnce the results. The propsed system design will be used in the Benghazi Medical Center to help patients and medical staff.

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