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.

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.

II. PROPOSED METHODOLOGY

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 Coocurrence 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 template 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, .................., I_n] represent intensity of pixel.
C= [C_1, C_2, .................., 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?

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

\[
P(I_i|C1) = \frac{1}{\sqrt{2\pi \sigma_0^2}} \exp\left(-\frac{(I_i - \mu_0)^2}{2\sigma_0^2}\right)
\]

Step 3: Adjust \( \theta_0 \) and \( \theta_1 \) to fit points assign to them.

Step 4: Iterate until 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^2, 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
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

<table>
<thead>
<tr>
<th>Actual</th>
<th>Negative</th>
<th>Positive</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>a</td>
<td>b</td>
</tr>
<tr>
<td></td>
<td>c</td>
<td>d</td>
</tr>
</tbody>
</table>

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).

\[
\text{Accuracy} = \frac{\text{sum of correct classification}}{\text{total number of classification}}
\]

\[
\text{Sensitivity} = \frac{\text{correctly classified positive samples}}{\text{True positive samples}}
\]

\[
\text{Specificity} = \frac{\text{correctly classified negative samples}}{\text{True negative samples}}
\]

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.

<table>
<thead>
<tr>
<th>No.</th>
<th>GM Vol</th>
<th>WM Vol</th>
<th>GM/WM</th>
<th>STAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>423603</td>
<td>742507</td>
<td>0.5705</td>
<td>1&lt;sup&gt;st&lt;/sup&gt;</td>
</tr>
<tr>
<td>2.</td>
<td>312353</td>
<td>811579</td>
<td>0.3849</td>
<td>Critical</td>
</tr>
<tr>
<td>3.</td>
<td>482063</td>
<td>720266</td>
<td>0.6693</td>
<td>Healthy</td>
</tr>
<tr>
<td>4.</td>
<td>321939</td>
<td>818074</td>
<td>0.3935</td>
<td>Critical</td>
</tr>
<tr>
<td>5.</td>
<td>250679</td>
<td>887727</td>
<td>0.2824</td>
<td>Critical</td>
</tr>
</tbody>
</table>

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%.
REFERENCES


