Using Machine Learning Techniques and Brain MRI Scans for Detection of Alzheimer's Disease

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INTRODUCTION AND BACKGROUND

- Dementia is a clinical syndrome characterized by cognitive and behavioral impairments.
- It mostly affects people aged 65 years and over.
- Alzheimer's Disease (AD) is the most common type of dementia, and accounts for 60% to 80%.

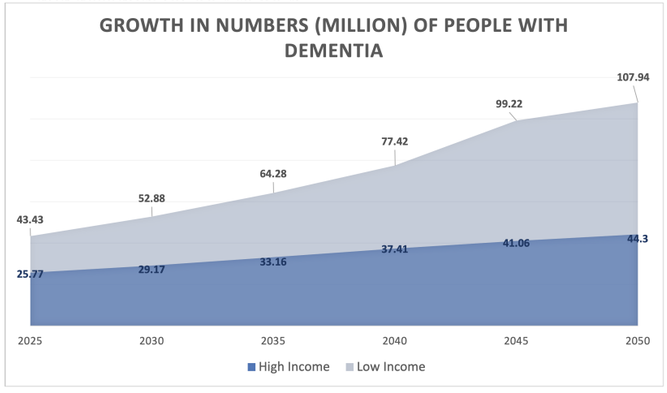
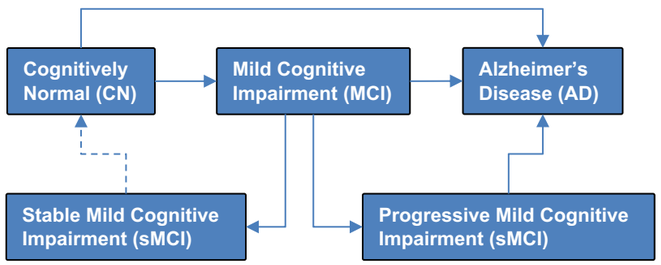


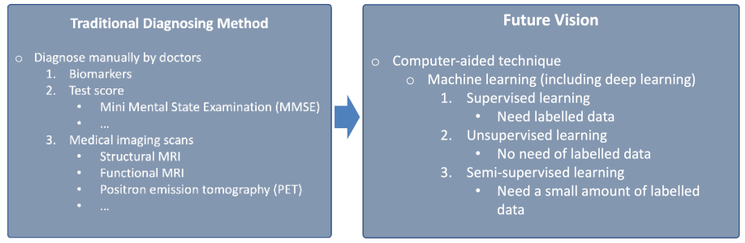
Figure 1 The predicted growth in the numbers (in millions) of people with dementia in high-income countries and low-income countries.

- The stages of how AD progresses are shown below:



Diagnosis of Alzheimer's Disease

- Diagnosed by doctors through biomarkers, test scores, or medical imaging scans.
- Requires professional knowledge and experience.
- Traditional methods of diagnosing dementia manually are time-consuming and resource intensive.
- Increased interest in employing **automated methods** in supporting diagnosis
- Supervised learning is the most common type of machine learning to support the diagnosis of AD; however, it **requires large volumes of labelled data to train**.
- **Labelling medical imaging scan is difficult**
- This research explores methods which rely less on labelled data (i.e., unsupervised or semi-supervised learning methods)



The aim of the study is to **develop machine learning methods to analyze structural MRI scans to discriminate between images of brains with Alzheimer's Disease (AD) and those from brains that are Cognitively Normal (CN)** using very few labelled data.

The study objectives are:

1. To extract the most appropriate features to support clustering tasks to discriminate between CN and AD;
2. To apply unsupervised learning methods to discriminate between CN and AD;
3. To evaluate the accuracy of the methods for discriminate between CN and AD.

We aim to answer the following Research Questions:

1. How can we extract features that are meaningful to discriminating between CN and AD?
2. Can the proposed method be used to discriminate between CN and AD effectively?

METHODOLOGY

In this study, we proposed a method to perform clustering CN and AD structural MRI scans only using a small amount of labelled data. In addition, the process also indicates the pathological regions between CN and AD groups.

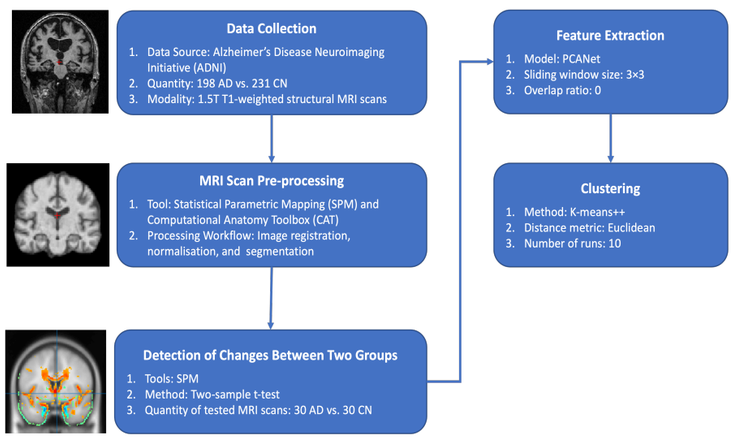
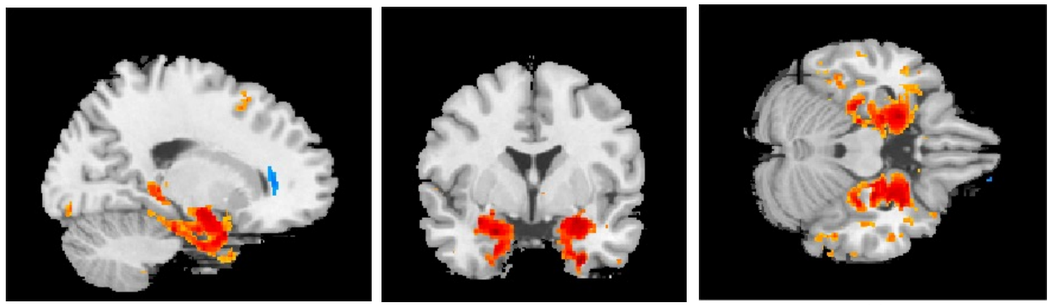


Figure 2 Workflow of the study

RESULTS



(a) (b) (c)

Figure 3 The red and orange regions are the regions of interest (ROI) between AD and CN groups, and they are shown in the three view planes: (a) sagittal plane, (b) coronal plane, and (c) axial plane. The red and orange regions mean that, within these areas, the value of voxels of CN group is greater than that of AD group.

Table 1 Evaluation of Clustering using one ROI and two ROIs. All means and standard deviations are results from ten runs.

	Accuracy		Sensitivity		Specificity		PPV		NPV	
	Mean	STD	Mean	STD	Mean	STD	Mean	STD	Mean	STD
One ROI	0.7730	0.0146	0.6945	0.0892	0.8403	0.0783	0.7980	0.0548	0.7666	0.0332
Two ROIs	0.8163	0.0203	0.7863	0.0553	0.8436	0.0630	0.8096	0.0561	0.8301	0.0338

**STD: Standard deviation* **PPV: Positive predictive value* **NPV: Negative predictive value*

There are five special subjects showed in the Table 2. The diagnostic status of all these five subjects is "CN", but in this study they were clustered into "AD" data in all 10 runs using either one ROI or two ROIs. Although they were mistakenly clustered as "AD", we can find that these five subjects developed to "AD" from "CN" in the final stages.

Table 2 Progression of some subjects which were clustered into AD cluster mistakenly in all runs

Subject	Baseline	6 month	12 month	24 month	36 month	72 month	96 month
005_S_0223	CN	MCI	MCI	MCI	AD	-	-
128_S_0230	CN	CN	CN	CN	AD	AD	AD
131_S_0123	CN	CN	CN	CN	CN	MCI	AD
941_S_1194	CN	CN	CN	CN	MCI	-	-
941_S_1202	CN	CN	CN	MCI	MCI	-	-

SUMMARY AND FUTURE WORK

The results of this study can be summarized as follows:

1. The ROI (red and orange regions) shown in Figure 3 are around hippocampus. In addition, based on Table 1 we can conclude that using the region has **a good performance on clustering**, which means that features extracted from **the ROI are meaningful to discriminating between CN and AD**;
2. According to Table 1, we can see that all measures are greater 0.8 or close to 0.8 when using both two ROIs. It potentially means that the proposed method is **effective to discriminate between CN and AD**;
3. From Table 2, we can conjecture that the proposed method can **potentially predict the development of AD**.

In the next steps of the study, we will discriminate sMCI and pMCI using unsupervised learning methods. In addition, in the future, we can also potentially implement the following work:

1. Using other modalities besides structural MRI scans, such as functional MRI scans and positron emission tomography (PET);
2. Employing other deep learning models, such as PCANet plus and anchor neighbor discovery (AND);
3. Utilizing other clustering algorithms, such as Gaussian distribution.
4. Collecting and analyzing data from multiple databases.