Dan Coughlin Biosensors

Kevin McCabe Report 1

Bob McCarthy

Steve Moffett

Using Electroencephalograms to Predict and Prevent Epileptic Seizures

Epilepsy is defined as a disorder of the brain characterized by an ever present predisposition to generate abnormal neuron activity in the brain (Fisher, 2005). The abnormal neuron activity then induces an epileptic seizure in the victim. When a person experiences two or more unprovoked seizures, they are considered epileptic (Epilepsy Foundation, 2011). This disorder includes many diseases that affect the brain in this way. Usually, the cause for epilepsy in an individual cannot be found (Epilepsy Foundation, 2011). The most common trigger for an epileptic seizure is missed medication, but other causes may include emotional stressors, external stimuli such as flashing lights, and even excessive use or withdrawal from alcohol or drugs (Epilepsy Foundation, 2011). Epilepsy affects 0.5% to 1% of the population, and about 2.5 million people in the U.S are diagnosed with this disease (WebMD, 2009). Most epilepsy cases are controlled with pharmaceuticals or diet. In some cases, surgery may be used to control epileptic seizures (WebMD, 2009). This literary review will discuss new methods to predict and possibly prevent epileptic seizures.

All of the methods that will be discussed in this literary review will be using Electroencephalograms or EEGs. EEG is a method of recording the electrical activity of the brain along the scalp (Niedermeyer, 2005). This electrical activity is produced by the firing of neurons in the brain. The first EEG was performed on a dog in 1912 by Vladimir Vladimirovich Pravdich-Neminsky, after studies of electrical activity of the brain by Richard Caton and Adolf Beck (Swartz, 1998). Shortly after the discovery of a unique spike waveform attributed to epileptic seizures, the first EG laboratory opened at Massachusetts General Hospital (Swartz, 1998). EEG’s main application is the prediction of seizures and to distinguish epileptic seizures. Other uses include the diagnosis of strokes, tumors, and other focal brain disorders. However, with the emerging of such technologies as CT scans and MRIs, EEG has become obsolete in detecting these diseases. EEG is also being used recreationally to control toys and games such as the Mattel Mindflex, and Uncle Milton Industries’ Star Wars Force Trainer. Methods of prediction using this EEG technology will be discussed in detail in the final paper.

In the diagnosis of epilepsy, it is important to determine where in the brain the event originates from and also try to determine how they occur so future seizures may be predicted. According to epilepsy.com, standard method for doing this is through the use of an electroencephalogram (EEG). These tests can show what areas of the brain are causing the events by looking at the EEG recordings around the time of a seizure and searching for epileptic spikes.

The final paper will look at the different methods currently being researched for the purpose of predicting epileptic seizures. There are several strategies that we have found across a number of published papers. For each paper, it needs to be distinguished whether the researcher is looking at ictal or interictal data. Ictal means that the EEG is being recorded during an epileptic event. Interictal refers to the period of time between events. Interictal is often preferred as you are able to still locate the area of the brain associated with the event without having to keep the patient in a hospital to be monitored while waiting for a seizure. Within these two monitoring time frames is a variety of strategies being used to actually predict where and how epileptic events generate.

These techniques include fuzzy logic, Support Vector Machines (SVMs) and Artificial Neural Networks (ANNs). All of these methods take the raw EEG data and process the signal in such a way as to get the desired information out of it. The first technique uses fuzzy logic, which, like Boolean, assigns, a truth-value. Unlike Boolean, however, there are areas between 0 and 1, which the value can fall. There are partial-truth and partial-false areas that can be assigned. This fuzzy logic is used to categorize the epilepsy risk level, allowing for further algorithms to predict whether or not an event is impending (Sukanesh, 2008). There are also Support Vector Machines, which is a type of artificial intelligence analysis algorithm. By taking a number of samples that correspond to whether or not and event is going to happen, the SVM is able to create a mathematical model for that person and determine if future events will occur. This method allows for the machine to constantly learn and improve on itself (Yuan, 2010). The final technique is the Artificial Neural Networks strategy. This method creates a mathematical model of the neural network that acts as a modern controller and is able to take internal and external information to adapt its analysis. There are two strategies within the ANNs. They are the Probabilistic Neural Networks (PNNs) and the Functional Neural Networks (FNNs). They are very similar, but differ slightly in the way the problems are looked at. For the PNNs, the random variable F = f(G) depends upon the random variable G = g(H) , which depends upon H =h(X) , which depends upon the random variable x. For FNNs, “the input x is transformed into a 3-dimensional vector, which is then transformed into a 2-dimensional vector, which is finally transformed into f” (Bao, 2009).
 For the remainder of the semester, the team will look into these papers in more detail. The group will analyze each technique, compare them to each other, determine which ones are most promising and which ones are most likely to be adapted in a real world application.

 Preventing epilepsy seizures is probably one of the biggest mysteries in the medical field to date. Although there are some cures, there are still hundreds of thousands of people that struggle with seizures generated from epilepsy. Through research, the final paper will be investigating current and new strategies researchers are trying in order to help us understand epilepsy and what those struggling with the disease can do to prevent seizures from occurring.

The most common way to prevent seizures is through medications prescribed by doctors. Unfortunately, not all patients will be positively affected by current medications. Another alternative is through surgery. This entails surgery of the brain and also is not one hundred percent efficient. This leads to another way to help those still struggling with the disease. Through the use of biosensors combined with electrical measurements, it gives another way to help solve this problem. Although it is just in the beginning stages of helping prevent seizures, there are more than one ways biosensors are playing roles to stop seizures.

Our team is doing a lot of research through the use of the Internet for ways to prevent seizures. Internet databases give us articles on what is being done and the future role biosensors will have to stop seizures. Some articles include first hand stories from people suffering with the disease. Others include future implementation of biosensors and how they are being introduced into the real world to prevent seizures. Along with reading and researching about ways to prevent these seizures, there is a lot of information regarding different companies that are in the process of manufacturing biosensors and what each of their methods are to prevent seizures.

An example of a method being used is to implant a sensor in the neck and have it pulse for different durations of on and off times. This allows the device to stop a seizure attack during a specific time interval and then it will turn off for another specific amount of time. If the person feels an attack coming while the sensor is not pulsing, they can use a magnetic that will cause the device to pulse that will stop the seizure from happening.

About one percent of the population in America suffering from epileptic seizures, which totals nearly 3 million people. Of those, there are 40,000 people that die annually from epileptic seizures. In an effort to prevent these fatal seizures, there have been a variety of products aimed at sensing seizures before they occur and also to alert others as they are happening. There are also other products which try to prevent seizures altogether.

One of the most vulnerable times for an epileptic seizure to take place is while sleeping. One type of products specifically sense movement typical of a seizure by placing a sensor type pad underneath the sleeping epileptic person. If that person has a seizure, then the pad will sense the convulsing movement resulting in alarms to go off in the area or even electronically alert a medical staff. Another type of product available for sensing epileptic seizures are Electrodermal Activity Sensors. These sensors actually detect changes in skin conductance with two electrodes, which can be related to epileptic activity. There are also types of products that are in vivo, which are surgically implanted to limit and prevent seizures. One type is called Vagus Nerve Stimulation (VNS), created by Cyberonics, Inc. This functions as a brain pacemaker of sorts to stimulate the nerve system enough to prevent seizures. There have been complications with the process as with any surgery that implants devices into the body. It has been effective for some, completely removing any epileptic seizures, but in a few cases the 1-3mA of current that the device outputs to the vagus nerve has stopped the heart of one particular patient for 30 seconds every 3-5 minutes.

Going forward, additional types of products will be researched. An analysis between the different types of products compared for their effectiveness, reliability, and practicality between the types of products will also be done to help determine which product is best for different situations.

Bibliography

"Epilepsy and Seizures: Provoked Seizures, Seizure Disorder, and More." *WebMD*. Web. 01 Mar. 2011. <http://www.webmd.com/epilepsy/guide/understanding-seizures-and-epilepsy>.

"Epilepsy Diagnosis: EEG." *Epilepsy.com*. Ed. Steven C. Schachter. 15 Dec. 2006. Web. 28 Feb.

 2011. <http://www.epilepsy.com/EPILEPSY/testing\_eeg>.

"Epilepsy Foundation-About Epilepsy - Information about Seizures -- Types, Treatment, Diagnosis and First Aid." *Epilepsy Foundation*. Web. 01 Mar. 2011. <http://www.epilepsyfoundation.org/about/>.

"Epilepsy Foundation-Causes of Epilepsy." *Epilepsy Foundation*. Web. 01 Mar. 2011. <http://www.epilepsyfoundation.org/about/types/causes/index.cfm>.

"Epilepsy Prevention: Warning Signs of an Approaching Seizure." *WebMD*. Web. 01 Mar. 2011. <http://www.webmd.com/epilepsy/understanding-epilepsy-prevention>.

Fisher, R. S., Boas, W. v. E., Blume, W., Elger, C., Genton, P., Lee, P. and Engel, J. (2005), “Epileptic Seizures and Epilepsy: Definitions Proposed by the International League Against Epilepsy (ILAE) and the International Bureau for Epilepsy (IBE)”. Epilepsia, 46: 470–472. doi: 10.1111/j.0013- 9580.2005.66104.x

Forrest Sheng Bao; Jue-Ming Gao; Jing Hu; Donald Lie; Yuanlin Zhang; Oommen, K.J.; ,

"Automated epilepsy diagnosis using interictal scalp EEG," Engineering in Medicine and Biology Society, 2009. EMBC 2009. Annual International Conference of the IEEE , vol., no., pp.6603-6607, 3-6 Sept. 2009.

Niedermeyer, Ernst, and F. L. Da Silva. *Electroencephalography: Basic Principles, Clinical Applications, and Related Fields*. Philadelphia: Lippincott Williams & Wilkins, 2005. Print.

"Real-time Imaging of the Glutamine-Glutamate Shuttle in Epilepsy - Dana Foundation." *Brain and Brain Research Information - Dana Foundation*. Web. 01 Mar. 2011. <http://www.dana.org/grants/imaging/detail.aspx?id=11182>.

Sukanesh, R.; Harikumar, R.; , "Fuzzy techniques and hierarchical aggregation functions decision trees for the classification of epilepsy risk levels from EEG signals," *TENCON 2008 - 2008 IEEE Region*  *10 Conference* , vol., no., pp.1-6, 19-21 Nov. 2008.

Swartz, B. "The Advantages of Digital over Analog Recording Techniques."*Electroencephalography and Clinical Neurophysiology* 106.2 (1998): 113-17. Print.

"Vagus Nerve Stimulation | Epilepsy.com." *Epilepsy and Seizure Information for Patients and Health Professionals | Epilepsy.com*. Web. 01 Mar. 2011. <http://www.epilepsy.com/epilepsy/VNS>.

Yuan,Ye "Detection of epileptic seizure based on EEG signals," Image and Signal Processing (CISP), 2010 3rd International Congress on , vol.9, no., pp.4209-4211, 16-18 Oct. 2010.