

Detection of Epilepsy from EEG Signal during Seizure Using Heuristic Algorithm of Fixed Point Iterations

¹Tahir Ahmad, ¹M. Ghanbari, ¹M. Askaripour and ²N. Behboodiyani

¹Department of Mathematics, Faculty of Science, Universiti Teknologi Malaysia

²Faculty of Computer Sciences and Information systems Universiti Teknologi Malaysia

Abstract: One of the major roles of Electroencephalography (EEG) is an aid to diagnose epilepsy. Abnormal patterns such as spikes, sharp wave complexes can be seen. Our main interest is to extract information about the dynamics from a few observations of this record signal. In this study, the Heuristic algorithm of Fixed point Iteration is used to cluster EEG signal of patients during an epileptic seizure. We obtained signatures of general epilepsy by superimposing results of the method.

Keywords: Cluster, EEG signal, epileptic patients, heuristic algorithm of fixed point

INTRODUCTION

Seizures are the result of sudden excessive electrical discharges in a group of brain cells. Epilepsy describes the condition of the patient having been recurring “spontaneous” seizures or brainstorm due to the sudden development of synchronous firing in the cerebral cortex caused by lasting cerebral abnormality. Surgical treatment may be an option in patients having an epileptic seizure refractory to medication (Engel *et al.*, 1993). Seizures are fundamentally divided into two major groups: partial and generalized. Partial (local or focal) seizures are those in which the clinical or electroencephalographic evidence suggests that the attacks have a localized onset in the brain (Gastaut, 1970).

EEG analysis still relies mostly on its visual inspection. Due to the fact that visual inspection is very subjective and hardly allows any statistical analysis or standardization, several methods were proposed in order to quantify the information of the EEG. McSharry *et al.* (2002) studied the detection of epileptic seizure from a scalp EEG recording. They used synthetic signal that was created by merging a linear random process and nonlinear deterministic process. A seizure prediction method was proposed by D’Alessandro *et al.* (2003) for deciding on the EEG features and electrode location within ten minutes of electrographic seizure onset. To obtain EEG signals from multiple intracranial electrode contacts, an intelligent genetic search process was applied. A method was introduced based on chaos theory and global optimization technique by Chaovallitwongse *et al.* (2005). The method has evaluated for identifying pre-seizure state in the dynamic of EEG signals. Zakaria (2008) proposed a new technique for visualization electrical activity in the brain during an epileptic seizure. They introduced a

technique for mapping recorded EEG signal into a flat. Then, fuzzy C-mean was applied to cluster of EEG signals.

In this study, we first briefly introduce Heuristic algorithm of Fixed point Iteration. Then, Heuristic algorithm of Fixed point iteration is applied to cluster of EEG signal of patients during epileptic seizure. Optimal number of cluster is obtained with using two types of cluster validity measure. Finally, the result of the clustering is shown using flattening EEG signal and programming by Matlab software.

Heuristic algorithms of fixed-point iterations: Clustering is a general methodology and a remarkably rich conceptual algorithmic framework for data analysis and interpretation (Bezdek, 1981). Heuristic algorithms of fixed-point iteration are other’s classes of the algorithm of fuzzy clustering that are related fuzzy c-Mean. One idea for fixed point iterations showed here. In this class of fixed-point algorithms uses a combination of an Euclidean or non-Euclidean dissimilarity and learning for centers. Let $D(x_k, v_i)$ be such dissimilarity. This algorithm is presented as follows (Miyamoto *et al.*, 2008):

- Step 1:** Set initial value for $m_i, i = 1, 2, \dots, c$.
- Step 2:** For $t = 1, 2, \dots$ repeat step3-step5 until convergence or maximum number of iteration.
- Step 3:** Select randomly $x(t)$ form X .
- Step 4:** Let:

$$u_{ki} = \left[\sum_{j=1}^c \left(\frac{D(x(t), m_j)}{D(x(t), m_i)} \right)^{\frac{1}{m-1}} \right]^{-1} \quad (1)$$

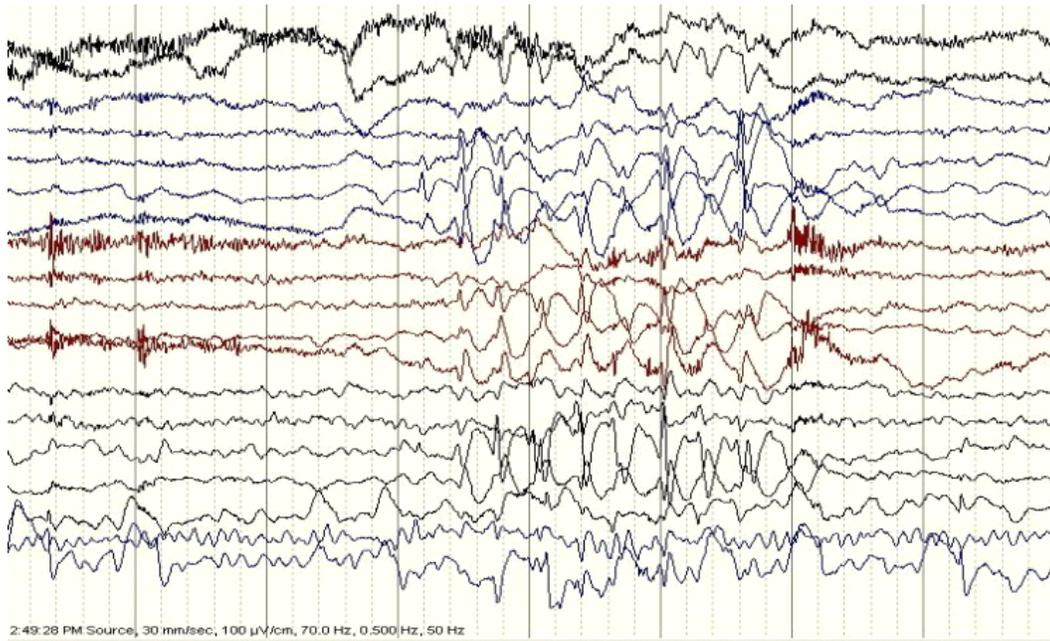


Fig. 1: EEG signal of patient during epilep

For $i = 1, 2, \dots, c$.

Step 5: Let $l = \arg \max_{1 \leq j \leq c} u_{kj}$ Update $m_1(t), \dots, m_c(t)$:

$$\begin{aligned} M_i(t+1) &= m_l(t) \alpha(t) H(u_{ki}) [x(t) - m_l(t)] \\ M_i(t+1) &= m_i(t), i \neq l. \end{aligned} \quad (2)$$

where, $H : [0, 1] \rightarrow [0, 1]$ is either linear or a sigmoid function such that $H(0) = 0$, $H(1) = 1$ and the parameter $\alpha(t)$ satisfies:

$$\sum_{t=1}^{\infty} \alpha(t) = \infty \quad \sum_{t=1}^{\infty} \alpha^2(t) < \infty, t = 1, 2, \dots$$

For example, $\alpha(t) = \text{Const} / t$ satisfies these conditions.

Cluster validity: Cluster validity is a difficult problem that is crucial for the practical application of fuzzy clustering techniques. In addition, we note that there are many purposes to employ cluster validity measures (Bezdek *et al.*, 1999). One of the most important applications is to estimate the number of clusters. Partition coefficient is one of the cluster validity measures that it is described as following:

$$F(U; c) = \frac{1}{N} \sum_{i=1}^c \sum_{k=1}^N (u_{ki})^2 \quad (3)$$

Another type of cluster validity measure is partition entropy:

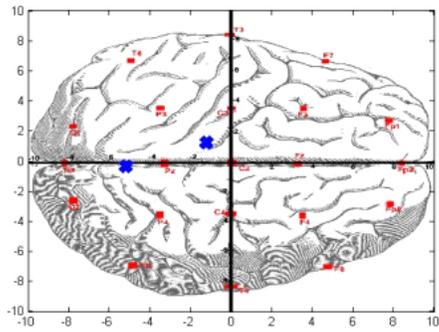
$$E(U; c) = -\frac{1}{N} \sum_{i=1}^c \sum_{k=1}^N u_{ki} \log u_{ki} \quad (4)$$

We should judge better clusters when one of these measures is larger.

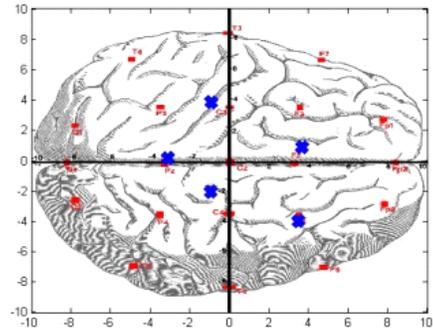
SIMULATION RESULTS

A set of EEG signal recorded from an epileptic patient as shown in Fig. 1 was sampled during seizure. This signal was sampled at 256 discrete data in every second by using Nicolet One EEG software. These signals are transformed by a novel method called Flat EEG that developed by Zakaria (2007). Then, Heuristic algorithm of Fixed point iteration is applied for cluster these signals. Cluster validity measure is used to find the optimal number of cluster for every second.

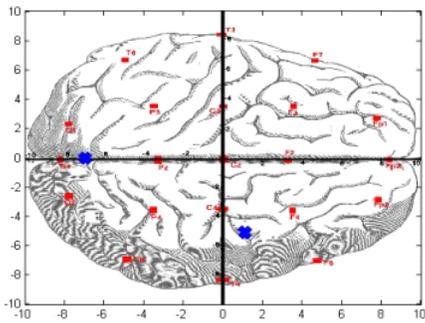
Furthermore, Matlab software programing is used for location of clustered EEG signals and clustered probes during seizure. As a sample of the implementation of the software, the result for EEG signal in Fig. 1 is presented in Fig. 2 where locations of sensors on the surface of the patient's head are in red, the cluster's centers for signal are in blue.



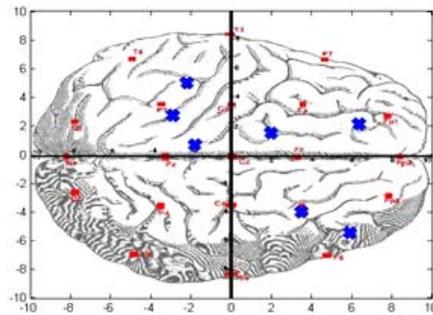
t=1



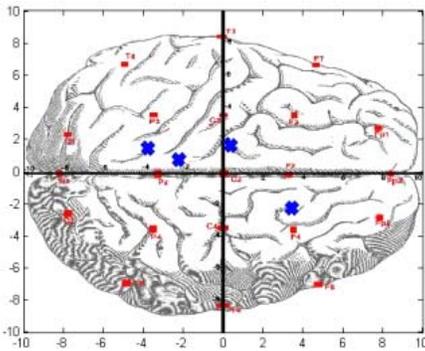
t=5



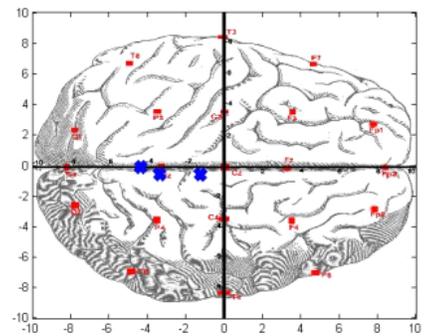
t=2



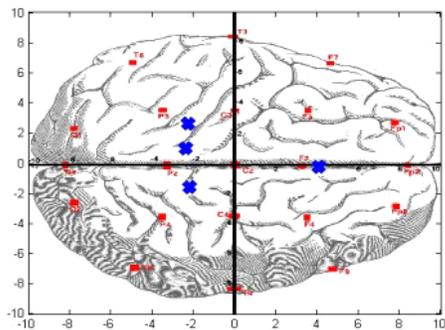
t=6



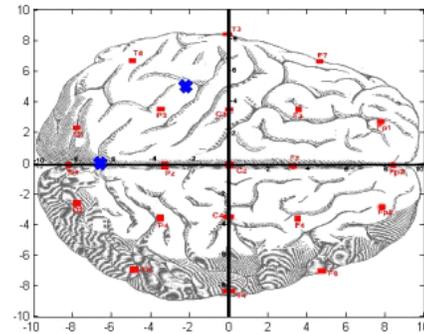
t=3



t=7



t=4



t=8

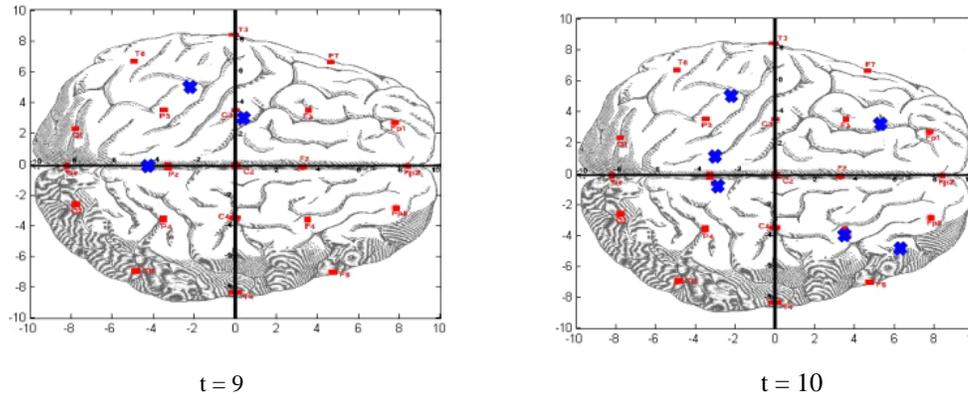


Fig. 2: Clusters centers of EEG signal from $t = 1$ to $t = 10$

CONCLUSION

We present the implementation of Heuristic algorithm of Fixed point iteration technique on the real time EEG data and probes obtained from a patient who suffer an epileptic seizure. The result shows the most signal activities occurs from $t = 3$ until $t = 7$ and starts to die out at $t = 8$.

REFERENCES

Bezdek, J.C., 1981. Pattern Recognition with Fuzzy Objective Function Algorithm. Plenum, New York.
 Bezdek, J.C., J. Keller, R. Krishnapuram and N.R. Pal, 1999. Fuzzy Models and Algorithms for Pattern Recognition and Image Processing. Kluwer, Boston.
 Chaovalitwongse, W., L.D. Iasemidis, P.M. Pardalos, P.R. Carney, D.S. Shiau and J.C. Sackellares, 2005. Performance of a seizure warning algorithm based on the dynamics of intracranial EEG. *Epilepsy Research-Elsevier*, 64: 93-113.
 D'Alessandro, M., R. Esteller, G. Vachtsevanos, A. Hinson, J. Echaz and B. Litt, 2003. Epileptic seizure prediction using hybrid feature selection over multiple intracranial EEG electrode contacts: A report of four patients. *IEEE T. Bio-med. Eng.*, 50(5): 603-605.

Engel, J.J.R., P.C. Van Ness, T.B. Rasmussen and L.M. Ojemann, 1993. Outcome with respect to Epileptic Seizures, In: Engel Jr., J., (Ed.), *Surgical Treatment of the Epilepsies*. Raven, New York, pp: 609-622.
 Gastaut, H., 1970. *Clinical and Electroencephalographical Classification of Epileptic Seizures*. Amsterdam, pp: 102-113.
 McSharry, P.E., T. He, L.A. Smith and L. Tarassenko, 2002. Linear and non-linear methods for automatic seizure detection in scalp electroencephalogram recordings. *J. Med. Biol. Eng. Comput.*, 40(4): 447-461.
 Miyamoto, S., H. Ichihashi and K. Honda, 2008. *Algorithms for Fuzzy Clustering*. Springer-Verlag Berlin Heidelberg.
 Zakaria, F., 2007. *Tracking the storm in the brain*. Ph.D. Thesis, Universities Technology Malaysia.
 Zakaria, F., 2008. *Dynamic profiling EEG data during seizure using fuzzy information space*. Ph.D. Thesis, University Technology Malaysia.