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# Early Detection Of Alzheimer's Disease Image Processing

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***ABSTRACT***

*Alzheimer's disease (AD) is irreversible, progressive brain disorders that slowly destroy memory and thinking skills. Alzheimer's is one of the most common causes of Dementia. Dementia means loss of Cognitive functioning – thinking, remembering and reasoning – and behavioral ability to such an extent that it interfere with Daily life. The image processing is widely used in medical field in order to detect disease and help doctor in decision making based on observation. The paper aim to detect the Alzheimer's disease at earliest so that patient can be prevented before irreversible changes occur in brain. We propose the image processing technique to process the Magnetic Resonance Imaging (MRI) of brain from axial plane, coronal plane and sagittal plane. The image segmentation is used to highlight the affected region in brain MRI. The diagnosed region in brain MRI includes hippocampus and volume of brain. The comparative identification of person affected with the Alzheimer's disease, Healthy cohort and Mild Cognitive impairment is done.*

## 1-NTRODUCTION

Alzheimer's disease (AD) is a progressive, degenerative disorder that attacks the brain's nerve cells, or neurons, resulting in loss of memory, thinking and language skills, and behavioral changes. As life span is increasing, an early detection of AD emerges as possible approach to delay its consequences on patients and to increase the chance of getting potential benefits from approved medications and maintain certain good level of life.

In 2006, the worldwide prevalence of AD was 26.6 million cases, and it was predicted that it will grow to 106.8 million in 2050. Among these, there were 12.6 million cases in Asia (48% of worldwide prevalence), and it was predicted that it will grow to 62.85 (59% of worldwide prevalence) in 2050 Routine structural neuroimaging evaluation is based on nonspecific features such as atrophy, which is a late feature in the progression of the disease.

Therefore, developing new approaches for early and specific recognition of Alzheimer disease at the prodromal stages is of crucial importance. Segmentation is an important issue in MRI image processing for diagnosis of (AD).

One of the simplest methods for image segmentation is thresholding. It is based on selection of a value that separates between two classes of gray-level values; this selected value is called threshold value; which classify the gray-level value into two ranges to separate the object from the background. The difficulty placed in determining the right threshold value or the optimal one.

However, this work's goal is improving Otsu's method, so it can estimate the optimal threshold values of images based on Gamma distribution, by using iteratively algorithm. Otsu's method is weak when it comes to dealing with low contrast images or where the object is small.

In general, Otsu's method produces a threshold value that maximizes between-class variances. This work focuses on improving Otsu's thresholding method to generate threshold value automatically for

Gray scale images based on Gamma distribution. Symmetric and asymmetric histogram distribution of the intensity values can be represented by using Gamma distribution. Gamma distribution is extensively more than Gaussian distribution, which only represents symmetric histogram distribution of the intensity values.

For each technique let f i,( j) is the original image, T is the threshold value, and g i,( j) is the output image:

$$g(i,j)=\begin{cases}1, & \text{for } f(i,j)\geq T;\\ 0, & \text{otherwise}\end{cases}$$

Sometimes declination in cognitive function does not happen normally. Faster and more serious declination in numerous cognitive ability found in dementia, which is a typical clinical disorder among elderly individuals. As the count of the old aged person increases then automatically the count of people suffering from memory related disease called dementia increases, which makes various demands on our society in terms of providing facilities for needy persons.

## 2-LITERATURE SURVEY

During the past two decades, lot of research has been done in this field regarding the application of image processing techniques for Alzheimer disease diagnosis. Magnetic resonance imaging (MRI) is one of the imaging techniques to analyses AD, preferred by doctors for the analysis of patient's condition. MRI has produced a beneficial in vivo technique to ingress the deformations that arise in the patient's brain during the advancement of AD disease, and pro-vides potential means for recognizing individuals in the preclinical stages. Desikan and Cabral proposed the technique in which they analysed the entire brain. They categorized the MRI data in two classes: whole brain analysis and the voxel of interest (VOI) (**Desikan et al., 2009**).

it's an automated entire brain measuring tool, used to analyses the structure of MRI brain image. It facilitates the non-biased measure of highly affected area that may not be accessed in hypothesis- based studies. Independent component analysis (ICA) techniques were also used for signal separation. This data driven method involves two or more variable quantities that quantifies the analytic examination of magnetic resonance imaging datasets which produces some unique patterns about the similarity between the smallest units of three-dimensional image called voxels in the specific portion of the human brain.

Some of the machine learning techniques has been used for detection and classification of patients with AD and mild cognitive impairment (MCI), such as ANN, SVM, LS-SVM etc.

A novel method was also proposed that used ICA to obtain the unique patterns from VOI and execute machine learning techniques mentioned above, for separating the AD controls from the healthy controls and achieved 87.3Huang and Print analysed the various spectral and nonlinear EEG that is used to detect the brains functional changes in the Alzheimer's disease.

They extracted the specific features from EEG that demonstrate the staging of the disease. They used sixteen AD patients with AD, their ages were between 61-82.

The extracted features from the EEG includes: Power spectral measurements, chaotic features, ERP features, after determining the features they used artificial neural network technique to classify the results (**Huang et al., 2000).**

coefficients, stander deviation of the wavelet coefficients, skewness of wavelet coefficients(skewness is the measure of a symmetry of data around the sample mean), Kurtosis of the wavelet coefficients (Kurtosis is a measure of how outlier-prone a distribution is. Also, it can be considered as the measure of the sharpness of the histogram)

They got 21%error with test set and no error with the training set and 100%accuracy among the training data. In recent studies, some phenomena in the brain have become popular for AD diagnosis, e.g., some type of brain atrophy, the number of senile plaques, size of senile plaques in patients' brain, deformation occur in shape of the brain, brain shrinkage and the pattern of neuron anatomic which will change if AD appears.

**Ceyhun and Devrim** proposed two approaches to determine the similarity between the different cases. While the first approach by implication utilizes the separation to support vector machine decision boundary as a similarity index measurement. And the other one targets at directly finding the similarity function based on the minimization of the empirical ranking risk. They used neural network approach to detect Alzheimer disease in early stages using visual similarity and user feedback system.

To calculate the atrophy (AT) only gray matter, white matter, is considered in comparison of cerebrospinal fluid in an MRI image. With the help of AT, we are also able to indicate other diseases like Picks disease, multiple sclerosis. Alzheimer disease factor (**Glickman, 2007**), and differentially diagnosed Alzheimer disease factor (DDAD) are also propounded to indicate the atrophy associated with early AD stages for the detection in first MRI and multiple subsequent MRIs respectively **(Sadek, 2012).**

These approaches offer easy reliable detection of the brain atrophy for the brain attacked by a neurodegenerative disease even before cognitive symptoms interfere with daily function. Schaefer and his team presented a pattern recognition method, by utilizing the typical statistical features, histogram features, mutual information-based features and cross co-occurrence matrix features as the feature extraction method and applied those features to classifier based on Fuzzy rule to classify the images (Fernndez et al., 2009). The classification rate of this classifier is 79% with the help of 14 partitions fuzzy.

## 3-SOFTWARE REQUIREMENTS

In this chapter we will discuss and software requirements for early detection of Alzheimer's disease

**MATLAB**

Programming assignments in this course will almost exclusively be performed in MATLAB, a widely used environment for technical computing with a focus on matrix operations. The name MATLAB stands for "Matrix Laboratory" and was originally designed as a tool for doing numerical computations with matrices and vectors. It has since grown into a high-performance language for technical computing. MATLAB integrates computation, visualization, and programming in an easy-to-use environment, and allows easy matrix manipulation, plotting of functions and data, implementation of algorithms, creation of user interfaces, and interfacing with programs in other languages. Typical areas of use include:

- Math and Computation
- Modeling and Simulation
- Data Analysis and Visualization
- Application Development

• Graphical User Interface Development 1.2 Getting Started Window Layout The first time you start MATLAB, the desktop appears with the default layout, as shown in Figure 1. The MATLAB desktop consists of the following parts:

• Command Window: Run MATLAB statements.

• Current Directory: To view, open, search for, and make changes to MATLAB related directories and files.

• Command History: Displays a log of the functions you have entered in the Command Window. You can copy them, execute them, and more.

• Workspace: Shows the name of each variable, its value, and the Min and Max entry if the variable is a matrix. In case that the desktop does not appear with the default layout, you can change it from the menu Desktop → Desktop Layout → Default. 1.3 Editor the

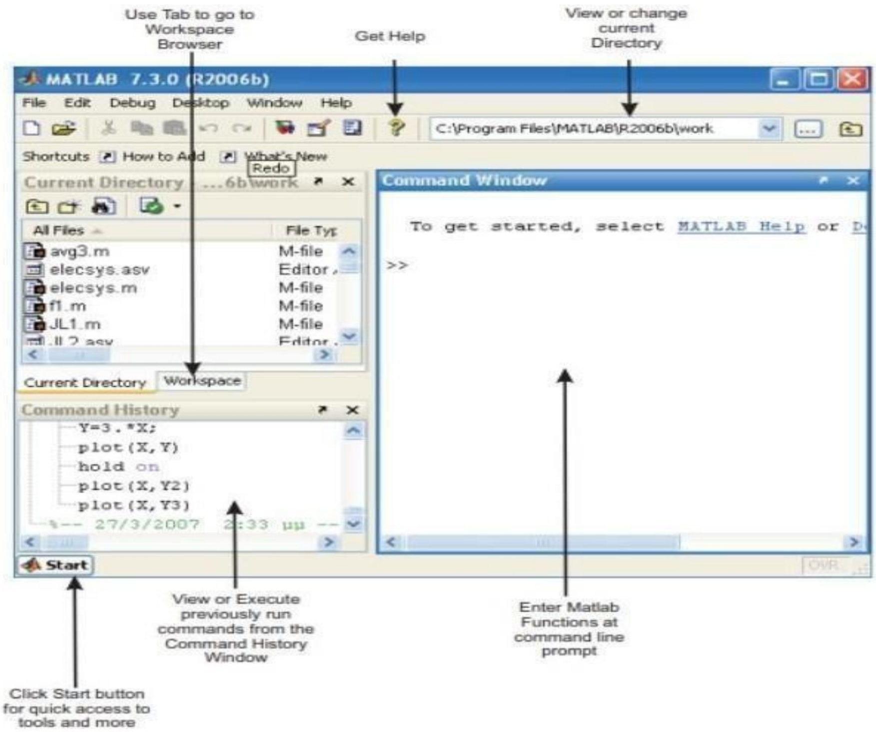


Figure 2.1: MATLAB Desktop (default layout)

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**4-EARLYDETECTIONOFALZHEIMER’S DISEASE**

In this chapter we will discuss about Existing/Proposed System, block diagram and methodology for Early Detection of Alzheimer’s Disease.

**EXISTING SYSTEM**

**FRG feature selection algorithm**

The traditional feature ranking methods like Fisher Score, Mutual Information, In-formation Gain are used to rank the top ′n′ features [130], [131], [132], [133], [134]. They select the top features within a threshold for the Machine Learning classifier. The Machine Learning classifier selects only the top ranked features for the classification purpose [130], [132], [134]. There are mainly two disadvantages for this approach.

Considering only the top ′n′ ranked features for the classifier results in missing out on the other features. There is a strong possibility that the suboptimal feature set consists of some specific combination of the missed features along with the top-ranked and selected features. For instance, the combination of a feature set consists of low-ranked features with the selected top-ranked features can be a better feature set for the classification purpose than the combinations of only the top-ranked features selected by the feature ranking criterion.

Finding the best combination of the features within the top-ranked features is also a challenging task. The selected top-ranked features need not be the best solution for a classification task. Consequently, it is important to find out the best solution for the features from the selected top-ranked features. However, this takes a lot of searches. Moreover, it is a time-consuming process.

**PROPOSED SYSTEM**

**Alzheimer's Disease Stage**

Simple test for clinical diagnosis of AD have been introduced to check the capability of patient's cognitive functions and social behaviour to find out the stage of disease. With these tests results we can the estimate how much part of patient's cognitive abilities declined and it can also be estimated that what would be status of disease after couple of years clinical dementia rating (CDR), Global Deterioration Scale (GDS), and the Mini Mental State Examination (MMSE). The MMSE test can be used to estimate the language function, memory declination and perception, concentration.

It is an appropriate and reliable method to estimate the cognitive decrement of the older people, but it is not that much effective in detecting very mild cognitive decrement in the initial stage of AD. The MMSE score correlates with the age of the patients and the education level. The researcher found that the younger and more educated people tended to perform better comparatively in the test.

**Methodology**

1. **Scientific Research**: Study the underlying biology of Alzheimer's, including amyloid-beta plaques and tau tangles.
2. **Clinical Trials**: Test in even larger populations to confirm efficacy, monitor side effects, and compare with standard treatments.
3. **Prevention and Risk Reduction Studies:** Test non-pharmaceutical approaches such as exercise, cognitive training, or dietary changes in preventing or delaying the onset of Alzheimer's.

## 5-ADVANTAGES, DISADVANTAGES AND APPLICATIONS

**Advantages**

**Better Understanding of the Brain**: Alzheimer's research has significantly contributed to our understanding of brain functions, memory, cognition, and neurodegeneration. It has expanded knowledge on how neurons communicate, age, and die.

**Discovery of Key Mechanisms**: Investigating Alzheimer's has led to discoveries of critical brain mechanisms like amyloid plaques, tau tangles, and the role of neurotransmitters, which may also help treat other neurological conditions.

**Early Detection and Biomarkers**: Research into Alzheimer's has driven the development of imaging techniques (like MRI and PET scans) and biomarkers (like amyloid-beta and tau proteins in cerebrospinal fluid), which can be used for early detection of various neurological disorders.

**Disadvantages**

**1. Memory Loss**: Alzheimer's causes progressive memory loss, starting with short-term memory and eventually impacting long-term memories, leading to confusion and disorientation.

**2. Loss of Independence**: As the disease progresses, individuals lose the ability to perform daily tasks (e.g., dressing, eating, bathing), requiring constant care.

**3. Impaired Judgment and Decision-Making**: The disease severely affects cognitive abilities, impairing judgment, problem-solving, and decision-making, which increases the risk of accidents.

**Applications**

1. **Drug Development**: Alzheimer's research has led to the development of drugs aimed at alleviating symptoms, such as cholinesterase inhibitors and NMDA antagonists. Ongoing research into disease-modifying therapies may lead to treatments that slow or halt the progression of Alzheimer's.
2. **Biomarkers and Blood Tests**: The search for reliable biomarkers for Alzheimer's, such as amyloid-beta and tau proteins, has applications for early diagnosis, monitoring disease progression, and developing personalized treatments. These biomarkers could be used for diagnosing other neurodegenerative disorders.
3. **Public Health Campaigns**: Alzheimer's awareness campaigns inform the general public about lifestyle changes that can reduce the risk of cognitive decline, such as managing cardiovascular health, quitting smoking, and engaging in cognitive activities.

## 6-RESULTS AND DISCUSSION

**Performance classifier**

Factors such as CR (classification rate), Sensitivity, Specificity, and Receiver operating characteristic (ROC) decide the performance of the classifiers. The values can be calculated by confusion matrix as shown below

:

| | |
|---|---|
| TP | FN |
| FP | TN |

**TP: Number of True Positives, FP: Number of False positives, TN: Number of True negatives, FN: Number of False negatives.**

$$CR = \frac{(TP+TN)}{TP+TN+FP+FN}$$

**Sensitivity**-It measures of how well a binary classifier correctly identifies the positive cases.

**Specificity**- It measures of how well a binary classifier correctly identifies the negative class. ROC Curve-It gives the relation between hit rate and false rate in a noisy communication channel. The performance of the classifier can be determined by considering the area under the curve.

It measures of how well a binary classifier correctly identifies the negative class. ROC Curve-It gives the relation between hit rate and false rate in a noisy communication channel. The performance of the classifier can be determined by considering the area under the curve.

We analysed the both diseased and non-diseased MRI brain images. In this analysis, initially we considered only the central section's which include Septum Pellucidum, fornix and hippocampus area. Original wavelet features' data were first used for performance assessment. Random 10-fold cross validation was used to obtain different training-test subdivisions and obtain a more precise performance estimation on unseen data shows the CV-performance attained. As mentioned, grid-search was used only for one of the subdivisions, and the optimal hyper-parameters selected were used for the rest of subdivisions.

Afterwards and as suggested in previous works, PCA was used to reduce the dimensions of features to a higher degree. Once the principal components and their associated variances were calculated, a number of them that preserves 95% of total variance was kept. See for summary of the datasets involved in this study. In this case the computational cost was around ten times lower for the PCA features, due to the lower dimensionality of the data involved in the problem.

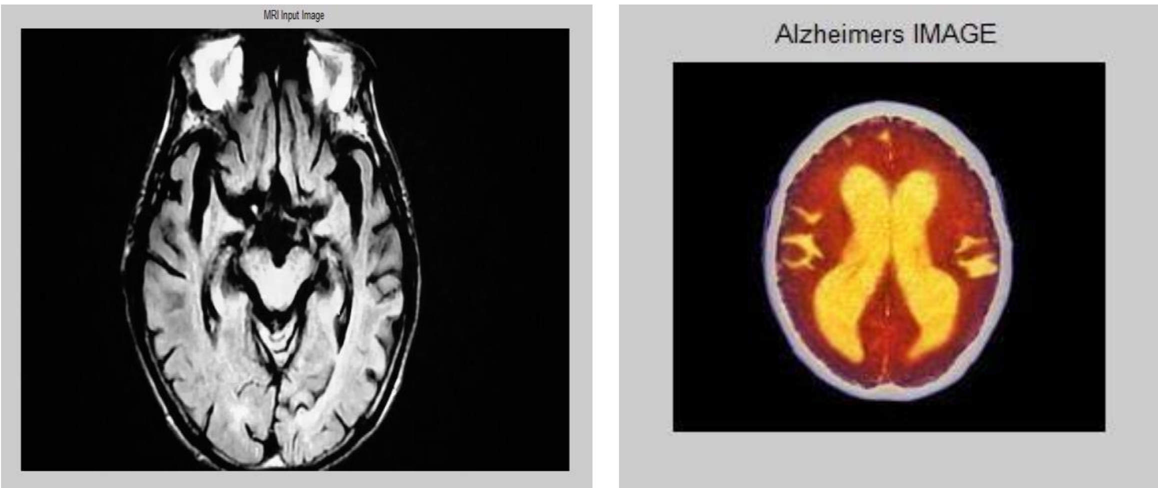


**Figure 5.1: MRI input image and Alzheimer's IMAGE**

After segmentation, we analyzed some parts of brain which changes as grow older and in case of Alzheimer disease. Most affected area of brain part is its middle part which involves hippocampus, Septum Pellucidum, Fornix and some part of Thalamus. We calculated the area of brain part lost in the central region. It gives an approximate idea about the subject's conditions. We categorized the subjects into three groups according to their CDR value, to analyses the brain loss occur during aging and in case of AD as we discussed earlier. First group of subjects (healthy subjects) have CDR value zero. Second group have CDR value half. And the last group is the severe case of AD, have CDR value of one.

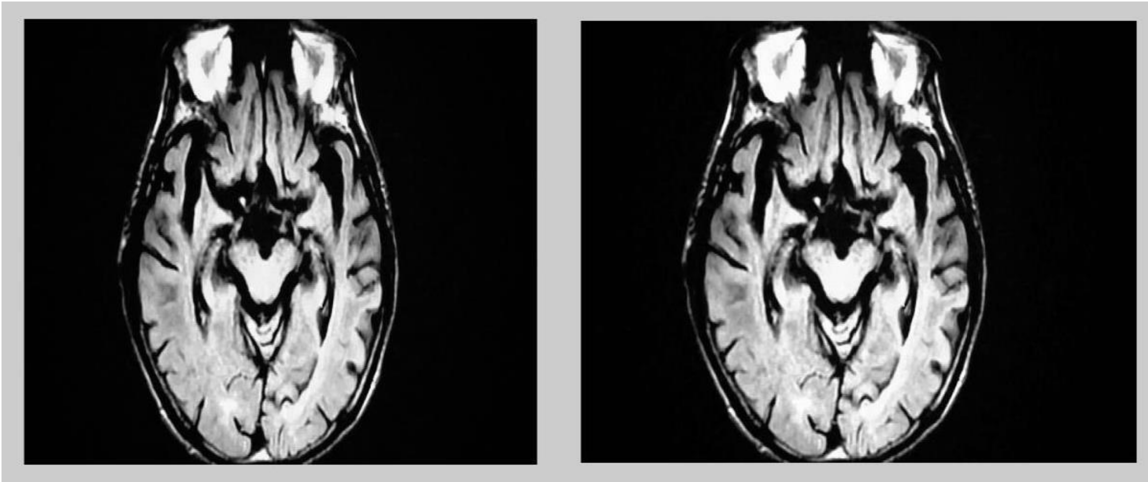

**Figure 5.2:** Sample images

The term "Probability Spectral Density" (PSD) might be a bit ambiguous, as spectral density is often used to describe the distribution of power across different frequency components of a signal. We masked the outer section of both the images to extract the hippocampus volume.

These two masked images shows that how much percentage of black region present in the central section of brain image. Whereas in case of diseased MRI brain image, when we analysed the histogram of central section, we got the higher density of intensity level in between 0 to 20. That indicates that in the diseased MRI brain image most of the area is covered by black pixels

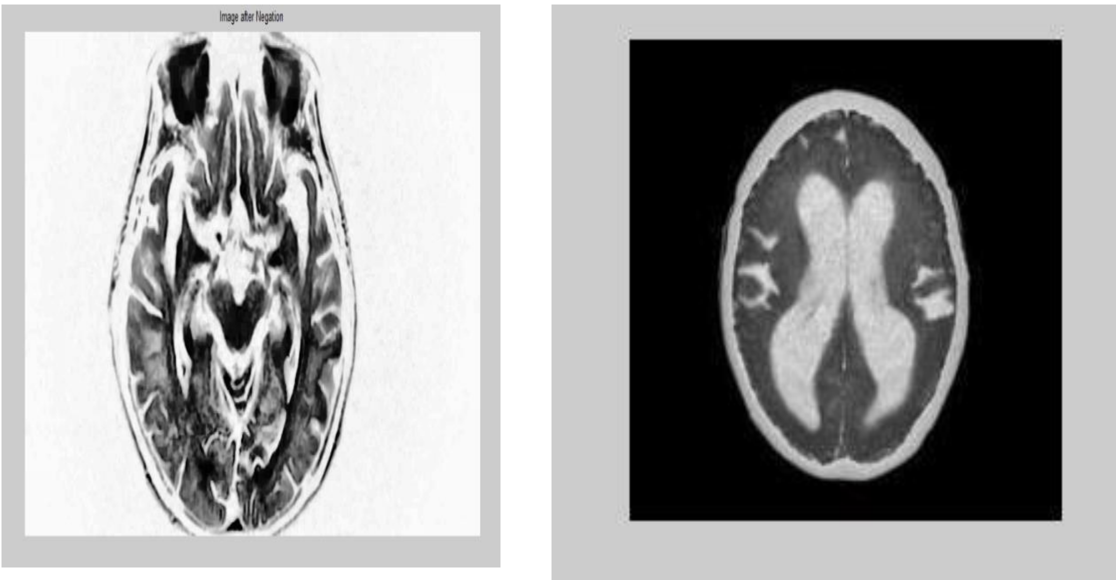


**Figure 5.3:** Image after Negation

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In Fig a we observed that the central section original image is Black, and the resultant image after performing Bottom Hat operation still have the same black region but the other part of MRI brain image except that central section has small sections of Black region distributed all over the image, is converted in to White. That means all the white part of MRI image is converted into Black but the vice-versa is not true.

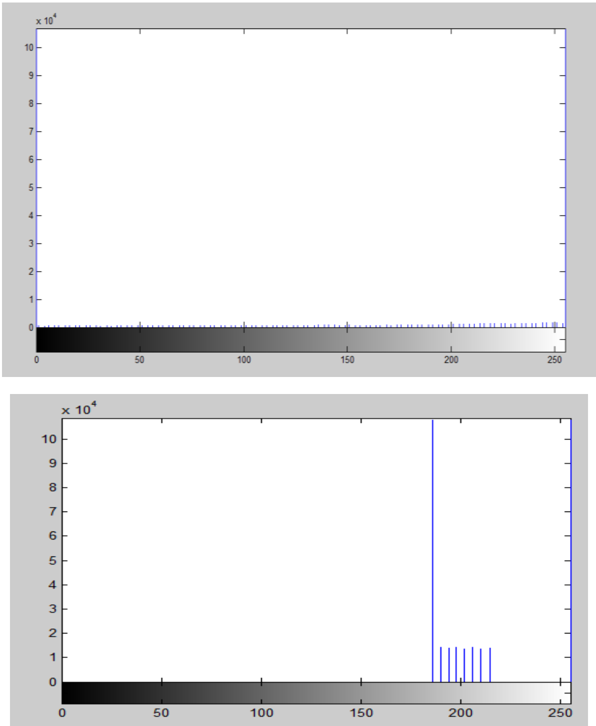


**Figure 5.4:** Histogram of Filtered Images

When we compare the histograms of both the bottom hat filtered images. We observe that the greater number of black pixels is still present in the diseased MRI image. As shown in fig, the density of intensity level varies from 0 to 0.3 in case of diseased MRI brain image. And it varies from 0 to 0.2 in case of non-diseased.

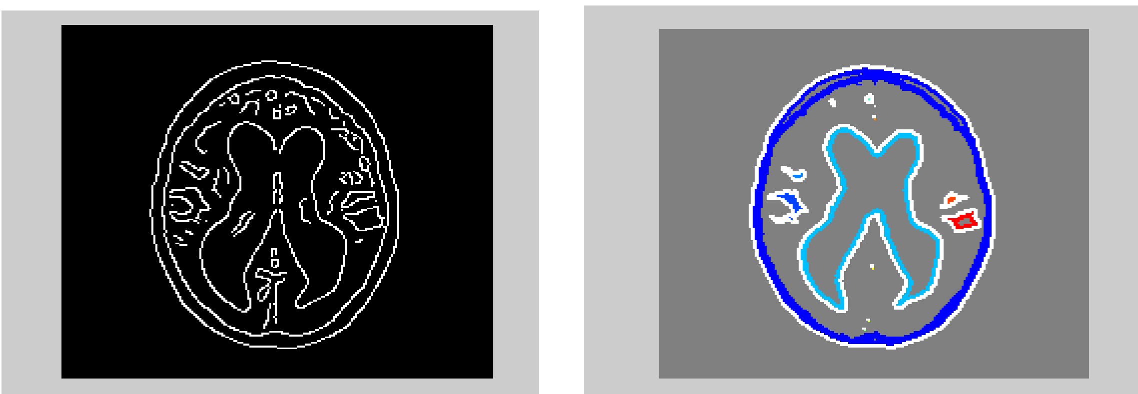

**Figure 5.6:** Final output with Layouts

## 7-CONCLUSION

The purpose of early detection of Alzheimer's disease is achieved. Enlarged Vascular and Brain atrophy. The implementation is done using image segmentation for the identification of enlarged Vascular. The amount of enlargement will classify the patient as Healthy patient, 1st stage AD, 2nd Stage AD, Mild Cognitive impairment cases. Another important factor for the detection of the AD is Brain atrophy. Watershed algorithm for image segmentation is used to detect Brain atrophy. Gradient of image is used to check the Cavity in Brain atrophy. This automated method is having simple methodology and low time complexity of the image. This overcomes the problem of earlier detection with no damage cause to brain. This will boost the research in the area of medical imaging.

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