Exploring Alzheimer's Disease Progression Through a Graph-based Retrieval System

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Background and Objective:

The cognitive decline spectrum includes cognitively normal (CN), mild cognitive impairment (MCI), and dementia stages. Alzheimer's Disease (AD) is a progressive neurodegenerative disorder that predominantly causes dementia. Thus, identifying patients likely to progress to AD is clinically pertinent. The Alzheimer Disease Neuroimaging Initiative (ADNI) dataset features chronological imaging, biomarker levels, and cognitive scores for over 2,500 individuals across the cognitive decline spectrum. A current challenge in AD research is comprehensively utilizing the volume and variety of information in databases like ADNI. Knowledge graphs (KG) simplify information using points (nodes) and connections (edges). Retrieval systems extract information from a source. In this work, we developed a graph-based retrieval system that utilized ADNI data to classify patients progressing from CN to MCI or AD.

Methods:

The ADNI KG, containing 2,513 patient nodes, 15,497 visit nodes, and 1,135,912 measurement nodes, was processed using NetworkX. Our retrieval system was coded in python and performed Amyloid-Tau-Neurodegeneration (ATN) scoring for each patient in the KG using conventional criteria. Patient progression was determined by comparing diagnoses from the first 25% of visits with the last 25% of visits. The system's ability to make predictions using cognitive, biomarker, and imaging data was validated on 200 randomly selected patients from the KG.

Results:

The system processed a KG with 1,153,922 nodes and 1,164,395 edges. For N=200 validation, the system removed 6 outliers, found 19 progressors (10 CN→MCI, 9 CN→AD), and achieved 76.7% accuracy when provided adequate biomarker data.

Conclusion and Potential Impact:

We present a graph-based retrieval system that can analyze large quantities of patient data, identify potential AD database errors, output patient-specific insights, and predict cognitive decline progression with reasonable accuracy. Future work will integrate this system with graph neural networks (GNN) and large language models (LLMs) to further improve its accuracy and clinical utility.