Detection of Epileptic Seizures using Wearable Devices: A Review

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Abstract: *Epilepsy is a brain disorder affecting people of all ages mainly seen in many developing countries. Till date many sufferers do not get proper diagnosis and treatment for the same because of its unpredictability. People with epilepsy and their families suffers from stigma*
Seizure disorder would not be nearly so distressful if the time of seizure occurrence were predictable. Unpredicted and unattended seizures can have life threatening complications. This paper reveals the detection of epileptic seizure using wearable devices developed in the last decade.
Keywords: *Epilepsy, epileptic seizure, devices, EEG, detection*

I. Introduction

Seizure detection and prediction has a history, starting from 1970s [1] with small data sets looking only at preseizure (preictal) events minutes to seconds before seizures. Over the past almost 40 years up to current methods it has been progressed, which use mathematical to analyze continuous days of multiscale IEEG (Intracranial Electroencephalogram) recordings. [2]

Seizure detection and prediction research, most important, has given hope for new warning to the 25% of epilepsy patients who cannot be successfully treated with drugs or surgery. Unpredictability of seizures is one of the most insidious aspects. Seizure detection and prediction is an important aim of clinical management and treatment, in patients of refractory epilepsy [9]

Devices do not cure epilepsy, but they may help to control otherwise refractory seizures. This overview will briefly summarize selected wearable devices for predicting epilepsy in its immediate preictal stage. [5]

II. Epilepsy

Epilepsy is a chronic neurological brain disorder that affects approximately 50 million people of all ages in every country in the world. According to the WHO (World Health Organization), epilepsy is characterized by recurrent seizures, which are physical reactions to usually brief, sudden, excessive electrical discharges in a group of brain cells [3]

When people suffer from more than one seizure is considered to have epilepsy, which is not related to a clear cause such as fever, a head injury or drug use. A seizure is caused by a sudden brief excess surge of electrical activity in the brain. Epilepsy affect the world's population almost 1% is one of the most common neurological disorders. About 25% to 30% of epileptic patients cannot be treated by surgery or medication; they suffer from refractory epilepsy. [4] Mainly epileptic seizures occur suddenly, at unexpected time. From patient to patient seizure frequency can be varied. Some patients suffer from seizure one in a month or less while others have multiple during the day and/or night.

2.1 Classification

"A transient occurrence of signs and/or symptoms due to abnormal excessive or synchronous neuronal activity in the brain" is defined as an epileptic seizure. [7] Epilepsy diagnosis requires only one epileptic seizure along with an enduring alteration in the brain capable of giving rise to other seizures. Different types of seizures exist and accurate classification is important for prescribing the appropriate therapy. [10]

In 1981, the ILAE (International League Against Epilepsy) formulated an international classification of epileptic seizures that classified seizures into two major classes: Generalized seizures and Partial seizures this classification is based on clinical and EEG (Electroencephalographic) observations of the extent to which the brain is affected by the ictal discharges. No major changes were introduced in the recently revised, the ILAE terminology and concepts for seizures organization [8]

"Focal seizures are perceived as originating within neural networks from only one side of the brain", according to this latest proposal. They may be widely distributed or affect a distinct region. In addition, in cortical or sub cortical structures focal seizures may originate.

On the other side, seizures of type generalized are thought to originate within rapidly recruiting bilaterally distributed networks. These networks do not necessarily involve the entire cortex and can include cortical and subcortical structures. [10]

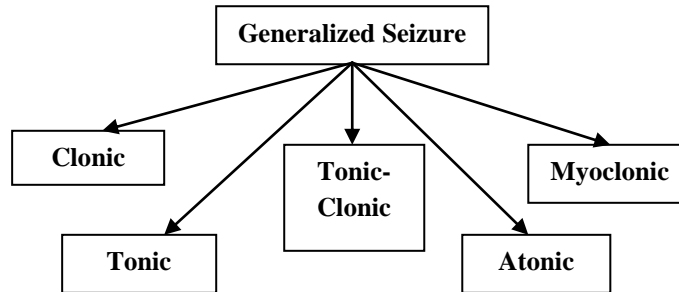Following are the 6 subcategories of the generalized seizures:

Fig. 1 Subcategories of the generalized seizures

2.2 Seizure detection and prediction

The unpredictable and random occurrence of seizures is of the most distressful issue affecting patients and their families. Unattended seizures can have serious consequences including injury or death. Since centuries prediction of seizure has been a challenging task for in neuroscience.[12] A series of international workshops has reviewed goals and problems with seizure prediction [2]

2.2.1 Patient awareness

According to the classification mentioned above the precipitating factors and premonitory sensations vary patient to patient. Each and every patient should know his/ her own preictal symptoms. To avoid functional impairment the patient should receive the immediate peculiar preictal signals out of his/ her other symptoms

2.2.2 Prediction by EEG

For epilepsy EEG has been gold standard diagnostic modality since decades. It helps in diagnosing epilepsy during aura phase. But it's a time consuming procedure, not feasible to do it in immediate preictal stage. It is quite impractical because of high false positive rate.

Although neuronal signals are the most obvious candidate for seizure detection, an EEG based approach has its disadvantages. To obtain high-resolution data, recordings need to be intracranial, which is highly invasive and not likely to have widespread applicability. Even if the quality of recordings from surface-based electrodes is improved, the technical requirements for the implementation of a portable EEG recorder are challenging. Furthermore, much effort will be needed to design a wearable electrode system that is not obstructive, unwieldy or stigmatizing.

2.2.3 Seizure prediction and devices

Epilepsy patients never know when the next seizure will strike. He/she could lose consciousness while driving a car or swimming. The fear of unpredictable episodes can affect his/ her life – from work to social activities

Now a day's devices can identify after patient is having a seizure and call for his/ her help. For example, the SmartWatch is a wristwatch like monitor that detects shaking motions. The watch will immediately send a warning signal to patient's family members or caregiver if he/ she have a seizure in his/ her work or sleep. [11]

Smartphone app, called Dialog is made up of a small bracelet that patient can wear, or a patch stick on skin. The device continually records temperature, pulse rate, and hydration level.
By analyzing these data, the app alerts for a possible seizure so action can be taken to prevent it. It also collects data during the seizure to give more insight into patient's condition. [11]

Table 1. Comparative study of some currently available devices [6]

Device Name	Device Type	Signal Processing	Website
SmartWatch	Wristwatch	Android app. Bluetooth signal	http://www.smart-monitor.com
EpDetect	Free mobile phone application (accelerometer)	Wireless transmission – SMS messaging, movement	http://www.epdetect.com
Emfit Seizure	Bed motion sensor	Wireless transmission	http://www.emfit.com

Monitor	(accelerometer under mattress)		
Epi-Watcher	Bed motion sensor (accelerometer under mattress)	Wireless (radio waves) alarm bell and wired version integrated	http://www.vahlkamp.nl/Epi-Watcher_gb.html
Aspire	Cardiac abnormalities during epileptic seizures	System linked to VNS system (closed-loop)	http://satorusystems.com/seizures.html

III. Conclusion

Any seizure is a frightening experience, for the patient and his/her family members. Current wearable devices can call for help while patient is having a seizure, but they can't tell whether he or she will have one. These wearable devices are very important with the point of safety. In the future the research is going on making the prediction devices for occurrence of epilepsy

Acknowledgement

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