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Cloud based monitoring and analysis of EEG to assess brain based disorder using Raspberry Pi

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***Abstract*—**As world is evolving into smart world, the devices connected to internet can be monitored and accessed remotely from any part of world. This project aims at real time remote monitoring of EEG signals. It helps to monitor patient in their natural environment. It helps in proper monitoring and analyzing of EEG signals of patients. EEG electrodes attached on head will sense brain signals. This brain signals are in analog form. So these signals are fed into MCP3008 ADC to convert analog signals into digital form. This ADC is connected to raspberry pi module. In raspberry pi these EEG signals will be analyzed and their vital parameters will be stored. These parameters are uploaded to cloud storage platform through Internet gateway by raspberry pi.

Keywords-*Electroencephalography,Electrodes,MCP3008, Raspberry Pi.*

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I. INTRODUCTION

In today's world, the telemedicine is rapidly evolving. Telemedicine is helping small towns and villages to get the multi-specialty services which are usually available only in the major cities. This work is related to telemedicine field where a patient irrespective of his location is able to get himself inspected and monitored remotely. Here we are dealing with the EEG. There are certain parameters from the EEG which helps doctors to detect brain disorders.
EEG are extracted non-invasively from the brain by means of the electrodes and then they are sent to the raspberry pi for further filtering, analyzing and extraction of the parameters. Then these signals are sent to the cloud for monitoring in real time.

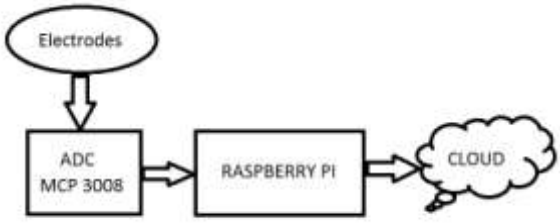

Figure 1: BLOCK DIAGRAM

A. MCP3008

Figure 2: MCP3008

For getting the analog signals from the electrodes to the raspberry pi, MCP3008 analog to digital converter is used. This ADC has got 10 bit accuracy and has 8 channels. It works on the SPI protocol. It is a low power device.
The cloud based service used here is the Thingspeak. In Thingspeak all the data is stored and can be viewed as per requirement in real time.

B. RASPBERRY PI 2 MODEL B

Figure 3: RASPBERRY PI 2 MODEL B

It has got 900 MHz processor and a 1 GB RAM. It has 40 GPIO pins, 4 USB ports. It has also got 2 SPI interfaces. The Raspberry Pi primarily uses Linux-kernel-based operating systems.
The ARM11 chip at the heart of the Pi (first generation models) is based on version 6 of the ARM. The current release of Ubuntu supports the Raspberry Pi 2. It can also run the Windows 10 IoT Core operating system, while no version of the Pi can run traditional Windows.

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II. WORK COMPLETED

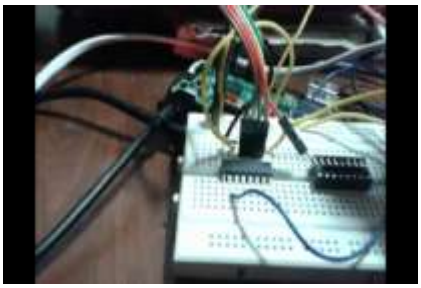

Figure 4: Interfacing MCP3008 with R Pi

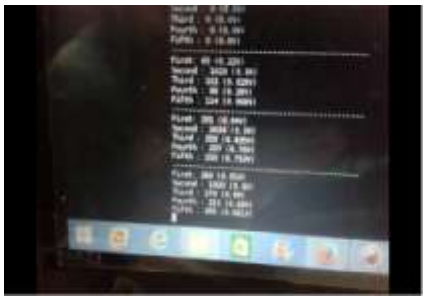

Figure 5: Reading ADC values

The MCP3008 ADC was successfully interfaced with raspberry pi. The sensor data was successfully obtained via the ADC channel to the raspberry pi.

The data received from the sensors was sent to the raspberry pi and was stored in .txt files. The data was taken from 5 different channels. And hence in 5 different files it was written. The writing was scheduled such that every after 10 readings, the files are erased and written all over again so that memory can be saved. Also the data saved in files was sent to Thingspeak cloud data server in real-time as shown in figure 6.

Figure 6: Data sent on Thingspeak cloud server

Raw EEG from the electrodes were acquired using MCP3008 at a sampling rate of .003906 seconds (1/256). The sampling rate was fixed at 256 Hz since the maximum signal frequency measured is only 30 Hz. Although the sampling frequency can be kept at 128 Hz, for better filter design in hardware it was kept as 256 Hz.

The raw signal thus acquired is not pure and must be filtered to minimize noises like 50 Hz power line noise, EMG, EOG and artifact due to head movements. So a generic Butterworth bandpass filters with cut-off 2 Hz to 40 Hz was used. The underlying principle behind analyzing the EEG of ADD or ADHD patients is monitoring their alpha, beta and theta waves. The frequency range for alpha wave is 8-15 Hz, Beta wave is 16-31 Hz and for theta it is 4-7 Hz. In order to extract these waves from raw EEG signal three Butterworth bandpass filters were used with respective cut-offs.

Once acquired and filtered all the signals i.e. raw EEG, alpha/beta/theta waves and their respective energies are written/appended to their respective files. Then the values from the files are uploaded to the cloud. For uploading data on the "Thingspeak" platform from raspberry pi it was consuming 1 sec for each value per field.

Figure 7: Upload timing

There are two methods to post data to the "Thingspeak". They are the POST and the GET. While using POST the time taken was 1 sec. But by using GET it was reduced to 0.33 sec per field. In POST we are using both httplib and urllib for sending data to server. So first it will get connected to thingspeak.com then it will be posting the data and after getting connected it will be posting the data to the respective channels.
In GET we are directly using httplib and not using urllib. Instead of domain name IP address of site is given for establishing connection.
There are 8 fields per channel and all of them can be simultaneously updated with a single value each. Therefore, at the rate of 1sec per reading it was taking nearly 40 mins for 2560 readings which was later reduced to 14 mins. It was taking 0.33 sec for reading. So total time taken was (.33*2560)/60=14 minutes

Even though it is reduced to 15 minutes, still it is a large delay. Currently work on reducing the delay is being carried out. There are several options. One is to exploit Thingspeak platform by creating several fields within the same channel and likewise creating several channels for parallel uploads. Second, is to rework the acquisition and uploading strategy by introducing thread based pseudo parallel execution. Thirdly, other cloud services like IBM Bluemix, kaa and azure can be tried. Of these IBM Bluemix and kaa requires JavaScript for programming.

We also worked on making our own website, that can be used by doctors to view EEG graphs. Login for doctors will be provided and in that each doctor will be having his own patients list. From that, screenshots are as shown below. We have used the php script for accessing the data from the database. The data of the thingspeak server is accessed by the direct link api.thingspeak.com using that particular channel's api key. For accessing this database we have used mysql language.

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The graphs of the parameters are displayed using the google high stock charts.

Figure 8: Website page

Figure 9: Patient List

Figure 10: Graph

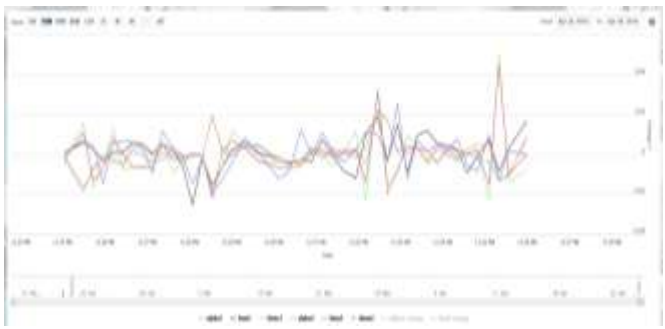

Figure 11: All parameters

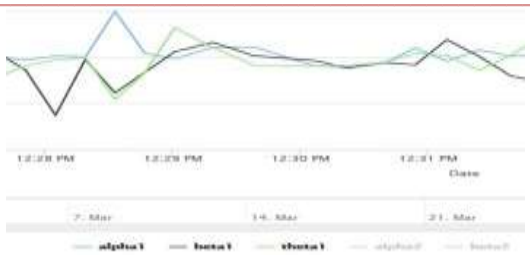

Figure 12: Alpha, beta and theta parameters

Currently we are also providing the option for accumulating the data in a .xls file as well as to save a .jpg file as shown in above figure 10.

As it can be seen from figure 11, alpha, beta and theta parameters of both the electrodes along with the energy calculated of alpha and beta electrode are displayed. While in figure 12, only alpha, beta and theta parameters of first electrode are displayed for easier and flexible comparison for doctors.

III. Conclusion

Sensor readings were successfully taken via MCP3008.These readings were stored text file created in text file. Data from these files was taken uploaded to cloud server. Sensor values were successfully obtained in real-time on cloud server.

IV. Future Scope

Data from electrodes attached on brain will be obtained via MCP3008 to raspberry pi. In RPi a script will be written which will analyze EEG values. Different EEG parameters like Alpha, beta, gamma, and theta will be obtained by passing EEG readings into RPi. All these parameters will be uploaded to Cloud server in real-time on different channels formed in server.

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