A Deep Learning Architecture Using EEG for Working Memory Assessment in Mild Cognitive Impairment

Sridhar, Sriniketan (School: Southwestern Educational Society)

Working Memory (WM) function is directly affected in subjects with Mild Cognitive Impairment (MCI) more severe than dementia and can lead to early Alzheimer's disease. Technological intervention for monitoring WM function that is easily accessible is currently unavailable. An application using Electroencephalogram (EEG) time-frequency signal processing and Deep Neural Network (DNN) was developed to predict WM load in to two categories as low or high more accurately and efficiently compared to state-of-the-art methods. Testing occurred with healthy subjects of age 20-40, 40-60, >60, and MCI patients. Working memory tasks of block tapping and N-back visuospatial tasks were presented to the subjects. The subjects performed three trials of working memory tasks during which 16-electrode EEG signals was recorded using an EEG cap. Independent components analysis was used to select the best electrodes. The Ensemble Empirical Mode Decomposition algorithm was then applied to the EEG signals to obtain the time-frequency Intrinsic Mode Functions (IMFs) input to the DNN for training. This prototype performs better than traditional machine learning methods and Convolutional Neural Networks for prediction of WM load. Prediction accuracies were consistently higher for both normal subjects and MCI subjects averaging 97.62%, which was 13.68% higher than the best method in the literature. The average Kappa score for normal subjects was 94.98% and 92.49% for subjects with MCI. Subjects with MCI showed higher values for beta and alpha oscillations in the frontal region than normal subjects. The average power spectral density of the IMFs showed that the IMFs ($p=0.0469$ for normal subjects and $p=0.0145$ for subjects with MCI) are robust and reliable features for WM load prediction.