

# Brain Tumor Segmentation from Magnetic Resonance Images Using Self-Organizing Map and Neural Network

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## ABSTRACT

Brain tumor is a deathly disease if not detected on time. A lot of research has been done to explore various techniques of brain tumor detection. So there are number of methods for brain tumor detection and segmentation. The timely and accurate detection and segmentation of brain tumor is very important task of any method for the convenience of doctor so that he may take necessary actions to liberate the patient's life. But the detection and segmentation of brain tumor is very challenging work to perform due to various reasons such as blur MR images, various environmental factors, ineffective skull stripping and also limited information. But irrespective of these problems, a lot of work has been done in the field of brain tumor detection and segmentation. In this paper, we present a method of brain tumor detection from MRI images. Segmentation is done by using Self-Organizing Map (SOM) and Neural network (NN). Stationary Wavelet Transform (SWT) is used to extract the features from an input image before the training process for segmentation. We proposed a new skull stripping algorithm for the purpose of effective skull stripping. We used BRAINIX medical images as a dataset for our method. The proposed method performs better than the methods discussed in the literature. It is easy to implement and robust.

**Keywords:** Brain Tumor, Neural Network (NN), Segmentation, Self-Organizing Map (SOM), Stationary Wavelet Transform (SWT).

## 1. INTRODUCTION

Image segmentation is the phenomenon of dividing an image into various parts or regions (also known as segments). It divides an image on the basis of region of interest (ROI). It is used to extract a portion from an image. Image segmentation is a very important and critical step in the image processing. It has also its applications in the field of medical imaging and is also used to detect brain tumor from magnetic resonance images (MRI). Segmentation of brain MRI is a very challenging task for detection of diseases. Brain tumor is a deathly disease. Occurrence of some abnormal cells within the human brain causes brain tumor. There are mainly two kinds of brain tumor namely cancerous tumor and benign tumors. Brain tumors may or may not affect the neighboring parts of the human body. It really becomes hard-won for the doctors to liberate the patient's life from the tumor if it is not detected on time. So brain tumor detection is a topic of deep concern.

So keeping all this in mind, various authors have developed various brain tumor segmentation methods so that it can be detected correctly and efficiently. But all of those methods have some advantages and disadvantages. Segmentation methods segment the brain tissue into three parts: Gray Matter (GM), White Matter (WM) and Cerebrospinal Fluid (CSF), but the desired accuracy cannot be achieved. These methods do not perform effective skull stripping and brain tumor detection.

This paper is organized as follows. In section II, some of the related work to the concerned topic is briefly described. The proposed work including the main flowchart and the various processing steps along

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with their equations and comparison with the base method is explained in section III. The result of the proposed work and the related discussion is presented in the section IV. Finally the paper is concluded in the section V along with the future scope of the proposed work.

## 2. RELATED WORK

[Sai Prasad Raya, 1990] proposed a segmentation method for magnetic resonance images. The proposed method was rule-based method that detected the area occupied by different parts of the brain. [Mathew C. Clark, 1998] presented an automatic tumor segmentation method based on knowledge-based techniques. It performs effective segmentation without human intervention. [Shijuan He, 2001] proposed a method for finding brain and contours and also constructed calculation models for EEG (Electroencephalographm) and MEG (Magnetoencephalography).

[Yong Fan, 2002] proposed an active model method based on parallel genetic-algorithm for segmentation of brain MR images and provides steady and robust segmentation. [Koen Van Leemput, 2003] proposed a framework for partial volume (PV) segmentation. It also extends the existing techniques. [Raquel Valdes-Cristerna, 2004] proposed a hybrid method for segmentation. It couples radial-basis network and active-contour model. It yields better result. [Merixell Bach Cuadra, 2004] presented a segmentation method based on atlas using model of lesion growth for segmentation of pathological magnetic resonance images.

[Shan Shen, 2005] presented a segmentation method based on an extension of the traditional Fuzzy C-means (FCM) using Neighborhood Attraction. The simulated and real MR images having different noise levels are segmented. [Hassan Khotanlou, 2009] proposed a hybrid method using region and boundary information of the image for the purpose of tumor segmentation. [Tao Wang, 2009] proposed a method for brain tumor segmentation, called the Fluid Vector Flow to solve the problems of limited capture range and also the problem of extracting complex regions.

[Jinyoung Kim, 2014] presented a semi-automatic segmentation method. It also introduced a tailored new edge indicator function. [Antonios Makropoulos, 2014] proposed intensity based brain tumor segmentation method for the neonatal brain. It performs better than the atlas-based segmentation methods. [EI-Sayed A. EI-Dahshan, 2014] presented a review on various brain tumor segmentation and classification techniques for MRI images and proposed a machine learning based hybrid method for computer aided detection system.

[Youyong Kong, 2015] presented a segmentation method based on information theoretic learning for supervoxel-level segmentation. [Selvaraj Damodharan, 2015] proposed a segmentation method for brain tumor based on Neural Network. The Quality Rate (QR) is used to evaluate the abnormal and abnormal MRI images of the brain. [Ayse Demirhan, 2015] proposed a segmentation method that segments brain into tumor, edema, GM, WM and CSF. It performs segmentation using Self-Organizing Maps (SOM). [Guangjun Zhao, 2016] proposed a segmentation technique for Chinese Visible Human (CVH) brain dataset. The proposed method is based on supervised learning and also used multilayer stacked auto-encoder (SAE) for feature representation.

The method proposed in [Ayse Demirhan, 2015] has also some of the problems. The PSNR is less, that means signal is not that much good. Also the skull stripping algorithm used by the author does not provide accurate results. It does not perform effective skull stripping and brain tumor segmentation. To overcome these problems, we propose a new skull stripping algorithm that improves the result. The PSNR also gets improved by using Weiner filter.

## 3. PROPOSED WORK

To overcome the problems evolved in [Ayse Demirhan, 2015], we propose a segmentation method for Brain MR Images to detect the tumor region. The input image is normalized and also the noise is removed

from an image using Weiner filter. The new proposed skull stripping algorithm is applied on the image to extract the outer regions of the brain. Then segmentation algorithm is applied to segment the tumor region from the brain MRI.

### 3.1. Normalization and Noise Removal

Normalization is a preprocessing step. It is a process that converts an image into the normalized one on the basis of intensity value of pixels. Normalization refers to the process of eliminating various parameters such as noise, illumination, etc from the image to make it available for further processing. The main goal of the normalization is to

Obtain normalized image by removing factors that are generated within the environment in which the image is taken. We normalized an input image with in the intensity range of [0 1] by dividing the intensity values of the pixels by the minimum and maximum value of the range. The equation for normalization is as:

$$I_n = \frac{I}{\max(I)} \quad (1)$$

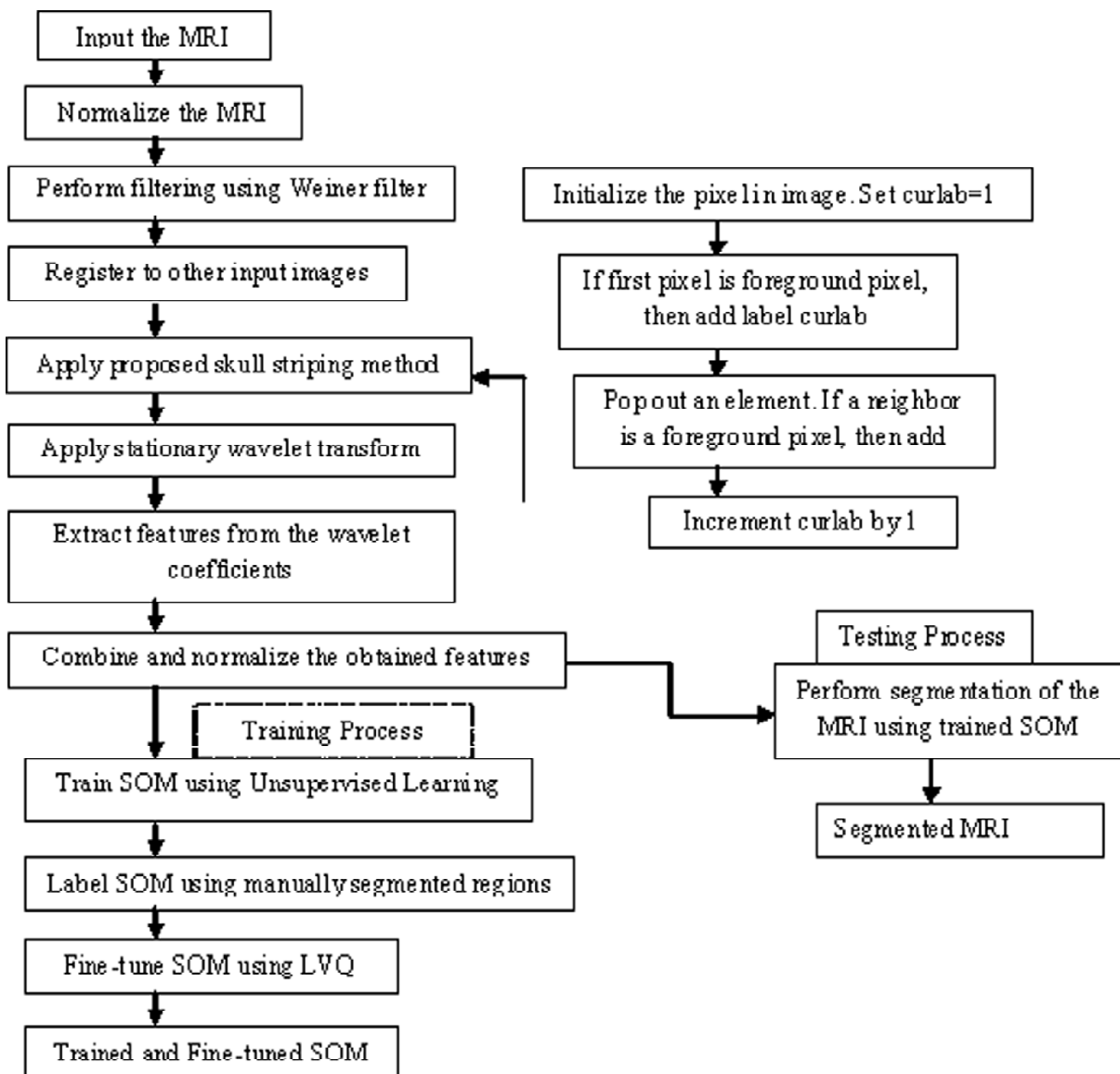


Figure 1: Flowchart of Segmentation and Proposed Skull Stripping Algorithm

Where,  $I_n$  = Normalized Image  
 $I$  = Original Image  
 $\max(I)$  = Maximum intensity range of pixel in image

The method in [12] used anisotropic filter that provide lesser PSNR. We used weiner filter to remove the noise from an input image and to get improved Peak Signal-to-Noise Ratio (PSNR). The inner details and edges of the images are smoothed and preserved. The comparison between anisotropic and weiner filter illustrates our result as shown in the graph:

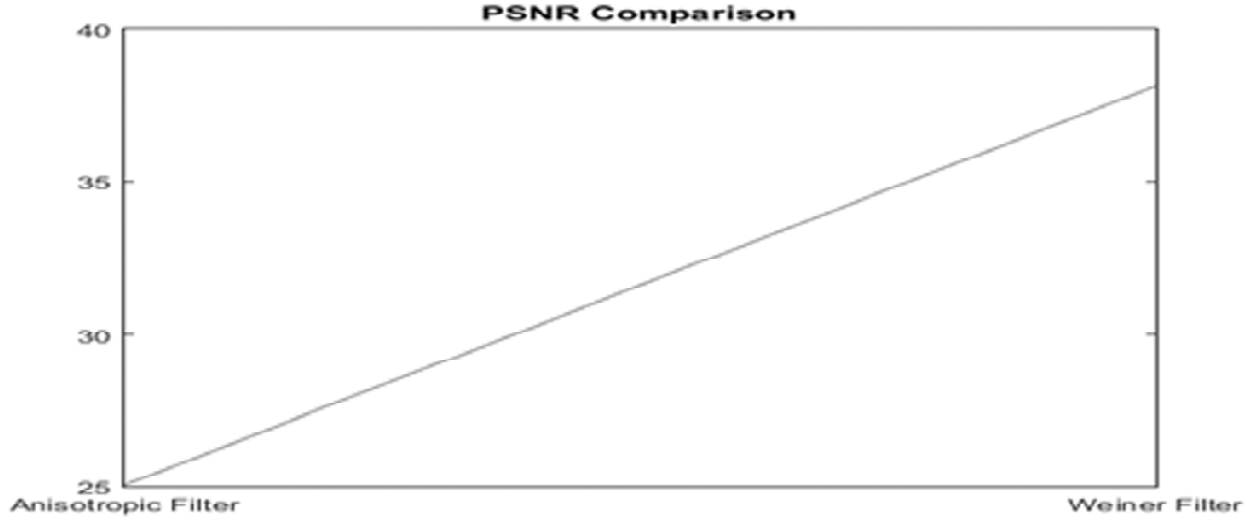


Figure 2: Comparison between Anisotropic Filter and Weiner Filter on the basis of their PSNR

### 3.2. Thresholding

Thresholding is the most simplest and important method of pixel-based segmentation. In its simplest case, it is used to create a binary image from grayscale image. For the segmentation using thresholding method, a threshold value, say  $x$  is chosen. Then for creating a binary image, the pixels of an image having intensity value less than  $x$  are converted to black. And the pixels having intensity value greater than  $x$  are converted to white color pixels. We used Otsu's method to get a threshold value and by using the obtained value an input image is converted to binary image. It is as:

$$x_y^2(tv) = y_0(tv)x_0^2(tv) + y_1(tv)x_1^2(tv) \quad (2)$$

Where,

$y_0$  and  $y_1$  are the probabilities of the two classes that are separated by a threshold value  $tv$

$x_0^2$  and  $x_1^2$  are the variances of these two classes

Find maximum value of  $x_y^2(tv)$  where,

$$y_0(tv) = \sum_{j=0}^{tv-1} a(j) \quad (3)$$

$$y_1(tv) = \sum_{j=tv}^{L-1} a(j) \quad (4)$$

Where,

$y_0(tv)$  and  $y_1(tv)$  are calculated from  $L$  histogram

### 3.3. Skull Stripping

Skull stripping is an important step during brain tumor segmentation. It removes skull, fat, skin and the regions of brain that are not of our interest. It removes the extra portion from the brain to simply the segmentation process. The skull stripping algorithm using morphological operations in [12] provide weak skull stripping and more problems when it has been used for DICOM images. We used blob detection and labeling method for the purpose of skull striping.

### 3.4. Feature Extraction

SWT is used to extract features from an input image for the purpose of segmentation. Wavelets are used to divide data into different frequency components. They are better than the Fourier methods because wavelets can be used for the data having discontinuities and spikes. Discrete Wavelet Transform (DWT) suffers from the lack of translation-invariance. SWT surmount the problem of DWT by removing the up and downsamplers in the DWT. We calculated the coefficients up-to second order. We also exploited four parameters such as energy, entropy, mean absolute deviation and standard deviation.

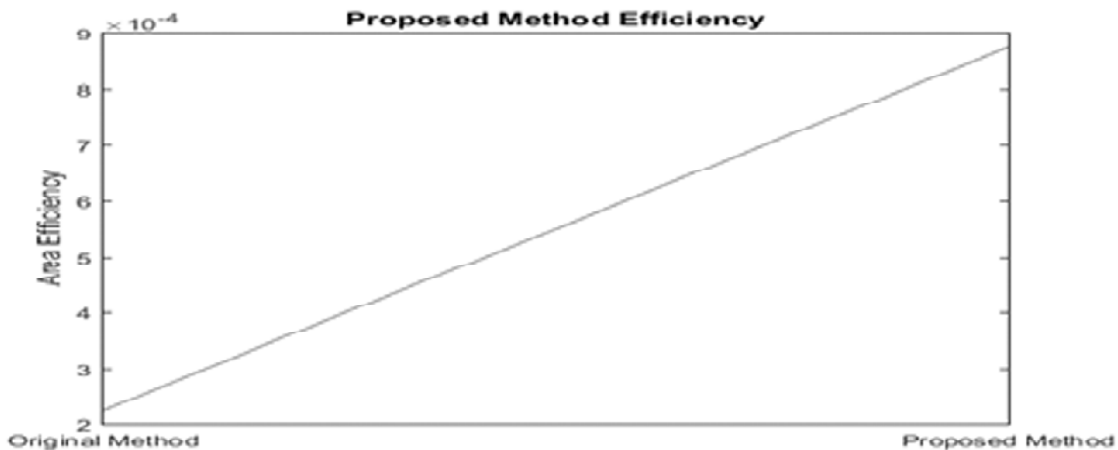


Figure 3: Efficiency of the original and proposed method

Table 1  
Statistical Parameters

<i>Sr. No.</i>	<i>Feature Name</i>
1.	Energy
2.	Entropy
3.	Mean Absolute Deviation
4.	Standard Deviation

### 3.5. Segmentation

Segmentation is a process of dividing an image into segments. It is used to extract the region of interest from an image. We used SOM for the purpose of detection of tumor region. The self-organizing map is a kind of artificial neural network. It is trained using unsupervised learning and Learning Vector Quantization (LVQ) is used to fine tune the SOM network.

## 4. RESULTS AND DISCUSSION

We give comparison of the base method and proposed method. The base paper used anisotropic diffusion filter for the filtering process and skull stripping algorithm was based on morphological operations. On the

other hand, the proposed method uses Weiner filter for the filtering process and the skull stripping algorithm is based on labeling method and blob detection. The comparison between both the methods is given here that shows the proposed method is better than the base method.

The table 3 shows the area efficiency of both the base and proposed methods. It also shows the PSNR of the filters being used in both the methods.

We also present here the results obtained from the proposed and base method to show the performance of both the methods.

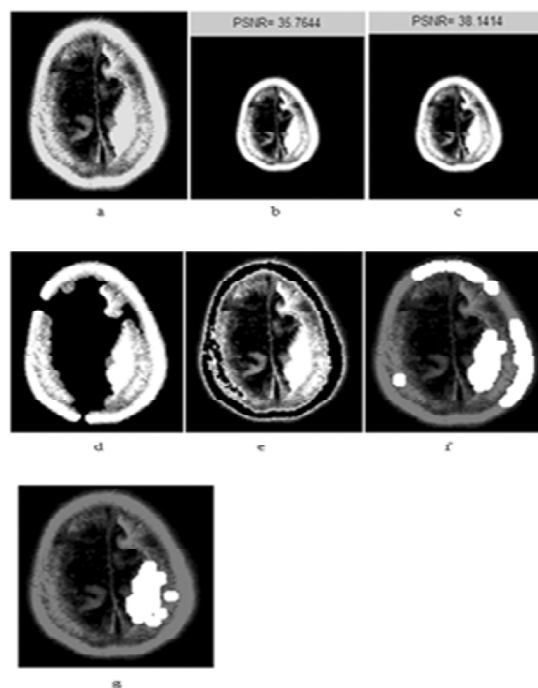
The area efficiency and PSNR of the base method is 0.3 and 25 respectively. And the area efficiency and PSNR of the proposed method is 1.6 and 34 respectively.

**Table 2**  
**Difference between the base method and the proposed method**

<i>Sr. No.</i>	<i>Base Method</i>	<i>Proposed Method</i>
1.	It used anisotropic filter. So the PSNR is less in this case.	It uses Weiner filter. So it has higher PSNR.
2.	It gives less filtered image for processing.	It offers good filtering.
3.	It does not perform effective skull stripping.	It performs effective skull stripping.
4.	The segmentation results are not that much good.	It performs better tumor segmentation.
5.	It does not provide good results for the DICOM images.	It provides better results.
6.	The area efficiency of the base method is lesser.	The area efficiency of the proposed method is more than the base method.

**Table 3**  
**Comparison of base and proposed method**

	Base method	Proposed method
Area Efficiency	0.3	1.6
Filter PSNR	25	34



**Figure 4: Segmentation Results of the Patient for each Processing Step**

The figure 4 contains results of the various steps for the segmentation process. Fig 'a' is the original brain MR image of the patient. Fig 'b' and 'c' is the filtered image with PSNR using anisotropic and Wiener filter respectively. Wiener filter provides higher PSNR, so it is better than the anisotropic. Fig 'd' and 'e' is the skull stripped image using base method and the proposed method respectively. And the fig 'f' and 'g' is the segmented image using base method and the proposed method.

## 5. CONCLUSION AND FUTURE SCOPE

In this paper, we presented a brain tumor segmentation algorithm that segments the brain into WM, GM, CSF and tumor region. We used Wiener filter for noise removal that improves the PSNR. We also proposed a new skull stripping algorithm based on blob detection and labeling method. According to the proposed skull stripping algorithm, each closed portion in an input MRI image is considered as a blob. Then starting from the outer side, we labelled each blob moving inward. This method effectively performs skull stripping as compared to the method of morphological operations using erosion and dilation.

We checked the accuracy of our method on BRAINIX medical image dataset using MATLAB. Our method performs better than other methods as discussed in the literature. It is also concluded that Wiener filter performs better than anisotropic filter. The proposed method effectively strips out the skull portion resulting in better segmentation. This method can be used in the hospitals, laboratories, for the experiments and also for research work. In future, the work is required to further improve the efficacy of the skull stripping method as there are still some traces (very less) of skull's outer region remains in the image. Though this is the outer region and does not affect much as we can see in the results, we still need to clear it out in order to get better skull stripping.

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