A Morphological Filtration Approach towards Brain Tumor Segmentation

Kumar Mohit[1] Rajan Mishra[2]
[1,2]Department of Electronics & Communication Engineering
[1,2]Madan Mohan Malaviya University of Technology, Gorakhpur (U.P)-273010

Abstract— The presented work through this paper is outcome of need for correct brain tumor identification, which is done here through a handy approach of segmenting tumor portion from different MRI slices taken of different patients. Tumor, which is of swelling appearance, is abruptly growth of cells in brain, causes a painful death. It's correct diagnosis and within less time is necessary, which has been tried to achieve through this paper. Paper shows serially connected steps of image process, consisting pre-processing using thresholding through morphological opening, watershed segmentation, entropy filtration, and again morphological opening for tumor extraction, performed via MatLab software. Idea behind is using high intensity value of image which is normally tumor indication. This algorithm is very efficient for best case of tumors and equally helpful for other cases, as area, centroid, pixel info and condition can be determined through present work.

Key words: Pre-Processing, Morphological Filter, Watershed Segmentation, Entropy Filter

I. INTRODUCTION

The growth of cells are specified within a life cycle, but when it started growing abnormally, it affects human body, and in a brain it causes tumor, which can be viewed as a swelling part. It is very painful disease and if it is not cured at early stage, it causes death. It can be classified into two types, as- Benign and Malignant. While Benign grows within the brain and does not spread over other areas and hence it not causes cancer, Malignant grows within the brain or may come from other tissues and grows rapidly over other areas also and hence causes cancer. Its symptoms can be viewed as headaches which go away after puking, vision problem, unconsciousness etc. [1]. Detection of tumor with its correct size within less time and early stage is equally important task, which in many places is done manually [2]. Its diagnosis is done medically examining along with MRI or CT scan, which is usually conformed through Biopsy. Chemotherapy, Radiation therapy or surgeries in combination, etc. are done for treatment [3]. Physician or Radiologist generally use CT scan or MRI scan brain image for detection, while MRI methodology is normally preferred over other method because it doesn't use radiations, so not harmful to human body, instead MRI uses magnetic field of about 1.5Tesla with radio frequency waves of 64MHz approx. for imaging of parts of body through scanning. Hence, MRI images are taken in this paper [4]. MRI slices affected by tumor conclude tumor area as high intensity pixels and rest as low intensity pixels[5] and front view of brain MRI is vertically symmetrical[6].

Morphology is normally applied to digital images, because it operates on pixel values of images, but it can also be applied to other spatial structures. It can be employed to binary or grayscale images. In other words it can be said as different structures and shapes study, where acting as a filter, information from an image is eliminated and retained according to shape of interest. Morphological analysis of medical images is a topic of interest, being popular rapidly in a variety of research and clinical studies that investigate diseases based on its properties. Region of interest has been traditionally used to investigate abnormal tissue structures with disease [7].

Segmentation is process of partitioning the image into different parts having similar features. Watershed can be defined as a region that drains water towards steep slope of the path along watershed ridge lines. It is a geographical term, seen as water falling from topographical area which is flooded with water, towards steepest region of attraction, known as catchment basin of a heightmap [8]. In image processing, this concept is used to segment objects in an image. It is region based segmentation technique where contrast between two minimum regions is preserved in watershed function. This contrast is same as minimum high surface joining two catchment basin in topographical region. Image is reversed on binary scale and watershed algorithm is applied because watershed ridge lines are labeled as 0 in the algorithm and so portion of our interest is changed into catchment basins, which construct one pixel thick segmentation line between two dissimilar objects [9]. The watershed segmentation technique has been widely used in medical image segmentation which make use of the watershed transform to segment gray and white matter from magnetic resonance (MR) images [10].

II. METHODS

The proposed system has mainly four steps which have been proceeded in MatLab software environment:

Pre-processing, segmentation, feature extraction, and recognition of the tumor shape and position in MRI image. Pre-processing is done by morphological filtering. Segmentation is carried out by watershed algorithms and entropy filtering. Extraction is by thresholding and finally, approximates reasoning method to recognize the tumor shape and position in MRI image. In the literature survey many algorithms were developed for segmentation but they are not good for all types of the tumor cases.

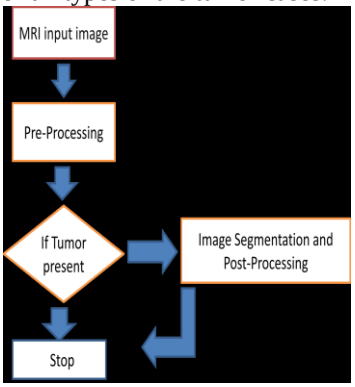


Fig. 1: Flowchart of proposed method

A. Pre-Processing

Pre-processing stage removes the noise and high frequency unnecessary data's present in the image, which can affect results. It removes the patient details and other marks present in the image. There are numerous methods available for pre-processing technique. This process is carried here by using morphological filter because at the same time it is useful for tumor identification. Pre-processing has been also focused in order to save processing time by initially checking presence of tumor and then further approach towards segmentation if necessary to give estimation of tumor existence, its shape and area.

This theory has been concluded through two basic steps.

1) Making use of the fact that tumor have highest pixel intensity than many other brain tissues pixels, we have used an algorithm based on morphological filter that will give a rough estimation of presence of tumor. Changing MRI standard image into grayscale image, we have applied tresholding function and retained image having pixels value greater than 240. This in a rough fashion dictates tumor presence and its orientation.
2) Brain image is vertically symmetrical when viewed from front and this can be an effective approach for tumor knowledge in less time as tumor is a random growth of cells, it is not symmetrical. For this approach, algorithm use morphological filter in a fashionable way to remove noise first and obtain a clear image, and then image is divided vertically into half. At the same time histogram of each part is plotted and matched. Histogram is plot of no. of pixels on y-axis vs. intensity of pixels on x-axis. Mismatching resembles tumor and so further proceeded for extraction part. Morphological filtration is performed by opening the image given by mathematically as-

$$A.B = (A \oplus B) \ominus B$$

B. Segmentation

Watershed function is employed for segmenting the objects in the image because it has an advantage of accuracy over other method in less time, although it may lead to over segmentation of regions. For that purpose entropy filter and morphological filter has been used.

In this region based segmentation technique contrast between two minimum regions is preserved in watershed function. This contrast is same as minimum high surface joining two catchment basin in topographical region. Image is reversed on binary scale and its distance transformation is calculated and watershed algorithm is applied, so portion of our interest is changed into catchment basins, which construct segmentation line between two dissimilar objects. Function identifies watershed ridge lines in input image where light pixels are considered to be high elevation and dark pixels to be low elevation. Based on the principle, watershed algorithm creates labeled matrix, which is an integer matrix whose elements 1 represent first watershed segmentation, 2 represent second, and so on. Element value 0 does not belong to a specific watershed region. Then watershed segmented image is passed through negate entropy filter. Entropy filter is a texture filter and creates texture of an image statically whose values reveals locally alteration of pixel intensity in an image. So, this filter can give desired result where biological object or tissues changes based on smoothness of the area.

C. Extraction

Tumor image extraction is done through applying thresholding function (T) on image pixels p(i,j). It can be given as-

$$f(x,y) = p(i,j) > T$$
$$= 0 \text{ if } p(i,j) < T$$

The output of the thresholding operation is f(x,y) which will represent only tumor image in its original representation, although it can be changed into binary image through this thresholding according to requirement of light tumor cases. Changing into binary image will also be helpful for tumor characteristics calculation.

D. Approximate Reasoning

Approximate reasoning is done for characterizing of tumor through its area, centroid and image pixels. This will help in proper diagnosis and treatment. From area calculated, stage of tumor can be known. If the area calculated comes greater than $6mm^{\wedge 2}$, then this denote critical case [4]. Centroid and image pixels are known through inbuilt region property function 'regionprops' in MatLab. For area calculation we need to change resultant image into binary image [4]. Then number of white pixels(w) are counted and according to following formula, area is calculated taking one pixel size = 0.264mm.

$$\text{Area} = (0.264 * \sqrt{w})\ mm^{\wedge 2}$$

Area is an important factor for curing tumor.

III. Algorithm

The basic algorithm for solution to current problem is given as-

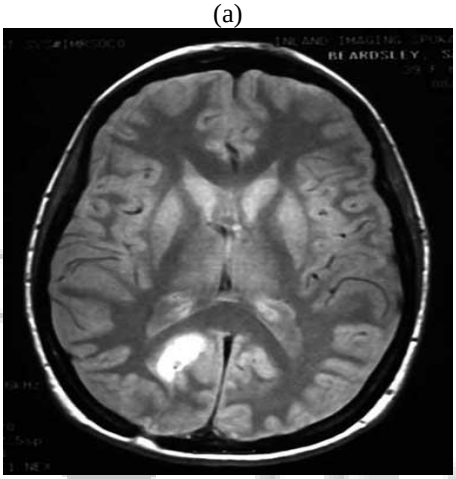
1) Obtain MRI image.
2) Convert it into grayscale image.
3) Perform morphological opening of the image.
4) Perform threshold filtering to reduce noise particles.
5) Divide image into two parts vertically.
6) Plot histogram of both parts and match.
7) If mismatches, proceed further.
8) Take complement of the image.
9) Calculate its distance transform.
10) Negate this matrix.
11) Apply watershed function to this matrix.
12) Calculate segmentation on the original image by comparing original with watershed matrix.
13) Apply negate entropy filter on this image.
14) Extract the image.
15) Perform thresholding to extract tumor image.
16) Apply approximate reasoning to calculate area and other characteristics.
17) Stop the program.

IV. Programming Result

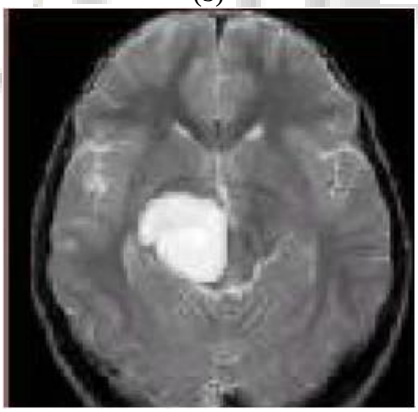
Proposed methods have been successfully evaluated and its result has been obtained in MatLab software environment. Result has been shown through various figures evaluated from basically grayscale converted image from different

MRI employed, some of which has been shown in this paper in this section. Following MRI images had been taken for our experiments.

(a)



(b)



(c)

Fig. 2: (a)-(c) are Input images.

Result obtained from pre-processing first algorithm performed on image (a) is as-

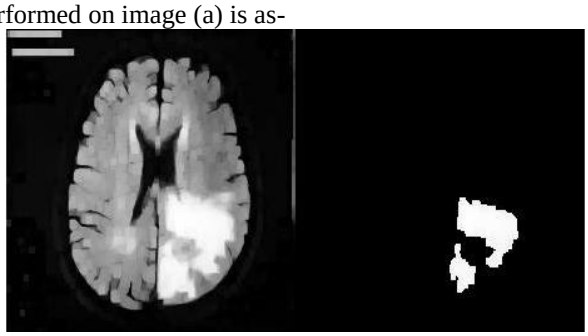


Fig. 3: Morphological thresholding

Result of pre-processing second algorithm performed on image (b) is as-

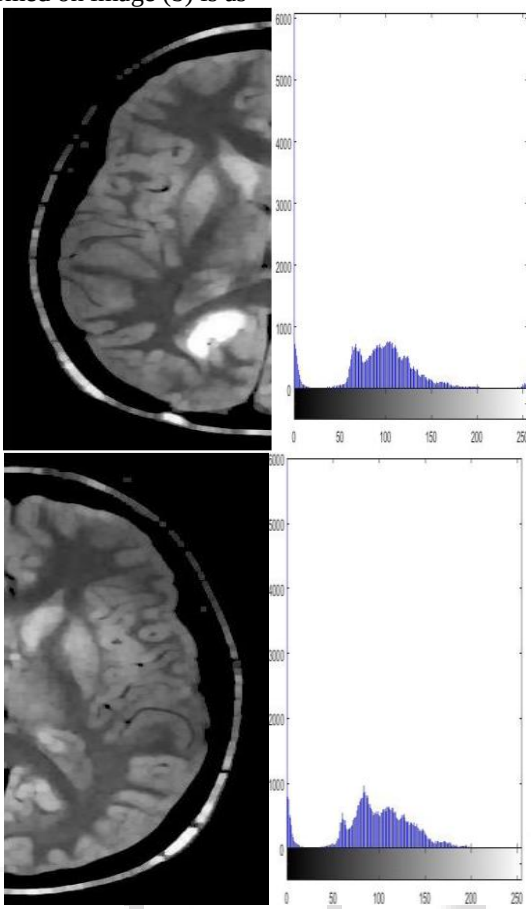


Fig. 4: Mismatching of histogram

Result obtained from main algorithm performed on image (c) is as-

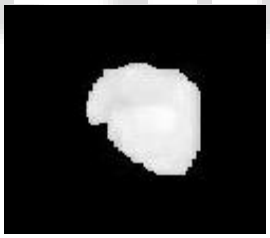


Fig. 5: Tumor extraction

Tumor characteristics from approximate reasoning and MatLab functions on image (a), (b), (c) is as follows-

Image	Area (mm^2)	Centroid (r,c)	Tumor pixels (r*c)
a	11.56	148,151	122*80
b	10.58	184,392	460*296
c	10.58	118,149	51*51

Fig. 6: Table of tumor characteristics

V. CONCLUSION

Proposed technique is advantageous approach over manual characterization of brain tumor, hence can be applied for tumor extraction in clinical approach under radiologist supervision. Algorithm has been performed on various MRI images of various cases and results stated accordingly, which have been well succeeded in achieving goal. A new texture filter based on entropy of image for smoothing segmented image is introduced for better result. Apart from

segmentation part, focused has been made on pre-processing part too, in which through various methods an easy approach is employed to investigate tumor and its properties, rather than first jumping to hectic segmentation module. It is beneficial in term of saving time also, as there are sometimes lots of patients to be examined by a good neuro-surgeon. Noise and other disturbing data's are excluded using morphological filter itself.

VI. AUTHOR DETAILS

[1]Electronics and Communication Engineering Department, MMM University of Technology, Gorakhpur, U.P, India.
[2]Assistant Professor, Electronics and Communication Engineering Department, MMM University of Technology, Gorakhpur, U.P, India.

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