A New Method for Brain Tumor Segmentation Based on Watershed and Edge Detection Algorithms in HSV Colour Model

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***Abstract*—In this work a new method for brain tumor detection is developed. For this purpose watershed method is used in combination with edge detection operation. It is a color based brain tumor detection algorithm using color brain MRI images in HSV color space. The RGB image is converted to HSV color image by which the image is separated in three regions hue, saturation, and intensity. After contrast enhancement watershed algorithm is applied to the image for each region. Canny edge detector is applied to the output image. After combining the three images final brain tumor segmented image is obtained. The algorithm has been applied on twenty brain MRI images. The developed algorithm has given promising results.**

Keywords-canny edge detector; segmentation; brain tumor; HSV color model; MRI; watershed

I. INTRODUCTION

Brain tumor is a group of abnormal cells that grows out of control of the normal forces inside the brain or around the brain [1]. Diagnosis of brain tumors is dependent on the detection of abnormal brain structure, i.e. tumor with the exact location and orientation [2]. Brain tumor can be of two types (1) beginning tumors or primary tumors (2) malignant tumors. Beginning tumors are generally not need to be treated. Malignant tumor is basically termed as brain cancer. Now a day's MRI (Magnetic Resonance Imaging) is an important tool for detection of brain tumor for the doctor.

Various algorithms are there for brain tumor segmentation depending upon the area of interest. K-means cluster is an iterative pixel based method [3]. Here the basic idea is to partition an image into K cluster. But it is dependent on the number of cluster and the value of K. Histogram based segmentation method can segment brain tumor effectively [4], but it has also some disadvantages that the peaks and valley detection can be difficult. Edge detection is another type of image segmentation method which can be used effectively, but it is dependent on the intensity value of the image. The quality of the segmented image is depending on the edge detected operator also. Watershed algorithm is another approach to image segmentation. Using this algorithm image can be segmented more precisely but there are some challenges regarding this algorithm, over segmentation is a common problem for this algorithm. To avoid this problem marker based segmentation process is used in this paper [2].

Here the proposed algorithm is based on the combination of marker based watershed algorithm and edge detection operator which applied to color brain tumor images. Canny edge detection operator which is known as the best amongst all edge detected operator is used here.

II. BLOCK DIAGRAM OF PROPOSED METHOD

General block diagram of the method is given in the Fig. 1

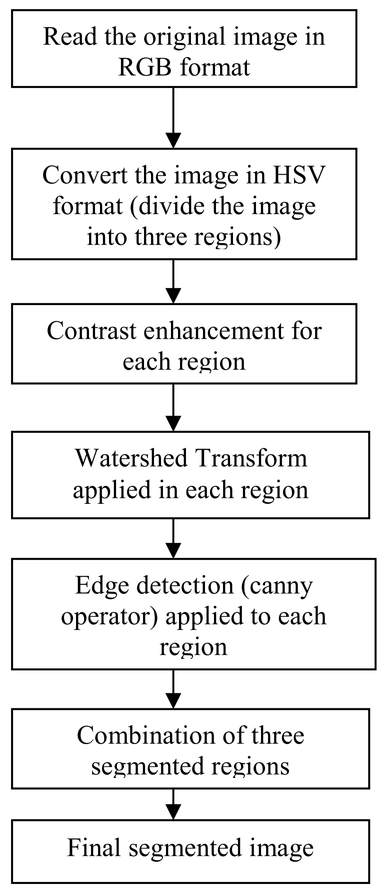

Figure1: Flow chart of the proposed algorithm

III. PROPOSED ALGORITHM

Here a new approach for brain tumor detection is developed using color image. For this purpose combination of watershed algorithm and edge detection is done. For the edge detection, canny edge detector is used. Before going into the results obtained from the developed algorithm, Marker based watershed approach and HSV color model are briefly discussed in section A and section B respectively.

A. Marker Based Watereshed Approach

Generally watershed algorithm is used to find the “watershed lines” in an image in order to separate the distinct regions. It is a mathematical morphological process. The basic principle is based on the fact of topology [5]. If it can be imagined that all minimum of the image is the source of water and they form “catchments basins”, immerging the surface, then the border of catchment basin is called watershed, as shown in Fig. 2.

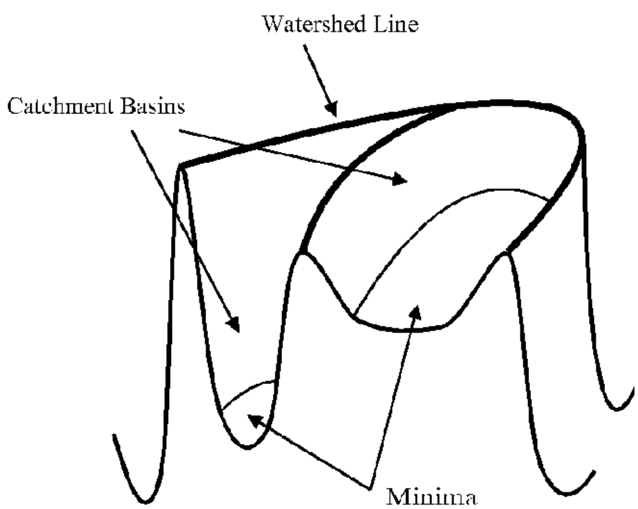

Figure2: Watershed Algorithm

But there sometimes occur over segmentation problem. To overcome this problem marker based watershed approach is used. Gradient magnitude is used here for preprocessing of the image to overcome the over segmentation problem [5]. In gradient magnitude images, pixels along the object edges are of high values, and other pixel are of low values. If f (x, y) is an image, then the gradient vector magnitude and the angle at which maximum rate of change of intensity level occurs for the image can be computed using the following two equations (1) and (2) [2]:

$$g(x,y) = \sqrt{(g_1^2(x,y) + g_2^2(x,y))} \qquad (1)$$

$$\alpha(x,y) = \tan^{-1}(g_2(x,y)/g_1(x,y)) \qquad (2)$$

Where $g_1(x,y)$ and $g_2(x,y)$ are the gradients in the x, y direction of the image. The magnitude of the gradient can be achieved by using sobel mask given in (3).

$$H = \begin{bmatrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix} \quad H' = \begin{bmatrix} 1 & 0 & -1 \\ 2 & 0 & -2 \\ 1 & 0 & -1 \end{bmatrix} \qquad (3)$$

If gradient image is applied directly to watershed transform then there will be still the problem of over segmentation [5]. Markers are used for modifying gradient images. There are basically two types of markers internal marker and external marker. For internal marker the location of all regional minima gradient image is computed using MATLAB toolbox. For external marker in order to identify the background in the gradient image, i.e. the pixel midway between the internal markers is found. That means here watershed transform of the distance transform of the internal marker is computed. Finally the gradient image is modified by imposing regional minima at a location of both internal and external markers using the MATLAB toolbox.

B. HSV Color Model

HSV color model is a method which defines color according to the three feature of the color hue, saturation, and intensity or value [5]. HSV color space can be represented as a hexacone while represented in three dimensional representation.

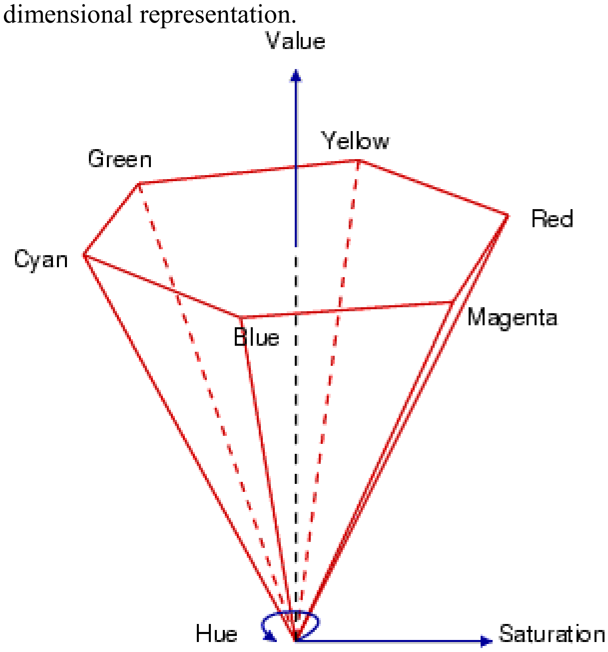

Figure3: HSV color model

Hue describes the basic feature of color i.e. only the color which contains the image. It is defined as an angle in the range $[0, 2\pi]$. Saturation is the measure of purity of color and can be measure in the range [0, 1]. It measures the amount of white color that is diluted with the color. It can be measured from the central axis to the outer surface as shown in Fig.3. Intensity or value is the brightness of the color that is generally impossible to measure; the vertical axis represents the intensity as shown in Fig.3 [7].

RGB image can easily be converted to HSV image using the following formula [5]:

$$H = \begin{cases} \theta \ if B \leq G \\ 360 - \theta \ if \ B > G \end{cases} \quad (4)$$

$$\text{With} \quad \theta = cos^{-1}\left\{\frac{\frac{1}{2}[(R-G)+(R-B]}{[(R-G)^2+(R-B)(G-B)]^{1/2}}\right\}$$

$$S = 1 - \frac{3}{(R+G+B)}[\text{Min(R, G, B)}] \quad (5)$$

$$I = \frac{1}{3}(R + G + B) \quad (6)$$

Where R, G, B represents red, green and blue component respectively with values between 0-255.

C. Detailed algorithm

The total algorithm is based on HSV color model. The brain tumor image is converted into HSV color model which separate the total image into three regions hue, saturation and intensity. Then the total process as described in the flowchart in Fig. 1 is executed using each of the three regions. First histogram equalization is done for contrast enhancement of hue region. Histogram equalization is a method for modifying the dynamic range and contrast. Then marker based watershed algorithm described in section A is applied to the contrasted enhanced image. Then edge of the image is obtained by applying canny operator to the output of the watershed algorithm. The whole process is repeated for saturation and intensity region of the image. Finally, the three output images obtained from canny edge detection is combined. The combined image is then converted to RGB color model, the model in which the image was taken.

IV. RESULTS AND DISCUSSION

The developed algorithm is executed in MATLAB platform and it is applied to twenty .jpg images. In all the cases the tumor is segmented from the brain MRI images. Here two samples are presented:

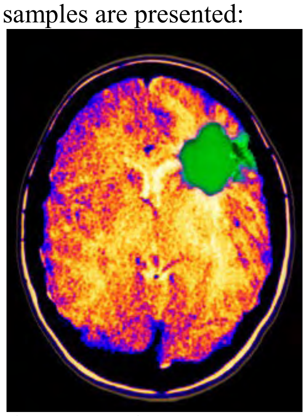

Figure 4: Sample Image1

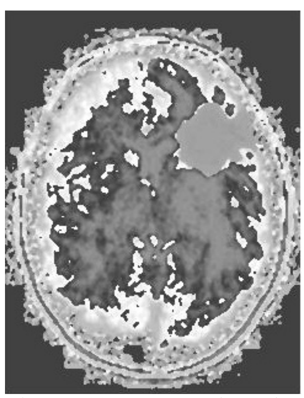

Figure 4 (a): Contrast enhanced Hue Region of Fig.4

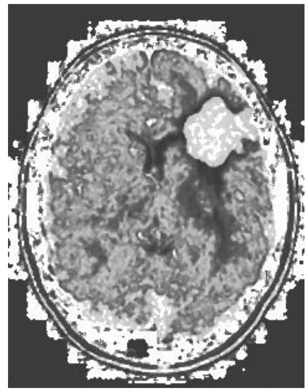

Figure 4(b): Contrast enhanced Saturation region of Fig.4

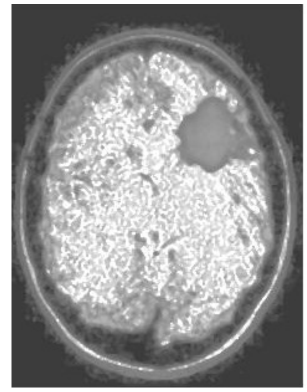

Figure 4(c): Contrast enhanced Intensity region of Fig.4

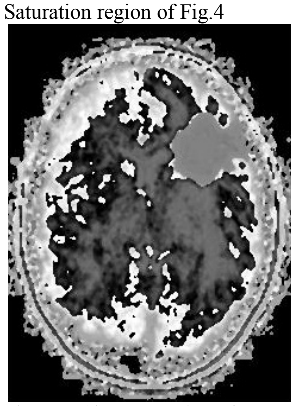

Figure 4 (d): Hue region after Watershed transform in Fig. 4(a)

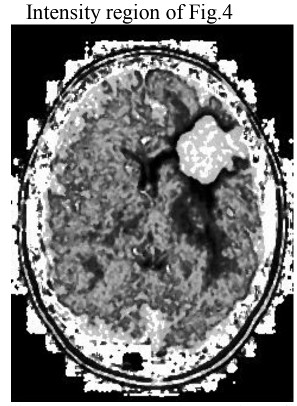

Figure 4 (e): Saturation region after Watershed transform in Fig. 4(b)

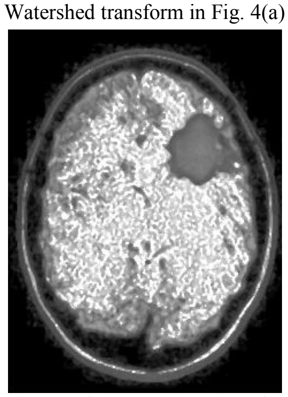

Figure4 (f): Intensity region after Watershed transform in Fig. 4(c)

Figure 4 (g): Output after applying Canny Operator in Hue Region .

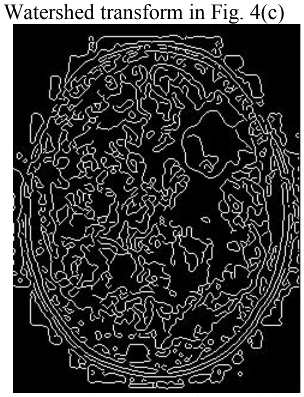

Figure 4 (h): Output after applying Canny Operator in Saturation region.

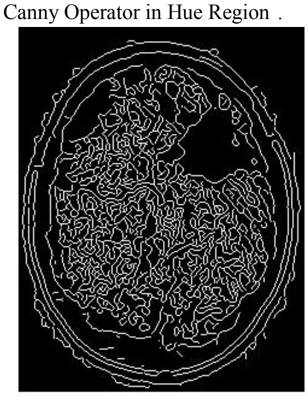

Figure 4(i): Output after applying Canny operator in Intensity region.

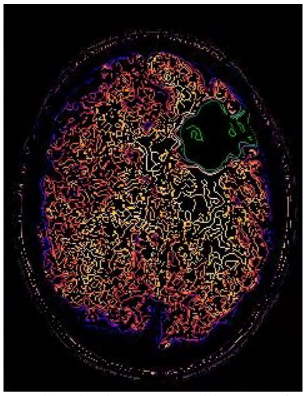

Figure4 (j): Final segmented image of Fig.4

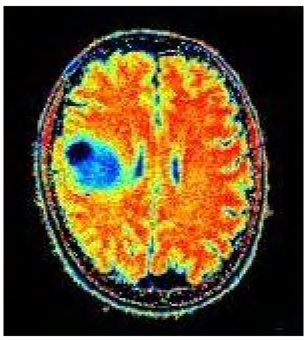

Figure 5: Sample Image2

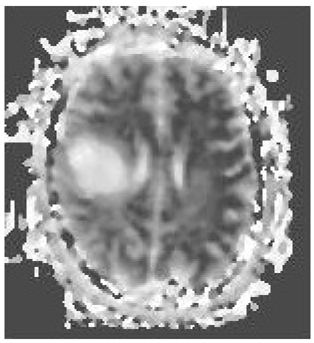

Figure 5(a): Contrast enhanced Hue region of Fig. 5

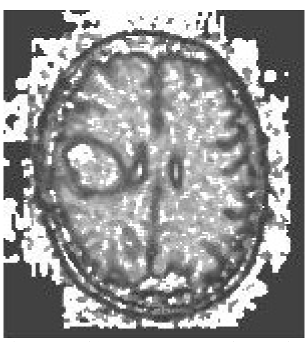

Figure 5(b): Contrast enhanced Saturation region of Fig.5

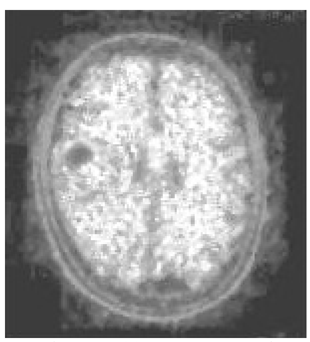

Figure 5(c): Contrast enhanced Intensity region of Fig. 5

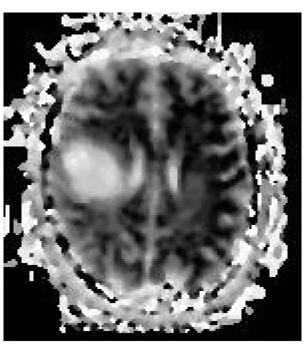

Figure 5(d): Hue region after Watershed transform of Fig. 5(a)

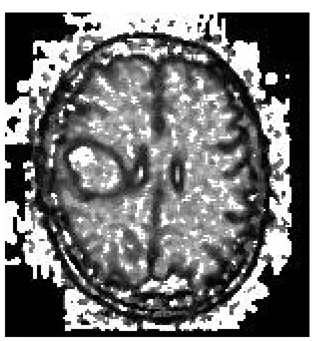

Figure 5(e): Saturation region after Watershed transform of Fig. 5(b)

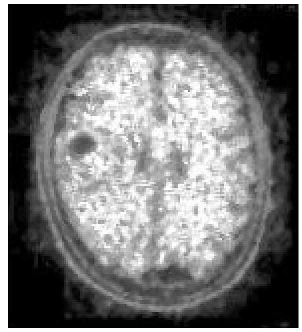

Figure 5(f): Intensity region after Watershed transform of Fig.5(c)

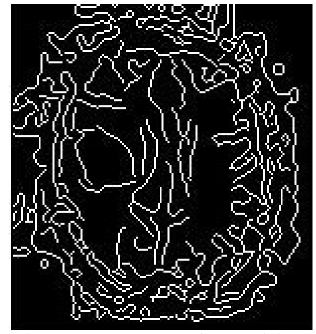

Figure 5(g): Output after applying Canny operator in hue region

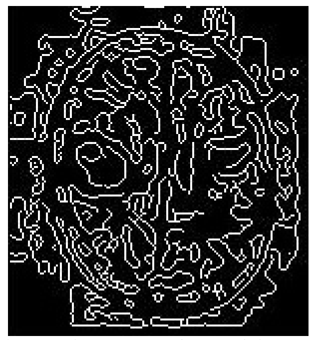

Figure5 (h): Output after applying Canny operator in saturation region

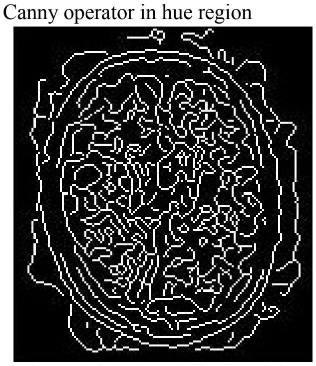

Figure5 (i): Output after applying Canny operator in intensity region

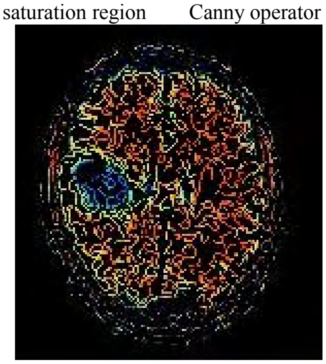

Figure5 (j): Final segmented image of Fig.5

From the above results it can be seen that the algorithm has performed well to detect the brain tumor. Tumor region can be detected effectively with the help of watershed algorithm, but after applying the canny operator the tumor portion is detected more accurately as seen from the fig5 (j) and fig4 (j).

In this work, it is found that when this developed algorithm is applied on gray image to segment the tumor region the performance is not so well as obtained in the colour model as HSV color space carries more information than the gray image. This can be said by comparing the Fig. 6 with Fig. 4(j) for Sample Image1 and Fig. 7 with Fig. 5(j) for Sample Image2.

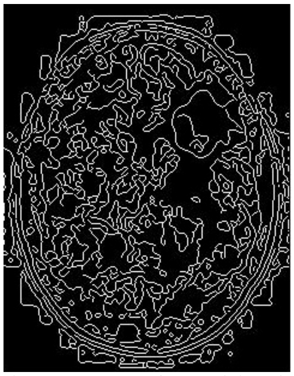

Figure6: Output after applying the algorithm in gray image

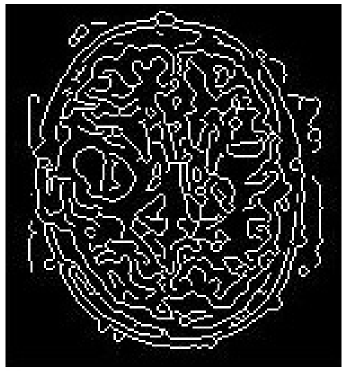

Figure7: Output after applying the algorithm in gray image

V. CONCLUSION

From the above result it can be concluded that this developed algorithm can segment brain tumor accurately.

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