Subtyping of mild cognitive impairment using machine learning model based on multimodal neuroimaging data

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Brain imaging represents one of the rapidly evolving and pivotal domains in modern medicine and neuroscience research. Brain atrophy and beta-amyloid protein deposition precede the onset of dementia and can be ascertained through neuroimaging. Our goal is to classify subtypes of mild cognitive impairment by multimodal neuroimaging using machine learning algorithms. Furthermore, we aim to evaluate the accuracy and the actual changes in cognitive function using two years of follow-up data. We used data from participants in the Biobank Innovations for chronic Cerebrovascular disease With Alzheimer's disease Study at Ajou University Hospital in South Korea. The 686 participants were categorized into three groups: 51 with normal subjects, 361 with mild cognitive impairment (MCI), and 127 with Alzheimer's disease. Each individual underwent a 3T brain MRI scan and Flutemetamol amyloid-beta PET scan. Brain volumes and white matter lesion volumes were automatically measured using AQUA, and Amyloid beta Standardized Uptake Value Ratio(SUVR) were calculated using ScalePET a newly developed brain quantification method by Neurophet. We selected 10 variables as features through multiple regression (stepwise method). We used four machine learning algorithms to predict cognitive state chages: K-Nearest Neighbor (KNN), Support Vector Machine (SVM) with linear and sigmoid kernels, Random Forest (RF), and Neural Networks (NN). The combination model incorporating brain volume, white matter hyperintensity, Amyloid SUVR data showed higher accuracy than the model each data alone. To validate our model, we used a five-fold cross-validation approach. The SVM with linear kernel showed the highest accuracy of 60% among the algorithms. We verified the follow-up information of 88 subjects who predicted MCI likely dementia with our model. All 88 subjects confirmed cognitive decline. In conclusion, our prediction model incorporating a combination of various image data types demonstrated improved accuracy. The higher percentage of false negatives in comparison between predictive and actual cognitive functional stat changes may be due to a shorter follow-up period and minimal changes in cognitive functional state. Further investigations with a longer follow-up period are needed to observe the development of dementia.