An adaptive filtering technique for brain tumor analysis and detection

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***Abstract*— Brain tumor detection in an early stage is a difficult task, as the imaging is quite unclear. The necessity of automated brain tumor segmentation and detection is high. To obtain an accurate MRI image of the brain tumor is challenging. An MRI image has high contrast images indicating regular and irregular tissues that help in differentiating the overlap margins. But in case of an early brain tumor, the edges of the image are not sharp which causes the segmentation results to be inaccurate. Hence, this paper puts forth a method for detection and segmentation of the tumor. The method proposed here is a segmentation process of 2D MRI image using various filtering techniques. MATLAB has been used for the implementation.**

Keywords— Brain tumor; Image segmentation; image enhancement; homomorphic filter; highboost filter; mean filter; median filter

I. INTRODUCTION

In the varied fields of electronics and communication engineering, consumer and entertainment electronics, control and instrumentation, biomedical instrumentation, remote sensing, robotics and computer vision and Computer Aided Manufacturing (CAM), digital image processing is proving to be a promising area of research. Digital Image Processing refers to processing of a two-dimensional picture by a digital computer. This digitized image can then be processed and/ or displayed on a high resolution monitor. Digital Image Processing has found its firm roots in medical imaging, in form of Magnetic Resonance Imaging (MRI), Nuclear Medicine Imaging, Computed Tomography (CT), etc. Cancer, as we know, is becoming a leading cause of death worldwide. Abnormal growth of cells or tumor is the main culprit, and it can occur at any part of the body. Tumor detection can be done using imaging techniques.

A brain tumor is an abnormal growth of cells within the brain. Brain tumors include the tumors inside cranium or/and in the central spinal canal. As the skull protects the brain, brain tumor detection at an early stage is only possible when a diagnostic tool is directed at the intracranial cavity. Even in the MRI image of a brain tumor, the edges of tumor are not sharp, hence the segmentation results are not accurate, i.e. the segmentation may be over-segmented or under-segmented. This may happen at the initial stage of the tumors. So, the main objective of the proposed work is to get an enhanced form of the tumor image by applying different methods, including filtering.

The following paper is organized as follows. Section II discusses the background work done. Section III shows the Section IV illustrates the results and Section V puts forth the conclusion.

II. BACKGROUND

An image can be defined as a two-dimensional light intensity function $f(x,y)$, where x and y denote spatial (plane) coordinates. The value at any point (x,y) is in proportion to the brightness of the image at that point. Images can be two-dimensional (photograph or screen display) or three-dimensional (statue or hologram). A continuous image can be digitized at sampling points. The sampling points are arranged in the plane and the geometric relation of the sampling points is known as a grid. A digital image is usually in a matrix form. A small sampling point, which is not further divisible, in the grid is a pixel. A pixel corresponds to one picture element. An image is built of a set of pixels. For digital image processing, operations are performed on the pixels.

Broadly, digital image processing can be classified into two classes: processing and analysis. Processing involves enhancement in the appearance and representation of the image. Analysis comprises of extraction of features, quantification of shapes, registration and recognition of the image. Efficient processing and analysis of an image allows efficient image processing. The same holds true for the brain tumor. The brain tumor has to be successfully processed, analyzed and then detected.

Work on semi-automated region growing segmentation method has been proposed for segmenting brain tumor through MRI images long back. With the help of the method, the tumor can be segmented provided that the parameters are set properly [1]. Even an algorithm for computation of image decomposition using a morphological filter with reconstruction has been proposed [2]. An automatic method for segmenting brain tumors in 3D MRI also has been proposed [3]. A color-based segmentation method using K-means clustering technique to track tumor objects in MRI also has been proposed earlier [4]. To obtain system adaptability, use of evolutionary techniques on a digital filter system is a possible method. The filter proposed in the above referral, works in consideration with spatial domain approach and uses overlapping window for removal of noise in the image.

III. Proposed Technique

Two techniques have been proposed, one for the analysis of the tumor and one for the detection of the tumor.

Fig. 2 shows the block diagram of the proposed technique for analysis of the brain tumor.

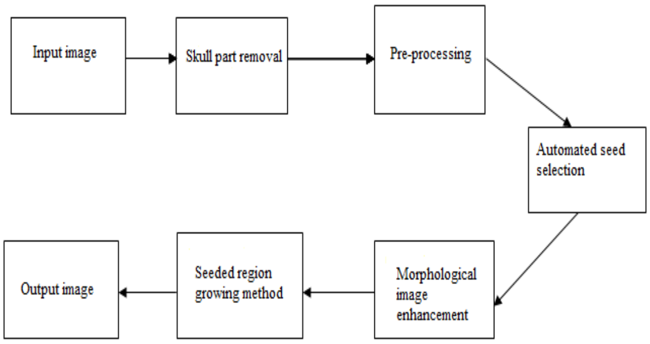

Fig. 2: Proposed Technique for analysis of brain tumor

The techniques used for analysis (segmentation) of brain tumor are as follows:

A. *Skull Part Removal*

This is a pre processing step which is required to produce better results. Skull is outer part of the brain surrounding. The main problem in skull-stripping is the segmentation of the non-cerebral and the intracranial tissues due to their uniform intensities. So it may affect the result of seed point selection [5].

In this process, first the size of the image is found out and the number of rows and columns are stored in separate variables. Iteration for half of the columns and all rows is performed. Then, half of the image is processed to convert white pixels into black. This is done by setting the gray value of the white pixels to zero. The same procedure is repeated for the remaining columns and rows.

B. *Image Pre processing*

Image pre-processing is primarily necessary for reducing the unwanted pixels and thereby increasing the clarity of the image. The usages of pre-processing filters (like Mean, Median, etc.) are involved in this step to increase the clarity of image and reduce unwanted pixels from the image. Fig. 3 illustrates the process flow of this step.

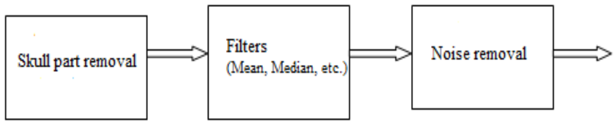

Fig. 3. Image pre-processing

C. *Automated seed selection(Seed Point Selection)*

The image obtained after skull removal is taken as input in this part of the circuit. For this procedure, it is assumed that the tumor region has grown to a considerable size. At first, the image is converted to a gray image. The number of pixels having intensity value greater than 100 and less than 100 are counted and stored in separate variables. Next, the difference between these two variables is found and if the difference is small, then the obtained gray image is converted to binary image. If the difference us large, the image is converted into its negative, intensity of the external part of the brain is set to zero and then the image is converted to binary image. The maximum length and breadth of the brain is found. From the center, pixels are converted to black color, in the area of a rectangle of size twenty rows and ten columns. The sum of all rows and all columns are calculated individually and stored in separate arrays. The intersection of the row and column having maximum sum is found out. This is considered as the seed point.

D. *Morphological Image Enhancement*

The most basic morphological operations are dilation and erosion. Addition of pixels to the boundaries of objects in an image is known as dilation and removal of pixels from object boundaries is known as erosion. The number of pixels added or removed from the objects in an image depends on the size and shape of the structuring element used to process the image. There are two built-in functions in MATLAB that perform the dilation/erosion functions. These morphological functions position the origin of structuring element over the pixel of interest in the input image.

E. *Seeded Region Growing Method*

The result obtained after morphological operation is taken as input in this stage. This approach examines neighbouring pixels of initial "seed points" and determines whether the pixel neighbours should be added to the region.

The above steps discussed were of the tumor analysis process. The steps used for detection of tumor are shown in Fig. 4.

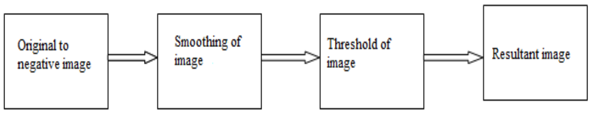

Fig. 4. Proposed Techniques for detection of brain tumor

A. Negative of Image

We take negative of an image by subtracting the input value from the maximum pixel value of the image.

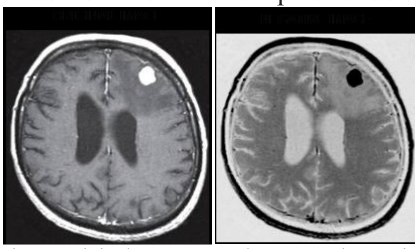

Fig. 5. Original MRI scanned Image and Negative of Image

B. Smoothing of image

The prime aim of smoothing is either highlighting fine details in an image or enhancing blurred details of the image. In this work, for smoothing of the image, different filters have been considered.

The following filters are considered:

1. *Mean Filter*: "A mean filter is a filter that takes the average of the current pixel and its neighbours". The proposal behind mean filtering is to replace each pixel value in an image with the mean value of its neighbours, including itself. In this method, the average of intensity values in *m x n* region of each pixel (usually m=n) is taken and the average is considered as the new pixel value. The normalization factor *mn* preserves the range of values of the original image. Fig. 6(a) shows a mean filtered image.

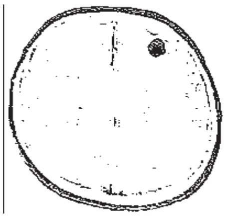

Fig. 6(a). Mean Filtered Image

2. *Median Filtering*: "The median filter is a nonlinear digital filtering technique, often used to remove noise". Salt and pepper and impulse noise can be removed from the image effectively, with the retention of the image details by using median filters. This is possible because the median filters do not depend on values which are considerably dissimilar as compared to the typical neighbourhood values. Fig. 6(b) shows a median filtered image.

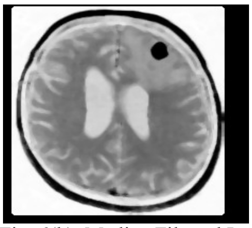

Fig. 6(b). Median Filtered Image

3. *Highboost Filtering*: A highboost filter is a filter that enhances the high frequency components (which represent the image details) without eliminating the low frequency components. Fig. 6(c) graphically shows the enhancement of the frequency components in a highboost filtering and Fig. 6(d) shows a highboost filtered image.

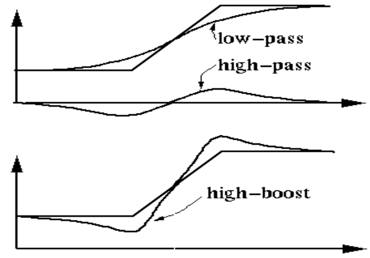

Fig. 6(c). Enhancement of low frequency and high frequency component using Highboost Filter

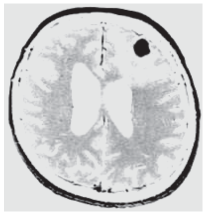

Fig. 6(d). Highboost Filtered Image

4. *Homomorphic Filtering:* By using homomorphic filtering, all kinds of illumination can be filtered out and the image can be restored. The homomorphic filtered image is shown in Fig. 6(e).

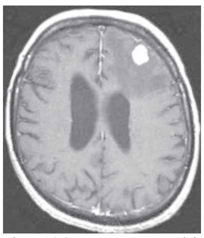

Fig. 6(e). Homomorphic filtered image

C. Thresholding

Thresholding of image takes place by considering a threshold value of the total pixel value and assigning '0' to the values below the threshold.

IV. Implementation Results

The proposed technique is implemented in MATLAB. MRI images have been selected for filtering using proposed filters. The two error metrics, Mean Square Error (MSE), Signal-to-Noise Ratio (SNR) have been calculated. These two metrics are essential for comparison of image quality. "The MSE represents the cumulative squared error between the compressed and the original image, whereas PSNR represents a measure of the peak error" [6]. Lower value of MSE is preferable as it represents low error and low error corresponds to high PSNR.

The entire implementation of the proposed technique in MATLAB has been illustrated in Fig. 7. The original image is first read then its negative is generated. The mean, median, highboost and homomorphic filtering is done on the negative image. The MATLAB simulation result is shown in Fig. 8. The MSE and SNR values for all filters are also found out (given in Table I).

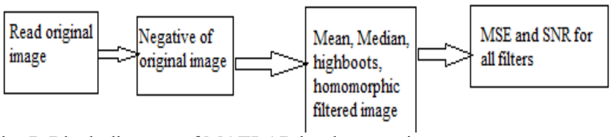

Fig. 7. Block diagram of MATLAB implementation

Fig. 8(a). MATLAB Simulated result-1

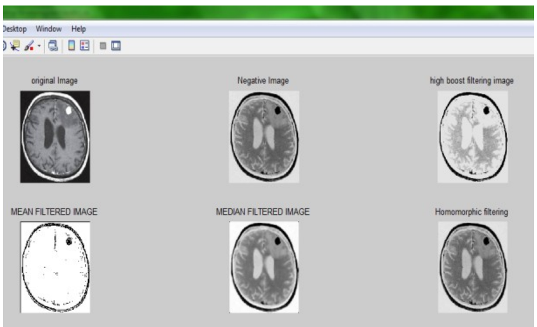

Fig. 8(b). MATLAB Simulated result-2

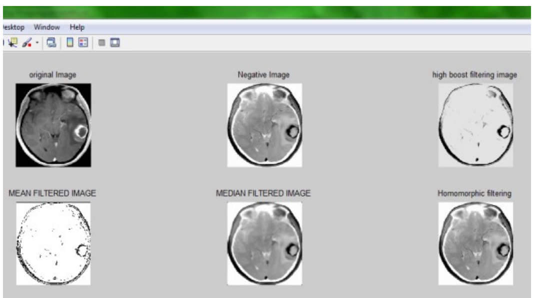

Fig. 8(c). MATLAB Simulated result-3

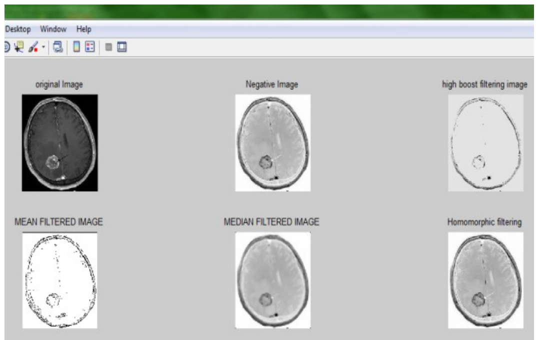

Fig. 8(d). MATLAB Simulated result-4

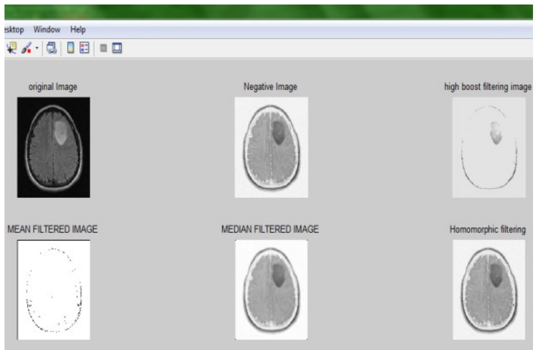

Fig. 8(e). MATLAB Simulated result-5

From the above shown results (Fig. 8 (a)-(e)), we can conclude that though we have taken different filters, but by using homomorphic filter we can get better output. (A number of images have been considered but few have been shown here.) The output of homomorphic filtering is much enhanced. This conclusion is supported by the numerical values of the parameters (MSE and SNR) given in Table I.

TABLE I. PARAMETERS COMPUTED FROM DIFFERENT FILTERINGS

Data	Parameter	Highboost Filtering	Mean Filtering	Median Filtering	Homomorphic Filtering
Data 1	MSE	251.9585	4.8807e+03	1.6000e+04	0.0455
	PSNR	-24.0133	-36.8848	-44.8223	13.4165
Data 2	MSE	209.0470	1.4138e+04	1.9186e+04	0.0051
	PSNR	-23.2024	-41.5038	-42.8298	22.9584
Data 3	MSE	251.4799	4.7610e+03	3.0058e+04	0.0759
	PSNR	-24.0050	-36.7770	-44.7795	11.1980
Data 4	MSE	240.2391	1.0962e+04	1.2512e+04	0
	PSNR	-23.8064	-40.3990	-40.9733	Infinite
Data 5	MSE	236.7388	8.2198e+03	2.3458e+04	0.0138
	PSNR	-23.7427	-39.1486	-43.7029	18.5973

From Table I, it can be concluded that the output through homomorphic filter gives low Mean Square Error (near to zero) and high peak Signal-to-Noise Ratio. Hence, we can state that the homomorphic filter is better if considered for the brain tumor detection. This owes to a more clear representation of the MRI scanned image (i.e. the tumor is more prominently visible) and thus the segmentation process is effective. On the basis of the above results, we can represent the performance of the filters graphically, as shown in Fig. 9.

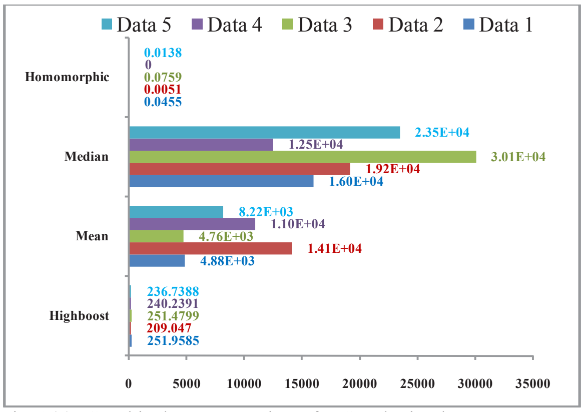

Fig. 9(a). Graphical representation of MSE obtained

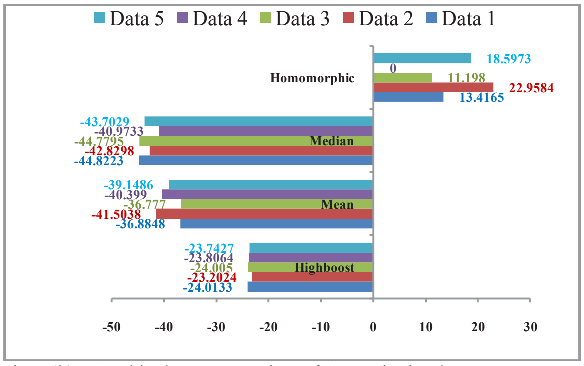

Fig. 9(b). Graphical representation of SNR obtained

V. Conclusion

In this paper, the idea of detection of brain tumor using certain filtering techniques had been discussed. Out of the many filters used in digital image processing, few are used for edge detection, image sharpening and image enhancement. In the proposed approach, automated seed selection method has been discussed, for the segmentation of tumor. This method saves a lot of human interference, and would be useful in many other approaches where seed selection is a complex task. The proposed method would be useful for neurologists and doctors, for identifying brain tumor, and other abnormalities in various parts of human brain.

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