Real time ECG on internet using Raspberry Pi

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***Abstract*—The current status of heart disease in India is alarming, with projections suggesting that by the year 2020, the population of heart patients in India will surpass all the countries. Thus, monitoring the electrical activity of heart i.e. electrocardiogram is a necessity rather than luxury. ECG machines available in hospital are rather expensive. This paper aims at charting the ECG signal using the Raspberry Pi Arm processor. The ECG signals are recorded from the patient via the AD8232 ECG module and then this data is digitized using serial ADC MCP3008. The processor maps the signal on an online graphics tool plotl.ly using python programming. The main advantage of this system is that the result can be viewed at any place at any time. In this way, Internet of Things (IOT) concept is used to diagnose the heart defect and abnormalities in ECG without involving expensive ECG machines.**

I. Introduction

In todays fast changing world, the lifestyle of people is changing. Lack of exercise, unhealthy fast food habits and superfast daily activities have raised a question on the cardiac health of people. There are approximately 40 million heart patients in India. It is estimated that 17.5 million people die each year in India from cardiovascular diseases, amounting to a staggering 31% of all deaths worldwide. 80% of all cardiovascular deaths are due to heart attacks and strokes. Direct and indirect costs of cardiovascular diseases and stroke are estimated to total more than $316 billion that includes both health expenditures and lost productivity. Information and communications technologies are changing our lifestyle, our workplaces and our social interactions. The analysis of ECG is widely used for diagnosing many cardiac diseases. Further, automated analysis of such recorded biomedical signals supports doctors in their daily work and allows the development of warning systems.

IoT (Internet of Things) is the network of physical sensors embedded with electronics, software and INTERNET connectivity. The IoT allows objects to be sensed or controlled remotely across existing network infrastructure, creating opportunities for more direct integration of the physical world into computer-based systems, and resulting in improved efficiency, accuracy and economic benefits in addition to reduced human intervention. Also due to IoT, continuous monitoring of biomedical signals will no longer be restricted to the home environment. With the help of INTERNET, we can see data on the web at any time at any place. The results or the collected information can be sent to multiple user.

Gupta, M.S.D., Patchava, V. and Menezes, V presented a system in which the sensed data was stored in MYSQLdb module connected to raspberry Pi and the doctor was alerted if any aberrancy via the interfaced GSM Module[1]. This data is stored in a database and can be displayed in a website that can be accessed only by authorized personnel. Yakut, O., Solak, S. and Bolat, E.D prsesnted a system which measured the ECG signal via e-health sensor shield connected to raspberry pi[2]. The measured ECG data was processed to get the heart rate variability values via matlab. To determine the heart rate,Pan-Tomkins QRS detection algorithm was used. Abdullah, A., Ismael, A., Rashid, A., Abou-ElNour, A. and Tarique, M. proposed a system in which patients physiological data was collected by ECG sensor and processed by Arduino microcontroller and LabVIEW software application which was installed in the doctors phone[3]. Thus the doctor could study the information once he received the patient's health data via email. Megha Koshti, Prof. Dr. Sanjay Ganorkar,presented a monitoring system that has the capability to detect abnormalities in the heart functioning. The system analyzed the ECG signal to extract features using matlab software .It further detects the abnormal conditions like arrhythmia and with the help of Raspberry Pi, the database of the ECG signals is maintained using MySql and PHP and result is sent to the web server. Ms. Gauravi .A. Yadav , Prof. Shailaja.S.Patil presented a system in which the Output signals are plotted on display unit which is connected to Raspberry pi via HDMI cable. GUI is created using Raspberry Pi for displaying results[4]. Sangle Sagar D, Deshpande Niranjan R, 3.Vadane Pandurang M, Dighe M. S presented a system in which sensed data is compared with standards values that are already stored in system consisting raspberry pi. If there are any abnormalities are occurring then it sends message immediately to doctor to avoid critical situations. The data is displayed on UI page which periodically loaded and fetches data from database.

II. Method

This paper presents an ECG monitoring system in which the hearts electric signal (i.e ECG) is acquitized using AD8232 ECG module. The analog signal is digitally converted using serial ADC MCP3008 and then embedded to raspberry pi model 3 processor. The signal is plotted on Plot.ly an online graphics tool. This signal can be viewed by anyone using the user id & login of the programmer. This System is designed considering how crucial ECG study is to detect and diagnose heart diseases and the overall well-being of patient. As real time data is being monitored continuously, abnormality if any is indicated and doctor can be alerted via some alarm system. It can thus avoid risk and handle critical situation. It also gives advantage that it reduces time laps between critical situation and its alert to doctor, that means doctor will become aware of situation immediately. Hence, the proposed design can provide very fast aid to the patient either in diagnosis or treatment and is a lifesaving tool. The designed system doesnt need any external hardware that needs to be hooked up to the doctors smartphone. Nor does the doctor need any other applicaton/software tool that needs to be install. Once the doctor enters the security login (plotly username and password), he can directly view the patient ECG signal. Another advantage of the system being the data being viewed is real time such that the patient is virtually being examined in front of the physician.

A. Block Diagram

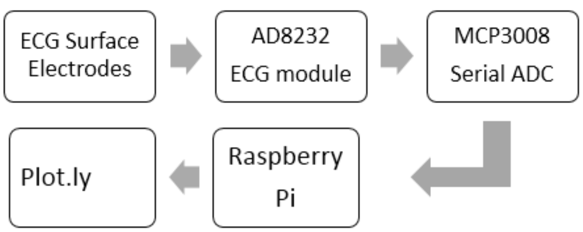

Fig. 1. block diagram

B. Components

1) ECG Surface Electrodes: An electrode is a conductive pad in contact with the body that makes an electrical circuit with the electrocardiograph. These electrodes detect the tiny electrical changes that occur on the skin that arise from the myocardium and the changes in the electrical voltage during depolarising and repolarising of hearts auricle and ventricles. The sensing material Ag-AgCl picks up this small voltages. The electrodes are arranged in Einthovens triangle on left arm, right arm and left leg.

2) AD8232 ECG Module: The AD8232 is an integrated signal conditioning block which consists of a specialized instrumentation amplifier, an operational amplifier, a right leg drive amplifier, and a mid-supply reference buffer for ECG and other bio-potential measurement applications[**?**] It has an integrated signal conditioning block for ECG designed to extract, amplify, and filter small bio-potential signals in the presence of noisy conditions, such as motion artifact or remote electrode placement.AD8232 contains a specialized instrumentation amplifier that amplifies the ECG signal while rejecting the electrode half-cell potential on the same stage. This two pole high pass filter is tightly coupled with the instrumentation architecture of the amplifier to allow both large gain and high-pass filtering in a single stage, thereby saving space and cost. This design allows for an ultralow power analog-to-digital converter (ADC) or an embedded microcontroller to acquire the output signal easily. The output of ECG module is connected to ADC.

3) MCP3008 ADC: The system monitors real time ECG which has frequency of upto 20 Hz and sampling rate upto 1khz[**?**]Thus, the ADC specifications need to be in accordance such that the sampling rate of ADC and ECG signal must match. Thus, an eight channel, 10 bit resolution MCP3008 ADC with SPI serial interface is selected. This ADC manufactured by Microchip Technology Inc. is successive approximation type Analog to-Digital (A/D) converter with on-board sample and hold circuitry. The maximum sampling rate is 20ksps. Communication with the devices is accomplished using a simple serial interface compatible with the SPI protocol. The MCP3008 connects to the Raspberry Pi using a SPI serial connection. There are two modes of connection using software SPI and hardware SPI. Hardware SPI is preferred in our project because of its high speed. The Adafruit MCP3008 python library needs to be installed in the raspberry pi using sudo get-apt install Adafruit MCP3008.

4) Raspberry pi: Raspberry Pi is the preferred processor because of its low cost and various GPIO (General Purpose Input Output) pins. Once, the output of MCP3008 is connected to raspberry pi GPIO pins, it works as a compact ECG monitoring device. It is mini sized computer with an integrated ARM compatible CPU, Broadcom system on chip (SoC) and on-chip graphics processing unit (GPU) to which mouse, keyboard etc can be interfaced via USB port. The processor speed varies from 700 Mhz to 1.2 Ghz and the on-board memory varies from 256MB to 1 GB. The operating system, Raspbian based on Linux is loaded in microSD card. There are various GPIO (General Purpose Input Output) pins that are available to the user which support common protocols like I2C and SPI. The processor is connected to the monitor via HDMI to VGA cable. If internet connection is provided to the Raspberry Pi will act like a server. Then the server can automatically upload data to the webpage. Wi-Fi modules are also inbuilt on the board. It enables computing and programming on languages like Python, Scratch. In this project, we are working on python. Setting up Raspberry Pi:

1) Format a minimum 8 gb microSD to .FAT format
2) Download Raspbian OS from the raspbian website and save it on the card
3) Insert the sd card in the dedicated slot of raspberry pi and fire it.
4) Connect the pi to monitor via HDMI to VGA converter cable and connect mouse, keyboard etc.
5) Plug the power cord and boot the raspberry pi and install the OS.
6) Configure the pi according to local time zone and start programming[5]

5) Plotly: Plotly is an online graphics tool which works on various graphic libraries like Python, Matlab, R, Arduino. The graphs can be embedded or downloaded and send to various individuals including the doctors. To use plot.ly one needs to create an account on the website. This account gives us an unique user name, stream token and API key. This acts as credentials to identify the specific user. Install plotly in raspberry pi by running following commands

1) sudo apt-get install python-dev
2) sudo apt-get install python-pip
3) sudo pip install rpi.gpio
4) sudo pip install plotly[6]

III. Experimental Design

A. Experimental Setup

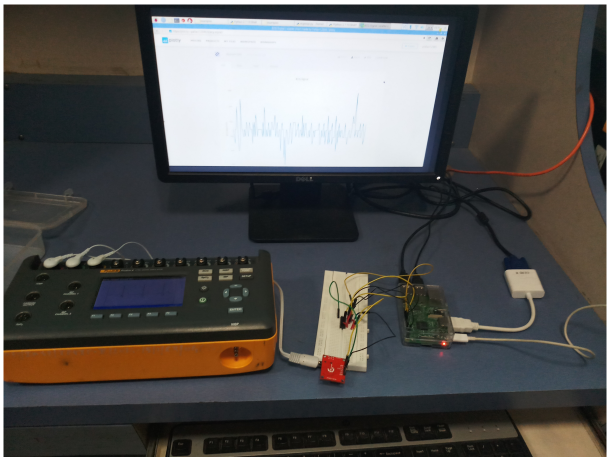

Fig. 2. Experimental Setup

B. Experimental Procedure

- The ECG electrodes are connected to the patients left arm, right arm and left leg to form Eithovens triangle such that heart is apt the centre of triangle.
- The output connector of ECG electrode is connected to the ECG module AD8232 which is used for ECG signal acquisition.
- The output of AD8232 is connected to the channel 0 of MCP3008. The clock , data in, data out , supply , ground pins are connected to the GPIO pins of raspberry pi as below
  - MCP3008 VDD to Raspberry Pi 3.3V
  - MCP3008 VREF to Raspberry Pi 3.3V
  - MCP3008 AGND to Raspberry Pi GND
  - MCP3008 DGND to Raspberry Pi GND
  - MCP3008 CLK to Raspberry Pi SCLK
  - MCP3008 DOUT to Raspberry Pi MISO
  - MCP3008 DIN to Raspberry Pi MOSI
  - MCP3008 CS/SHDN to Raspberry Pi CE0[7]
- After installing plot.ly in raspberry pi, execute the python code by the run command or in the terminal by the sudo python codename.py and add the unique API key , username and stream token in the code.
- After the successful execution of code, the shell will show a message showing that the data is being transferred on the plotly website.
- The code gets redirected to plot.ly url, where the real time ECG graph is streaming.
- Once the graph is obtained, it can be studied for various changes in ECG aberrancy.

IV. Results and Discussion

After the code has been executed successfully, the following message is displayed on the python shell terminal.

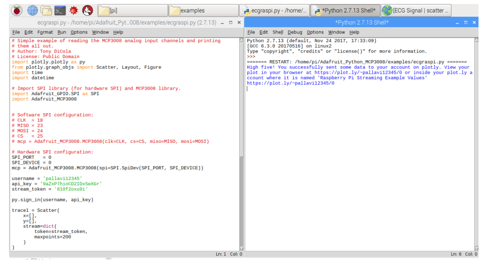

Fig. 3. python shell terminal

The website shows the following graphical display of real time ecg data that is streaming:

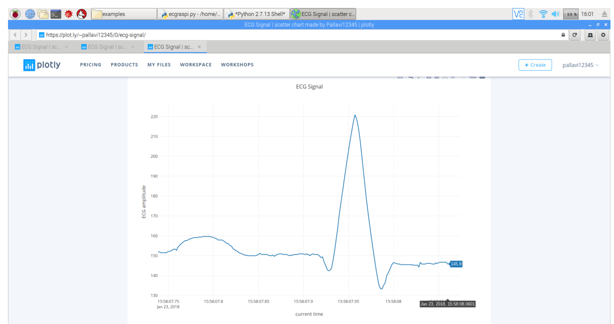

Fig. 4. ECG waveform

V. Conclusion and Future Scope

The system proposed is a small application towards integrating health care with INTERNET of things.The availability of patient's live streaming data anywhere anytime allows doctor to take fast and efficient decision.In long time this can help in saving patients life because of the quick diagnosis .Also the data streaming is continuous thus this can be termed as a continuous ECG monitor. The only constrain of this system is fast INTERNET connectivity.After entering patients credentials, the system will start displaying data of the patient who might be living in the other end of the world. If the ECG leads are replaced by wearable chest electrodes , the monitoring wont require the patient to be constrained to his static position.The patient is mobile and can go with his/her activities without any hindrance.

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