DETECTION OF BRAIN TUMOR USING MAGNETIC RESONANCE IMAGES

Madhusudan B Kulkarni*1, Dr.Channappa Bhyri*2 and Dr.Kalpana Vanjerkhede*3

* PG Scholar, Department of Electronics and Instrumentation Engineering, Poojya Doddappa Appa College of Engineering, Kalaburagi, Karnataka, India
* Professor, Department of Electronics and Instrumentation Engineering, Poojya Doddappa Appa College of Engineering, Kalaburagi, Karnataka, India

Abstract— Tumor can be defined as abnormal growth of the tissues or cells in the brain. Brain tumor is an abnormal mass of tissue in which cells grow and multiply uncontrollably, seemingly unchecked by the mechanisms that control normal cells. Brain tumors are divided into two main categories that are primary or metastatic, and either malignant or benign. Magnetic Resonance Imaging (MRI) is an advanced medical imaging technique used to produce high quality images of the parts contained in the human body MRI imaging is often used when treating brain tumor. The proposed system introduces a new algorithm which takes the gradient differential as specified criteria for identification and detection of brain tumor in magnetic resonance images. This algorithm eliminates the regions of brain that doesn’t matches the criteria of maximum intensity and entropy since these are the two specified characteristics for the identification of tumor part. At last by applying extension of maximal transformation and regional transformation and by collecting the regional properties it can be noticed the most susceptible part of tumor. In proposed system, random walk solver based segmentation technique is used to detect the tumor more accurately. Experimental results on various MR images containing brain tumor verifies that the proposed algorithm has more accurate accuracy and reduced execution time which is several times better when compared with existing methods.

Index Terms— Magnetic resonance imaging, maxima transformation, random walk solver, regional transformation, spatial frequency.

I. INTRODUCTION

A mass of tissue that does originate by a gradual growth of abnormal cells is called a tumor. Usually, in our body the cells get aged, dies and then replaced by newly born cells. But in case of cancers and tumors, this cycle gets interrupt which causes to their formation. Tumor cells are those cells that grow, even though when the body does not requires them, and even when the normal old cells, they do not expire. Tumors can be either malignant (cancerous) or benign (noncancerous). The tumor cells which stay in one place in the body are called benign and are not generally life-threatening. The tumor cells are able to invade nearby tissues called malignant and scattered and spared to another parts of the body. The cancer cells, which are spreading over other parts of the body, are called metastases. Magnetic Resonance Imaging (MRI) is an advance technique to detect the tissues and the disease of brain cancer. MRI provides the different information about different structures in the body which are achieved with the help of an X-ray. Computed tomography (CT), Ultrasound but MRI is the best technique for higher quality of its images and has the advantage of lack of side effects on the body tissues. MRI technology has a magnetic field and train pulses of radio wave energy that makes pictures of structures and organs within a body. Moreover, the amount of the resultant data is analysed too much manually. It constitutes the effective use of MRI images as main hurdle and obligates the effective application of computer aided automatic or semiautomatic methods to analyse the product images. In the diagnosis analysis of MRI images, segmentation of image is required and analysis of image segmentation is very important part of any type of detection in image analysis. Image segmentation techniques help to get the meaningful information, which is very much easy to analysis. Segmentation of tumor can be done based on the edge detection technique. It also segments other unknown regions too and limited to justify the brain tumor in a particular direction of left and right. When the algorithm is applied, the position of tumor should be known for the perfect detection in left or right direction. Finding of multiple tumors is also challenging and most of techniques user interface. Biomedical signal processing in Matlab is the integrated solution of the problems in tumor detection, real time access of tissue destruction, processing and time to time scaling for pathological and biological processes. Methods used by Neurologist and Radiologist to detect the tumor it takes two stages, tumor detection and screening method. Tumor detection: if any abnormal growth in the cell, which is uncontrolled, uncoordinated. Demarcation and Quantification by Neurologist method: a) extension and location of tumor part b) locating its size and shape c) studying the Morphology [ring/solid/cyst] d) in terms of numbers [single/multiple] e) verifying the presence of edema.

Human cells are having cancer as one of the major disease. The human body contains a group of cells united together to form organs and tissues such as bones and muscles, liver and
In each cell order, genes inside each cell work, reproduce, grow, and die. Basically, human cells follow these orders, and persons remain healthy. Sometimes, these instructions are mixed together and can cause the cells to form lumps or tumors, and spreading through the lymphatic system and bloodstream to other regions of the human body.

The brain is covering 3 main parts as shown in Fig. 1:

(i) The cerebrum is the biggest part of the brain and it consists of the left and right cerebral hemispheres. It permits human body to move, see, think, feel, and speak..

(ii) The position of the cerebellum is exactly in the back of the brain and it is responsible for control and coordination and also for maintaining the body balance.

(iii) Vital bodily functions in human body, like breathing, heartbeat, and reflexes are controlled by the brain stem. Brain is connected to the spinal cord with the help of brain stem.

II. LITERATURE SURVEY

Tumor segmentation from magnetic resonance image (MRI) takes a Gradient Differential as specified criteria for extraction and detection of brain tumor. Nobuyuki Otsu [1] to get the maximum separable of gray levels as results the selection of discrimination criteria, which governs by optimal threshold. Michael R.Kaus et.al [2] the automatic algorithm allows the quick detection of brain tumor tissue with an accurate and reproduction compared to that of manual segmentation. Lynn M. Fletcher-heath et.al [3] has proposed the automated segment which has separated non-enhancement brain tumor size over time function. Aliaan pitiot et.al [4] has prescribed “detecting demarking and quantifying using a hybrid approach “focused on the tumor detection in brain and also simplifying the tumorous area. DjamalBoukerroui et.al [5] a way to implement the method is performed using a wavelet i.e. decompose into sub-bands basis and can be used for processing 2D as well as 3D data. Kristin R.swanson et.al [6] implemented a boot strapping algorithm from which we could form a statistically reliable opinion on being limits of clinically observed data. Yuri Boykov et.al [7] the composed a combinative optimized literature which provides more min-cut/max-flow methods with different polynomial time complexity. Stuart S.C. Burnett et.al [8] proposed the method by applying it to spinal canal. Segmentation is performed in three different steps: (a) partial delineation (b) a deformable-model (c) original shape into its final position. Weibei Dou et.al [9] illustrated a fuzzy model describing the tumor characteristics, the fusion based on fuzzy fusion operators and the adjustment by the fuzzy region growing based on fuzzy network connection. Kyungsuk (PETER) pyun et.al [10] HMGMMS describe the supervised learning, fitting the observation probability distribution given by each class by a gauss mixture estimated using vector quantization. Hassan Khotanlou et.al [11] has implemented a detection process which is based on selecting asymmetric areas with respect to the approximation brain symmetry plane. Jason J.Cors et.al [12] the main contribution of paper is a Bayesian formulation for incorporating soft model assignments into the calculation of affinities, which is conventionally model free. T.Logeswari et.al [13] a clustering based approach using a self organizing map (SOM) algorithm is illustrated for medical image segmentation. Sufyany.Ababneh et.al [14] the segmentation algorithm includes a novel content- based, two pass disjoint block discovery mechanism, which is design for support automation. P.Narendran et.al [15] presented an original and new method that combines region and boundary information in two phases: initialization and refinement.

III. METHODOLOGY

A. Tumor Database Images:

The Tumor Database contains various tumorous and Non-tumorous images which are collected from different standard online medical library resources such as UCI repository and are stored in database as inputs. One of the images is taken from the database input and is subjected for detection process.

B. Image Pre-Processing:

The acquired image consists of speckle noise and is of low contrast. Due to this, the image quality may not be good for analyzing. For surgical operations it is very important to identify the location of brain tumor. To overcome speckle noise, and low contrast, pre-processing of image is required. Image pre-processing plays an vital role in the digital image processing. Here image pre-processing is carried using median filter. Median filter acts as noise removal non linear tool. In this filtering technique each image pixel is replaced by the neighborhood median pixel.
C. Contrast Enhancement:

To improve contrast and to obtain uniform intensity histogram equalization, the Gamma transformation technique is used. This technique is an inbuilt function of matlab. This approach can be used on whole image or part of an image. In this system, enhancing the contrast of images is done by transforming the values in an intensity image, such that the histogram of the output image approximately matches a specified histogram. The output signal is of same data type as the input signal.

D. Regional Properties:

In regional properties, the image is segmented into four quadrants and then evaluates two basic properties named entropy and intensity for each quadrant window individually. The purpose of division has been done due to rather than working on whole image, only focus on that quadrant which has the tumor portion.

E. Random walk solver method:

Random walk solver method is one which is used for MRI segmentation. Random walk solver is an advanced technique of region growing. This random walk solver method is a built-in function of matlab. It takes the seed pixel as input. Probability of each pixel being foreground is found and further segmented based on the threshold value.

F. Detected input images tumorous/Non-tumorous:

Finally, the images taken from database are pre-processed, enhanced and segmented accordingly, thus the tumor detected images are displayed as tumorous and normal images without containing tumor region are displayed as non-tumorous respectively.

IV. BUILDING DETECTION ALGORITHM

The proposed algorithm describes the method of using spatial frequency for combining the image modeling techniques, extension of maximal transformation and regional maximal transformation.

Step 1: Input images are taken from folders and read using Matlab software.

An Input image or digital image is just a data arranged in a form of matrix. It has numbers as data which demonstrates red, green, and blue and their modification at a peculiar location. An image is read by using imread command in matlab. However this command is used to read image from graphics file. Then need to convert from colored image into a grayscale image. For this conversion there are two basic methods. First is Average method and another one is weighted method or luminosity method. Average method is the simplest one as we can take just the average of three colors (Red, Green and Blue).

\[
\text{Grayscale image} = \frac{R + G + B}{3}
\] ..........................(4.1)

But due to this conversion the image is turned out to black image. These problems arise due to the average of the red, green and blue colors and these colors have three different wavelengths so they contribute in their own way while forming an image. The solution to this has been given by luminosity method. As we know that the wavelength of color red is more than other two components, another color green gives to the eyes a soothing effect and moreover it’s values of the wavelength is less than that of red color. Further it has to be decreased with the significance of red color, and enhance the contribution of the green color, and set the range of blue between these two. New equation formed will be:

\[
\text{New Grayscale image} = (0.3 \times R) + (0.59 \times G) + (0.11 \times B)
\] ..........................(4.2)

Accordingly the Red has contributed 33%, Green is 59% (> red and blue colors) and Blue is just 11%.
Fig. 3: Flow Diagram of Proposed system

Step 2: Pre-processing is done using median filter to remove noise.
In this pre-processing technique, a median filter is used for noise removal or noise suppression which is a critical responsibility. Due to its property of preservation of the edges during smoothing this denoising method had helped in retaining the information. It is a nonlinear operator as the pixels are arranged in a local window in accordance to their intensity values and finally replacing the value of the pixel in the result image by the middle value in this order.

Step 3: Gamma transformation (Contrast enhancement) is applied for the images.
The contrast enhancement is one of the most important aspects in image processing technique; the process of contrast enhancement technique plays a critical role in enriching the medical images quality, which is used to improve quality of input images and thus provides clearer and smoother images for better and easier screening process. The command imadjust is a Matlab inbuilt function that creates Gamma transformation. With the help of gamma \(\gamma\) transformation we will be able to curve the components of the grayscale towards the brightening up the intensity (if \(\gamma < 1\)) and on the other hand it would darken up the intensity of the pixels (if \(\gamma > 1\)). Gamma is a supreme characteristic for almost entire digital imaging systems. Gamma exemplifies the association of numerical values of pixels and its luminance. If the gamma is left out, the colors grabbed by the cameras would not come out as they normally seen by our eyes (on a standard monitor). This technique could be called as gamma compression, gamma correction or gamma encoding, but basically all these are referred to a congruent theory. Gamma correction can be defined as the function to calculate gamma correction for a particular image is given by:

Correction= \text{gammacorrection}(\text{InputImage},\Gamma) \quad \text{.................} \quad (4.3)

Where, InputImage is input image file; GammaValue (\(\gamma\)) is gamma correction factor; if not specified gamma=1.

Step 4: Segmenting the image into Quadrants.
In this step, the applied Image is segmented into four equal parts further the max and min values of both intensity and entropy are calculated based on standard formulae. Random walk is a walk or series of steps where each step taken by the object is independent of the previous step. It is also known as a Drunken walk method. A random walk is a mathematical formalization of a path that consists of a succession of random steps. Random walk solver method is used for MRI segmentation. Random walk solver is advanced method of region growing.

Step 5: After dividing image into four equal quadrants, calculate max and min values of pixels in each quadrant:
Further divide an MRI image into four equal quadrants and evaluate the two basic properties i.e. entropy and intensity for each quadrant window individually. The division has been done due to the purpose that rather than working on whole image, only focus on that quadrant which behaves as most suspected to have the tumor. The entropy could be explained in the following way:

\[ E_{\text{tp}} = - \sum(p.*\log_2(p)) \quad \text{.................} \quad (4.4) \]

Where, \(p\) contains the histogram counts returned from imhist.

Intensity adjustment is an image enhancement technique that maps an image's intensity values to a new range.
Spatial frequency (SF) is written by the following equation:

\[ SF = \sqrt{(RF)^2+(CF)^2} \quad \text{.................} \quad (4.5) \]

Where, RF and CF are Row frequency and Column frequency respectively.

Step 6: Build matrix for intensity and entropy for analysis and pick the quadrant having max values of intensity and entropy.
Next step is to build the matrix for the values of intensity and entropy so that the quadrant is selected based on which work has to be done and ignoring all other quadrants except the one which is having maximum values of intensity and entropy. The quadrant which possesses highest values of entropy and intensity is now found, since these two parameters of the tumor portion are always at maximum in the image as compared to other parts of the image.

**Step 7:** Calculate temporal lower bound of threshold, using upper and lower bound threshold to the target quadrant.

A temporal lower bound threshold is applicable to normal image observation models involving degradations of blur, signal-dependent and signal-independent noise, and sensor nonlinearity is derived. Lower bound on average mean-square errors for any unbiased image restoration scheme is derived. This bound is analytically expressed as a function of degradation parameters of imaging systems. Further the calculated values of upper and lower bound threshold are applied onto the targeted quadrant.

**Step 8:** Apply extended maxima transformation, Regional maxima transformation.

Under this scope, the extended maxima transformation is applied in which we get the maximum (plural: maxima) of a function (intensity range that represents the tumor), known collectively as extrema (singular: extremum), and thus the largest value of intensity represented as function is found, which takes at a point either within a given neighborhood quadrant (local or relative extremum) or on the function domain (image under observation) in its entirety (global or absolute extremum) and finally the applying of regional maxima, which are nothing but the connected components of pixels with a constant intensity value, and whose external boundary pixels all have a lower value which do not represent the tumor part.

**Step 9:** Run Region properties.

Here the scenario is to know about the properties of a particular connected component (or say object) in order to identify it. In this context, the major task is to detect the tumor present in human brain which is considered as a connected component. Now to verify, whether it’s a tumor or not, apply regionprops which is built-in command of Matlab over that portion to validate its identity. Also need to be concerned with the solidity property (known as convexity) of the region. Solidity is the ratio of an area of an object to that of some other enclosing container. The solidity property of the region specifies the proportion of the pixels which are in the region also in the convex hull. It could be computed as area or convex area. Solidity is bit tough, but probably a good distinguisher of cells with projections or uneven shape v/s round cells generally within the region (intensity and entropy are also high).

**Step 10:** Mark the Boundary around the area which matches to the Max profile.

Under this step, the boundary line around the detected tumor portion is being built up so that the area of tumorous region could be clearly visible and easily differentiated and hence the most susceptible part of tumor portion is detected accurately.

**V. RESULTS AND DISCUSSIONS**

![Image 1](a) (b) (c) (d)

Image 1: a) Image with brain tumor b) Enhanced image c) Regional properties d) Tumor region in first quadrant

![Image 2](a) (b) (c) (d)

Image 2: a) Image with brain tumor b) Enhanced image c) Regional properties d) Tumor region in second quadrant

![Image 3](a) (b) (c) (d)

Image 3: a) Image with brain tumor b) Enhanced image c) Regional properties d) Tumor region in third quadrant
Image 4: a) Image with brain tumor b) Enhanced image c) Regional properties d) Tumor region in fourth quadrant

Table No. I: Results for four different cases containing Tumor

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Im g. 1</td>
<td>Quad I</td>
<td>59</td>
<td>0.728</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>577</td>
<td>0.4851</td>
</tr>
<tr>
<td>Im g. 2</td>
<td>Quad II</td>
<td>163</td>
<td>1.413</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>424</td>
<td>0.8418</td>
</tr>
<tr>
<td>Im g. 3</td>
<td>Quad III</td>
<td>121</td>
<td>0.816</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1338</td>
<td>0.5044</td>
</tr>
<tr>
<td>Im g. 4</td>
<td>Quad IV</td>
<td>76</td>
<td>1.403</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>109</td>
<td>0.8028</td>
</tr>
</tbody>
</table>

From the above experimental analysis, the results obtained for different images containing brain tumor in different regions of quadrants namely I, II, III and IV respectively, as recorded in the table no. I describe the comparison between existing and proposed system in terms of tumor size and execution time respectively. For example, consider the acquired results of Image No. 3: where the tumor part detected in the quadrant III, here the tumor size (in pixels) for the existing system was recorded as 121 pixels, but when with respect to the proposed system using random walk solver method the tumor size recorded 1338 pixels. Now consider the acquired results of Image No. 1: where the tumor portion detected in the quadrant I, here the execution time (in seconds) for the existing system was recorded as 0.7287 seconds, but when with respect to the proposed system using random walk solver method the execution time recorded 0.4851 seconds. It is clear that the proposed system is much better than the existing system in both acquiring the size of tumor portion in pixels and reduced execution time.