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Opinion

Application of Artificial Intelligence-Machine Learning in Dementia

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Abstract

Neuroimaging, body fluid biomarkers, genetic or proteomic data can detect dementia spectrum, both mild cognitive impairment and dementia, from normal ageing. With the advance technology, Artificial Intelligence (AI) displays encouraging results in supporting with recognition of early-stage dementia. By now AI and Machine Learning (ML) have advanced neuroimage analysis. Though, integration of heterogeneous biological data from different modalities into clinical practice is not quite there yet.

Keywords: Artificial intelligence; Machine learning; Dementia; Ageing; Neuroimage analysis; Biomarkers; Amyloid-β; Neuronal injury

Abbreviations: AI: Artificial Intelligence; AD: Alzheimer Disease; MCI: Mild Cognitive Impairment; NFTs: Neuro Fibrillary Tangles; MRI: Magnetic Resonance Imaging; FDG: Fluorodeoxyglucose; PET: Positron Emission Tomography; CSF: Cerebrospinal Fluid; NFL: Neurofilament Light; VR: Virtual Reality; SVM: Support Vector Machines; KNN: K-Nearest Neighbor; LR: Logistic Regression; EEG: Electroencephalography; DTI: Diffuse Tensor Imaging; LPE: Landmark Patches Extraction; FTD: Frontotemporal Dementia

Introduction

Fifty million people worldwide have dementia. Dementia is the fifth important cause of death worldwide [1]. Alzheimer Disease (AD) is the commonest cause of dementia etiology. Mild Cognitive Impairment (MCI) is a prodromal stage of dementia. It is a clinical challenge to differentiate AD from other causes of dementia, and to predict progression of individuals with MCI. In addition to clinical information in aiding the diagnosis, biomarkers help to distinguish brain pathology and function beforehand offered from post-mortem investigation. Biomarkers [2] in dementia are features that measured and evaluated as guide of normal biological or pathogenic processes. They play a role in research, providing knowledge on disease progression and on responses to treatments, defining relevant outcome measures. In AD, extracellular amyloid-β aggregates and tau Neurofibrillary Tangles (NFTs) are the 2 neuropathological characteristics of the disease. A group of experts proposed classification of biomarkers for AD as A/T/N scheme [3]. "A" indicates a β-amyloid biomarker; "T," refers to a tau biomarker; and "N" is a biomarker of neurodegeneration or neuronal injury. Biomarkers in dementias can be divided into imaging modalities and biofluid modalities. Structural Magnetic Resonance Imaging (MRI) and functional imaging such as a Fluorodeoxyglucose (FDG)-Positron Emission Tomography (PET), amyloid and tau PET Imaging are examples of imaging biomarkers for Alzheimer Disease (AD) and other neurodegenerative. Cerebrospinal Fluid (CSF) biomarkers for AD include decreased CSF amyloid 42/40 levels, increased CSF p-Tau181, increased CSF t-Tau, increased CSF Neurofilament Light (NFL) protein, and increased CSF neurogranin levels. Examples of blood biomarkers for AD are decreased serum amyloid 42/40, increased plasma phosphorylated-tau181, increased plasma phosphorylated-tau217, and increased plasma NFL levels. Recently, dementia management and care has introduced new technology in cooperate with standard management. New technology

in dementia includes wearables, smart home systems, robots, Virtual Reality (VR), Artificial Intelligence (AI) and driverless vehicles [4]. Technology has likely applications to dementia from diagnosis and evaluation to care delivery and assisting ageing in the community setting. Artificial Intelligence (AI) is a technology that help analyze, learn and self-correct to capture the complex relations of the data models hidden in several aspects across the data spectrum. Machine Learning (ML) is a subset of AI. Currently, many scientists and researchers are using ML algorithms and data-mining procedures in the healthcare management for predicting and diagnosing diseases. Examples of supervised ML techniques are Support Vector Machines (SVM), K-Nearest Neighbor (KNN), and Logistic Regression (LR).

Application of AI-ML in Dementia

AI has beneficial application in dementia field to assist screening dementia, to classify the data to help the diagnosis of dementia or mild cognitive impairment, to predict disease progression, to evaluate screening drug development for treatment to delay Alzheimer's Disease, and to evaluate dementia prevention. Most of the previous research is focused on the use of AI to classify neuroimaging for predicting the development of AD from MCI [5] (Figure 1). Evaluations revealed up to 36 months before the progression to AD. Previous review [6] found that all Machine Leaning (ML) AI produce high accuracy for differentiating healthy controls from AD but lower accuracies for differentiating healthy controls from MCI, or MCI from AD. Current review [7] found that utilizing cognitive performance, FDG-PET or Electroencephalography (EEG) and magnetoencephalography techniques considerably increased predictive function compared to not incorporating them, while including T_1 MRI did not show a substantial effect. Interestingly, 15% of the studies, hesitated on the application of the method into medical practice. Earlier studies rarely included lifestyle, comorbidity, and socioeconomic variables in the assessed models. Recent review [8] demonstrated that multi-modality studies overtook single-modality ones. Neuroimaging modalities such as MRI, PET, functional MRI, and Diffuse Tensor Imaging (DTI) are essential to AD detection. Categories of MRI or PET preprocessing techniques include Region of Interests (ROI), Landmark Patches Extraction (LPE), and Regular Preprocessing (RP). Other features such as age, gender, educational level, memory performance, and genetic information are likewise valuable. There is a trade-off between greater accuracy and the cost of obtaining other biomarkers. Reports using ML to classify subtypes of Frontotemporal Dementia (FTD), AD, and other neurodegenerative dementia base on cortical thickness, brain volume from MRI or on blood biomarkers, models had an average accuracy of 80-90% to separate different dementia syndromes [9-11].

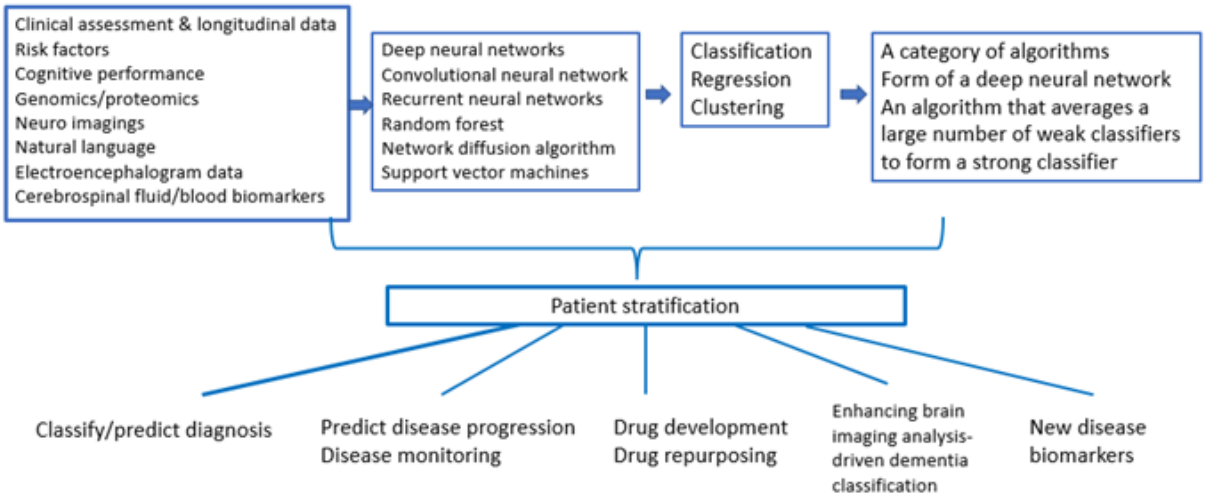

Figure 1: Application of artificial intelligence and machine learning in dementia.

Speech and language performances are often changed as neurodegenerative dementia progress. There are interactive AI methods to AD diagnosis and progression monitoring utilizing dialogue or monologue and speech technology to extricate "digital biomarkers" for machine learning modelling. AI can notice subtle changes in speech and behavior earlier and more reliably than person observers. Encouraging results are described, but few items have been employed in clinical practice [12,13]. Moreover, the application of machine learning to longitudinal patient data including speech, mobility, gait and balance, sleep, data from wearable monitoring device, cognitive performance, activity of daily living records, CSF or blood biomarkers, molecular and genetic data collection has the potential to apprise prognosis projection and patient classification [14]. The risk of dementia can be decreased by approving healthy lifestyles and managing treatable disorders such as diabetes, dyslipidemia and high blood pressure. This year, AI-Mind project has received funding from the European Union's Horizon 2020 research and innovation program. It is an intelligent digital tool for screening of brain connectivity and dementia risk assessment in individuals with MCI. This project addresses the urgent need for early accurate diagnosis and risk prediction in the current circumstance with the goal hopefully to reduce the disease's burden. Results from this study should come out in the near future.

In drug discovery research, recognizing innovative drug targets is critical for the fruitful development of a satisfying drug. Drug repositioning [15] is another approach to establish the safety of a target drug. Another machine learning approach of drug development is relational inference on a knowledge graph [16]. Knowledge graph approaches can learn non-obvious connection between diseases and biological drug targets with one downside is that it lacks graininess in their biological relationships such as for different brain regions. Machine learning also helps identify patient stratification. The heterogeneity of the patients made it difficult to predict response in different individuals from group studying. Therefore, stratifying the patients into detailed clinical, cognitive, genetic data, and biomarker identification can predict treatment response by machine learning techniques. This moves toward a precision medicine approach. Amyloid is common target in AD trial. One study used AI technique to compute model performance metric to predict cortical amyloid burden [17] in individuals with early MCI and late MCI. They used clinical data, sex, identified risk factors, and cognitive performance data to predict amount of amyloid burden from amyloid PETS. They found that accuracy for late MCI female was above 85%. Precise ML prediction models can classify the appropriate subjects for AD clinical trials. Some limitations of AI in dementia involves, firstly, ethical considerations [18] in intelligent machine assessment. Data management, including the processes of data attainment, storage, handing and sharing is a crucial concern when utilizing digital technology. Secondly, there are several techniques being used to obtain prognostic parameters for dementia. Comparison to which ones performed best showed challenging because different variables have different predictive potentials. Thirdly, the restriction of data size is also important. Bigger data could be divided into training set and performance set. The transfer learning technique can improve training speed and performance of the study.

Conclusion

The incorporation of machine learning into diagnostic tool, prognostic tool, and a design for future drug development in dementia is challenging. Multidisciplinary research with AI to improve dementia outcome hopefully can immensely facilitate dementia care at the primary care level, in low middle income country [19], and worldwide.

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