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Brain Alzheimer's disease Detection in Magnetic Resonance Images Using Image Processing

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Abstract- Alzheimer Disease is a chronic neurodegenerative disease and genetic disease that harm the brain nerve cells and tissue loss throughout the brain which causes loss of memory and thinking ability and change in its behavior. In this paper we determine early detection of Alzheimer disease through image processing on Magnetic Resonance Image (MRI) and classification of MRI of brain based on extraction of different features. The paper manifest the application of several image processing technique such as Otsu's Thresholding and Hidden Markov Random field model (HMRF-EM) and expectation maximization. The feature use for this project acquire from grey Level Co-occurrence Matrix (GLCM) such us Entropy, Homogeneity and Correlation and also the volume ratio of grey matter and white matter to cerebrospinal fluid. This project design in software MATLAB for early detection of Alzheimer disease.

Keywords: *Brain Alzheimer's disease, MRI scan, GLCM, HMRF-EM.*

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I. Introduction

Human Brain is most complicated organ and central part of our nervous system which control the function of human body. It takes the input from sensory organ and give the result to muscles. Human brain consists a large number of neurons approximately 10^{11} with 10^{4} interconnections. Any abnormal behavior of brain leads to disintegrate the function of entire body. One such brain abnormality cause in brain Alzheimer disease. Alzheimer is a neurodegenerative disease of brain that causes change in function of brain. The chances of Alzheimer disease before 65 year is 5% and after that the chances of Alzheimer disease is high which causes in progressive decline in memory. The two main characteristic of AD are Tangles and Plaques another main effect is due to forgetting of connection between neuron as shown in figure1. The evolution of Tangles and Plaques causes in demising of brain which leads in loss in functional capability due to which the neuron dies to detect the brain Alzheimer disease we use MRI scan because of high intensity, sensitivity, specificity and clarity which is optimal for analysis rather than CT scan X-ray.

Fig.1. Plaques & Tangles

II. PROPOSED METHODOLOGY

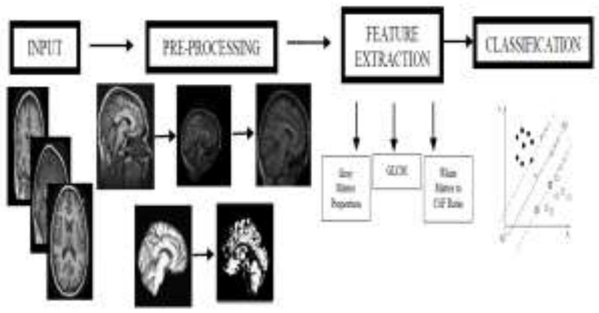

Fig. 2. Block Diagram

From the given block diagram for proposed methodology as shown in figure 2. The techniques used in proposed methodology is to first we pre-processed the MRI scan of brain in which we increase the intensity of image such that there is clear distinction between white matter, grey matter and cerebrospinal fluid. Then we apply feature extraction on the pre-processed image in which we find grey matter proportion, Grey Level Cooccurrence Matrix (GLCM) & white matter to CSF ratio. After then we classify the available dataset through Support Vector Machine (SVM) which give best result for binary classification.

A. *Magnetic Resonance Imaging (MRI)*

MRI is a medical imaging technique which is widely used in biomedical science which uses magnetic field, field gradient, radio wave to detect and visualize the proper details of anatomy and physiological process of the body. We mostly prefer to detect the Alzheimer disease rather than X-Ray & CT scan because it uses ionizing radiation which harms the body part and there is a most chances of causing cancer.

B. DATASET

The MRI image for our project has been obtained from Open Access Series Of Imaging (OASIS)[1]. OASIS provide free dataset for project community and they hope to facilitate future discovery in neuroscience. We have used 40 MRI image aged between 18 to 90 years. The dataset mainly have Nifti files that consist two type of files .img and .hdr files. Each Nifti files gives 3D images show three different view of brain at different pixel position that are Axial, Coronal & Sagittal. The images in the files are T1 weighted and consist both type of MRI image people with Alzheimer's Disease and people with no disease(i.e. normal).

III. PREPROCESSING

From our dataset, it consist Nifti files gives 3D images show three different view of brain at different pixel position that are Axial, Coronal & Sagittal. The images are of different shape and size, convert it into same templet which is easily preprocessed.

The MRI images consist of three main parts 1.White Matter(WM), 2.Grey Matter(GM), 3.Cerebrospinal Fluid(CSF). This three tissues intensities have chances to overlap with regions of brain after thresholding like bone and skin. This non brain pixels (bone and skin) in MRI may reduce the accuracy of identifying the main brain region like White Matter(WM), Grey Matter(GM), Cerebrospinal Fluid(CSF). For this we require to remove the non-brain pixel of MRI.

In preprocessing we mainly use three steps:

A. Thresholding

This method is based on clip-level (or threshold value) to turn a gray-scale image into a binary image by selecting a threshold value and adjusting the intensity to increase the contrast in the images such that there is clear distinction between WM,GM and CSF.

B. Image Segmentation

The basic technique used in proposed system to extract the region of interest i.e. WM,GM and CSF. To isolate the white matter, grey matter and CSF we use **Hidden Markov Random Field Model and Expectation Maximization (HMRF-EM)[5].**

In HMRF-EM segmentation implementation, if

I= $[I_1, I_2, \ldots\ldots\ldots\ldots, I_n]$ represent intensity of pixel.

C= $[C_1, C_2 \ldots\ldots\ldots\ldots\ldots, C_n]$ are all possible level for classes.

Step 0: Start with two randomly placed Gaussians $\theta_0(\mu_{0,}\sigma_0^2)$ and $\theta_1(\mu_{1,}\sigma_1^2)$ with their probabilities P(C1) and P(C2).

Step 1: For each point: P $(C1|I_i)$ =does it look like it came from C1?

$$P(C1|I_i) = \frac{[P(I_i|C1) * P(C1)]}{[P(I_i|C1) * P(C1) + P(I_i|C2) * P(C2)]}$$

$$P(I_i|C1) = \frac{1}{sqrt(2\pi\sigma_0^2)} * \exp\left(\frac{-I_i-\mu_{c2}^2}{2\sigma_{c2}^2}\right)$$

Step 3: Adjust θ_0 and θ_1 to fit points assign to them.

Step 4: Iterateuntil convergence.

The three intensity were labeled 1,2 and 3 for WM, GM and CSF respectively.

IV. BRAIN VOLUME

The GM, WM, CSF in each slide are isolated using image segmentation technique. The volume of GM, WM and CSF are calculated using slice thickness by applying trapezoidal rule. The tested data uses slice thickness of 6.5 mm.

V. FEATURE EXTRACTION

The WM, GM and CSF were of different intensities and labeled 1,2&3. The features that were extracted from this project were as follows

A. Grey Level Cooccurrence Matrix

It measures how the different combination of grey levels occur in an image at fixed orientation and distance. This matrix is a 2D array of size m*m, where m is the number of grey levels. The (a,b)th element of matrix is the probability of transition from a pixel with intensity a to pixel with intensity b lying at distance d with given orientation in the image. Contrast, Homogeneity, Entropy and Correlation are few such common use measures.

B. Grey Matter Proportion

It is the ratio of grey matter volume to the cerebrospinal fluid volume.

C. White Matter Volume To Cerebrospinal Volume Ratio

It is the ratio of white matter volume to CSF volume. Then their volume ratio and GLCM parameter which is feature for our classifier to classify the dataset.

VI. CLASSIFICATION

For classification we use Support Vector Machine. SVM are supervised learning model each can be used to train and test the dataset to give the best result. The importance of SVM is that its performance doesn't effect by the dataset size. Feature vector is six dimensional which

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is based on GM proportion, WM to CSF volume ratio and GLCM parameters.

The accuracy, specificity and sensitivity were evaluated using confusion matrix. Confusion Matrix stores the information of about actual and predicted classification

Table

•		Predicted	
		Negative	Positive
Actual	Negative	a	b
	Positive	c	d

Table 1. Predicted and Actual Values

Where a is total number of True negative(TN). b is total number of False positive(FP). c is total number of False negative(FN) and d is the number of True positive(TP).

$$\textbf{Accuracy} = \frac{sum\ of\ correct\ classification}{total\ number\ of\ classification}$$

$$\textbf{Sensitivity} = \frac{correctly\ classified\ positive\ samples}{True\ positive\ samples}$$

$$\textbf{Specificity} = \frac{correctly\ classified\ negative\ samples}{True\ negative\ samples}$$

VII. RESULT

The three-targeted portion namely the WM volume, GM volume and CSF volume have been implemented successfully. The results for brain volume calculation as shown in Fig.3 the ratio of GM and WM in each case helps to detect whether the patient is healthy or going through AD. According to the ratio[4] we i.e.,

- If the ratio between GM to WM volume is greater than 0.6 patient is healthy.
- If the ratio is in between 0.6 and 0.5 than patient have AD in first stage.
- If the ratio is in between 0.5 and 0.4 than patient have AD in second stage.
- If the ratio is less than 0.4 than the patient is in critical stage.

SM	GM Vol	WM Vol	GM/	STAGE
1.	423603	742507	0.5705	1st
2.	312353	811579	0.3849	Critical
3.	482063	720266	0.6693	Healthy
4.	321939	818074	0.3935	Critical
5.	250679	887727	0.2824	Critical
6.	226375	910101	0.2487	Critical
7.	279930	853524	0.3280	Critical
8.	258987	901489	0.2873	Critical
9.	513558	650970	0.7889	Healthy
10.	284083	844337	0.3365	Critical
11.	260805	882622	0.2955	Critical
12.	531651	696840	0.7629	Healthy
13.	237833	897854	0.2649	Critical
14.	455861	699223	0.6520	Healthy
15.	430675	706206	0.6098	Healthy
16.	254658	849102	0.2999	Critical
17.	307483	794680	0.3869	Critical
18.	470895	701242	0.6715	Healthy
19.	355446	793919	0.4477	2nd
20.	388856	746751	0.7207	Healthy
21.	401557	719445	0.5581	1st
22.	480460	720775	0.6666	Healthy
23.	175065	935017	0.1872	Critical
24.	295870	820524	0.3606	Critical
25.	252991	852726	0.3201	Critical
26.	433815	693668	0.6254	Healthy
27.	232738	900407	0.2585	Critical
28.	388397	730381	0.5318	1st
29.	538428	620557	0.8677	Healthy
30.	526883	701911	0.7506	Healthy
31.	436979	680837	0.6418	Healthy
32.	276726	859557	0.3219	Critical
33.	505828	697640	0.7251	Healthy
34.	261117	862562	0.3027	Critical
35.	265329	867771	0.3058	Critical
36.	376810	755674	0.4986	2nd
37.	289907	845304	0.3430	Critical
38.	400191	758376	0.5277	1st
39.	484111	646134	0.7492	Healthy

Table 2. Categories of Images

The dataset of 39 different patients were used to carry out the project successfully. The accuracy obtained from the project using MRI scan is 75%. According to the previous paper "Early Detection Of Alzheimer's disease using Image Processing on MRI scan"[4] by department of E&C, NITK Surathkal, Mangalore the accuracy was 56.1% but in our case the result improves and it becomes 75%.

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