Global Science Research Journals

Global Journal of Neurology and Neurosurgery

Open Access

Optimization of cortical responses in hybrid SSVEP + p300 brain computer interface systems and its application to computer cursor control

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Abstract

Patients with neurological disorders like Amyotrophic Lateral Sclerosis (ALS), cerebral palsy, Parkinson's disease, epilepsy and so on makes patient bound to wheelchair and requires support for day to day activities including wearing cloths, eating food and working. Electroencephalogram (EEG) based brain computer interface (BCI) systems are systems developed for assisting disable as well as healthy humans by mapping individual cortical activity into directive commands. But present BCI systems are in naïve stage, to work efficiently in real time noisy environment due to poor understanding of the fundamental brain mechanisms and non-stationary EEG signals. We have made efficient visual BCI systems by optimizing external stimulus factors to evoke stronger cortical responses and adaptive processing models that reduce effect of non-stationary EEG on BCI performance. In my study, I have captured cortical EEG signals non-invasively from human scalp of 10 patient, training of patients and experiments are done under neurosurgeon supervision and written consent from patients are taken as per good clinical practices (GCP) guidelines. Work focused on optimization external stimulus in terms of its size, color, frequency and incorporation of human facial content such that result would be evocation of stronger cortical responses that make BCI system with maximum accuracy and communication rate. We have developed adaptive EEG signal processing machine learning algorithms that could reduce effect of non-stationary EEG signal on BCI performance thereby improve BCI robustness and reliability.

In this work we have developed a new hybrid SSVEP + P300 BCI system with 4 independent commands which uses circled stimuli flickering at 15 Hz frequency and changing color between yellow and green to evoke SSVEP, centered with emotional human facial structure flashing to evoke P300 that reached a mean information transfer rate (ITR) of 27.15 bits/min and approximate success rate of 100%. Due to incorporation of emotional facial content in visual stimuli in hybrid SSVEP + P300 BCI system GUI design the visual field occlusion was substantially minimized, and long-term user fatigue was reduced. This further reduce user neural adaptation effect (ANA) thereby increases reliability of system further. In hybrid SSVEP + P300 BCI system where both SSVEP and P300 potentials evoked simultaneously, it was observed that if both signals evoked by facial stimuli it would deteriorate SSVEP responses than situation where one signal is evoked by facial stimuli and other signal is evoked by non-facial stimuli.

Biography

Deepak Kapgate has completed his PhD at the age of 31 years from Nagpur University, India. He is the professor in computer science department at Nagpur University, India. He has over 53 publications in reputed international journals that have been cited over 132 times and has been serving as an editorial board member of total nine (9) reputed Journals. He was worked as program committee member of international conferences in India and abroad.

5th International Conference on Brain and Spine | July 27, 2020

Citation: Deepak Kapgate, *Optimization of cortical responses in hybrid SSVEP + p300 brain computer interface systems and its application to computer cursor control*, Brain and Spine 2020, 5th International Conference on Brain and Spine, July 27, 2020, Page 02