Available online at www.sciencedirect.com
ScienceDirect
Mathematics and Computers in Simulation 81 (2011) 2471–2491
MATHEMATICS AND COMPUTERS IN SIMULATION
www.elsevier.com/locate/matcom

Original article

Bifurcation analysis of the Poincaré map function of intracranial EEG signals in temporal lobe epilepsy patients

Mahmood Amiri [a], Esmaeil Davoodi-Bojd [a], Fariba Bahrami [b], Mohsin Raza [c,*]

[a] *School of Electrical and Computer Engineering, College of Engineering, University of Tehran, Tehran, IR Iran*
[b] *CIPCE, School of Electrical and Computer Engineering, College of Engineering, University of Tehran, Tehran, IR Iran*
[c] *Section of Neurosciences and Ethics, Chemical Injuries Research Centre, Baqiyatallah University of Medical Sciences, Tehran, IR Iran*

Received 20 December 2009; received in revised form 23 February 2011; accepted 24 March 2011
Available online 13 April 2011

Abstract

In this paper, the Poincaré map function as a one-dimensional first-return map is obtained by approximating the scatter plots of inter-peak interval (IPI) during preictal and postictal periods from invasive EEG recordings of nine patients suffering from medically intractable focal epilepsy. Evolutionary Algorithm (EA) is utilized for parameter estimation of the Poincaré map. Bifurcation analyses of the iterated map reveal that as the neuronal activity progresses from preictal state toward the ictal event, the parameter values of the Poincaré map move toward the bifurcation points. However, following the seizure occurrence and in the postictal period, these parameter values move away from the bifurcation points. Both flip and fold bifurcations are analyzed and it is demonstrated that in some cases the flip bifurcation and in other cases the fold bifurcation are the dynamical regime underlying epileptiform events. This information can offer insights into the dynamical nature and variability of the brain signals and consequently could help to predict and control seizure events.

Keywords: Poincaré map; Bifurcation analysis; Epilepsy; Evolutionary algorithm

1. Introduction

The brain is a complex network of interacting subsystems and it is now well documented that synchronization plays an important role in normal and abnormal brain functioning. A well-known case for pathophysiologic neuronal synchronization is epilepsy [2,20]. Epilepsy is a common neurological disorder, second only to stroke, that affects more than 50 million people worldwide. It is characterized by recurrent *seizures* or *ictal* events and impairs normal functions of the brain. These seizures are signs of excessive synchronous neuronal activity in the brain [1,11]. Two-thirds of the patients achieve sufficient seizure control from anticonvulsive drugs and about 8–10% could benefit from resective surgery. For the remaining of patients, no satisfactory treatment is currently available [24].

* Corresponding author.
E-mail address: mohsinreza60@yahoo.com (M. Raza).

0378-4754/$36.00 © 2011 IMACS. Published by Elsevier B.V. All rights reserved.
doi:10.1016/j.matcom.2011.03.012