Detection of brain abnormalities using Internet of Things

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Abstract—Today with the advancement of medical science, major part of the research is being focused on the diagnosis of the different abnormalities of the brain. Using brain waves one can detect the abnormal behavior of brain and these waves are recorded using EEG electrodes and the obtained artifacts can be analyzed to predict the mental wellness of the patient. These artifacts can be uploaded to cloud hub for easy access from all over the world. With the popularity of IoT(Internet of Things) reaching new heights and with each passing day, the devices getting smarter, it is very easy to access any information from any part of the world at a single touch of human hand. The IoT revolution has redesigned health care by narrowing the gap between medical condition and the response from the specialist. This work presents an idea to reform the existing access control system of detecting medical conditions related to brain and getting timely response from doctors in case of a medical emergency and hence this paper ensures that people can get good quality of healthcare facilities from doctors worldwide.

Keywords—Brain waves; brain diseases; EEG waves; Electroencephalogram; IoT; healthcare; remote health monitoring

I. INTRODUCTION

A disease is a condition of the living animal or plant body or of one of its parts that impairs normal functioning and is manifested by distinguishing the science and symptoms. Electroencephalogram is a test used to identify problems related to electrical activity of the brain. An EEG tracks and records brain wave patterns with the help of small metal discs with thin wire termed electrodes placed on the scalp and then the electrical signals are sent to a computer to record the results. Normal electrical activity in the brain makes a recognizable pattern. The EEG signals are commonly decomposed into 5 types of brain waves as shown in Fig.1: delta, theta, alpha, beta and gamma waves. Generally, the amplitude of alpha wave is recorded to be low. Mostly it is recorded from the occipital and parietal regions of the brain. The amplitude of the beta wave is quiet low and it is mostly recorded from the temporal and frontal lobe. Delta waves are rhythmic in nature and the amplitude of this wave is high. It is recorded from the occipital lobe.

Fig.1 Brain waves with different frequency
Theta waves are slow in nature and the amplitude of this wave is low-medium. Gamma waves are fastest brain wave frequency. Its range is from 31 to 100 hertz with the smallest amplitude [1]-[2].

In the proposed work, EEG signals will be continuously recorded and correlated with patient’s brain waves [3] and relay the resulting data to a database linked with his health records. When the patient shows up for physical examination doctor is not only provided with convectional test based static data but can also use much richer longitudinal data which is provided by sensors.

II. PREVIOUS REVIEW

Most of the frameworks which have been proposed until now for remote health monitoring consist of a three grade structure as depicted in Fig.2: a wireless body area network which consists of wearable sensors for the purpose of data acquisition, communication and networking, IoT hub,[11],[12],[13].

For instance [4] puts forward the idea of a system that includes sensors which can be worn by the patient to measure various parameters like blood pressure and body temperature. Gathered information in then transmitted through Bluetooth connection to a gateway server. The data stored in server is then converted into an observation and measurement file which can be later retrieved by doctors through internet. This file is stored on a remote server. [4]-[5] present a health monitoring system which can be accessed by the medical staff through the stored data online utilizing a cloud based medical data storage. Along with the technology for data gathering, storing and accessing, analysis and visualization of medical data are important parts of remote health monitoring system. Data analysis becomes a quite frustrating and error prone task. Processes like data mining and visualization have newly come under limelight in remote health monitoring [6]-[7].

III. SYSTEM ARCHITECTURE

The major components of the system architecture for remote health monitoring system are shown in Figure 1. The major components are described as follows [8]:

Data Acquisition is the work of multiple sensors that measure physiological aspects of a patient such as blood pressure, temperature, muscle activity and gait (posture). All these sensors are connected to the network through an intermediate data aggregator or concentrator, which can be a smart phone or a device which is located near the patient.

Data transmission components of the system convey recordings of the patient from his location to the data centre of the respective Health Care Organization(HCO). There is a sensory acquisition which is installed with devices like Zigbee or low power Bluetooth which helps in transferring sensor data to concentrator. This cumulative data is further transferred to a HCO using internet connectivity on the concentrator. Sensors which help in data acquisition form an Internet of Things based architecture as each of the sensors data is accessible through the internet.
Cloud processing has three different elements which are storage, analytics and visualizations. This system is designed in such a way that biomedical information and health professional with diagnostics information can be stored for a long time. Analytics which utilizes the sensor data as well as e-Health records are becoming popular as they can help with diagnosis and prognosis for various health condition and disease. In addition to this, visualization is a key pre-requisite for any such system as it is impractical to expect physicians to think over the humongous data and analyses from the wearable sensors. If the wearable sensors are to impact clinical practice, it is essential that visualization methods are incorporated that make the data and analyses accessible in a digestible form. Fig 3 clearly depicts the working procedure of remote health care monitoring system using EEG.

![Fig 3 Working Procedure](image)

IV. HARDWARE DESIGN

Here three electrodes are used to capture electrical activity. These electrodes are placed below each ear and reference electrode on forehead as shown in Fig 4.1(a)

![Fig 4.1(a) Placement of electrodes](image)

Amplification and filtering of EEG signals:

Output of electrodes is in order of microvolts which is fed to EEG measurement module. Self-made measurement module can be made in order to reduce cost. Figure 4.1(b) shows hardware setup of analysis of EEG signals using self-made measurement module.
It is computer-on-module designed by Intel. It is widely used to bridge the gap between development enthusiast and advanced Internet of Things. It is a physically tiny computer that draws small power to create interaction between user and electronics. It measures around 1 by 1.5 inches and has dual core Atom CPU, 1GB of RAM, 4GB of storage with additional facility of Bluetooth.

V. WORKING

The data is collected using wearable electrodes positioned as mentioned above. That includes miniature sensor which can measure various parameters. Preprocessing hardware and a platform is used to communicate and transmit the measured data. Here the hardware used is Intel Edison board with Microsoft Azure IoT platform. Microsoft Azure IoT cloud server is very safe and compatible with Intel Edison and helps in communication of the cloud server with Intel Edison [9][10]. The cloud server comprises of three tiers of protection: device security, connection security and cloud security. Each IoT appliance is given a unique identity key to increase device security. In this case, one Edison board is used, hence only a single identity key is created. For the purpose of connection security, encryption is done between the connection of IoT devices and cloud servers using X.509 based certificates. The connection supports HTTPS protocol as well as Advance Message Queuing Protocol (AMQP). For the purpose of user authentication and authorization, Azure Active Directory is realized. This ensures only active user can have access to the data stored in the cloud server. All this is done for the purpose of cloud security. This multi-layered security protection ensures enhancement in the data of the patients. Figure 5 shows flow chart that depicts the clear working of data acquisition and transmission.
VI. RESULTS

The EEG records brain activity from the scalp. These waveforms depict cortical brain activity. EEG measures the electrical activity of brain in microvolts. Brain cells communicate each other through electrical impulses. Therefore it is popularly used to detect potential problem related with this activity. Electrodes attached to scalp surface analyzes electrical impulse in the brain and these signals are send to personal computer to record results. These electrical impulses look like wavy lines with peaks and valleys. Different level of consciousness like sleeping and waking has different range of frequencies. Also different condition of brain corresponds to different frequency. Figure 6 depicts impulse being recorded to computer for analysis.

Fig. 5    Procedural Working

Fig. 6   Impulse being recorded on computer    Fig. 7   Actual EEG signal depicting detected peaks
Table 6. Mental health corresponding to output readings

<table>
<thead>
<tr>
<th>Output from Edison</th>
<th>Voltage</th>
<th>Neural condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-100</td>
<td>0-1.96</td>
<td>Brain inactivity</td>
</tr>
<tr>
<td>100-140</td>
<td>1.96-2.74</td>
<td>Depression</td>
</tr>
<tr>
<td>140-200</td>
<td>2.74-3.92</td>
<td>Normal</td>
</tr>
<tr>
<td>200-255</td>
<td>3.92-5</td>
<td>Overexcited</td>
</tr>
</tbody>
</table>

Figure 7 depicts the peaks observed in a real time EEG signal. Edison board gives value from 0 to 255. Each value from Edison corresponds to voltage output. This voltage output helps to check mental health of the person. Figure 6 shows the readings and mental condition accordingly.

VII. CONCLUSION

This paper gives insight into a simple device that can help people to locate abnormalities in the human brain and getting consultations from doctors without even visiting clinics or health care centers. This ensures timely treatment and diagnosis of life threatening diseases, if detected at a later stage. All the observations and procedural working of the device are mentioned in the paper and results have been discussed elaborately. Thus IoT revolution has redesigned health care by narrowing the gap between the patient and the response from the specialist.

REFERENCES

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