Hierarchical Self-Organizing Map (HSOM) based Segmentation of Brain Tumour from Brain MRI Images

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Abstract— The main objective of this research work is to segment a tumor from a collection of MRI brain images. While extracting the brain tumor, the following steps involved namely, Preprocessing, Clustering, feature extraction and segmentation. The MRI brain images are blurred and contains noise. So, the Median filter is used to remove noise from the MRI images. Then, the brain is clustered into well known regions like White Matter (WM), Gray Matter (GM),Cerebrospinal fluid (CSF) and background by using Fuzzy c-mean and HSOM segmentation which is used to extract the brain tumor from the clustered image and also used to segment the image row by row.The proposed method is evaluated using the elapsed time and accuracy based on SVM classification.

***Key words*:** Brain tumor, MRI images,Median filter, Fuzzy c-mean, HSOM segmentation, SVM classification.

I. INTRODUCTION

A brain tumor is a cluster of abnormal growth of cells in the brain. A tumor that begins and tends to keep growing in the brain is called Primary brain tumor whereas metastatic brain tumors are those which appear as cancer elsewhere in the body and start migrating to the brain. There are more than 120 different types of brain tumors; some are malignant (cancer), and some are benign (non-cancerous). The cause of brain tumors is still unknown. Benign or malignant, primary or metastatic, brain tumors are treatable. The abnormal growth of cells in the brain or central spine is known as a brain tumor. When the growth of these cells is above 50%, the tumor might be cancerous and dangerous. Therefore early and accurate detection of tumor is essential.

A. Magnetic resonance imaging

MRI is also known as nuclear magnetic resonance imaging or magnetic Resonance Tomography. It is used for visualizing the detailed internal structures of the brain. MRI uses the nuclear magnetic resonance (NMR), property whose image nuclei of atoms are situated inside the body. MRI provide a contrast between soft tissues of the body which is useful in imaging the brain, muscles, the heart and cancers compared with other medical imaging techniques such as CT or X-rays. Unlike CT scan or traditional X-rays, MRI does not use the ionizing radiation.

B. Tumor

A tumor is popularly known as a neoplasm. It is an abnormal mass of tissue which may be fluid-filled or solid. It does not mean as a cancer. The tumors can be benign (not cancerous), pre-malignant (pre-cancerous), or malignant (cancerous).

C. Brain Tumor

A brain tumor is a localized intracranial lesion which occupies space with the skull and tends to cause a rise in intracranial pressure. The brain tumor classified as a Primary brain tumor and Secondary brain tumor.

D. Image processing for MRI images

Image Processing is a technique to enhance raw images. Various techniques have been developed in Image Processing. The common steps in image processing are image scanning, storing, enhancing and interpretation. The various image processing techniques are, image preprocessing, clustering, feature extraction, segmentation.

II. ANALYSIS AND FOUNDATION

According to the survey conducted by neuro-oncology disease management group (DMG) crude incidence of primary brain tumor in India is 3.4 per 100,000 populations for males and 1.2 per 100,000 populations for females. It represents less than 1% of tumor cases detected every year in the country. However, there has been an increase in the incidence of primary brain tumors over the last decade therefore segmenting brain tumors more accurately was felt as the need of the hour. Hence this research work was taken up to automatically segment the brain tumors.

III. PROPOSED METHODOLOGY

The proposed algorithm comprises of four stages. The first stage encompasses pre-processing of the given MRI image. The second stage consists of clustering the pre-processed image. The third is the feature extraction stage, followed by segmentation.

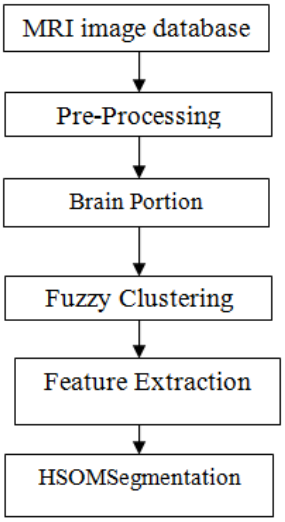


Fig. 1: Steps in proposed HSOM based brain Tumor Detection

A. Preprocessing

Median filter is used for preprocessing that removes noise and other high frequency components from MRI images without disturbing the edges. This technique calculates the median of the surrounding pixels to determine the denoising value of the pixel.The comparative results of mean, median and smoothing filter are summarized in following Table 1 (M. N. Nobi and M. A. Yousuf, 2011).

Filtering Methods	PSNR	MSE
Smoothing Filter	43.43	18.44
Median Filter	43.64	16.26
Mean Filter	42.08	18.40

Table 1: Comparison results of different filtering method

1) Skull removal from brain MRI

The thresholding and morphological processes are used to separate the brain from non-brain portions. Further an intensity threshold is computed, by means of which a rough binary brain portion is generated. The morphological operations, erosion, connected component analysis and region properties are performed on the rough brain portion to produce the brain mask. Finally the brain mask is used to extract the brain from MRI.

B. Fuzzy C-Mean Clustering (FCM)

The FCM algorithm is one of the most widely used fuzzy clustering algorithms. Fuzzy c-mean (FCM) is a method of clustering which allows one piece of data to belong to two or more clusters. It is frequently used in pattern recognition. It is based on minimization of the objective function.

The Fuzzy c-mean Algorithm:

Step 1: Initialize$U$= [u_{ij}] matrix, U(0)

Step 2: At k-step: calculate vectors C^k=[c_j] with $U^{(k)}$

$$c_j = \sum_{i=1}^{N} (u_{i,j}^m . x_i) / \sum_{i=1}^{N} u_{i,j}^m$$

*Step 3:*Update $U_{i,j}$ matrix,

$$u_{i,j} = 1 / \sum_{k=1}^{C} \left(\left\| x_i - c_j \right\| / \left\| x_i - c_k \right\| \right)^{2/(m-1)}$$

Step 4: if $\|U^{(k+1)} - U^k\| < \varepsilon$ then Stop; otherwise return to Step 2.

In the proposed method Fuzzy C Mean is used for clustering. The aim of using FCM is to find a cluster centre that minimizes an objective function.

C. The Intensity Based Features:

The intensity based feature is one of the most widely used features. In the proposed method Mean Standard Deviation (MSD) is used for feature extraction. It calculates the mean and standard deviation of pixels in each bin. Each bin consists of a range of pixel values. The values in each bin are used to calculate the mean value, which in turn represents an appropriate value of brightness of the image of the bin. The standard deviation is also calculated by using the mean and pixel values of each bin. The standard deviation also reveals information about the contrast of an image in a particular bin.

1) Mean:

The mean defines the average level of intensity of the image or texture.

$$\mu = \sum_{i=0}^{N_g - 1} i . p(i)$$

Where,

$$p(i) = \frac{h(i)}{N_x N_y}, \; i = 0, 1, 2, \ldots \ldots N-1$$

$$h(i) = \sum_{x=0}^{N_g - 1} \sum_{y=0}^{N_g - 1} \delta(f(x,y), i), \; i = 0, 1, 2, \ldots \ldots N-1$$

$$f(x,y) = \begin{bmatrix} f(0,0) & f(0,1) & f(0,2) & \ldots\ldots\ldots\ldots & f(0,N_y-1) \\ f(1,0) & f(1,1) & f(1,2) & \ldots\ldots\ldots\ldots & f(1,N_y-1) \\ f(0,0) & f(0,1) & f(0,2) & \ldots\ldots\ldots\ldots & f(0,N_y-1) \\ \vdots & \vdots & \vdots & & \vdots \\ \vdots & \vdots & \vdots & & \vdots \\ f(N_x-1,0) & f(N_x-1,1) & \ldots\ldots\ldots & & f(N_x-1,N_y-1) \end{bmatrix}$$

$$\delta(i,j) = \begin{cases} 1 \; ; \; i = j \\ 0 \; ; \; i \neq j \end{cases}$$

Where,

f(x,y) be a two dimensional function of an image,

h(i) be the intensity level of an image, and p(i) be the probability density.

2) Standard Deviation: (SD)

$$SD \text{ or } \sigma = \sqrt{\sum_{i=0}^{N_g - 1} (i - \mu)^2 . p(i)}$$

Where,

N_g be the total number of gray levels in the entire image,

μ is the mean,

p(i) be the probability density and

$\sigma_j$is the standard deviation.

D. HSOM Segmentation

The SOM is usually used for mapping high-dimensional data into one, two, or three dimensional feature maps. SOM encounters several drawbacks, such as being computationally expensive, needing much learning time, being memory opulent, and search drive being comparatively low. These disadvantages are overcome by various other methods. One of the first revisions of the original algorithm was the Hierarchical SOM (HSOM). HSOM differs from the original SOM algorithm. HSOM is the combination of self-organization and topographic mapping technique.

In the proposed work, HSOM segmentation is based on Agglomerative HSOM based on clusters which in turn solely depended on clusters. This method is used to

segment the brain tumor from the fuzzy c mean output image, with less execution time and to detect the size of the tumor accurately. The agglomerative HSOM has the advantage of mapping the same data twice using SOM, which is performed at a different level.

IV. RESULTS AND DISCUSSIONS

As given in the reference, (S.Murugavalli et al. (2007), (T.Logeswari et al. 2010), used as HSOM for segmentation. As per the proposed study, the segmentation is done in 13.76 seconds. In the proposed method, mean standard deviation is used for feature extraction and the execution time for HSOM is between 7-10 seconds. Hence there is a reduction in execution time when compared to existing methodology.

A. Preprocessing

When median filtering is applied, the noise from the image is removed and clarity of the image is achieved. The comparison between the original image and filtered images is show in following Figure 3 and Figure 4.

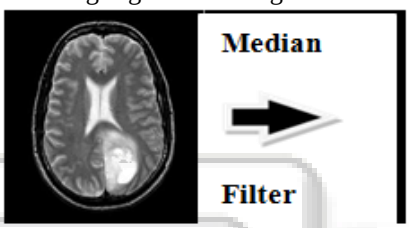


Fig. 3:Original image Fig. 4: Filtered image

1) Skull Removal

The skull removal method is used to separate the brain portion from the non-brain portion. In the proposed method the preprocessing is performed by using the techniques like threshold value, connected components, morphological operation and erosion.The comparison between the pre-processed image and skull removed image is shows in figure5 and figure6.

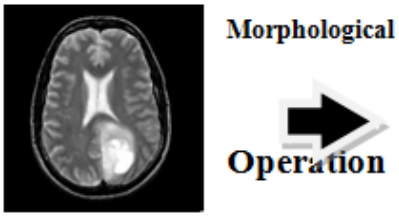


Fig. 5: Preprocessed image Fig. 6: Skull removed image

B. Clustering technique

Fuzzy C Mean technique is used to cluster the image. The clustered image makes the subsequent tasks of the system easier. The clustered image is shown in figure7 and figure 8.

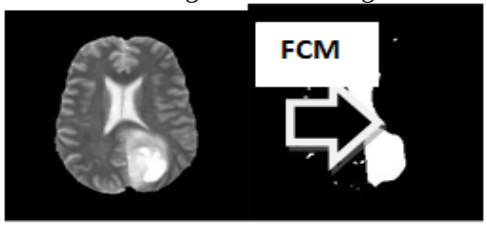


Fig. 7: Skull removed image Fig. 8: Clustered image

C. HSOM Segmentation

This HSOM segmentation work efficiently by extracting the tumors in less computational time, tumor size and accuracy is achieved in effective manner. The segmented image is shown in Figure9 and Figure 10.

Fig. 9: Clustered image Fig. 10: Segmented image

1) Accuracy

In the proposed method, accuracy was calculated by using SVM classification based on Hierarchical Self-Organizing Map (HSOM) segmentation result and from the results, the accuracy obtained was 98.88% on the average.The overall performance, accuracy is evaluated and the results are projected in Table 2.

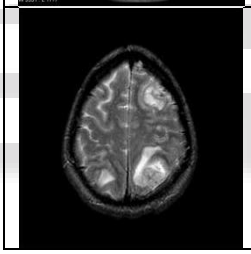
Images	SVM Accuracy (%)
	98.88
	98.87

Table 2: SVM Accuracy

2) Elapsed Time:

The execution time taken to detect the tumor using proposed method HSOM is shown in Table 3, which is comparatively less than the time taken for other segmentation techniques specified in the literature. As per the literature review (T.Logeswari and M.Karnan ,2010) the time taken for segmentation is 13.76%.

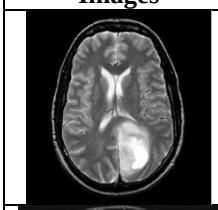
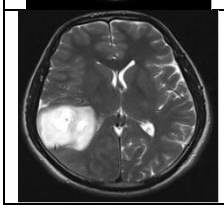
Images	Time (seconds)
	7.57
	7.29

Table 3: Execution Time

In the proposed method, Hierarchical Self-Organizing Map (HSOM) segmentation uses the following phases. They are

preprocessing, clustering and segmentation. By adopting HSOM segmentation accuracy attained was about 98.88% on an average and computational time was reduced to an extent of 7 to 10.3 seconds.

V. SUMMARY AND CONCLUSION

This research work was used to segment the brain tumor from the medical brain MRI image. The main technique was HSOM segmentation, which is done by using a method on preprocessing, morphological operations, clustering and feature extraction. In the proposed method, 60 MRI medical images are processed through segmentation technique thus given efficient result.

The MRI brain tumor segmentation is a challenging and time consuming process in the field of medical imaging since the intensities of the gray matter and white matter are very close in different tissues. Here, segmentation is used to extract the salient features of an image from the clusters. Various kinds of segmentation techniques are used such as Threshold techniques, Edge-based, region-based and statistical methods. Among these, Hierarchical Self Organizing Map (HSOM) was used for the study. To conclude the HSOM technique adopted for brain tumor segmentation resulted in reduction in execution time and considerable increase in classification accuracy.

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REFERENCE

[1] Deepak , C., Dhanwani , Mahip, Bartere, M., (2014) Survey on Various Techniques Of Brain Tumor Detection From MRI Images, International journal of computational engineering research,vol :04,issue: 1.
[2] Dou, W.B., Ruan, S., Chen, Y.P., (2007) A Framework of Fuzzy Information Fusion for the Segmentation of Brain Tumor Tissues on MR Images. Image and Vision Computing, Vol. 25 No.2, pp: 164-171.
[3] Iftekharuddin, K.M., Zheng, J., isiam, M.A., (2009) Fractal-based Brain Tumor Detection in Multimodal MRI, Applied Mathematics and Computation,Vol:207 ,No:1,pp: 23-41.ISSN: 2249 – 8958, Vol-3, Issue-4.
[4] Lau, P.Y., Ozawa, S., (2004) A Region- and Image-Based Predictive Classification System for Brain Tumor Detection, Symposium on Biomedical Engineering, Hokkaido, Japan, pp: 72–102.
[5] Logeswari, T., and Karnan, M.,(2010) An Enhanced Implementation of Brain Tumor Detection Using Segmentation Based on Soft Computing, In Proc. International Journal of Computer Theory and Engineering, Vol. 2, No. 4, pp:1793-8201.
[6] Magdi,B.M., Amien, Ahmed Abd-elrehman and Walla Ibrahim, (2013) An Intelligent Model for Automatic Brain Tumor Diagnosis Based on MRI Images , International Journal of Computer Applications(0975-8887) Vol:72,No:23 ,pp 21-24.
[7] Mancas, M., Gosselin, B., Macq, B.,(2005) Fast and Automatic Tumoral Area Localization Using Symmetry, in Proc. IEEE ICASSP Conference, Philadelphia, Pensylvania, USA.
[8] Marroquin, J.L., Vemuri, B.C., Botello, S., (2002) An Accurate and Efficient Bayesian Method for Automatic Segmentation of Brain MRI. IEEE Transactions on Medical Imaging, Vol :21, No:8, pp: 934-945.
[9] Murugavalli, S., Rajamani, V., (2007) An Improved Implementation of Brain Tumor Detection Using Segmentation Based on Neuro Fuzzy Technique ,Journal of Computer Science, pp. 841-846.
[10] Nobi,M. N., and Yousuf ,M. A., (2011) A New Method to Remove Noise in Magnetic Resonance and Ultrasound Images, journal of scientific research, Vol.3,No.1,pp: 81-89

