The Chinese University of Hong Kong

Department of Biomedical Engineering

Graduate Seminar – PhD oral Defence

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Date : April 25, 2018 (Wednesday)

Time : 3:00 p.m.

Venue : Room 222 Ho Sin Hang Engineering Building

Title: **Brain Computer Interface (BCI) System for Restoration of Hand Function for Stroke Rehabilitation and EEG Analysis using Fuzzy Approximate Entropy (fApEn)**

Abstract

Entropy-based algorithms have been suggested as robust estimators of electroencephalography (EEG) predictability or regularity. This study aimed to examine possible disturbances in EEG complexity as a means to elucidate the pathophysiological mechanisms in chronic stroke, before and after a brain computer interface–motor observation (BCI-MO) intervention. Eleven chronic stroke and nine unimpaired subjects were recruited to examine the differences in complexity of their brain wave signals. The BCI-MO intervention was designed to facilitate better functional recovery of the hand in stroke subjects. Fuzzy approximate entropy (fApEn), a novel entropy-based algorithm designed to evaluate complexity in physiological systems, was applied to assess the EEG signals acquired from unimpaired and stroke subjects before and after training. Frequency band power, frequency band suppression, EEG topography, and time-frequency maps were also used in this study as complementary techniques to EEG fApEn.

The results showed that, before training, stroke subjects had significantly lower EEG fApEn than unimpaired subjects ($p < 0.05$) in the motor cortical area of the brain (C3, C4, FC3, FC4, CP3, and CP4), in both hemispheres. However, after training, motor function of the paretic upper limb, assessed using the Fugl-Meyer Assessment-Upper Limb (FMA-UL), Action Research Arm Test (ARAT), and Wolf Motor Function Test (WMFT), improved significantly ($p < 0.05$) in the stroke subjects. Furthermore, after training, the EEG fApEn in the stroke subjects increased considerably in the central area of the contralesional hemisphere ($p < 0.05$). A significant correlation was noted between clinical scales (FMA-UL, ARAT, and WMFT) and EEG fApEn in C3/C4 in the contralesional hemisphere ($p < 0.05$). This finding suggests that the increase in EEG fApEn and higher complexity in the brain could be an estimator of improvement in the upper limb motor function.

An explanation for the phenomenon that stroke and healthy subjects have a significant difference in EEG complexity is provided in this study. Simulation of a Neural Mass Model (NMM) showed that a decrease in neural synapses results in a decrease in EEG fApEn. It could be concluded that neuronal death after stroke leads to a decline in EEG complexity. However, neurons fail to regenerate after rehabilitation training, and the NMM also shows that an increase in self-regulatory feedback inhibitory connectivity in interneurons leads to an increase in EEG fApEn. This could explain the increase in EEG complexity after training.

In summary, fApEn could be used in combination with BCI-MO training to identify abnormal EEG complexity in chronic stroke. Moreover, these findings based on fApEn of EEG signals also expand the existing interpretation of training-induced functional improvement in stroke subjects. The entropy-based analysis might serve as a novel approach to understanding abnormal cortical dynamics in stroke, and the neurological changes induced by rehabilitation training. Additionally, the evaluation method is non-invasive and relatively easy to operate. The results of this study have potential clinical application in evaluating stroke patients. The findings might in future assist rehabilitation therapists to make a quantitative evaluation of stroke patients, and help to develop a reasonable rehabilitation plan.

*****ALL ARE WELCOME*****

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