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Machine Learning Based Alzheimer's Disease Detection in MRI Images

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Abstract: Magnetic Resonance Image is a medical imaging technique which can be used to diagnose problems associated with brain. The advantage of this technique is that it is completed contactless – no need to do any surgery to know what's wrong with the brain. This paper shows different ways through which Dementia can be diagnosed, all by using MRI images and computer vision. Also in this paper, a machine learning based method is proposed to identify Alzheimer's disease.

Keywords: MRI; Alzheimer's Disease; CAD; Survey; Computer Vision; Dementia; Machine Learning

I. INTRODUCTION

Magnetic Resonance Image is a medical imaging technique used in Radiology of anatomy and the Physiological processes of body. It uses strong magnetic field, magnetic field gradient, radio waves. It does not involve X-ray or ionizing radiation which distinguishes it from CT / CAT scan. It is a painless procedure and detects abnormal findings that CT/PET misses in more than 50% of patients scanned. It is also superior in regard to the details of the image.

Neurodegenerative diseases are a heterogeneous group of disorders where progressive degeneration of structure and function of Central Nervous System (CNS) or Peripheral Nervous System (PNS) takes place and also it is irreversible disease. Most commonly known diseases include Mild Cognitive Impairment (MCI), Alzheimer's Disease (AD) and Parkinson's disease. Alzheimer's is not an obscure disease but, early diagnosis will help in controlling rate of development of the disease [1].

Computer Aided Diagnosis (CAD) should be used instead of manual diagnosis which is prone to human error and personal ability. Because there are chances that there could be false detection which can lead to life-taking decisions.

Recently, increasing number of neuroimaging data based machine learning studies are aiming at developing diagnostic tools that help brain MRI classification and automatic volume segmentation and to understand the mechanics of neurodegenerative diseases ; however, the datasets collected in neuroimaging studies are usually very small it is important to build network architectures capable to learn features for classification based on small datasets.

Alzheimer is the most common form of dementia, a disease of old age, and becomes increasingly frequent with every passing decade after 60 years which causes problems with memory, thinking and behaviour. It is difficult to identify in early stages since progression of disease is slow. Alzheimer is not an obscure illness but an ailment affecting real people in real families. People lacking knowledge and attention to current issues regarding Alzheimer's disease make it difficult to detect their loved one illness earlier [2].

There is a rapid growth in the number of people living with Alzheimer's disease. It is estimated that there are approximately 44 million people worldwide living with Alzheimer's disease or a related form of dementia and only around one in four people with the disease get diagnosed. In India, nearly 4 million people are suffering from Alzheimer's and other forms of dementia, giving the country the third highest caseload in the world, after China and the US. Alzheimer's disease in India is estimated to reach almost 7.5 million by the end of 2030.

This paper is divided into the following sections – Section 2 introduces the motivation, Section 3 focuses on literature survey, Section 4 on proposed method, Section 5 on Results and Section 6 concludes the paper.

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II. MOTIVATION

Many people are living alone and far from their children because of their career. The main motivation to choose Alzheimer's detection is parents are our responsibility after a certain stage and that should be the top priority in our life.

The ultimate goal is to make sure everyone can recall their precious memories on the last stage of their life and they remember their likes and dislikes, everything that was once special for them.

III. LITERATURE REVIEW

Jian Li et al [3] proposed the concept of the improved box-counting method to estimate fractal dimension of image. This method assigns the smallest number of boxes to cover the entire image surface, thereby yielding more accurate estimates. But the drawback of this method is that, it has fit errors.

Ahmed OB et al [4] proposed a concept of Hippocampal visual feature for identifying groups containing mostly informative voxels and Handling higher dimensionality data. It gives better accuracy in discriminating between AD and MCI. Major drawback of this method is signature generation effects the images, with clearly identified signature vectors.

Shams-Baboli A, Ezoji M. [5] proposed a method of Zernike Moment for Classification of various stages of dementia diseases based on back propagation method. Main drawback of this method is computational complexity and it needs all three orthogonal directions of MRI.

Wehenkel M et al [6] proposed a method of Tree ensemble to identify brain areas related to Dementia disease. It helps in identifying groups containing mostly informative voxels and Handles higher dimensionality data. But the drawback is that it will not give precision values.

Sergey Korolev et al [7] proposed a residual and plain convolutional neural network architecture to classify brain MRI. In this paper machine learning has been used to develop diagnostic tools that help brain MRI classification and automatic volume segmentation. Advantages of this method are the ease of use and no need for handcrafted feature generation. Drawback of using this method is they could not achieve better results for images that were not pre-processed for alignment and skull stripping, since convolutional neural networks are invariant to translation of the object.

IV. PROPOSED METHOD

The objective of the method is to detect Alzheimer's disease using patient's MR images. Early diagnosis of this disease helps in appropriate treatment and controls the rate of development of disease.

The methodology mainly involves three stages namely: Pre-processing, morphological processing and developing Regression Based Algorithm for Pre-processed image. Fig 1 shows the flow of the algorithm.

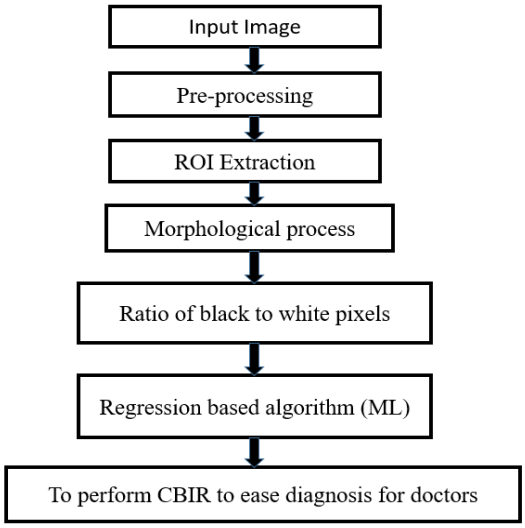

Fig 1. Flow chart of proposed methodology

A. *Pre-processing*

Initially, we have obtained data from publically available dataset ADNA [8] source, which are completely unprocessed. Therefore, pre-processing operations are done to enhance image features. Firstly, we have converted the original image into separate colors , to find out which converted image has better clarity and contrast for further processing. Further segmentation is done for partitioning digital image into multiple segments comprising of pixels. A label to every pixel is assigned so that it becomes easier to analyze the image. Here we have selected simplest form of image segmentation called threshold method.

B. *Morphological operations*

We have obtained an image after non-linear operations, such as erosion and dilation which is related to the shape or morphology of features in an image to remove noise in the image.

Later, ratio of black to white pixel is found to know the condition of brain. We have converted the background pixels to white, so that background pixels do not add to the object of interest pixels. By doing this false pixel counts ratio can be prevented and precise cavity is obtained.

C. *Regression based machine learning*

In this paper we are using regression based machine learning (ML) . Regression is a statistical approach to know the relationship between variables. In machine learning, it is used to predict the outcome of an event based on the relationship between variables obtained from data-set.

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Since we have don't get large amount of dataset for neurodegenerative diseases and the relationship to be modeled is not extremely complex regression based machine learning is the optimum choice. And it is also very simple to understand.

In this method accuracy depends on degree, so by increasing the degree of polynomial equation more accuracy is obtained, but calculation becomes difficult, so we choose a degree, where our ratios gets saturated.

Therefore, a third degree polynomial is chosen as shown below in Eq. (1), where a,b,c,d are coefficients obtained using regression.

$$y= ax^3 + bx^2 + cx + d \text{ …….(1)}$$

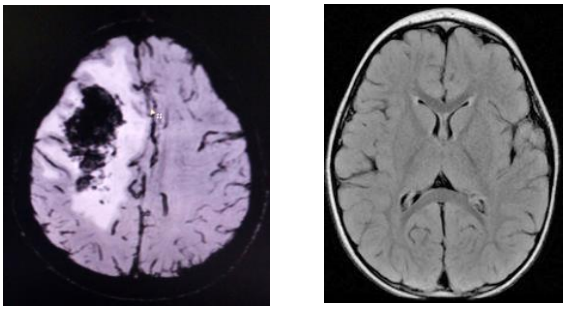
The ratios of black to white pixel that is 'x' is applied to the above equation to train the machine. So, when we feed in the image of live MRI it gets compared with all the images in database. It tells us which image in the database matches to this image and how that patient was cured and diagnosed. 'Y' predicts whether Alzheimer's is detected or not.

Content based image retrieval is also known as query by image content or content based visual based retrieval, which is application of computer vision techniques to the image retrieval problem of searching for digital images in large data base. This is used to perform regression on all images and compare the results.

We have implemented the above methodology in Simulink tool since we are doing Content Based Image Retrieval (CBIR) where in the doctor can feed in live MRI image and the image gets compared to all the images in the database and then tells the doctor to which image in the database given image matches and how that patient was cured and diagnosed.

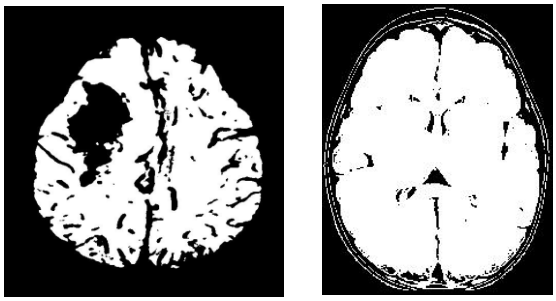
V. RESULTS

The following figures show the output at each stage.



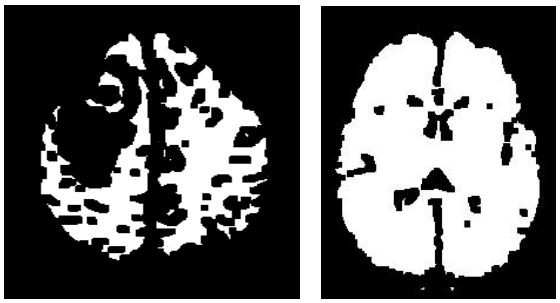
(a) (b)

Fig 2. Original images (a) with Alzheimer's (b) Without Alzheimer's



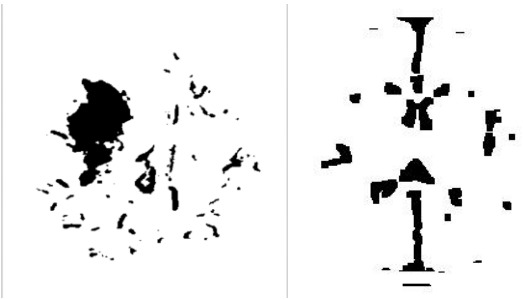
(a) (b)

Fig 3. Segmented images (a) with Alzheimer's (b) Without Alzheimer's



(a) (b)

Fig 4. Morphological operator outputs (a) with Alzheimer's (b) Without Alzheimer's



(a) (b)

Fig 5. Cavity shows the presence of Alzheimer's (a) with Alzheimer's (b) Without Alzheimer's

In the above figure , Fig. 2 represents input images. Images are then preprocessed as shown in Fig. 3. Later morphological operations are performed as shown in Fig 3. Finally, cavity in MR images has been found as shown in Fig. 4.

VI. CONCLUSION

With the aging of population in developing countries, the dementia diseases become has major problem of public health. The proposed work uses image processing and regression based method machine learning, which is best suited for analysis of Brain MRI, as disease progression is proportional to area of brain. This combination gives

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better results. These methodologies can be used to develop standalone machines to diagnose the problems associated with one's brain.

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