Application and Methods in Data Science

Early Prediction of Alzheimer's Disease using Artificial Intelligence

Aroona Atmaram

Northwestern University

Introduction

Alzheimer's disease (AD) is an irreversible neurodegenerative disease. It affects millions of people with dementia around the world, eventually leading to a loss of memory and cognitive dysfunctions. Despite the standard symptomatic medical criteria, clinical diagnosis is still difficult. A conclusive diagnosis can only be made after death by observing the characteristic neurofibrillary tangles and plaques in the brain (Jamison, 2000, p. 814). Although there is no cure, drugs in development are likely to work better in the earlier stages of the disease. Currently, many researchers use Brain Magnetic Resonance Images (MRI) to detect the earliest signs of AD because of its high resolution and noninvasive nature, which can recognize the degeneration of brain structures (Farzan et al., 2015). Machine learning models applied to MRI data can identify changes in the brains with greater precision by capturing even the slightest tissue alterations, which are likely to get a diagnosis of AD much before doctors can diagnose it from symptoms alone (Lin et al., 2018).

Methods

A classification model attempts to draw some conclusion from observed values with a goal to predict a Boolean value e.g., {1, 0}, {True, False}. Some of the most widely used advanced classification models are Support Vector Machine, Logistic Regression, Random Forest Classifier and Convolution Neural Network.

Support Vector Machines (SVM) are used to build classifiers and regressors. A SVM finds the best separating boundary between the two sets of points by solving a system of mathematical equations.

In Logistic Regression, given a set of data points, the goal is to build a model that can draw linear boundaries between classes using a logistic function. This regression is mainly used for classification.

A Random Forest Classifier fits a large number of decision trees on various samples drawn from a dataset and uses an average to improve prediction.

Convolutional Neural Network (CNN) is an artificial neural network that uses layers and hierarchy to pick out or detect patterns and make sense of them.

Among all the mentioned models, CNN has emerged as the model of choice due to its ability to implicitly combine the benefits obtained by a standard neural network training with the convolution operation within the layers to classify images efficiently. A classic MRI-based automated AD diagnostic system has mainly two building blocks—feature/biomarker extraction from the MRI data and classification based on those features/biomarkers (Islam & Zhang, 2018).

Data Collection: Data collection is the first step and starts with acquiring the structural MRI data of patients with AD and normal controls (NC). For each subject, this data collection needs to offer structural MRI scans of the full brain for up to three time points (screening, 12 and 24 months; sometimes multiple scans per visit).

Feature Extraction: Training a classifier independent from the feature extraction process may result in sub-optimal performance due to the possible heterogeneous nature of the classifier and features. Deep learning models (CNN's) have the ability to learn feature representations. From the input data, using its layered and hierarchical structure, CNN's can learn simple, low-level features and build complex high-level features in a hierarchical fashion

Model: The key idea behind CNNs is inspired by the mechanism of receptive fields in the primate visual cortex. Local convolutional filters and pooling operations are applied successively

to extract regional information. The hidden layers, called convolutional layers, receive MRI input, transform the input, and output a transformed input to the next layer. Each layer has filters that detect a pattern. Filters start off with high-level patterns like an edge and as they progress, the filters become more sophisticated and are able to detect specific patterns (Hutchison et al., 2018).

Management

Total payments in 2020 for health care, long-term care, and hospice services for people age 65 and older with dementia are estimated to be $305 billion. By the time AD is diagnosed in most cases the cells have degenerated and the damage is irreversible. Early diagnoses during the mild cognitive impairment (MCI) stage of the disease would lead to cost savings of up to $7.9 trillion while helping patients maintain their existing cognitive abilities and a fulfilling life (Alzheimer's Association, 2020). When healthcare AI is used on a large data set of MRI available in real-time, it can classify diseases such as AD with a high degree of accuracy. It offers sophisticated methods and higher processing speeds to analyze the large sets of data, ultimately leading to new knowledge and approaches for treatment development.

Conclusion

Detecting cognitive impairment, diagnosing Alzheimer's and other dementias, and disclosing that diagnosis to the individual are necessary elements to ensure that people with dementia, together with their families, have the opportunity to access available treatments, build a care team, participate in support services, enroll in clinical trials, and plan for the future. The hope and effort is that AI, in this case, helps with early diagnosis to improve research and eventually find a cure.

References

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