Assessment of Mild Cognitive Impairment (MCI) with a Novel Deep Neural Network-based Brain-Computer Interface (BCI)

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Cognitive deterioration caused by Mild Cognitive Impairment (MCI), which is often a transition between regular aging and neurodegenerative disease (Alzheimer's disease), is displayed before symptoms are. Timely detection of cognitive deterioration is currently inaccessible. A Brain-Computer Interface based on a sensorimotor paradigm (auditory, olfactory, movement, and motor-imagery) that employs a Bidirectional Long Short-Term Memory (BLSTM) Network was developed to assess cognitive deterioration and identify its relationship with brain signal features, hypothesized to consistently indicate cognitive decline. Testing occurred with healthy subjects of age 20-40, 40-60, and >60, and MCI patients. Auditory and olfactory stimuli were presented, and the subjects imagined and conducted movement of each arm. The application trains a deep BLSTM Neural Network with Principal Component features from evoked signals and assesses their corresponding pathways. Wavelet analysis was used to decompose evoked signals, and calculate the band power of component frequency bands. This BCI system performs better than conventional networks in detecting MCI. Most features studied peaked at age range 40-60 and was lowest for the MCI group. Detection accuracy of left-hand motor imagery signals best indicated cognitive aging ($p=0.0012$); here, the mean classification accuracy per age group declined from 82.31% to 79.63%, and was 76.86% for MCI subjects. Motor-imagery-evoked band power, particularly in gamma bands, best indicated ($p=0.007$) cognitive aging. Although classification accuracy of the potentials effectively distinguished cognitive aging from MCI ($p<0.05$), band power did not. This application can be conducive in developing effective diagnostic tools for dementia.