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Wearable ECG Monitoring by using IOT for Medical Applications

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Abstract

The Biomedical Instrumentation Engineering field is a rapidly developing field. The electronics used in this medical field is very much helpful in the diagnosis of diseases. The proposed project is used in capturing and displaying the Electro Cardiogram of a patient. In this embedded system based project, IoT (Internet of Things) is used. The embedded system captures and transmits the ECG signal to cloud. Then the patient's ECG signal is viewed on Personal Computers or Mobile phones through the Internet.

***Keywords**: Bio medical, IOT, ECG, Cardiogram, Cloud*

1. Introduction

Wearable devices are smart electronic devices that can be worn on the human body as accessories. They can transfer data without the need for constant monitoring. ECG refers to Electrocardiogram which represents the electrical activities of the heart. IoT module is used for wireless transmission of signals using internet. Cloud services are for voluminous data storage. Wireless transmission is used for easy portability, accessibility, as well as real time monitoring.

2. Literature Review

(1) Proposed a remote mobile health monitoring system with mobile phone and web service capabilities, in which physiologic parameters, including respiration rate and heart rate, are measured by wearable sensors and recorded by mobile phone.

(2) A portable wireless monitoring system for real time Electrocardiogram Monitoring, for multi subject monitoring to detect the irregular heart rhythm was proposed.

(3) Designed a real time Electrocardiogram device for cardiac patient, in which the system proposes a wireless, wearable ECG device capable of processing the patient's ECG in a real time environment.

Advances in wearable electronics and embedded computing system for biomedical application was proposed by (4), in which the application of wearable electronics in biomedical research and commercial fields was proposed.

(5) Designed a wearable 2.0 Enabling Human-cloud Integration in Next Generation Healthcare Systems, in which the user's physiological data is collected unconsciously and personalized healthcare services are done by big data analytics on clouds.

(6) Proposed a Design and Modeling of Wearable ECG Monitoring device for heart patients, which performs ECG monitoring in real time and delivers it to heart patients.

Monitoring of vital signs with Flexible and Wearable Medical Devices is dealt by (7), in which the authors proposed the advances in wireless technologies, low power electronics and IoT.

The advantages over existing systems are, it has higher data rate and larger memory, since IoT is used for communication.

3. Advantages of Wearable monitoring

(1) Afford Ability

This project uses an IoT module which transmits data wirelessly. The ECG device can be paired with larger displays allowing aged people to monitor easily. Because of constant monitoring, the number of visits to hospital and hence the cost are reduced. The modules and components used are less expensive and hence affordable to all. Existing apps also can be customized to suit our needs.

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(2) Real Time Monitoring

The patient can be monitored constantly without any human intervention. Improvisation can be made to give out warning signals, alerting the doctor instantly. It can be used to detect Arrhythmias and Sleep Apnea. Real time monitoring captures and records high precision wave with least error. It also reduces the risk of infection and other complications giving high attention to patients. The proposed system has a simple structure, high reliability, good capabilities and low computational complexities which enable early detection and intervention of acute diseases.

4. Proposed Hardware Platform

ECG electrodes are used to record the bio electric signal, which is produced due to the depolarization in the heart muscles. Electrodes are placed on human body at three places, at right chest, left chest, and right abdomen. Electrodes should be wet in order to prevent the conductivity between skin and electrodes. Electrodes comprise of plastic substrate that is covered by silver/silver chloride ionic compound which ensures the conductivity of signal.

ECG Amplifier is simply used to increase the CMRR; thereby increasing gain of the Amplifier. AD8232 is used as ECG amplifier. It consists of 20 lead 4mm*4mm LFSCP (lead frame chip scale package). It has Fast restore characteristics, which makes the amplifier output the measured signal as soon as the leads are connected.

Analog to Digital Converter is needed in order to convert the original input analog signal to the output digital signal, which is necessary for the ARM processor. ADC0809 with 8-channel multiplexer uses Successive approximation technique for conversion. It has 26pins, and works with 0- 5V input.

The proposed ARM Microcontroller is stm32f103c8f6. It allows real-time acquisition and diagnosis of heart disease, which is able to process up to 1000 samples/sec. It is a 32 bit RISC core with 48pin IC with 37I/Opins. It has an operating frequency of 72 MHZ, including Flash memory of 128 kilo bytes and SRAM of 64 kilo bytes.

Level Converter is needed to convert the TTL logic to RS- 232 logic. Max 232 is used as the Level Converter. In Max 232, the conversion of logic levels takes place while charging and discharging. Here, transmission and reception take place simultaneously.

Internet of Things is used here for wireless communication. ESP8266 is a self-contained Wi-Fi network. Cloud storage is preferred for higher date rate and larger memory. It is used specifically for mobile devices, wearable electronics and networking applications design. The main advantage of ESP8266 is lowest energy consumption.

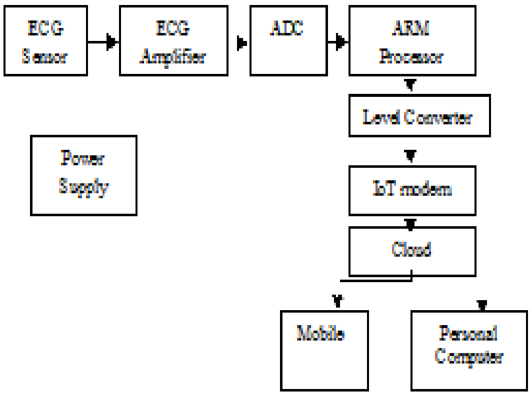

Figure 1: Block diagram of wearable ECG

5. Architecture of the IOT cloud for ECG monitoring

After the system obtains large amounts of ECG data through the monitoring node, an IoT cloud is in demand to provide a speedy and convenient way to store these data in a database, and to display the ECG signal when required. Therefore, based on the state-of-the-art techniques of web services, cloud computing and data storage, an IoT cloud is implemented which is illustrated in Fig 2.

Based on the traditional request-response mechanism, the HTTP server is able to accept users' responses and respond accordingly. In order to access to the ECG data, users need to send a GET request to the IoT cloud via a URL. Then a file written in the Hypertext Markup Language (HTML) is transmitted to the browser through the HTTP protocol. The browser is able to convert the HTML file into a user friendly graphical interface for users to securely log into the server. After successfully gaining the access, the HTTP server sends another HTML file which is used to present a graphical interface for displaying the ECG signal;

Step1 - Request: The user sends a request to the HTTP server to access the webpage;

Step 2 - Response: The HTTP server sends an HTML file back to the user, which can be converted to a webpage by the web browser;

Step 3- Subscribe: Using the Application Programming Interface (API) of the IoT cloud, the web page is able to subscribe certain topics related to the ECG monitoring node;

Step 4 - Publish: The ECG monitoring node publishes data to the MQTT server on a certain topic. These data are forwarded to all the web pages that have subscribed the same topic; and

Step 5 - Storing: ECG data are stored into the database managed by the storage server.

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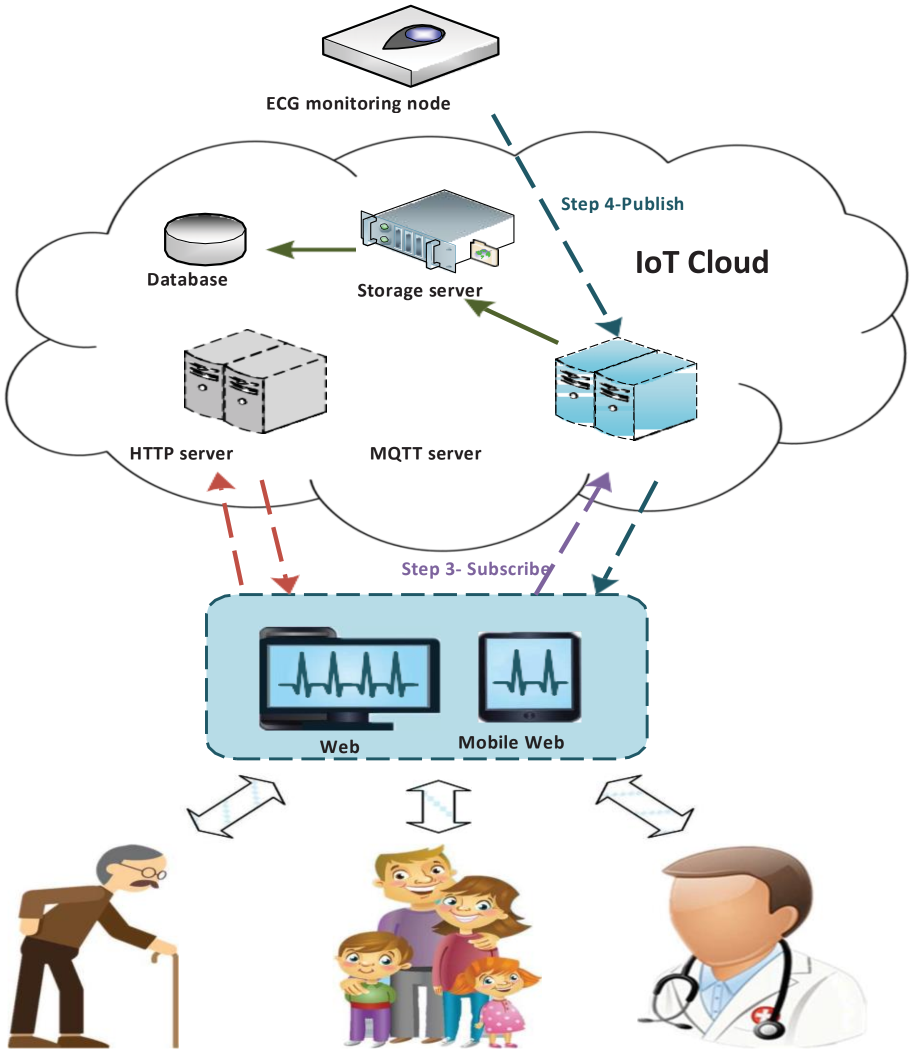
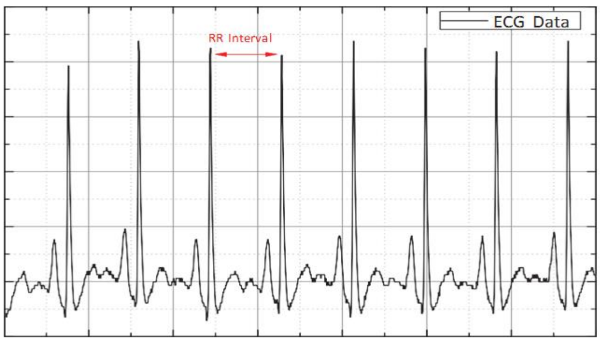


Figure 2: Architecture of the IoT cloud for ECG monitoring

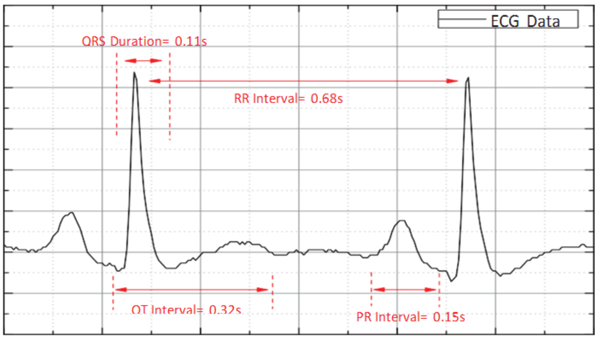
6. Working

In this system, three wet electrodes which are placed on the left chest, right chest and right abdomen record the bio potential signal (Analog signal) produced by the human body, which is sensed and amplified by the AD8232 ECG Amplifier. Since the embedded system can accept only Digital signal, the Output of the AD8232 is fed to Analog to Digital Converter. ARM Processor (stm32f103c8f6) then processes the digital signal which is transmitted to Max 232, where TTL Logic is converted to RS 232Logic. MiCroCpro Software using C language is used to code the ARM processor. ARM processor has a better sampling rate than PIC and is reprogrammable. This makes the ARM more preferable than PIC. The use of C language makes the user to understand the coding and change them later. The signals are then sent to ESP8266 Wi-Fi module. From the module, the signals are received by the android device or Computer.

7. Results and Analysis



a) Portion of the measured ECG signal.



b) Key features of the measured ECG signal

Table 1: Key Parameters of the ECG monitoring system.

	Parameters	Values
ECG sensor	Type	AD 8283
	Power voltage	3.6 v
	Output voltage	0-3.3 v
Wi-Fi module	Wireless transmission protocols	IEEE 802.11 b/g/n
	Power voltage	3.3 v
	Power consumption	<71 mA
Server	CPU	Intel Core i7-3632QM 2.2GHz / i7-3770 3.4GHz
	Operation system	Ubuntu 12.04 LTS, 64 bit
	HTTP server	Apache Tomcat 8.0.27
	Database	Redis 3.2
Volunteer	Gender	Male
	Age	22
	Height	179 cm
	Weight	65 kg

8. Conclusion

A new model for ECG monitoring system is made. The system is found to have higher accuracy levels. The SNR is better than the other conventional wired systems. Here wet electrodes are preferred in order to increase the conductivity between the skin and electrode. Because of portability and affordability, it is more convenient to the user. The ARM Processor with wet electrode processes up to 1000 samples/sec, thereby increasing the acquisition rate and speed of diagnosis. We designed and implemented an ECG monitoring system based on cutting-edge IoT techniques. The architecture of the ECG monitoring system was presented at first. Typical ECG sensing networks including Wi-Fi, Bluetooth, and Zigbee were introduced and compared. Based on the proposed architecture, an IoT-based ECG monitoring system was implemented. Through a wearable monitoring node with three electrodes, real-time ECG signals can be collected with satisfactory accuracy. The gathered data were transmitted to the IoT cloud using Wi-Fi, which supports high data rates and wide coverage areas. The IoT cloud is responsible for visualizing the ECG data to users and storing these valuable data for further analysis, which is implemented on the basis of three servers, the HTTP server, MQTT server, and storage server. Eliminating the need of mobile applications, the web-based GUI provides a versatile means independent of any mobile OS platform for users to access to the ECG data. Further studies on ECG monitoring are still needed in the future. For example, the accuracy of diagnostic results based on the ECG signal needs to be improved so as to provide a more reliable disease diagnosis. It is believed that long-term and user-friendly ECG monitoring can greatly help mitigate existing healthcare problems to a certain extent.

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