Towards predicting Alzheimer's disease using machine learning

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Dementia is becoming a leading cause of death for people older than 85 globally. In Switzerland, the absolute number of deaths caused by this disease has steadily increased since it was first recorded in 1995. In 2021 approximately 146,500 people in Switzerland had dementia (BAG, 2022). Dementia family diseases affect cognitive abilities such as memory, orientation, and language. The most common form of dementia is Alzheimer's disease (AD). There are many interdisciplinary efforts for fighting AD, though, to date, there is no established treatment or cure for it . However, there are some prevention measures based on lifestyle adjustments which are potentially helpful. Thus, it is crucial to identify people at risk at the earliest stage possible (Alzheimer Schweiz, 2021). Several efforts based on digital biomarkers yield promising outcomes for predicting cognitive decline (e.g., Buegler et al., 2022; Meier et al., 2022), but the challenge remains complex. In this paper we tackle the question of how healthy ageing people differ from those who develop AD based on an open data set. Specifically, we consider neuropsychological tests and magnetic resonance imaging (MRI) brain scans in this study. Of particular interest were subjects with a change in diagnosis. To investigate diagnosis changes, we identified neuropsychological test scores indicating a transition. Based on either these relevant test scores or MRI images, predictions for the progression of the disease were made. For the analyses, we used the open data from the Alzheimer's Disease Neuroimaging Initiative (ADNI). ADNI is a longitudinal study with the goal to detect AD early and support advances in its prevention and treatment (ADNI, 2017).

Logistic regression on all neuropsychological test scores suggests that several variables of the Clinical Dementia Rating Scale (CDR) are key indicators for the diagnosis of cognitive impairment. However, since the CDR was used for diagnostic classification to begin with, this observation in essence only confirms the relative internal validity of the methods used in the study. On the other hand, accuracy rates at best at 87% suggests there may be issues with the data at the clinical classification / recording stage, and that the methodological approach could still be improved (e.g., having three classes in the diagnosis for CN/MCI/AD, but applying binary classification in our study may be a key explanation). Interestingly, the commonly used Mini Mental State Examination (MMSE) appears to have a fairly strong accuracy (74%) in detecting conversion from a healthy cognitive state to cognitive impairment, suggesting that this quick and easy-to-administer test might be able to compete with more complex and longer tests. As cognitive impairment proceeds, memory tests such as the Rey's Auditory Verbal Learning Test gain predictive value for further progression.

Since cognitive tests show the effects of dementia rather than the causes of it, MRI brain scans from the ADNI study were also examined to find differences between healthy and impaired brains. A residual neural network (ResNet) with 152 layers was used for classification of MRI brain scans. The model classified 88% correctly according to the patient's diagnosis. As a next step, a combination of the ResNet and the classification model created based on the cognitive test scales could be used to build an objective diagnostic model for this life-changing disease.

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