MRI-based machine learning system allows for early diagnosis of Alzheimer's disease using a new algorithm

Tiana Castiglione
Honours Life Sciences, Class of 2026, McMaster University
castiglt@mcmaster.ca

Abstract

The majority of dementia cases are due to Alzheimer's disease (AD), characterized by a continuous and irreversible decline in cognitive abilities.[1] Alzheimer's cases are on the rise, driven not only by the current aging population, but also in response to a rising average age of death. In 2015, it was predicted that the number of AD patients would increase by 250% by the year 2050 for elderly 90 years and over.[2] That being said, with the proliferation of new potential treatments being proposed, early diagnosis of AD is crucial before symptoms become life-changing.[3]

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Magnetic resonance imaging (MRI) is a tool utilized in evaluating brain function.[1] Recent research combines MRI with machine learning, allowing the system to identify key features in Alzheimer's progression that are unnoticeable to the human eye, such as the shape and texture of the gray-level matrix of the brain.[1] This newly derived algorithm is thus able to identify changes in an AD brain, even prior to apparent shrinkage.[1] The machine-learning system is able to mechanically segment MRI images into 115 brain regions and distinguish individuals with AD-related pathology at a high level of accuracy.[1]

This new research began by first testing the effectiveness of the system on discriminating individuals with and without AD-related pathology.[1] The study then focused specifically on the individuals identified as having AD-related pathology, testing the aptitude of the system at differentiating AD patients from individuals with mild cognitive impairment (MCI) due to AD.[1] In multiple internal test sets, the algorithm reliably classified individuals with and without AD-related pathology at an accuracy of 98%, without the necessity of neuroradiological examinations.[1] Likewise, when distinguishing between AD patients and those with MCI due to AD, the algorithm achieved 79% accuracy on internal datasets and 86% accuracy on external datasets.[1] This degree of precision in the second test is still quite compelling considering that both populations are affected by AD-related pathology.

The accuracy of this new system, which focuses on several internal data sets, outperforms all other previously developed systems that merely target a single internal test set.[1] For instance, in 2017, an automatic computer-aided diagnosis system was applied to segmented MRI, classifying normal controls from AD patients with only 89% accuracy as opposed to 98%.[4] Currently, several other biomarkers are being used to determine the presence of Alzheimer's pathology in

individuals, including the presence of cerebrospinal fluid (CSF) β-amyloid.[1] With respect to previous research specifically on CSF, three immunoassays were used to reveal a high correlation between CSF and positron emission tomography (PET) classification, making CSF biomarkers robust replacements for PET in the diagnosis of AD.[5] CSF biomarkers are not only associated with clinical progression in AD patients, but also in MCI due to AD individuals.[5] Although CSF biomarkers have been shown to be effective in identifying individuals with AD, their reliability is limited through inconsistency in laboratories and test batches in which the CSF biomarkers were processed.[1]

To summarize, this MRI-based machine learning system serves as a fast and accurate diagnosis method to detect early stages of AD, successfully distinguishing individuals with and without AD-related pathology at a high proficiency.[1,2] The algorithm holds the potential to initiate treatment before symptoms become too severe, as the system can detect the architecture of Alzheimer's disease at a mesoscopic level and thereby diagnose earlier stages of AD.[3] This system proves itself more successful than previously discovered diagnosis measures, such as standard hippocampal atrophy with an accuracy of 26% and CSF β-amyloid levels with an accuracy of 62%, offering itself as a promising alternative for future adoption in clinical practice.[1] Attention should be drawn to the fact that the algorithm does not include CSF amyloid levels, which is used as a measurement in other diagnosis methods.[1] To optimize the algorithm and achieve an even better diagnostic system, future research can be conducted to determine whether including CSF amyloid levels in the MRI-based machine learning system algorithm would enhance the diagnosis process further.

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References

1. Inglese M, Patel N, Linton-Reid K, Loreto F, Win Z, Perry RJ, et al. A predictive model using the mesoscopic architecture of the living brain to detect Alzheimer's disease. *Commun. Med.,* [Internet] 2022 [cited 2022 Nov 13];2:70. Available from: https://www.nature.com/articles/s43856-022-00133-4 doi: 10.1038/s43856-022-00133-4

2. Brookmeyer R, Kawas CH, Abdallah N, Paganini-Hill A, Kim RC, Corrada MM. Impact of interventions to reduce Alzheimer's disease pathology on the prevalence of dementia in the oldest-old. *Alzheimers Dement.*, [Internet] 2016 [cited 2022 Nov 13];12 (3):225-232. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4808364/ doi: 10.1016/j.jalz.2016.01.004

3. Lang K. 2022. Early Alzheimer's diagnosis possible in a single MRI scan using new algorithm [Internet]. [Place unknown]: Medical News Today; 2022 [cited 2022 Nov 12]. Available from: https://www.medicalnewstoday.com/articles/early-alzheimers-diagnosis-possible-in-a-single-mri-scan-using-new-algorithm

4. Kheder L, Illán IA, Górriz JM, Ramírez J, Brahim A, Meyer-Baese A. Independent component analysis-support vector machine-based computer-aided diagnosis system for Alzheimer's with visual support. *Int. J. Neural Syst.*, [Internet] 2017 [cited 2022 Nov 14];27 (3). Available from: https://www.worldscientific.com/doi/abs/10.1142/S0129065716500507 doi: 10.1142/S0129065716500507

5. Hansson O, Seibyl J, Stomrud E, Zetterberg H, Trojanowski JQ, Bittner T, et al. CSF biomarkers of Alzheimer's disease concord with amyloid-β PET and predict clinical progression: A study of fully automated immunoassays in BioFINDER and ADNI cohorts. *Alzheimers Dement.*, [Internet] 2018 [cited 2022 Nov 16];14 (11):1470-1481. Available from: https://alz-journals.onlinelibrary.wiley.com/doi/10.1016/j.jalz.2018.01.010 doi: 10.1016/j.jalz.2018.01.010