Automatic Tumor Detection and Area Calculation from Brain MR Image Using Image Processing

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Abstract: **There is a big challenge in front of doctors in current days is accurate and correct identification of disease. The medical image processing is playing most important role for help of doctors. One of the most dangerous diseases nowadays is cancer. The doctors identify it by observing brain MR image. In this paper, brain MR image is converted into new form which gives easy way of separating all three matters in an image using BBHE. The equalized image is then segmented and white matter is extracted automatically. The tumor present in it also extracted using region based segmentation and area is also calculated automatically. This work will be useful for doctors and will act as supporting tool only.**

***Keywords: brain MR image, BBHE, segmentation, area*.**

I. INTRODUCTION

In today's world of very fast life, everyone is trying to maintain his/her fitness. But then also due to changing environment, no control on proper food, increase in fast food eatables, running lifetime & increase in the use of chemicals etc. number of diseases are entering in human life. So now the medical treatment should give fast & accurate results to such diseases. So this field is taking help of different technological aspects to improve outcomes. One of the mostly used technology in the medical field is digital image processing. With the different types of processes used in image processing, medical field is improving performance of diagnosis with increase in speed also. This is called 'medical imaging'.

One of the dangerous diseases in today's world is Brain tumor. Brain tumor is any mass that results from abnormal growths of cells in the brain. It may affect any person at almost any age. Brain tumor effects may not be the same for each person, and they may even change from one treatment session to the next. Brain tumors can have a variety of shapes and sizes; it can appear at any location and in different image intensities. Brain tumors can be benign or malignant [1].

The digital image processing provides help for making this work easy. Image enhancement is one of the processes for changing the look as per requirement. Enhancement is a fundamental task in digital image processing and analysis, aiming to improve the appearance of image in terms of human brightness perception. Many algorithms for image enhancement have been proposed that encompass a variety of operations such as noise removal, de-blurring, and grey-level dynamic range modification. Contrast enhancement is among them and is often part of image processing systems in the preprocessing and/or post-processing stage [2]. There are three matters in MR image as white, grey and csf. It is proved that tumor is always present with high intensity i.e. in white matter of image. For this tumor extraction, all 3 matters viz. white, grey and CSF can be extracted using different techniques [3]. With some segmentation techniques like region growing, it is proposed that tumor can be easily separated from original image. This is going to be useful information for doctors for better diagnosis. So this entire work will be like a supplementary tool for tumor specifications and extraction.

II. LITERATURE SURVEY

The MRI may contain both normal slices and defective slices. The defective or abnormal slices are identified and separated from the normal slices and then these defective slices are further investigated for the detection of tumor tissues.

Matthew C. Clarke et al. [4] developed a method for abnormal MRI volume identification with slice segmentation using Fuzzy C-means (FCM) algorithm.

In order to achieve higher degree of brightness preservation without annoying artifacts, Chen and Ramli proposed minimum mean brightness error bi-histogram equalization (MMBEBHE) [5]. Their method uses the minimum absolute mean brightness error (AMBE)—the absolute difference between input mean value and output mean value, to compute the threshold gray level to separate the input histogram. Since this algorithm is time consuming, the authors adopted an approximation approach to compute integer values of AMBE recursively to facilitate real time implementation.

Chen and Ramli also proposed another enhancement scheme called recursive mean separate histogram equalization (RMSHE) [6]. The mean of each sub-histogram is computed as the threshold gray level iteratively. This process is repeated *r* times, and generates 2*r* sub-histograms. It is mathematically confirmed that the mean brightness of the output image will converge to the one of the input image as the iteration number increases. In addition, the repeating nature of RMSHE provides scalable brightness preservation. But their method invokes two problems: how to choose optimum value of *r* and number of sub-histograms must be power of two.

For separation of three matters, researchers proposed different techniques. Evangelia I. Zacharaki et.al. present a computer-assisted WML segmentation method, based on local features extracted from conventional multi-parametric Magnetic Resonance Imaging (MRI) sequences [7].

Jorge D. Mendiola-Santiban et.al. gives method for separation of matters by morphological flat zone filtering and contrast mapping [3].

III. METHODOLOGY

On the original image, first I have applied enhancement techniques to get the new form of image having histogram showing three regions. First I have applied BBHE i.e. brightness preserving bi-histogram equalization as explained below.

A. BBHE:-

The BBHE firstly decomposes an input image into two sub-images based on the mean of the input image. One of the sub-images is the set of samples less than or equal to the mean whereas the other one is the set of samples greater than the mean. Then the BBHE equalizes the sub-images independently based on their respective histograms such that one of the sub-images is equalized over the range up to the mean and the other sub-image is equalized over the range from the mean based on the respective histograms. Thus, the resulting equalized sub-images are bounded by each other around the input mean, which has an effect of preserving mean brightness [8].

Denote by Xm, the mean of an image X and assume that Xm € [X0, X1,...., XL-1]. Based on the mean, the input image is decomposed into two sub-images Xl and Xu as

$$X = Xl \; U \; Xu$$

Where

$$Xl = \{X(i,j), X(i,j) \le Xm, \forall X(i,j) \in X$$

And

$$Xu = \{X(i,j), X(i,j) > Xm, \forall X(i,j) \in X$$

Next, respective probability density functions of sub-images are defined as:

$$Pl(Xk) = \frac{nkl}{nl} \; ; k = 0,1,\dots,m$$

And

$$Pu(Xk) = \frac{nku}{nu}; \; ; \; \mathrm{k} = \mathrm{m}+1,\dots,\mathrm{L}-1$$

Where the numerators are respective number of grey levels in lower and upper images respectively. The sum of denominators is nothing but total number of pixels in an image. The respective CDF's are given as:

$$Cl(x) = \sum_{j=0}^{k} Pl(Xj)$$

And

$$Cu(x) = \sum_{j=m+1}^{k} Pu(Xj)$$

Similar to HE, a new transformation functions for lower and upper images are defined as:

$$Fl(x) = X0 + (Xm - X0) * Cl(x)$$

And

$$Fu(x) = Xm + 1 + (Xl - 1 - Xm + 1) * Cu(x)$$

Finally, based on these functions, sub-images are equalized independently and combined to form the resultant image as output of BBHE [8].

B. White matter separation:-

The segmentation of brain MRI for tumor detection is done using matters separated from brain MRI. The brain image contains three regions as shown in fig.3.1. For the same, BBHE is applied on original image to convert the output image having histogram like figure below. The general idea is to apply thresholding on BBHE image. Note that during the enhancement process, several clear regions will be merged, thus white matter is obtained for certain grey levels [3].

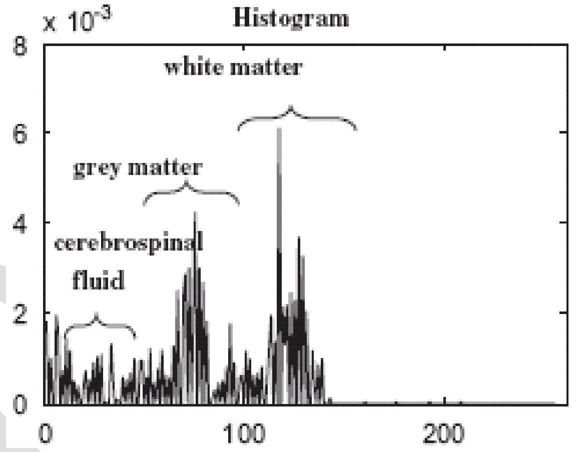

Fig.-3.1: Histogram showing all three regions

Algorithm to segment white and grey matter – [3]

(i) Compute the threshold of the BBHE image as per normalized-histogram with proper selection of intensities.

(ii) Obtain from original image, the grey levels where the binary image in step(i) takes the value of 1. White matter will be separated.

(iii) Compute point by point the arithmetic difference between the original image and the image in step (ii). Here the grey matter and other structures are detected.

(iv) Compute the threshold of the image obtained in step(iii) as per normalized-histogram with proper selection of intensities. Here, cerebrospinal fluid is eliminated.

(v) Obtain from original image, the grey levels where the binary image in step(iv) takes the value of 1. Grey matter will be separated.

C. Tumor extraction:-

It is proved that tumor is always present with highest intensity i.e. in white matter. So white matter is used for further extraction of tumor. There are some homogeneous areas present in white matter and tumor region is also homogeneous in nature. The homogeneous regions are separated using famous region growing (labeling) method. The tumor is extracted from same regions with maximum area.

D. Area calculation [9]:-

Area of tumor is the total number of pixels present in its region. It can be calculated in length units by multiplying the number of pixels with dimension of one pixel. From the properties of image, we get horizontal and vertical resolution in dpi.

$$Area\ of\ single\ pixel = \frac{1}{horizontal\ resolution} * \frac{1}{vertical\ resolution}$$

$$Area\ of\ tumor = area\ of\ single\ pixel * number\ of\ pixels\ in\ tumor\ region$$

This is area in square inch.
Final area is represented in square cm as:

$$1\ sq.inch = 2.54\ sq.cm$$

IV. EXPERIMENTATION AND RESULTS

The proposed work is implemented on a real human brain dataset collected from different hospitals from Maharashtra. All images taken for experimentation are abnormal as per radiologists report. The machine strengths of the dataset vary from 0.3T to 1T. The range of patient’s age used in dataset is 18-81 years.

A .White matter separation:-

Using BBHE method of contrast enhancement, I have separated three basic matters present in each brain MRI image using algorithm explained in 3.2.

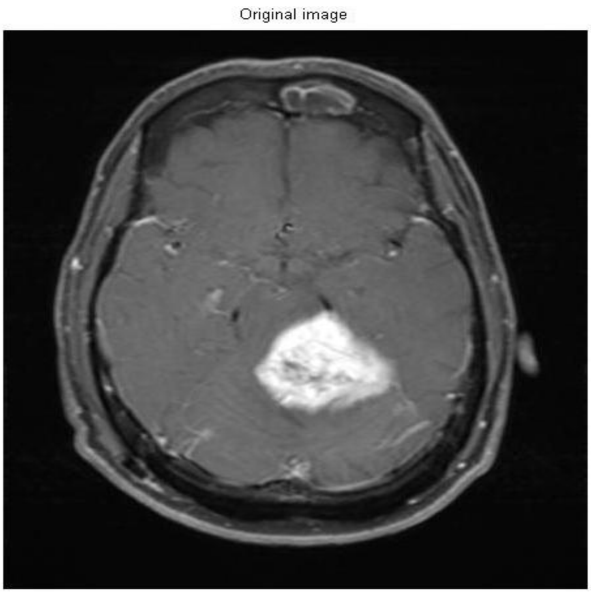

Figure 4.1: Original real image

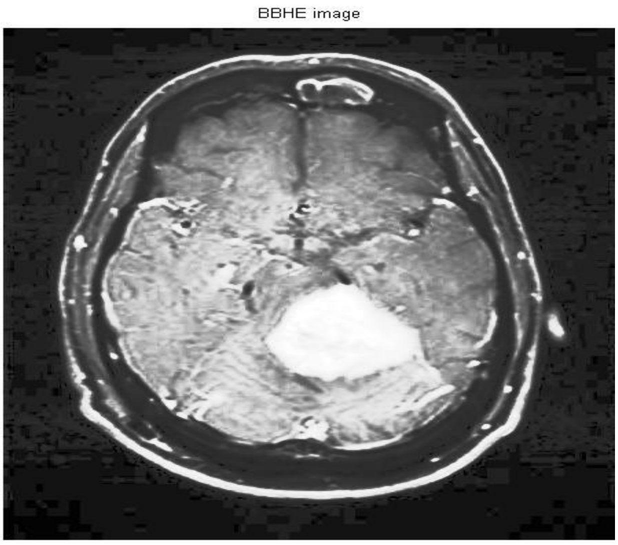

Figure 4.2: BBHE image

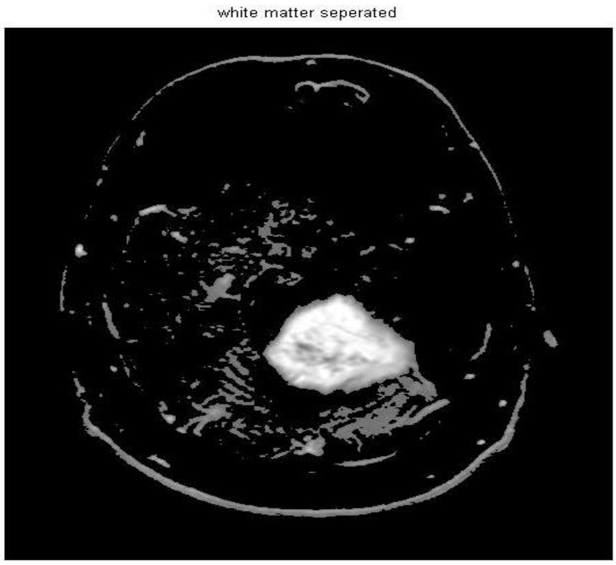

Figure 4.3: white matter

Figure 4.4: grey matter

B. Tumor Extraction:-

As theory says that tumor present in brain MRI is always with high intensity. It means that, it is always present in white matter image. So white matter image is considered for tumor extraction. By using region growing method, tumor is separated from image keeping size of image constant.

From the result, area of tumor is measures by method explained above [9].

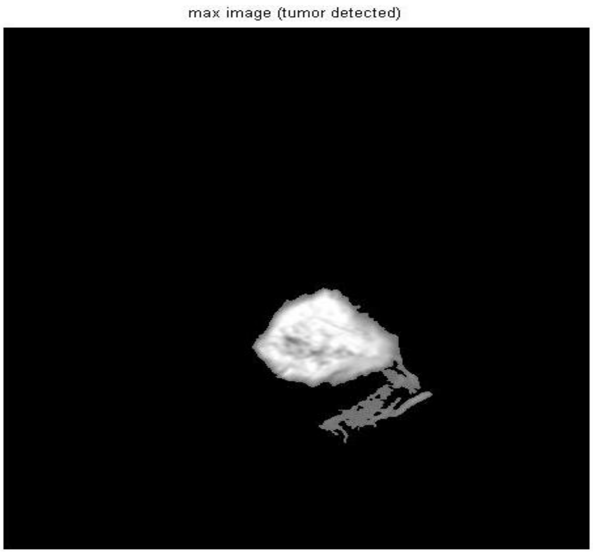

Figure 4.5: Tumor extracted

Area of tumor= 4.4572 sq.cm

Intensity of tumor= 185.7239

The database output of tumor area is verified from the radiologists and hence proved the method explained above. I have got 90% accuracy in the area calculation.

V. CONCLUSION

The work can be used for automatic tumor detection from brain MR image. Area of tumor can tell about severances of disease i.e. big tumor is more serious than small. This work can be used as computer aided diagnostic tool for doctors for tumor specification. But radiologist decision will be final.

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