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Brain Cancer Segmentation in MRI Medical Image Using Combined Watershed Algorithm and Thresholding with Multilayer Perceptron (CWTMP) Neural Network

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ABSTRACT
Digital image processing is the use of computer algorithms to perform image processing on digital images. Image segmentation refers to partitioning an image into various sub regions and also identifying a tumor part in a brain MRI image. This paper proposes an efficient algorithm for combined watershed and thresholding with multilayer perceptron(CWTMP) image segmentation technique,to segment tumor portion in a given MRI medical image.This proposed method consists of preprocessing, segmentation, classification and performance evaluation. Preprocessing uses Gaussian smoothing, Improved watershed method is applying for segmentation process, a Multilayer Perceptron neural network(CWTMP) classification method is used for classification. The performance of the proposed method(CWTMP) is validated both quantitatively and qualitatively,using performance metrics such as peak signal noise ratio.
Keywords- Magnatic Resonance Imaging, Thresholding, Watershed Algorithm, MultiLayer Perceptron, Peak Signal Noise Ratio

I. INTRODUCTION

Cancer is counted among the most deadly and intractable diseases (Kothari, 2012). Tumor is an abnormal tissue that grows in various parts of human body. It is identified by processing an image to highlight a tumor part. The MR imaging segmentation methodologies are the best to find out the tumor in its higher resolution (Gupta, 2011). The knowledge of volume of a tumor plays an important role in the treatment of tumors. Manual segmentation of brain tumors from Magnetic Resonance images is a challenging and time consuming task. The proposed method can be successfully applied to detect the contour of the tumor. It uses a combined watershed and thresholding with multilayer perceptron(CWTMP)method. The rest of the study is organized as follows: A brief review of the research related to the proposed technique is presented in section 2.Efficient proposed image segmentation technique (CWTMP)is presented in section 3. The detailed experimental results and discussions are given in section 4 and 5. The conclusions are summed up in section 6.

II. RELATED WORK

A lot of research work has been undertaken by researchers, for image segmentation and tumor detection. A brief review of some of the recent research is presented here.

A.R.Kavitha and C.Chellamuthu(2010)states about the watershed algorithm, it is an important technique for image segmentation which converts the gray-level image to a segmented Image. Watershed algorithm is a novel recursive algorithm for deriving clustered images, used to increase the quality of an image.

A.R.Kavitha and C.Chellamuthu (2013) describes an effective modified region growing technique for detection of brain tumour.

Modified region growing technique includes an orientation constraint in addition to the normal intensity constraint. The performance of the proposed technique is systematically evaluated using the MRI brain images received from the public sources. For validating the effectiveness of the modified region growing, the quantity rate parameter has been considered.

Gupta (2011) describes about the computer based procedures to detect tumor blocks or lesions and classify the type of tumor using artificial neural network in MRI image and feature extraction using fuzzy classifier.

Kothari (2012), states about the novel technique that is used to detect tumor from brain using segmentation methods and histogram thresholding and the way it provides a handy tool for the practitioner to the physicians engaged in this area.

Dr.Samir Kumar Bandyopadhyay (2011), the segmentation of brain tumours in magnetic resonance images (MRI) dedicated to full enhanced tumours or specific types of tumours. The amount of resources required to describe large set of data is simplified and selected for tissue segmentation.

Mustaqeem and Tehseen (2012), explains about the watershed and thresholding method that is used to detect the tumor portion from a given MRI image. He states about the morphological operations that is used to segment abnormal tissue from organic matter.

Rajeshwar Dass, Priyanka, Swapna Devi (2012) describes the different segmentation techniques used in the field of ultrasound and SAR Image Processing. Firstly, this paper investigates and compiles some of the technologies used for image segmentation. Then, a bibliographical survey of current segmentation techniques is given in this paper and finally general tendencies in image segmentation are presented.

Wang *et al*. (2011) explains about the median filter that is used to remove noise from a given image and to preserve the edges and the technique that is used to segment abnormal tissue from a given image.

Priyanka and Balwinder Singh (2013) describes on survey of well-known brain tumour detection algorithms that have been proposed so far to detect the location of the tumour.

Dr.N. NandhaGopal (2013) describes to develop and effective algorithm for the segmentation of brain MRI images. The Segmentation process has three different approaches like block based (non algorithmic), PSO and HPACO algorithm segmentation.

In existing system, watershed algorithm was used to segment tumor part from a given MR image using morphological operation. It is very difficult to define a region descriptor for images with intensity in homogeneities. Existing methods were computationally too expensive and sensitive to the initialization of the contour, which greatly limits their utilities. These problems were overcome by using the proposed method improved watershed algorithm(CWTMP)which combines the threshold value of image and morphological operation.

3. Materials and Methods

The proposed methodology for segmentation methods are shown in **Fig. 1**, it explains four processes namely noise removal, segmentation , classification and performance evaluation. The steps using in the proposed methodology are:

- Input MRI brain image
- Smoothen the image using Gaussian filter
- Convert gray scale into binary image and segment the image
- Classify the tumor part using MLP
- Performance evaluation

2.1. Input Image

The MRI brain image is used for segmentation. The 2D input MRI image is stored in a database. The image is a color image whose size is 256×256. The input image is shown in **Fig. 2**.

2.2. Preprocessing

The image obtained consists of noise (unwanted signal) and it is removed using Gaussian smoothing. The visual effect of this blurring technique is a smooth blur resembling that of viewing the image through a translucent screen. It uses a Gaussian function for calculating the transformation to be applied to each pixel in the image. The equation of a Gaussian function in two dimensions is given in the Equation

$$1\ G(x.y) = \frac{1}{2}\prod \sigma^2 e^{-\frac{x^2+y^2}{2\sigma^2}} \qquad (1)$$

where, x represents the distance from the origin in the horizontal axis, y represents the distance from the origin in the vertical axis and σ is the standard deviation of the Gaussian distribution. When applied in two dimensions, this formula produces a surface whose contours are concentric circles with a Gaussian distribution from the center point. Values from this distribution are used to build a convolution matrix which is applied to the original image.

2.3. Image Segmentation

Improved watershed is used for segmentation process which is a combination of thresholding and morphological operations.Thresholding is mainly used to convert a gray image into binary image. The binary image consists of only 0's and 1's. The light particles are separated in the binary image, while the various darker shades of gray are all set to black. The converted binary image is now segmented to display the affected tumor part. The improved watershed algorithm is described below:

Input: Smoothened image
Output: segmented image

1. Read an image and store it in a variable si
2. Create a matrix m from the si
3. Initialise variable dark to true
4. Check the variable dark to true
 4.1 Subtract gray value from matrix
5. Endif
6. Create an object for the watershed class
7. Pass m, height, width, dark as variable
8. Perform step 17 to step 20
9. Initialise variable step to 6
10. Declare shed as two dimension of Boolean type
11. Perform step 21 to 30
12. Store the seed value in shed variable
13. Check variable shed for true
14. Create a float‘t’ variable with one dimension
15. Initialise variable t [0] to 0
16. Set the pixel with‘t’ array value
17. Check the dark variable for true
18. Subtract gray value from matrix ‘m’
19. Return the ‘m’ matrix
20. Set level to zero
21. Check gray value with pixel
22. While true
23. Create pixel list for segmenting region
24. Check the list for empty
25. Break
26. Else extend the pixel and segment it
27. Return the list of segmented part
28. End do
29. Set variable shed to 255 or 0
30. The segmented values are stored in the shed matrix
31. Display the segmented part from the matrix shed

BY USING THE ABOVE IMPROVED WATERSHED ALGORITHM SMOOTHENED IMAGES ARE CONVERTED TO SEGMENTED IMAGES

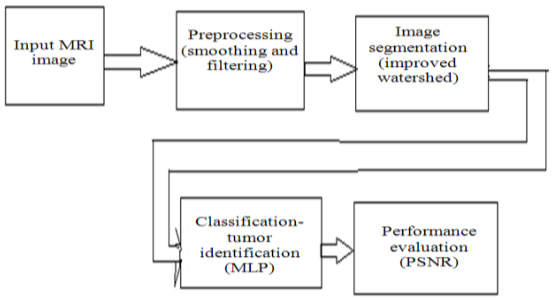


Fig. 1. Proposed methodology

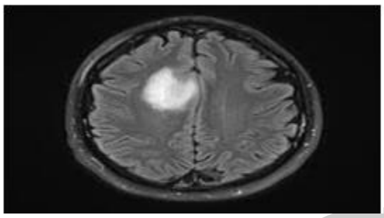


Fig. 2. MRI input brain image

2.4. Classification

After segmentation, classification is performed based on the neural network method Multilayer Perceptron (MLP). An MLP consists of multiple layers of nodes in a directed graph, with each layer fully connected to the next one. Except for the input nodes, each node is a neuron (or processing element) with a nonlinear activation function. MLP utilizes a supervised learning technique called back propagation for training the network. The multilayer perceptron consists of three or more layers (an input and an output layer with one or more hidden layers) of nonlinearly-activating nodes. Each node in one layer connects with a certain weight (wij) to every node in the following layer. A Multilayer Perceptron (MLP) is a feed forward artificial neural network model that maps set of input data onto a set of appropriate output. A model of MLP is shown in the **Fig. 3**.

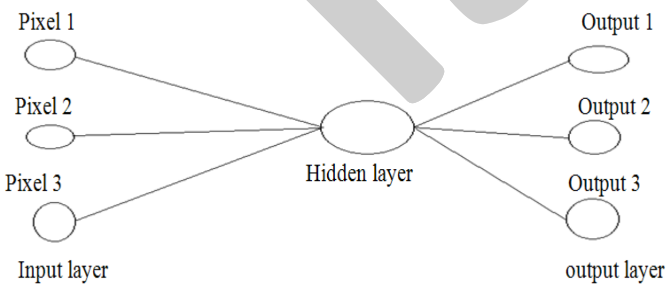


Fig. 3. (a) Model of multilayer perceptron

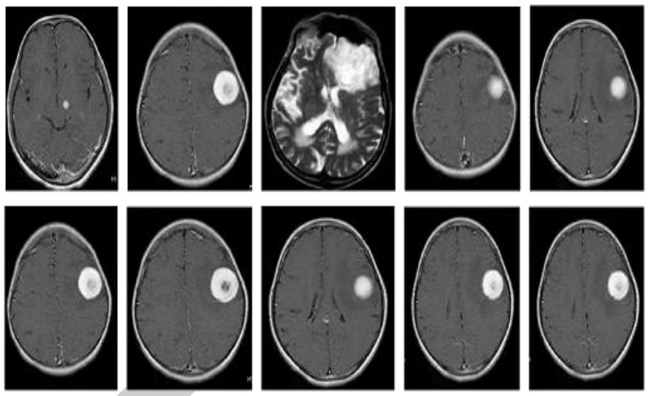


Fig. 3. (b) MRI-Brain data set

The MLP procedure is as follows:

- Initialise the weights and threshold value. Weights may be initialized to zero
- network is trained depending upon the learning rate occurs in the perceptron by changing connection weights after a piece of data is processed
- A piece of data consist of matrix value which shows tumor affected part as a white portion

By applying the above algorithm, classification (affected or not affected) can be done exactly and easily can identify tumor affected part in the image.

2.5. Performance Evaluation

The comparison between existing and proposed methodology is done using Peak Signal to Noise Ratio (PSNR). PSNR is most easily defined via the Mean Squared Error (MSE). Given a noise-free m×n monochrome image I and its noisy approximation K, MSE is defined in Equation 2:

$$MSE = \frac{1}{mn}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}[I(i,j) - K(i,j)]^2 \quad (2)$$

The PSNR is defined in Equation 3:

$$= 20.\log_{10}\left(\frac{MAX_I}{\sqrt{MSE}}\right) \quad (3)$$

$$= 20.\log_{10}(MAX_I) - 10.\log_{10}(MSE)$$

HERE, MAX_I IS THE MAXIMUM POSSIBLE PIXEL VALUE OF THE IMAGE. WHEN THE PIXELS ARE REPRESENTED USING 8 BITS PER

III. RESULTS

Simulation was carried out using the programming JAVA Language. The input MRI images are shown in **Fig. 4** are taken from the publicly available sources.

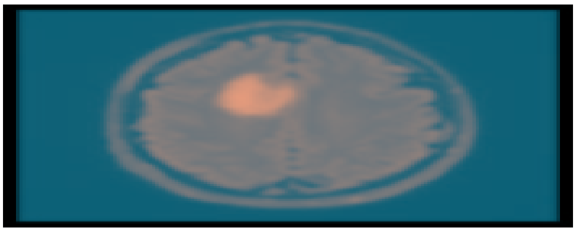


Fig. 4. Preprocess image

Fig. 5. Threshold image

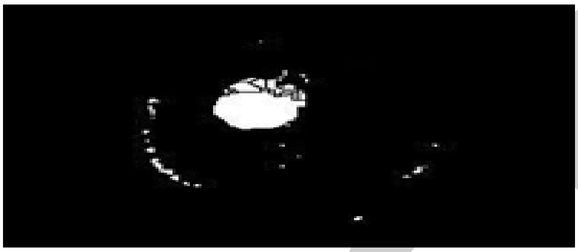


Fig. 6. Segmentation using IWMP method

Various stages of the output are shown in the **Fig. 4-6** respectively. The smoothened image does not contain noise and it looks blurred. The threshold image contains black and white portion. The segmented image is used to display tumor affected part.

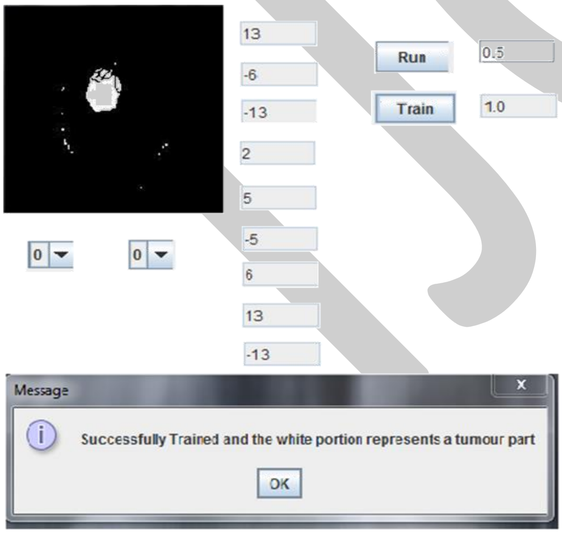


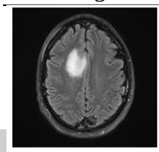
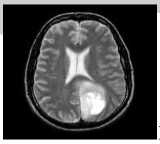
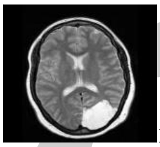
Fig. 7. Classified and tumor identified image

Image classification analyzes the numerical properties of various image features and organizes data into categories. The **Fig. 7** shows a tumor part that is identified from a given MRI image.

IV. DISCUSSION

Validation is necessary for analyzing the quality of the segmented image. In a qualitative analysis, the performance metrics PSNR is used for analysis. It is also compared with the existing segmentation methods. Proposed algorithm extracts accurate tumor part from the source image, provides better results as compared to the existing segmentation techniques.The comparison results are shown in **Table 1.**

Table 1. Comparison of PSNR value between existing and proposed method

MRI image	K-Means method PSNR value	Proposed IWMP method PSNR value
	13.407628108822	12.275008808004
	12.398605427726	10.965450041697
	11.993442107269	10.987105123068

V. CONCLUSION

A new method for tumor detection based on CWTMP segmentation method is proposed in this paper. The proposed CWTMP algorithm segments the accurate tumor part from the source image. The PSNR is evaluated for the various set of images and the tabulated results indicate that the output of the CWTMP algorithm provides better results,when compared to the existing k-means method.

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