IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Design and Implementation of Algorithm to Extract Texture and Shape Features to Detect and Grade Alzheimer's Disease

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Abstract:

The difficulty in cognitive functional thinking is called Dementia. Alzheimer's disease is the most common cause of Dementia. Alzheimer's disease appears commonly for the people of age 65 or above. The symptoms of Alzheimer's disease include language speaking problem, memory loss and behavioral changes. And the non-memory aspect symptoms include vision issue, word finding problem, impaired reasoning and impaired judgement. This paper discusses how to detect the presence of Alzheimer's disease and grade the various stages of Alzheimer's disease. The proposed model combines MRI image, age and gender of the patient as input to the Multi-class classification for detecting the presence of Alzheimer's disease. The model comprises of initial pre-processing of MRI images, then image segmentation and identifying the area of interest, then performing pixel segregation based on intensity of pixels. Then using Machine learning techniques to count the amount of white and grey matter based on pixels. Then using that data to detect the presence of Alzheimer's disease and grading into further stages.

Keywords: Alzheimer's disease, Dementia, Computer aided diagnosis, Early detection, Image processing, Machine learning, stages of Alzheimer's disease.

I. Introduction

The brain is the important part of the body. The diseases and disorders that affect the brain are difficult to handle, because once changes occur to our brain it is difficult to reverse. Alzheimer's disease is irreversible and progressive. It slowly degrades the memory and thinking skills. Alzheimer's disease can be classified into 4 types such as, Very Mild Decline, Mild decline, Moderate decline, and Severe decline. Early detection of Alzheimer's disease is very important so that the preventive measures can be taken. Current techniques based on cognitive impairment testing which may not provide accurate diagnosis until the patient's disease has progressed beyond the moderate decline stage. Some computer-based diagnoses are now used to aid the disease. So, the automated and reliable computer-based system for diagnosis is important for classifying the brain disease.

With the help of Image processing and Machine learning, it is possible to detect the amount of damage happened to the brain and determine whether Alzheimer's Disease is present or not. First, pre-processing of MRI images is done, then image segmentation and identifying the area of interest, then performing pixel segregation based on intensity of pixels. Then using Machine learning techniques to count the white and black or grey pixels. Then using that data to detect the presence of Alzheimer's disease and grading into further stages. The feature extraction and selection methods are implemented from matplotlib python libraries. Some Machine learning methods are implemented using pandas from python libraries. The system implements the supervised learning from machine learning, in which the programs learn from the training data and draws conclusion based on the inputs and in-built program data. Thus, the identification of Alzheimer's disease patient is done.

II. Literature Review

Exhaustive analysis and accuracy of various machine learning techniques on a combination of different biomarkers associated with the disease. And using of various machine learning techniques is used for the early detection of Alzheimer's disease and proper diagnosis [1]. A Comparative Analysis on Various Assistive Technologies is used for early prediction of Alzheimer's disease. A systematic review of various analysis and evaluation techniques performed on recent work for the early detection of Alzheimer's disease using various approaches of machine learning, IOT (internet of things), Artificial Intelligence is reviewed [2]. Detecting the Alzheimer's disease and classifying into further stages using MRI Images and it also discusses a method which uses the MRI brain to identify and distinguish characteristics using a range of characteristics recognition techniques [4]. Convolutional Neural Network and machine learning for the detection and diagnosis of Alzheimer's based on the detailed analysis of the existing literature. It discusses the use of a Convolutional Neural Network (CNN) in the detection of Alzheimer's Disease and neuroimaging procedures for dementia diagnosis [7].

The literature review provides a view on the application of machine learning. It summarizes the algorithms that can be applied for the better prediction and classification of Alzheimer's disease. It focuses on detection of Alzheimer's disease using various approaches of machine learning, IOT, Artificial Intelligence etc., The existing methodology is based on the principle of quantity of brain volume damaged and calculating the cognitive changes in the patient to detect the Alzheimer's disease. As disease progress, the protein Tau Tangle keep on increasing and the volume of brain keep on decreasing. The existing technology focuses on identifying the brain volume then determining the presence of disease.

Existing System:

From the literature review it is found that many methods and systems are developed for detecting the Alzheimer's disease. MRI scans can be used in image processing to detect the possibility of early Alzheimer's disease. Some deep learning methods are introduced for determining the Alzheimer's disease that overcomes some drawbacks of machine learning. It is also used to detect mild cognitive impairment cases. Commonly the volume of the brain is calculated using some algorithms. The existing system calculates the amount of brain volume that is damaged because of Alzheimer's disease. As the disease progress the connection between neuron cells decreases and they die and the volume of brain decreases. The existing system calculates the volume of brain from axial plane view, coronal plane view and sagittal plane view.

Some systems calculate the presence of Alzheimer's disease only by analysing the volume of hippocampus region of brain and age of the patient. The detection of Alzheimer's not only based on the volume of hippocampus but also other parts of brain. The brain elastic property is used in determining the deformation of its shape. And the results are used to grade the Alzheimer's disease. But the problem is, the brain deformation not only happens due to Alzheimer's but also for pathological reason.

III. Proposed System

The existing system is concerned with the amount of the brain volume degraded in detecting the presence of Alzheimer's disease. But the brain's shape is not always deformed by the diseases, it is a natural process through which shape of the brain transforms. So, the proposed system detects the presence of the Alzheimer's disease by calculating the white and grey matter of the brain. The white matter represents the living cells and the black or grey matter represents the dead cells.

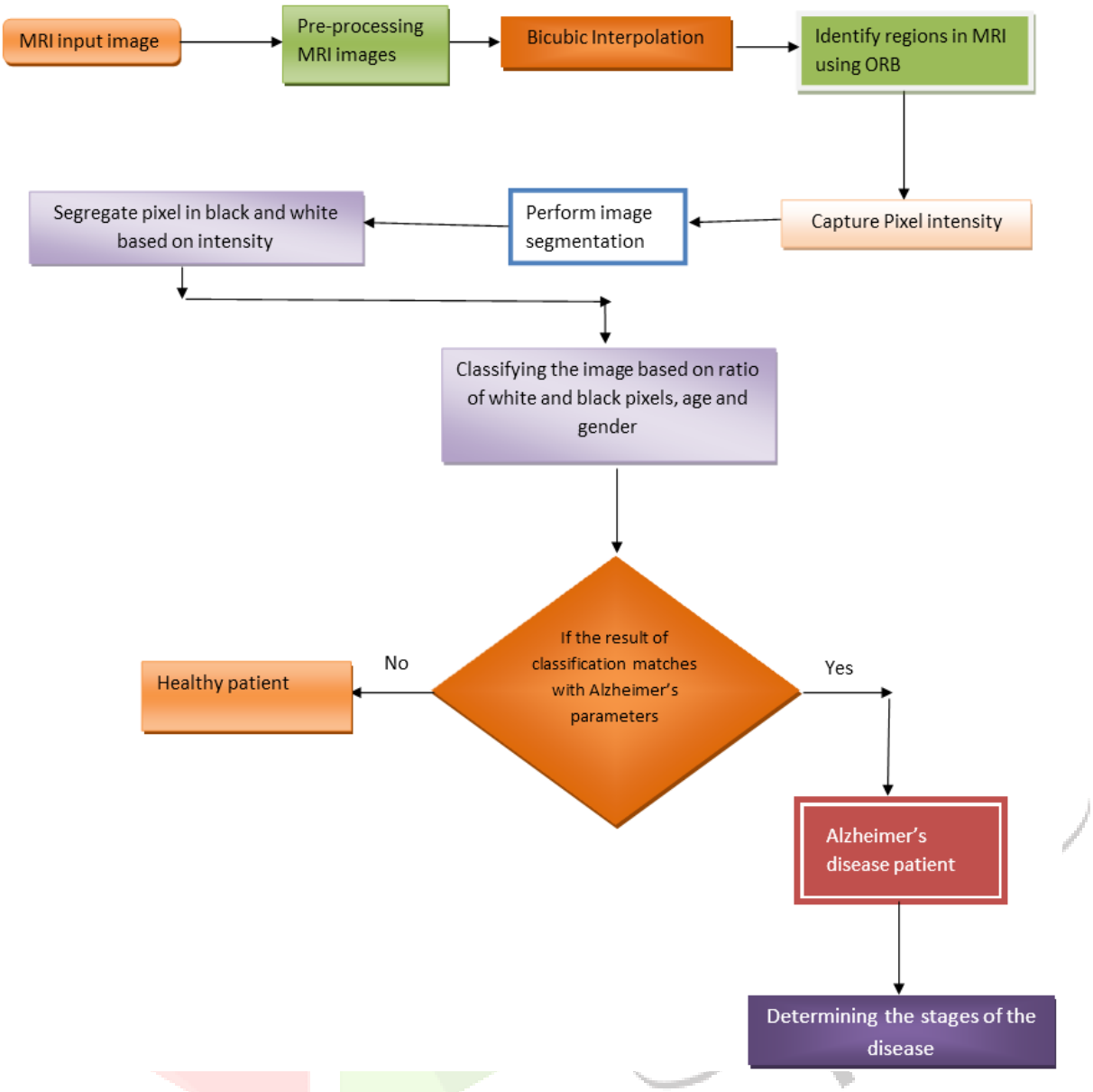


Figure 1 - Flow chart of Proposed Algorithm

The figure 1 represents the brain MRI processing for determining the presence of Alzheimer's disease. The following are the processes done for detecting the disease.

- **MRI input image and pre-processing:** The MRI image is taken and done image pre-processing. It doesn't add any features to the image but it removes some unwanted features and does image resizing, intensity adjustment etc.,

- **Bicubic Interpolation:** The original MRI images of brain cannot be used for detection of feature that is possessed by the pixel. The bicubic interpolation is the technique that enhances the image, makes it smooth enough to be used in image processing. It is a 2-D system technique. It also used for scaling the image. The image surface obtained from bicubic interpolation is better than other types of interpolation such as bilinear interpolation or nearest-interpolation.

- **Identify important features and extracting from image:** Feature extraction of image is about capturing the visual content. It includes some general features such as colour extraction, texture and shape features. The method used for feature extraction is ORB (Oriented FAST and Rotated BRIEF). ORB is the efficient method compared to SIFT method. It requires less time complexity, improved matching performance. It identifies the region of interest. It includes hippocampus, parietal lobe and many other regions of brain that is used to determine the presence of Alzheimer's disease. The position of area of interest is noted and that region is cropped. The image is cropped using PIL (Python imaging library) module from Image class from python libraries.

- **Image segregation:** It involves the identification of colour of pixels in the cropped images. We obtain the colour of the pixel by using PIL and matplotlib library of python. It gets the value of each pixel in RGB format and then classifies it as white and grey or black pixels. Then counting the number of white and grey or black pixels.

- **Multi-class Classification using Decision Trees:** It is a Machine learning technique. Classification is categorizing data and created groups depending on their similarities. The classification task with two or more classes. It gets the count of pixels, age and gender information. And compares it with the medical data of Alzheimer's disease. Then it classifies whether Alzheimer's disease present or not. If the disease is present then the disease will be graded into further stages by calculating the variance of white and black pixels.

Block diagram:

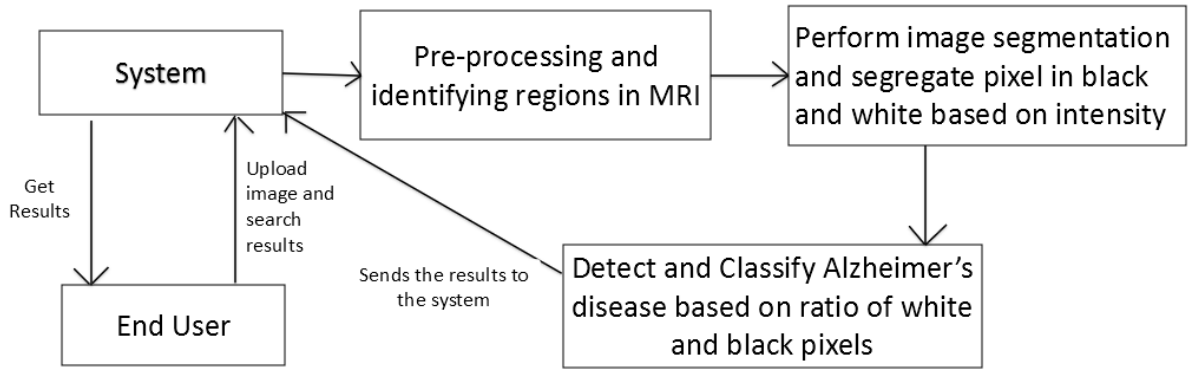


Figure 2 - Block diagram of Alzheimer's detection system

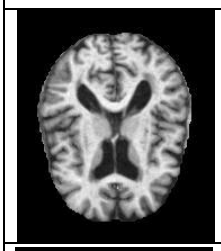
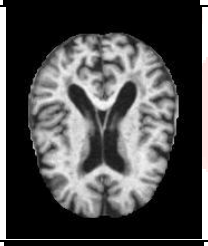
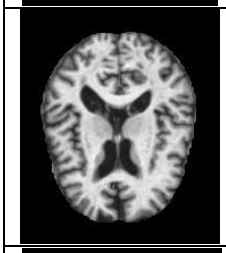
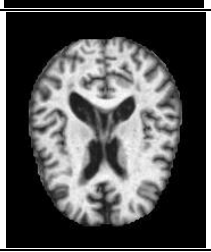
The figure 2 shows the implementation of the Alzheimer's detection system, it involves interaction of the user and system, and also various process done in the system to determine the result.

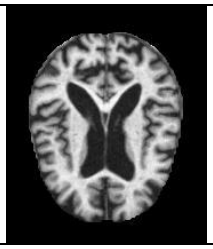
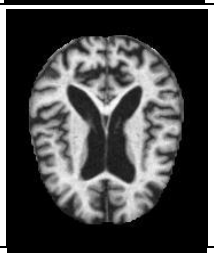
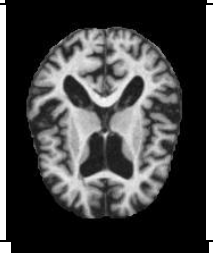
System accepts the MRI image and gives results to user, it uses MRI image for further processing, it copies the result and displays it for user. End User uploads the MRI image requests the result from system. Pre-processing and identifying regions in MRI, accepts the MRI image and performs some image Pre-processing techniques on the image, and identifies region of interest. Then Image segmentation is done on the region

of interest and segregate pixel in black and white based on intensity. Then applying classifier methods for detecting and classifying Alzheimer's disease based on ratio of white and black pixels.

IV. Result

The proposed system can detect the disease and can grade it into further stages. Many MRI images are given to check the accuracy of the result.

Images	Expected Output	Actual Output
	Normal Patient	Normal Patient
	Normal Patient	Normal Patient
	Very Mild Decline	Very Mild Decline
	Very Mild Decline	Normal Patient (Failed)
	Mild Decline	Mild Decline
	Mild Decline	Mild Decline

	Moderate Decline	Moderate Decline
	Moderate Decline	Moderate Decline
	Severe Decline	Severe Decline
	Severe Decline	Severe Decline

Accuracy of the result = (Total No. of images – Failed No. of images) x 100/Total images.

The total number of images used for checking the results are 460, in which results of 421 images are correct and 39 images are wrong.

So, the accuracy = (460-39) x 100/460 = 91.522%

The accuracy is found to be approximately equal to 92%. It shows that the presence of the Alzheimer's disease cannot only be conformed based on the computer-aided result, but also needs the conformation from medical specialists.

V. Conclusion

The detection of Alzheimer's disease is achieved. The system detects whether Alzheimer's disease is present or not, and identifies the various stages of Alzheimer's disease by using MRI images. The techniques used such as ORB and python libraries for cropping pixel identification. The ORB is used for feature selection. PIL module from Image class is used for cropping and segregating pixels. And the decision tree classifier has simple methodology and it takes less time complexity. This computer-based system can help in reducing human errors and results in effective diagnosis.

VI. Future Work

The proposed system can detect the Alzheimer's disease of one image at a time. Repository of number of images can be used a input, the system will scan all the images and provide result for all the images. Some machine learning techniques and deep learning like CNN (Convolutional Neural Network) can be used for generating more accurate results.

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