Opportunities and Barriers to Neuroimaging-based AI in Memory Clinics for Age-related Dementias

Timothy Rittman Organizer
University of Cambridge
Cambridge, Cambridgeshire

Rose Bruffaerts, MD PhD Co-Organizer
KU Leuven
Leuven, AK

AmanPreet Badhwar, Ph.D. Co-Organizer
University of Montreal
Montreal, Quebec

Esther Bron Co-Organizer
Erasmus MC
Rotterdam, Zuid-Holland

Overview

AI/ML methods offer objective, automated classifiers for learning complex patterns in high-dimensional data. We have identified an exponential increase in published academic studies using AI/ML neuroimaging methods for diagnostic classification and prognosis in dementia (see our structured review at: https://www.medrxiv.org/content/10.1101/2021.12.12.21267677v1). In this study we highlight the increased use of multimodal imaging, and the rapid rise in use of deep learning AI methods over the past 4 years.

Despite this growing interest, barriers remain so that very few methods are available for use in memory clinics (reviewed by one of our speakers Prof.Dr Vernooij https://pubmed.ncbi.nlm.nih.gov/30852630/). Key barriers include technical and clinical validation (Pemberton et al, https://link.springer.com/article/10.1007/s00234-021-02746-3).

The number of people living with dementia is rapidly growing worldwide, from 50 million people in 2018 to an expected 152 million in 2050. Early, accurate diagnosis is crucial to enable personalised care plans based on reliable information, and for stratification into disease modifying clinical trials.

The combination of growing clinical need and rapid methodological innovation means that now is the ideal time to address key opportunities and barriers in the clinical translation of neuroimaging AI/ML tools for patient benefit in dementia.

Participants will leave the symposium with a better understanding of the clinical, methodological, infrastructure and regulatory challenges that face the successful translation of neuroimaging AI/ML methods in dementia for clinical use. This learning will facilitate new cross-disciplinary collaborations in this field and increase mutual understanding between disciplines.

Lecture 1: *A clinical perspective of AI for neuroimaging in memory clinics*

Rose Bruffaerts, MD PhD Presenter

The first talk of the symposium will introduce the clinic context and pressing need for AI and machine learning solutions.
AI has been introduced in many aspects of daily life, but clinical practice is lagging behind. In the ideal Memory Clinic of the future, the use of AI tools will benefit both the patient and the clinician. This presentation will outline issues that AI/ML tools may be able to address which are specific to the field of dementia, such as the uncertainty of clinicopathological correlation in neurodegenerative disease, and the challenges posed by rare neurodegenerative diseases. From a clinician's perspective, she will demonstrate how the increased sensitivity offered by AI and machine learning methods for neuroimaging can decrease diagnostic uncertainty, facilitate clinical trial monitoring and alleviate clinician workload. Prof Bruffaerts talk will summarize the existing body of work on AI for neuroimaging in the Memory Clinic, drawing on our recently completed structured review. Based on the available evidence, a synergistic role for AI can be envisaged in the Memory Clinic. On the other hand, AI has inherent limitations which impact its use in some aspects of clinical diagnostics.

Lecture 2: *AI methodology for image-based diagnosis in dementia*
Yong Liu Presenter

This talk will showcase worked examples of AI methods to derive clinically relevant neuroimaging biomarkers in Mild Cognitive Impairment (MCI) and Alzheimer's disease.
Firstly, Prof Liu will outline a roadmap for studying imaging biomarkers in Alzheimer's disease using imaging radiomics. The approach derives regional radiomics similarity networks (R2SNs) based on structural MRI. Classification based on R2SN features predict clinical progress from MCI to Alzheimer's disease, and other disease specific biomarkers (e.g. amyloid PET).
Secondly, he will demonstrate a systematic analysis to verify whether the Individual Brain-Related Abnormalities In Neurodegeneration (I-BRAIN) could provide new neuroimaging biomarkers for Alzheimer's disease from a variety of perspectives. The biological properties of the I-BRAIN have been evaluated by relating it to the "A/T/N" scheme (Aβ, Tau, neurodegeneration). Prof Liu will demonstrate how the I-BRAIN is specific for Alzheimer's disease compared to other neurodegenerative diseases (Frontotemporal dementia patients (FTD), Parkinson's disease (PD), Vascular dementia (VaD), and Amyotrophic lateral sclerosis (ALS)). He will go on to present a longitudinal analysis to test the sensitivity of the I-BRAIN to identify individuals who convert from MCI to Alzheimer's disease.
In summary, he will outline novel, robust and biologically plausible insights into how AI/ML methods applied to structural brain images can be used to develop biomarkers for Alzheimer's disease.

Lecture 3: *Ti Infrastructure challenges: machine learning in the cloud as a future-oriented solutiontle*
Ondrej Klempir Presenter

Appropriate infrastructure for data sharing, interoperability and processing, often in the cloud, has the potential to dramatically accelerate the development of AI/ML neuroimaging analysis, specifically in the field of ageing and dementia. In the first part of this talk, the essential blueprints for working in the cloud with available neuroimaging datasets will be introduced. Next, we will focus on data preparation and machine learning model deployment, using a real-world example of dataset extension with the results of ML models trained on the UK Biobank neuroimaging dataset. We will demonstrate new insights that can lead to improved diagnostics, new targeted therapies and better patient care by

leveraging the UK Biobank, one of the world's largest collections of imaging data. More specifically, we will show how neuroimaging can be combined with whole exome & whole genome sequencing data and phenotypic data, within a secure and collaborative environment using a multi-omics approach to combine data at scale.

Lecture 4: *Clinical validation of commercial automated volumeric MRI tools in the memory clinic*
Esther Bron Presenter

The final talk will cover logistical and regulatory aspects of the translation of AI/ML tools for use in memory clinics, specifically focussing on AI for quantitative neuroimaging. The current state of AI/ML tools approved for use in clinical practice will be reviewed. While several FDA-approved/CE-marked AI tools for normative quantification of brain atrophy are available for use in the memory clinic, Prof. Vernooij and her team demonstrated in a recent systematic review (https://pubmed.ncbi.nlm.nih.gov/30852630/) that there is a lack of evidence of validating these AI tools in the clinical setting. Two significant and understudied barriers are: 1) clinical validation, and 2) integration into the daily workflow of the end-user. She will summarise the important bottlenecks that future research must address.