A SURVEY ON PERCEPTION OF SEIZURES AND EMERGENCY CARE USING WIRELESS SENSOR NETWORKS

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Abstract— Abnormal and deviant behaviour of faulty parts of brain result in Seizures. The seizures may be caused due to various reasons and some causing even death. So to prevent this patient needs continuous monitoring even in out of hospital surroundings area. There are several ways to monitor seizures. In earlier days, for monitoring epileptic seizures electro encephalography (EEG) is used. The electrical activity along the head scalp is recorded in EEG and it uses electrodes that have to be clipped to the scalp. This makes it uncomfortable for the patient when he sleeps and this also requires long term home overseeing which is not feasible. In some cases patient had a mesh of electrodes inserted beneath skull and draped over the surface of his brain. A new advance towards in brain-machine interfaces(BMIs), which assess electrical activity from the brain and use the signal to control something. BMIs come in many shapes and sizes. They detect the tiny voltage changes in the brain that occur when neurons fire to trigger a thought or an action, and they translate those signals into digital information that is conveyed to the machine. Instead of making use of EEG, our objective is to make use of sensors i.e., Inertial Measurement Unit(IMU)to monitor the patient. The IMUs are clipped to the wrist and seizures in any direction (X, Y, and Z) can be detected. We also intend to make use of a smart phone application to detect the presence of a seizure, along with a mobile (3G or 4G) network to relay information urgently from these sensors to the nearest hospital and call for immediate care.

Keywords— Seizures, EEG (Electro Encephalogram), IMU(Inertial Measure- ment Unit), Accelerometers, Gyro meters, Magnetometers.

I. INTRODUCTION

Epilepsy is one of the most prevalent neurological disorders. 80 Million people all over the world were affected with this neurological disorder. Drug therapy can help 78% people in recovering from Epilepsy while Neurosurgical procedures can help (8% - 9%). Nonetheless any available therapy can help 25% of patients [1]. Intensive monitoring of EEG and video for longer periods can help management in daily care and drug therapy in refractory patients, who have frequent seizures [2]. refractory patients who continue to have frequent seizures, it has been shown that intensive monitoring with electroencephalogram (EEG) and video over a long period, contributes to the management of daily care and the adjustment of drug therapy[2]. For patients it is inconvenient to measure their EEG and Videos for a longer periods while it is a very tedious job for medical personnel to analyze large data. Adding to this, these methods cannot yet be used for real-time processes. In [3], the EEG was used as a sensor to obtain information about seizures for which software called OpenViBE is used in support with the Saolucas Hospital and the Inscer Brain Institute. The automatic spike detection was performed using MAT- LAB and provided a sensitivity of 90%. This spike detection was performed using private cloud resources. In addition, a smart phone is also used to connect with the cloud and to perform data analysis during emergencies.

This approach therefore intends to reach more patients and reduces costs.

The EpiCare[3] Free epilepsy sensor is a wrist-worn device from Tunstall Emergency response. It has the ability to detect tonic-clonic seizures in adults and children above the age of 10. The advanced 3-axis accelerometer is able to detect convulsions and vibrations that occur during the seizure. In such a situation, an in-built app on the patients phone will detect and immediately sends an SMS to the designated people along with the GPS coordinates of his/her location.

The sensor unit consists of 3 axis accelerometer, microprocessor and a recharge- able battery[4]. Here, the seizure is detected real time by an algorithm that helps the control unit to trigger an alarm. It also creates diaries for patients suffering from frequent seizures so that they can be provided with more attention.

II. MULTIPLE APPROACHES TO CAPTURE NEUROLOGICAL SIGNALS

To address these concerns, the United States National Institutes of Health en- couraged researchers to develop a neural prosthesis with a non-invasive control mechanism. System based on EEG Signals would be an ideal one, simply using electrodes attached to the scalp. As brain signals that external electrodes receive are faded and attenuated by their passage through the skull and scalp. ECoG signals seems to be the trade-off which our team selected.

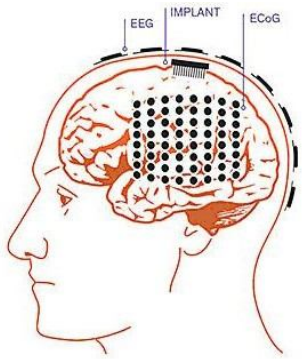

Fig. 1. This is Caption for head Figure

i) Tapping the Brain – Three Ways

A. Electodes can be implanted by penetrating them into cortex. These elec- trodes can be used by neuro-scientists to record the activity of brain cells. Signals from this method are clearest, but its also the riskiest. Comparatively, electroen- cephalography (EEG) electrodes attached to scalp carry no risks, but the signal they capture is feeble.

B. By draping electrodes draped over the surface of the cortex, Electrocorticography (ECoG), may represent the sweet spot, a compro- mise between risk and clarity. ECoG systems provide a improved signal-to-noise ratio (SNR), than EEG. The data by ECoG includes high-frequency components that EEG cant easily capture. As Electrodes are placed over the motor cortex can specifically listen in on the electrical activity most relevant for controlling a prosthetic arm, ECoG systems also do a better job of extracting the most useful information from the brain. In a similar way Signals associated with ver- bal communication can also be captured by these electrodes as they are draped over the brain areas associated with speech.

C. Raw ECoG signals appear to be a confused mess of squiggly lines with little discernible pattern. To make sense of the data, our team performs a spectral analysis to deconstruct the signal and find oscillations at certain specific frequencies. These are the brain waves you may have heard about. Neuroscientists have learned that different oscillation fre- quencies are associated with specific mental states, such as deep sleep, focused attention, or meditative contemplation. Several epileptic volunteers with ECoG arrays tested our novel system. The first, the woman described at the beginning of this article, focused her eyes on the image of a ball on a computer screen; the computer was streaming video from a setup across the room. An eye-tracking system recorded the direction of her gaze to locate the object she wanted to ma- nipulate. Then, as she reached toward the screen, her ECoG electrodes recorded neural signals associated with that action. All this information was relayed to a robotic arm across the room, which was equipped with a Microsoft Kinect to help it recognize objects in three-dimensional space. When the arm received the signal to reach for the ball, its path-planning software calculated the necessary movements, orientations, and grasp configuration to smoothly pick up the ball and drop it in a trash can. The results were encouraging: In 20 out of 28 trials, this womans brain signals successfully triggered the robotic arm, which then completed the entire task. A braincomputer interface (BCI), sometimes called a mind-machine interface (MMI), direct neural interface (DNI), or brainma- chine interface (BMI), is a direct communication pathway between an enhanced or wired brain and an external device. BCIs are often directed at researching, mapping, assisting, augmenting, or repairing human cognitive or sensory-motor functions. In light of those concerns, the United States National Institutes of Health challenged researchers to build a neural prosthesis with a less invasive control mechanism. The ideal would be a system based on EEG signals, simply using electrodes attached to the scalp. Unfortunately, the brain signals that ex- ternal electrodes pick up are blurred and attenuated by their passage through the skull and scalp. This led our team to investigate the middle road: the use of ECoG signals.

ii). Limitations of Earlier Prediction Methods

Epilepsy is one of the most prevalent neurological disorders.

Neurological disorder affects 85 Million people all over the world. Drug ther- apy can help 75% people to recover from Epilepsy while Neurosurgical proce- dures can help upto (7% - 8%). Unfortunately 20% of the affected people cannot be under any medication. Furthermore, this method cannot yet be applied in real-time procedures.

- Nearly 75% of patients with epilepsy continue to have seizures despite opti- mal medication management[7].
- Long-term home monitoring can provide the neurologist an objective mea- sure of the frequency of seizures during the day.
- For refractory patients who continue to have frequent seizures, it has been shown that intensive monitoring with electroencephalogram (EEG) and video over a long period, contributes to the management of daily care and the ad- justment of drug therapy [8] will be difficult.
- The long-term monitoring with EEG and video can be very unpleasant for patients, and analyzing large amounts of EEG/video-data is very labor in- tensive for medical personnel[9].
- Systems employed to detect seizures may have the potential to improve out- comes in these patients by allowing more tailored therapies and might,
- ad- ditionally, have a role in accident and SUDEP prevention.
- Automated seizure detection and prediction require algorithms which em- ploy feature

computation and subsequent classification. Over the last few decades, methods have been developed to detect seizures utilizing scalp and intracranial EEG, electrocardiography, accelerometry and motion sensors, electrodermal activity, and audio/video captures[7].

- To date, it is unclear which combination of detection technologies yields the best results, and approaches may ultimately need to be individualized.

  Electrodes on the scalp only pick up activity from about one third of cortex . This means that seizures originating from the sulci , basal regions and inter- hemispheric regions of the brain are not picked up. Furthermore, approximately a 2.5 inch square of the cortex must be involved in generating a seizure for it to be detectable on EEG.

iii) Advantages of senors

- A sensor can detect seizure even when the patient is not within the hospital environment.
- A sensor can capture the signals which can cause dangerous conditions for the patients.
- This detection system can locate the patient using Wireless Sensor Network.

III. SENSOR

i)Sensor

A sensor is a device which converts any physical quantity to be measured into a signal which can be read, interpreted, displayed, stored or used to control some other quantity. This signal measured is proportional to the quantity to be ob- served. Sensors measure a particular characteristic of any device or object. A thermocouple will sense heat energy (temperature) at one of its junction and produce equivalent output voltage at other junction this voltage can be mea- sured by Voltmeter. More the temperature rises, higher the voltage shown in the Voltmeter. Calibration of sensors with respect with some reference value or stan- dard device is done to achieve accurate measurement. Thermocouple is shown in the figure below.

Note that a transducer and a sensor are not the same. In the above given example of thermocouple. The thermocouple acts as a transducer but the addi- tional circuits or components needed like the voltmeter, a display etc together from a temperature sensor. Hence the transducer will just convert the energy

Fig. 2. This is Caption for sensor Figure

from one form to another and all the remaining work is done by the additional circuits connected. This whole device forms a sensor. Sensors and transducers are closely related to each other.

1 **ii) Characteristics of Sensors**

A good sensor should have the following characteristics High Sensitivity: Sen- sitivity indicates how much the output of the device changes with unit change in input (quantity to be measured). For example the voltage of a temperature sensor changes by 1mV for every 1C change in temperature than the sensitivity of the sensor is said to be 1mV/C. Linearity: The output should change linearly with the input. High Resolution: Resolution is the smallest change in the input that the device can detect. Less Noise and Disturbance. Less power consumption.

2 **iii) Types of Sensors**

- Sensors are classified based on the nature of quantity they measure. Following are the types of sensors with few examples.
- Acoustic and sound sensors e.g.: Microphone, Hydrophone.
- Automotive sensors e.g.: Speedometer, Radar gun, Speedometer, fuel ratio meter.
- Chemical Sensors e.g.: Ph sensor, Sensors to detect presences of different gases or liquids.
- Electric and Magnetic Sensors e.g.: Galvanometer, Hall sensor (measures flux density), Metal detector.
- Environmental Sensors e.g.: Rain gauge, snow gauge, moisture sensor.
- Optical Sensors e.g.: Photo diode, Photo transistor, Wave front sensor.
- Mechanical Sensors e.g.: Strain Gauge, Potential meter (measures displace- ment).
- Thermal and Temperature sensors. e.g.: Calorimeter, Thermocouple, Ther- mistor, Gardon gauge.
- Proximity and Presences sensors A proximity or presences sensor is the one which is able to detect the presences of nearby objects without any physical contact. They usually emit electromagnetic radiations and detect the changes in reflected signal if any. e.g.: Doppler radar, Motion detector.

Further classification can be done based on the principle of operation and nature of output signal (analog or digital).

3 **iv) Detection based on sensors**

A Wireless Inertial Sensor [5] can be used to detect human body movements. Wireless Accelerometer, Gyroscope, and Magnetometer form the Bluetooth com- patible IMU (Inertial Measurement Unit) that can send the real time data from the IMU to the Bluetooth enabled Smartphone device. In general , the signals from the IMUs can be collected and saved in a flash memory unit and can be sent via Bluetooth to the smart phone. The IMU requirements would include a data-sampling frequency of at least 20Hz (given that for our application ,we consider the possibility of a patients wrist moving at the rate of 20 times every second during a seizure attack). The hardware architecture of the IMU consists of an accelerometer connected to the processor through an I2C module and the gyroscope, magnetometer and temperature readings passed as analog signals to it. This processor is also connected to a micro SD module ,a Bluetooth module and a battery management module [6].It also manages a user interface which consists of a controller which allows the user to turn off the device when unnec- essary.

IV. PREREQUISITES OF SENSOR

i) Accelerometers

They measure the linear acceleration whose measurements are required to be accurate.The commercially available accelerometer that serves this application well is LIS3LV02DQ from STelectronics as it has 640Hz of bandwidth that can support this application as it demands a bandwidth of 20 Hz [6].In general,the sensitivity of the accelerometers is required to be at least ±*tt* for a seizure patient.The data obtained from it has to be digitized and sent to the microcon- troller.

ii) Gyroscopes

They measure the angular speed.This application demands a sensitivity of atleast 20 degree per second.

Fig. 3. This is Caption for devices Figure

iii) Magnetometers

They are required for the measurement of orientation information.For this ap- plication,they require to have a full scale of +/-6 Gauss [6].

iv) Microcontroller Unit

The MCU unit must have atleast 128kB of flash memory and 16kB of RAM memory.It has one ADC with atleast seven input channels of 10 bits because we are assuming seven analog input channels(three each from gyroscope and mag- netometer and one from the temperature sensor).The MCU must also allow the sleep mode of operation in order to support power management. The algorithm used will divide the data into short windows (with atleast 50% overlap to prevent data loss) of around 512 bytes and sent to the micro-SD card [6].

Once a window is filled in with data,the microcontroller is alerted and the data is sent via the Bluetooth network to the smartphone. When a seizure is detected, a Wireless sensor network is used to send an alarm to hospital staff or the relatives of the patient.It is proposed to use such a device on the wrist of the patient in order to track his rate of movement.

A sensor captures a neurological signals from human body. The system con- sists of three units Sensor unit, Transceiver unit and Processing unit .The sensor unit captures neurological signal .The transceiver unit converts the signal from

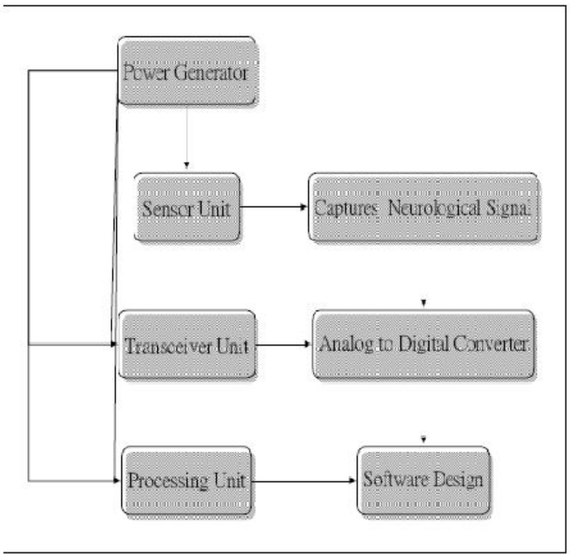

Fig. 4. Basic Transaction flow of a sensor to capture Neuro signal

analog to digital representation using ADC (Analog to Digital converter).The processing system then applies the collected information further using software designed.

CONCLUSION

Health monitoring is one of the most interesting applications of Wireless sensor networks. In this paper we explained how a monitoring system based on wireless sensor network for detecting epileptic seizures. The patients being at home doing daily routine chores can be monitored by this wireless sensor networks, just by living a clinical environment. This system proves to be more appropriate than earlier methods. This system provides free mobility to the subject under measurement as the sensors are wireless in nature. As they are small and tiny in nature they are easily wearable for any patient.

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