

A Survey on Early Detection of Alzheimer's using PET Scan

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Abstract: Amyloid beta protein is usually the main precursor used to arrive at the conclusion if the subject has Alzheimer's disease. Most of the classification techniques tend to classify the three stages namely Alzheimer's disease, cognitively normal and mild cognitive impairment. The other classification techniques tend to just give the output as to which the subject has Alzheimer's disease. The objective of this paper is to assess the image processing techniques used, features extracted, image classification technique used and from where the dataset is downloaded.

Keywords: Alzheimer's, Data processing, Feature extraction, Machine Learning, PET.

1. Introduction

Alzheimer's is a neurodegenerative disease; it is very slow in the beginning but it catches pace with time. Although Alzheimer's disease is difficult to detect in the initial stages using MRI, groundbreaking advancements are done using PET scan images. Almost 1.60% of deaths in India occur due to Alzheimer's disease. In the research papers that we have accumulated, the majority of classification is done by looking at the accumulation of amyloid beta protein in the hippocampus. There are many machine algorithms used to classify or detect the stages. Some of them are Deep Learning which includes Back propagation algorithm, Convolutional neural network of Inception V3 architecture and so on.

In the United States of America approximately 5.8 million people who are 65 years or older ail from Alzheimer's disease. 60 % to 70 % of the total world population which is 50 million with dementia are said to have Alzheimer's disease. The onset of dementia is identified by symptoms which include forgetting conversations and recent events. As the disease advances the person with Alzheimer's will lose the ability to perform day to day tasks and will develop memory impairment which can be severe. Conditions of patients taking drugs may improve slightly or advancement of symptoms might be decelerated. As a result of this the patient might have a sense of independence and their abilities to perform functions can be maximized. There have been many camps and services and programs which are being held all over the world to provide some comfort to the Alzheimer's patients. Currently no treatment for Alzheimer's disease has been found that can cure Alzheimer's disease or

alter the process of disease in the brain. Dehydration, infection which can lead to death and malnutrition are some of the complications which can occur due to severe loss of brain function.

In the current scenario F-FDG PET will require the specialists in neuroimaging and nuclear medicine to make interpretations to perform pattern recognition decisions that will be done using qualitative readings. AD is a heterogeneous disease due to which the classification and extraction of clinical data is always challenging. The role of diagnostic techniques which are computer aided with the goal of having an in depth understanding of disease classification and process is emphasized by the literature. To meet this end many of the machine learning algorithms are being used to record complex sample of the data and to the point forecast of the disease, and to assort patients not only from the healthy individuals but also from patients enduring significant memory concern and mild cognitive impairment.

2. Materials and Methods

a) Datasets: The datasets used in the bulk of the papers can be accessed from the open Alzheimer's disease neuroimaging initiative (ADNI) database. The ADNI, which is led by Principal Investigator Michael W. Weiner is a public-private partnership, and was launched in 2003. The dataset has been downloaded in the form of NIFTI or DICOM.

b) Image preprocessing: Image preprocessing method includes the devising and censure of data to minimize the priming time and to improve the identification skills of neural networks. Some of the techniques we have encountered are:

- Average pixel per node approach: Images are spontaneously cropped to detach frames which are black from the region of interest, which swells computational cost during priming and generalization with zero values [1].
- Grid method: Classification techniques are applied to images after resampling them to 2mm isotropic voxels and trimmed to a 100x100x90 pixel grid in a 200x180 mm³ volume [2].
- Free-surfer: Carried out under Linux system 108 to transform the native PET to the standard MNI 305 space,

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producing the image cited to 109 as T1.mgz, used as the reference image in the registration procedure, followed by skull-stripping, segmentation, and depicting cortical and subcortical regions with the 111 corresponding image result which is termed as *aparc+aseg.mgz* [3].

- In some of the research papers the images are directly fed into the machine learning algorithms for classification.

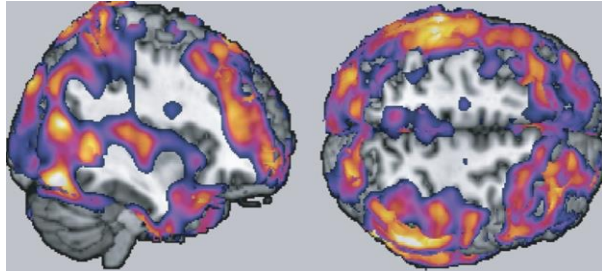


Fig. 1. Brain regions showing reduced CMRglc on FDG-PET in cognitively normal individuals with a maternal family history of AD [11].

c) *Feature extracted*: There has to be some criterion to detect the stage of an Alzheimer's patient. Some of which includes,

- **Amyloid protein**: Accumulation of amyloid beta protein is observed as the beginning of a degenerative process. The accumulation occurs in the hippocampus of the brain [1].
- **Atrophy pattern in cortical and subcortical regions of the brain** [3].
- **Feature extraction utilizing blob detection**: A piece 116 regions is fed for the objective of feature extraction. Mostly blob detection strives to spot light circular structures from images as an attribute [4].
- **Glucose metabolism**: In the affected part of the brain the rate of metabolism can be abnormally high or abnormally low [5].
- **Shrinkage of the ridges of the brain**: As the cortical volume decreases the brain starts to collapse on itself [7].
- **Gray matter density**: There will be significant reduction in density of gray matter this happens mostly in the hippocampus [9].
- **Cortical volume**: There may be posterior cortical atrophy. The cortical volume will be significantly decreased [10].

3. Model Training Techniques

1) *Back propagation*

Back Propagation (BP) is one of the supervised learning algorithms in ANN which is most widely used and effective. Values normalized are dispatched to the input layer of the neural network where the preprocessing may or may not be done and for the hidden layer the total potential is calculated by using initially randomized weights and these input values [1]. Using activation function the output for each neuron is calculated. The next layer of 3-layered network is output layer where all the steps are repeated. This has produced an accuracy of 87.9%.

2) *Convolutional neural network inceptionV3*

Inception V3 is used for image classification, it is a deep learning model which is based on Convolutional Neural Network [2]. This has produced an accuracy of 91%.

3) *Gaussian Discriminative Component Analysis (GDCA)*:

GDCA is used to delineate changes which are subtle in the early stages of mild cognitive impairment [3]. This has produced an accuracy of 87.9%.

4) *SVM (Support Vector Machine)*

pSVM is used to provide a probability output for each normal or abnormal class in the regions of the brain [4]. This has produced an accuracy of 89.49%.

5) *Three pathway algorithm using deep learning*

Pathway 1 is preferred if AD is the suspected diagnosis i.e., analysis of accumulation of amyloid. Pathway 2 is recommended if Alzheimer's is not a surmised diagnosis or for older (>80 years) individuals [5]. If the result of the ¹⁸F-FDG-PET scan of the brain is incontestable, no further tests are required. Pathway 3: But if further specification is needed then further test is done, else no further test is required. This has produced an accuracy of 87%.

6) *Recurrent Neural Network*

Here individual regions of the brains are made into vector numbers [9] which are then used for classification. This has produced an accuracy of 83.7%.

4. Conclusion

In this paper, the different image processing techniques, from where the dataset is downloaded, features extracted, and different image classification techniques were discussed. The development of a classification technique for Alzheimer's disease has to be developed considering all the metrics such as accumulation of amyloid protein, Tau-protein, cortical thickness, gray matter density and shrinking of the ridges which can be life threatening.

This shows us satisfying classification of Alzheimer's disease. More research effort should be devoted on how to increase specificity and sensitivity. This can be done combining many classification metrics.

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