Abstract

Electro-physiological source imaging (ESI) or Source localization (SL) is the analysis of scalp electroencephalogram (EEG) through the estimation of the sub-surface neural activation sequences. SL or ESI algorithms act on the scalp EEG and estimate the underlying electric field on the cortex based on certain assumptions regarding the physical properties of the intermediate surfaces.

This thesis creates several experimental scenarios to induce sleep deprivation and varying vigilance levels, to determine the effects on the underlying EEG sources. In experiment 1, the acquisition of EEG was carried out while the subjects were driving in a simulated condition under a laboratory environment. Sleep deprivation of a total period of 36 hours, divided into 12 equal stages was carried out for all the subjects. In experiment 2, the effect of sustained attention is investigated through motor actions based tasks. Lastly, an electrooculogram (EOG) is captured by a novel system and analyzed to obtain the peak saccadic velocity. The test subjects are simultaneously asked to play a game, whose response time is also taken as an indicator of the alertness level.

EEG activities acquired during the sleep deprivation is used in this thesis to quantify the regularity and similarity between the EEG sources for classifying normal and sleep-deprived states. The standardized low-resolution brain electromagnetic tomography (sLORETA) algorithm has been used for estimating the source activations on the neocortex. Approximate and sample entropies in voxels nearest to specific electrodes are computed as measures of complexity, similarity, and regularity. These measures are then used to train a support vector machine, which classifies the measured values between 'alert' and 'extremely fatigued' states, and up to 86 % classification accuracy is achieved.

Secondly, neural activation during a simple motor acts as a response to auditory stimuli has been modeled, as information flow paths. EEG sources are computed on brain regions by two separate algorithms- sLORETA and spatiotemporal unifying tomography (STOUT), and then the localization performance of both the algorithms are compared.

Finally, we have developed a system to compute an alertness index of a person using physiological (eye movement parameters), as well as, psychometric (response of a game) measures. The fusion of these two parameters has been carried out to enhance classification performance.