Understanding Alzheimer's Disease with Medical Image Processing

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Abstract

Alzheimer's disease is a progressive neurological disorder that causes memory loss and cognitive decline. It is the most common form of dementia, accounting for approximately 60 - 80% of dementia cases. An estimated 35.6 million people have Alzheimer's disease worldwide. Although the exact causes are not known, it is believed to be caused by a combination of genetic and environmental factors.

Advanced techniques like medical image processing and machine learning play a crucial role in helping us understand Alzheimer's disease:

- **Early Detection and Diagnosis**
- **Biomarker Identification**
- **Disease Progression Modeling**
- **Image Analysis and Segmentation**

Python toolkit of medical image processing functions to train students for Alzheimer's research

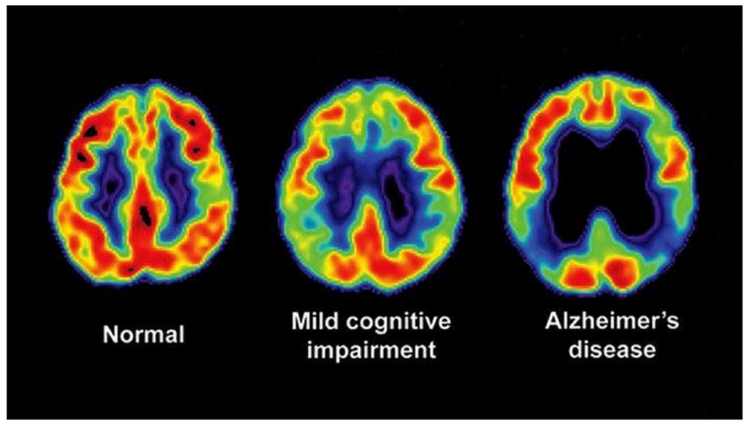

Fig 1: Progression of Alzheimer's disease. [Img 1]

Data

We have access to MRI images [Kaggle1, Kaggle2] of images pre-classified as mild demented, moderate demented, very mild demented, and non-demented.

Alzheimer's Disease Data Initiative (ADDI) and Related Work

Preprocessing

Image Structure: Multiple image structures (MRI/PET) and dimensionalities (4D, 3D, 2D) can be used.

Image Registration: Aligning and overlapping multiple images to create a unified view for accurate comparison and analysis.

Skull-Stripping: Removing non-brain tissues from medical images to focus solely on the brain region of interest.

Fig 2: Axial cut of an MRI without skull-stripping [Img 2]

Fig 2.1: Axial cut of a registered and skull-stripped MRI [Img 3]

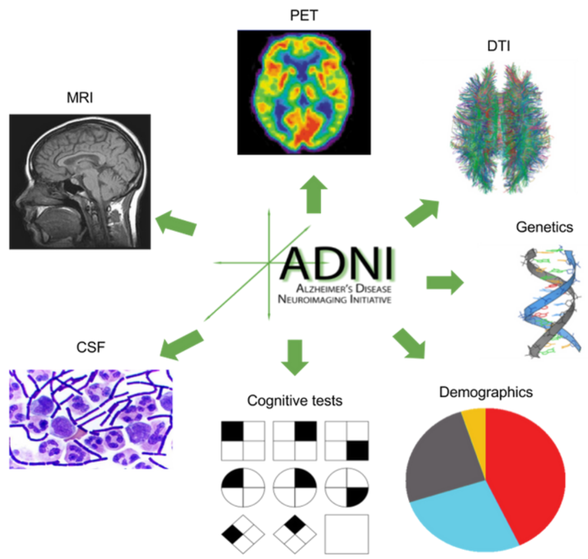

Fig 3: Various facets of Alzheimer's Disease research.
Image taken from [Data1]

Training Models

Convolutional Neural Networks (CNN): Popular algorithm that produces excellent results in image classification.

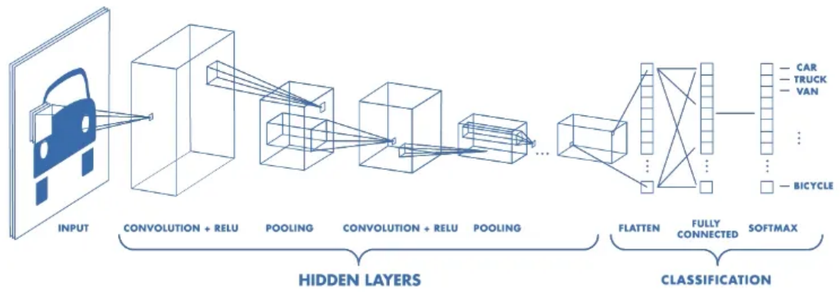

Fig 4: Axial cut of an MRI without skull-stripping [Img 4]

Support Vector Machines (SVMs): classification algorithms that find the best line or boundary to separate different groups of data points based on their features.

Independent Component Analysis (ICA): a technique used to separate mixed data into its underlying components, helping to identify and classify different sources or patterns within the data.

Challenges and Future Steps

- **Limited availability** of labeled data
- The **structural variety of images**
- **Ethical and philosophical** problems

We hope to include all types of data, like the one shown in Figure 2 above, to create a comprehensive library of 'simplified' functions for students.

References

[Img1] From https://www.pacificneuroscienceinstitute.org/brain-health/diagnostics-procedures/brain-imaging/
[Kaggle1] Alzheimer MRI Preprocessed Dataset, https://www.kaggle.com/datasets/sachinkumar413/alzheimer-mri-dataset [Kaggle2] Dataset Alzheimer, https://www.kaggle.com/general/233667
[Data1] TADPOLE, https://tadpole.grand-challenge.org/Data
[Img 2] & [Img 3] From https://towardsdatascience.com/alzheimer-diagnosis-with-deep-learning-a-survey-265406fa542a
[Img 4] From https://towardsdatascience.com/convolutional-neural-networks-explained-9cc5188c4939

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