Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 4, 2021, Pages. 4433 - 4441
Received 05 March 2021; Accepted 01 April 2021.

Pre-Processing on Alzheimer MRI images

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Abstract
Health issues are common developing factor in the recent era. Brain is an important part of the body which activates the human functionalities. There are many health issues related to brain, Alzheimerdisease is one among them. If brain is dead it cannot be reversed. So, each distortion of the brain ought to be grant significance. Early diagnosis helps to reduce and avoid death rate due to Alzheimer. There are many medical diagnosis methods applied to provide medication on this issue. Computing algorithm plays a vital role in giving assistance to physicians in the diagnosis of Alzheimer disease. Objective of the work is detection ofAlzheimer disease from MRI data set. In this paper, the Alzheimer image is implemented with pre-processing techniques to reduce noise in the image which leads to the next level. In the pre-processing, filtering techniques are used to blur, and smoothen the image without changing the pixel values. Filtering techniques like Arithmetic mean, median, Gaussian, bilateral are used to remove the din in the image and Fast FourierTransform (FFT) is used to find the frequency distribution in image. Before pre-processing the image, the distribution of pixels is determined using histogram distribution for both normal and three types of Alzheimer images are Mild demented, moderate demented, very mild demented. The pixels values before pre-processing and after applying pre-processing are compared. The comparison shows the outliers removed in the types of Alzheimer image. The accuracy has proved the efficiency of the techniques used for this work.

Keywords: Digital image pre-processing, Filtering techniques, Histogram equalization, Fast Fourier transform, Alzheimer image.

I. INTRODUCTION

Human beings are the most beautiful creatures in this world. For long life human beings ought to watch out for their wellbeing. Brain is an important part of the body that sends signals to the nerves and to the other parts of the body [1]. Even human actions and emotions are controlled by this brain. Alzheimer disease is the deformity which occur due to the age factor, hyper stress and trauma. This may lead to loss of sensation, paralysis, stops the daily task, and stops the thinking skill, even it will cause death if it is not diagnosed well in advance. Early diagnosis and the medication will help to reduce the problems due to this deformity [2].

There are many tests available to find the Alzheimer disorders. Some of them are memory test, neurological test for functionality, CT and MRI. The MRI shows the clear image of the objects in the image with its deviations [3]. There are three types of Alzheimer diseases. They are mild dementia, moderate dementia and very mild dementia. Very mild is the starting stage of Alzheimer disease that occurs due to age factors. People with this kind will forget the familiar words and names. Next is the mild Alzheimer disease which leads the memory lapses, struggle in daily activities.Moderate Alzheimer disease will lead to the sever stage. This stage needs assistance to do the daily activates. So,decision should be takenat the earlystage throughMRI to avoid complications. There are many ongoing researches to solve this issue. This research attempts to find the Alzheimer disorder in the MRI brain image.

Computing algorithms are performed well in different field. It plays a vibrant role in medication [4]. It simplifies the diagnosis by the models and methods developed using its techniques. Digital image processing used for the medical image analysis. So from the images from different modalities are processed using the digital image techniques. Researches which provided support [5] to do this work are listed follows.

William R et al [2010] proposed the method instigated with the arithmetic mean to know the functionalities and structural measurements of the brain image. Ibrahim et al [2013] designed a neural network model to identify the tumour in the brain image. They have pre-processed the image using arithmetic mean and used PCA algorithm to extract the feature values. George et al [2012] enhanced their brain image using filtering techniques. They removed the skull and uniform the distribution of intensity by histogram equalization. Finally, it is applied with the enhanced median filter. senel et al [2002] tested the median filter they introduced which is not disturbed by the neighbourhood pixel changes. phophalia et al[2015] used bilateral filtering techniques to

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remove noisingin the brain MRI. Mustafa et al [2011] used bilateral filtering techniques to remove the noise. This technique is enhanced filter multiresolution bilateral fileting produced the better result.

Herholz et al [2002] gave a comparison study to discover the Alzheimer disease between PET and SPECT scan. Gaussian filtering techniques is used to smoothen the image. Chaddad et al [2016] used the laplician of Gaussian filter which was used to remove the noise and smoothen the Alzheimer image. They achieved the accuracy above 70%. They have extracted the identified the features, brain, texture feature. Saeed et al [2016] used the Fourier transformation to identify the tumor and leakage of cerebral fluid. This Fourier transformation is implemented with segmentation algorithm to identify the issues. They have achieved better results.Zahng et al [2015] used the wavelet with supporting the Fourier concept to identify the Alzheimer disease and the mild cognitive disorder. SVM, PCA are used to classify the mild dementia.

The above are the base papers that gave the key idea to use the filtering techniques for further enhancement. In this work, the research is aimed to detect the Alzheimer disease in the brain through MRI. To do that, all the images taken for the processing should be pre-processed. Because the MRI image has noise due to thermal effect and other effects.In the pre-processing, filtering techniques is used to blur, smoothen the image without disturbing the pixels of the images. It also saves the borders of the image. Arithmetic mean, median, Gaussian, bilateral are used to smoothen the image by preserving the edges of the images. Fast Fourier transformations is used to find the frequency of the image. Before pre-processing the histogram for image which give the pixel distribution is determined. This helps to know how the pixel values are distributed in the grey image. Finally, the pixels values of pre-processed image compared with its original image to find the accuracy of the image.
This entire paper is organised in five sections. First section talks about the introduction about the Alzheimer disease and role of the digital computing algorithms, explains the problem found in the existing research. Second, Methodology describes how the work is carried out and explained with its schemas. The work flow diagram shows the step by step process of the work. Third section presents the dataset, fourthdisplays results and discussions which explain the entire work process with its results. Finally conclusion which summarizes the wok and its future enhancement.

II. METHODOLOGY

Methodology explains the design process of the work. There are five filters namely arithmetic mean, median, bilateral, Gaussian and fast Fourier transformations (FFT). The following figure 1 shows the block diagram of the implementation methodology.

The Alzheimer normal image and its three types namely very mild Alzheimer, mild Alzheimer, and moderate Alzheimer images are given as an input. Each filtering techniques applied on the data set are explained below.

a) **Arithmetic mean**: it is used to eliminate the identical noise in the image [].

$$ms_{xy} = \frac{1}{mn}\sum_{(s,t)\in s_{xy}} g(s,t) \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. (1)$$

Where s_{xy} is the coordinates of the window in rectangle shape. *m*n* are the window size. This mean is calculated based on the pixel values represented by s. average computed in *g(x,y)*.

b) **Median Filtering**: it is used to remove the noise which are very strong. Itprovides the less blurs than smoothening the image [].

$$y[m,n] = median\{x[i,j],(i,j) \in w\} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. (2)$$

Where *m*n* are the window size, *i & j* are the coordinates. *W* is the neighbourhood pixel of image.

c) Gaussian Filtering: It protects the edges of the image and smoothen the image by specifying the weight value. It is defined as sigma.

$$\boldsymbol{G(x,y) = e\text{^}\,(-(x\text{^}2 + y\text{^}2)/\,(2 * sigma\text{^}2))} \ldots\ldots\ldots\ldots\ldots.(3)$$

Where, x and y are the pixel coordinates of the image.

d) Bilateralfiltering: It preserves edges by blurring the flatten region in the image. Weight is set as the pixels of centre value. It is compared with neighbourhood pixel [].

$$\boldsymbol{g}(\boldsymbol{x}) = (\boldsymbol{f} * (G)^s)(\boldsymbol{x}) = \int_{\boldsymbol{R}}^{\boldsymbol{0}} \boldsymbol{f}(\boldsymbol{Y})\,(G)^s(x-y)dy \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.(4)$$

Where, ||*xy*||gives the spatial distance of G(*xy*) , weight is set in *f(y)*

e) **Fast Fourier Transformation:** It transfer the signal form in to frequency domain. It always carry with finding factorization []. It reduce the complexity in frequency transformation.

$$\boldsymbol{x_{n-k} = x_k^*} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(5)$$

Where,n is the size, and k =0, which defines the n output.

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These are the above filtering techniques used to implement on the Alzheimerimage. This can be explained in the following pseudocode.

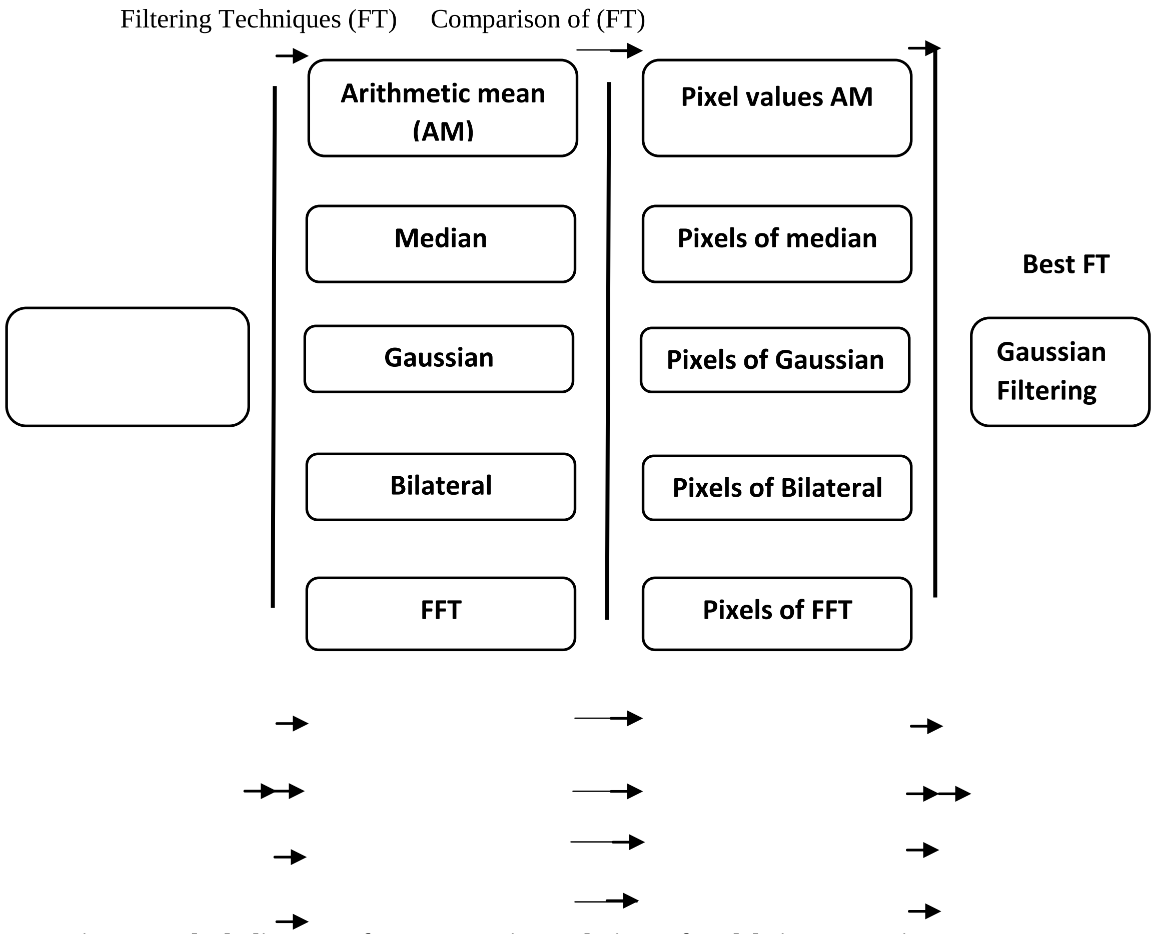

Figure 1. Block diagram of pre-processing techniques forAlzheimer MRI image

Table1. Pseudocode of pre-processing techniques

Input: MRI Alzheimer image

Output: Alzheimer pre-processed image

Begin

Import cv2, numpy// file loaded for the implementation

Define 1 to n images // total no. of images

Read image G// read images in jpeg format

Convert dimensions 512*512 //image conversion

Computewindows m,n or i,j and pixel coordinates x,y , G ground truth image

Calculate

$ms_{xy} = \frac{1}{mn} \sum_{(s,t) \in s_{xy}} g(s,t)$ // arithmetic mean

$y[m,n] = median\{x[i,j], (i,j) \in w\}$ // median

$(x, y) = e\text{^} (-(x\text{^}2 + y\text{^}2)/ (2 * sigma\text{^}2))$ // Gaussian

$\boldsymbol{g}(\boldsymbol{x}) = (\boldsymbol{f} * (G)^s)(\boldsymbol{x}) = \int_{\boldsymbol{R}}^{\boldsymbol{0}} \boldsymbol{f}(\boldsymbol{Y})\, (G)^s (x-y) dy$//bilateral

$\boldsymbol{x_{n-k}} = \boldsymbol{x_k^*}$ // fast Fourier transformation based on kernel

Store the output in folder (…n)// save near the input image

End

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2.1. Dataset

The dataset taken for the implementation is Alzheimer MRI image. It is collected from different sources like hospitals, scan centres, and online repositories. The MRI dataset collected will be in the form of DICOM: digital imaging communication in medicine. To process this image it must be converted into .Jpeg image with the dimensions of 512*512. The MRI image has three types of plane such as Axial, sagittal, coronal. The axial view of the Alzheimer MRI is taken for the analysis. There are three types of Alzheimer disease image 1. Very mild Alzheimer dementia image (VM), 2. Mild dementia Alzheimer image (MD) 3. Moderate dementia Alzheimer image (MO). These three types and the normal Alzheimer images are processed in this work are given in figure 2.

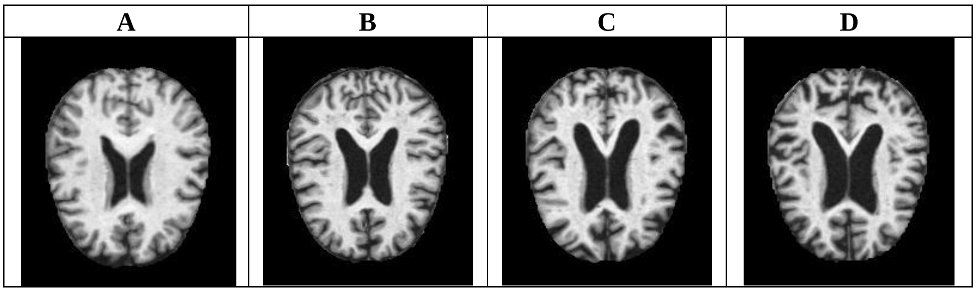


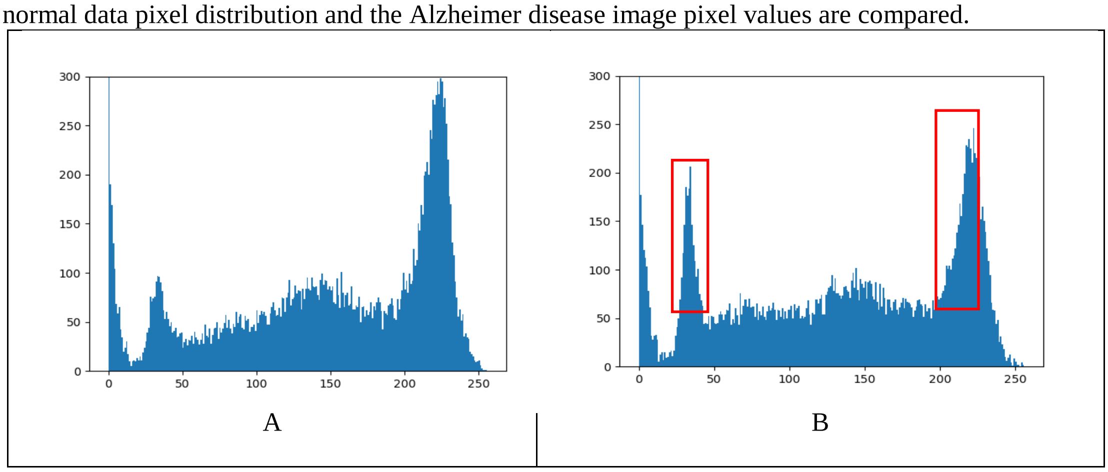
Figure 2. Input images. A) Normal image B) Very mild dementia C)Mild dementia D) Moderate dementia

III. RESULT AND DISCUSSION

The Alzheimer image is pre-processed using filtering techniques to remove the noise, blur and smoothen the image by preserving the details. The implantation work and the result obtained are explained in three ways. First finding the pixels distribution in the image. Secondly, pre-processing the image. Third finding the difference between the pixels of different types of Alzheimer image to determine the accuracy. As per the discussion in dataset section, the DICOM is converted in to .jpeg and preserved the uniformity in the dimensionality as 512*512.

3.1. Histogram

The first step of the work is finding the pixels distributions in the Alzheimer image. The intensity range is lower to higher. The intensity of thegrey image starts from 0 to 255. The black is given in 0and the pure white will be in 1.The figure 3 shows the intensity values. The normal brain image is shown in A, the very mild dementia is in B, mild dementia is shown in C and moderate Alzheimer is shown in D. The variation in the intensity is marked in red colour rectangle box. From the analysis the Alzheimer disease has the little variation between them but it has high variation between the normal images. The threshold value of the abnormality image is determined based on the trial and error method. The range-based threshold set as 90 to 140 for the Alzheimer image tested with 50 images. The pixels distribution in the image is calculated by finding the black and white pixels count. The difference of these pixel value shows exactly how much the nerves are compressedin each types of disease. The normal data pixel distribution and the Alzheimer disease image pixel values are compared.



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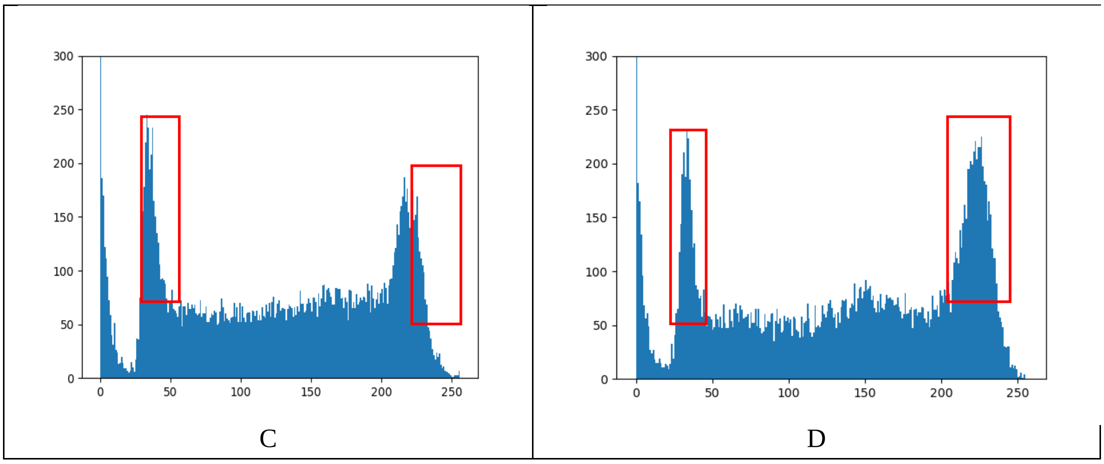
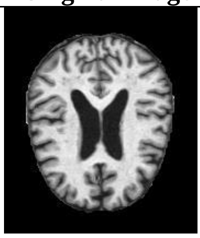
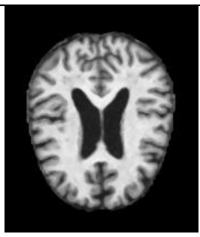
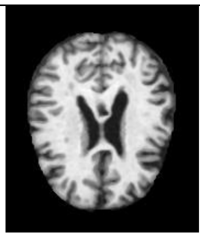
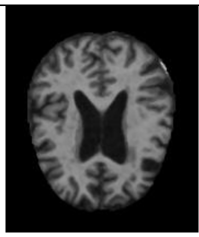
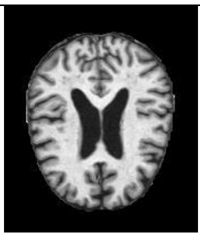
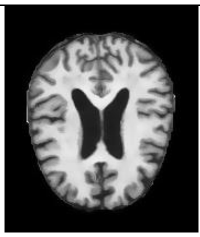
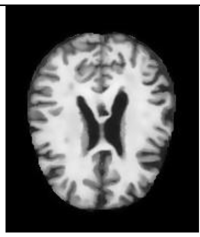
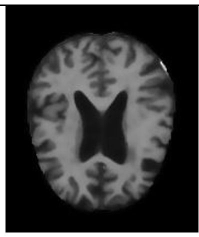


Figure 3. Histogram of dataset A) Normal image B) Very mild dementia C) Mild dementia D) Moderate dementia

3.2. Pre-processing

Processing the noisy image will culminate in bad result when the segmentation or the feature extraction are applied. Enhancement technique helps to achieve the best result when we do the identification and extraction. There are many enhancement techniques available in digital image processing. Filtering techniqueis one among them which is used to sharpen the image, smoothen the image and blurs the noise, removes the high-density noise, provides density equalization.

In this work arithmetic mean (AM) which was used to remove the uniform noise, median was used to remove the strong noise in the image. Gaussian filter was used to remove the noise by changing the values sigma and it sanctuaries the facts of the image. The sigma value must be 1.0 for the Gaussian filtering on medical images. The kernel with sigma value of Gaussian for Alzheimer image is 0.96 .This was attain by trial and error method. Bilateral filtering works based on finding the spatial distance between the neighbourhood pixels using the tonal weight. And it smoothens the image. Fast Fourier transformations (FFT) are used to represent the frequency of the grey image. Where the spectrum in the image shows the high frequency. Corners shows the low frequencies. All the pre-processing (pp) result is shown in figure 4.

PP	**Original image**	**VM**	**MD**	**MO**
Gaussian				
Bilateral				

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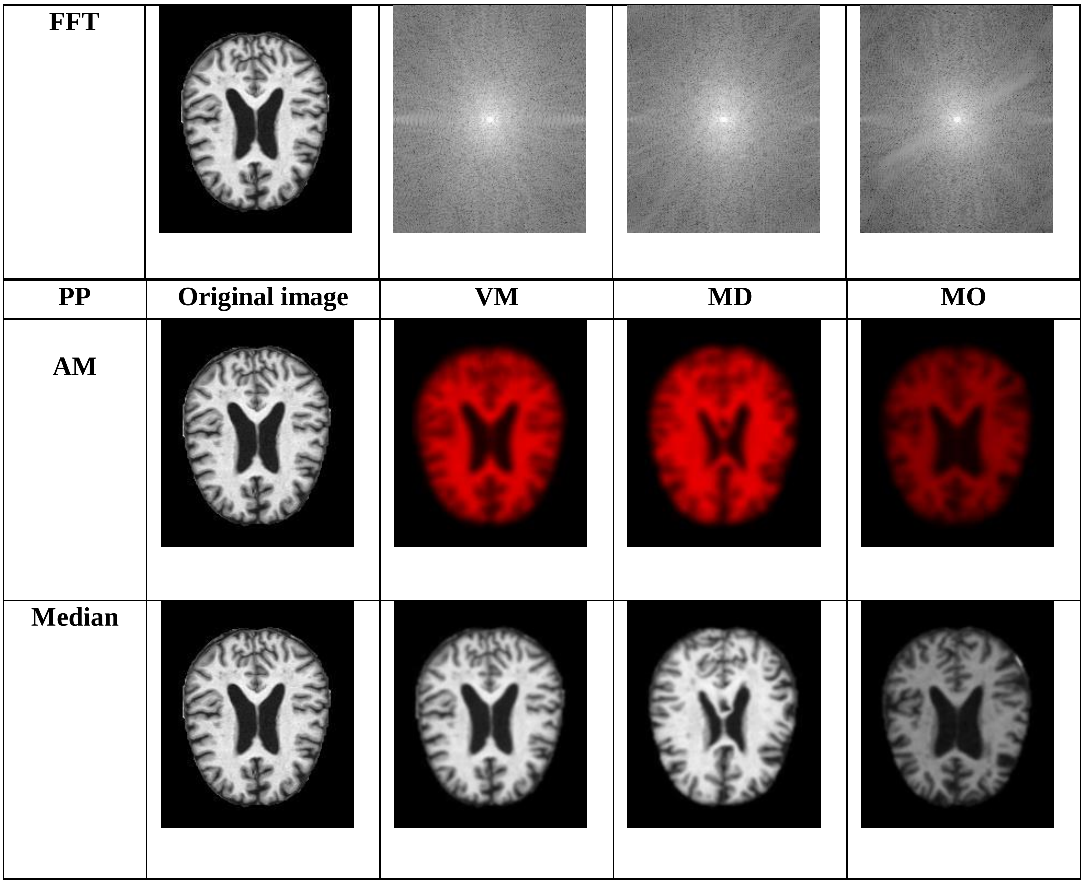

Figure 4. Pre-processing filtering techniques for Alzheimer images

IV. SELECTING THE BEST FILTER BY COMPARISON ANALYSIS

The best filter is selected based on the comparison analysis. The pixels of the image from Alzheimer ground truth image and the pre-processed images are computed. Find the variance between the processed and unprocessed images. The difference shows the noise removed without changing the pixels in the image.The values derived are given in the table 2.

Table 2. Comparison of pixels in the Alzheimer's image

NI		MD		AM		M		B		G		R1			R2	
W	B	W	B	W	B	W	B	W	B	W	B		AM	M	B	G
12340	24268	10626	25982	10477	26131	10521	26087	10762	25846	10634	25974	1714	149	105	136	8
11930	24678	10311	26297	10067	26541	10097	26511	10366	26242	10271	26337	1619	244	214	55	40
9045	27563	10012	26596	9738	26870	9770	26838	10039	26569	9945	26663	967	274	242	27	67
		MO		AM		M		B		G		R1			R2	
		W	B	W	B	W	B	W	B	W	B		AM	M	B	G
		27010	27010	9490	27118	9518	27090	9687	26921	26998	27024	14670	10517	17492	28	12
		11498	25110	11432	25176	11490	25118	11524	25084	11490	25118	432	66	8	58	8
		10012	2619	9515	27093	9535	27073	9718	26890	9982	26999	967	497	477	20	30
		VM		AM		M		B		G		R1			R2	
		W	B	W	B	W	B	W	B	W	B		AM	M	B	G
		10744	25864	10517	26091	10567	26041	10823	25785	10735	25873	1596	227	177	79	9
		11848	24760	11781	24827	11851	24757	12031	24577	11889	24719	82	67	3	183	41
		4870	31738	9515	27093	4398	32210	4548	32060	4847	31761	4175	4645	472	322	23

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In the above table 1, NI refers the normal image AM is the arithmetic mean, M is the median, B is the bilateral and G is the Gaussian filtering. R1 is the ratio between the NI and the three types of Alzheimer image MD, MO, VM. The best fileting techniques is selected based 1. How much noise is reduced? 2. How much pixels are affected when reducing the noise (white pixel difference of Alzheimer type and the fileting techniques).
So, based on this condition the Gaussian filter performs well in all types of Alzheimer image and it is proved by calculating R1 and R2. The filter which has reduce more noise and pixel disturbance is very less are computed by comparing the one filters to other fileting techniques. It should preserve the edges of the image without affecting the pixels. Accuracy of the pre-processing technique is determined based on these two values R1 and R2.
R1 gives the value of noise reduced in an image.

$$R1= AT_i–FTi \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.(6)$$

Where,FT_i is the arithmetic mean, median, Bilateral, Gaussian
$AT_i$is the Alzheimer image types
The values found using this formula are plotted in the graph. They are shown in figure 5.

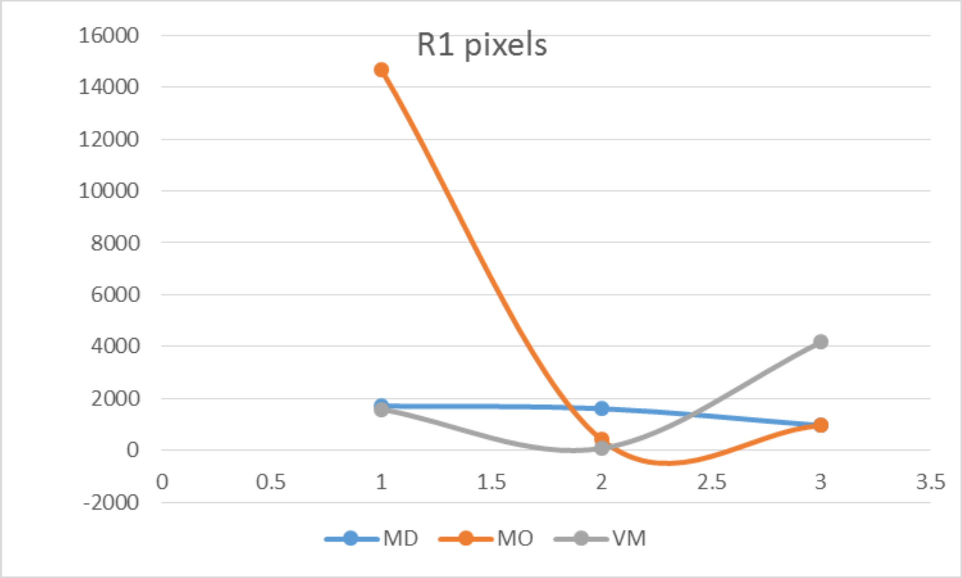

Figure 5. Chart representation for R1.

Chart represents how the pixels are varied from one to another. Three types of Alzheimer image R1 values are computed andgiven in the table 1 are compared in the chart. Three images from each category taken for the analysis. The result shows that the maximum of noise pixels removed from the original image after applying filtering techniques.
R2 describes how much it has distressed the original pixels. The more changes in the pixel lead to elimination. The less pixel changes consider for selection.
$R2=FTw_{pI}-AT_i$ ………………………… (7)
Where, $FTwp_i$ is the pre-processed white pixel of arithmetic mean, median, Bilateral, Gaussian
$AT_i$is the Alzheimer image types
The values of R2 derived using this formula are plotted in the chart. They are shown in figure6.

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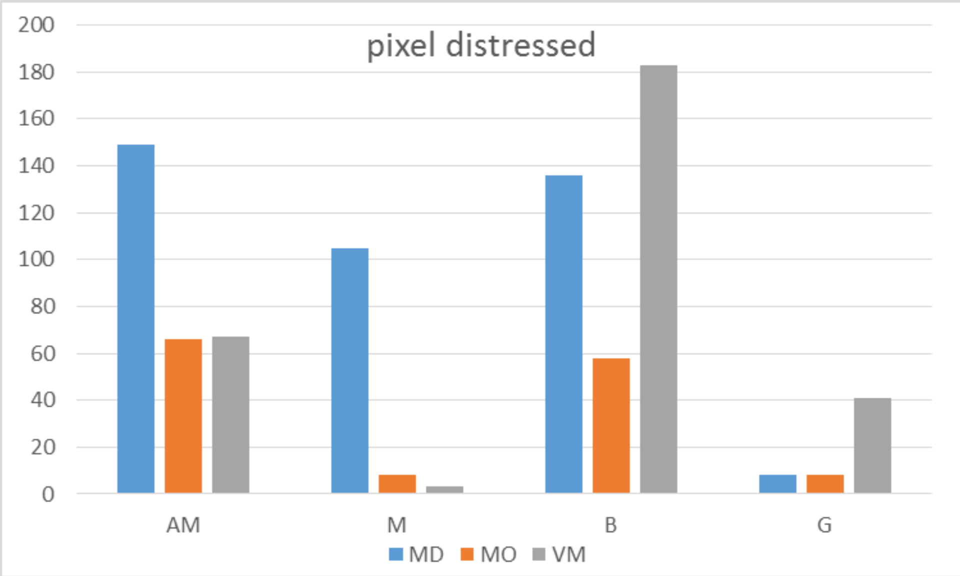

Figure 6. Chart representation for R2.

Figure 6 represents how the pixels are disturbed in the original image after applying the three filters. Three types of Alzheimer image R2 values are computed by finding the difference between the original Alzheimer types and the pre-processed Alzheimer types of images. It is plotted based on the determined values in the table 1. One image from each category taken for the clear analysis. The result shows that the minimum affected pixels in the image are in Gaussian filter.So, from the table values and the chart analysis the Gaussian filtering method performed well for three types of Alzheimer images by removing more noise, smoothen and preserve the details of the pixels.

V. CONCLUSION

The MRI Alzheimer image is applied with the computing algorithms to detect the existence of the abnormality. Three ways are followed to implement and prove the accuracy of the pre-processing techniques in this work. In the beginning the MRI images are converted in to processing data format and then the histogram intensity distribution is calculated among the Alzheimer images. This is applied with the filtering techniques. Pixels of white and black are compared and estimated under two ratiosthat help us to find the accuracy. The values are determined based on the noise removal ratio and the pixels distressed ratio when it is applied with filtering. Filtering techniques Arithmetic mean, median, Gaussian, bilateral are used and Fast Fourier transformation used to find the frequency of the image. Gaussian filter satisfies the condition fixed for finding accurateness. It removed the noise and it haddistressed very less pixels in the image.

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