

Research Article

Fractional Diffusion Based Modelling and Prediction of Human Brain Response to External Stimuli

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Human brain response is the result of the overall ability of the brain in analyzing different internal and external stimuli and thus making the proper decisions. During the last decades scientists have discovered more about this phenomenon and proposed some models based on computational, biological, or neuropsychological methods. Despite some advances in studies related to this area of the brain research, there were fewer efforts which have been done on the mathematical modeling of the human brain response to external stimuli. This research is devoted to the modeling and prediction of the human EEG signal, as an alert state of overall human brain activity monitoring, upon receiving external stimuli, based on fractional diffusion equations. The results of this modeling show very good agreement with the real human EEG signal and thus this model can be used for many types of applications such as prediction of seizure onset in patient with epilepsy.

1. Introduction

Brain as the most complex organ in the human body controls all bodies' actions/reactions by receiving different stimuli through the nervous system. Any stimulus stronger than the threshold stimulus is translated by the number of sensory neurons generating information about the stimulus and the frequency of the action potentials. After the action potential has been generated, it travels through the neural network to the brain. In various sections of the network and the brain, integration of the signals takes place. Different areas of the brain respond depending on the kind and location of stimuli. The brain sends out signals which generate the response mechanism.

During many years, numerous studies related to the brain response to external stimuli have been reported by scientists. Some researchers studied the brain response to different kinds of stimuli without proposing any model. In case of visual stimuli, we can mention the work done by Kaneoke et al. in analyzing the effect of the visual stimulus size on the human brain response using magnetoencephalography (MEG) [1]; see also [2, 3]. Other groups of researchers

investigated the effect of auditory stimuli on the brain response. For instance, Will and Berg studied and compared the brain responses to periodic stimulations, silence, and random noise using electroencephalography (EEG) [4]; see also [5, 6]. Olfactory stimuli also were the main focus of some researchers. Sutani et al. investigated the brain response to pleasant and unpleasant olfactory stimuli using MEG signals. They found out that the MEG signals have recorded from frontal/prefrontal cortical areas of the brain has some differences in case of pleasant versus unpleasant stimuli [7]; see also [8, 9]. Different works have been reported on the investigation of the brain response to other kinds of stimulus such as emotional stimuli [10, 11] and pain stimuli [12, 13].

On the other hand, some scientists proposed some models of the human brain activity. On the microscopic level, the work done by Freeman in the modeling of the EEG arising from the olfactory bulb of the animals during the perception of odors is noteworthy. He developed a set of nonlinear equations for this response which generates EEG like pattern [14, 15]. In another work Seetharaman et al. proposed a mathematical model for generation and propagation of action potential in a node of Ranvier and they called it as