IOSR Journal of Computer Engineering (IOSR-JCE)
e-ISSN: 2278-0661,p-ISSN: 2278-8727, Volume 17, Issue 1, Ver. 2 (Jan – Feb. 2015), PP 01-05
www.iosrjournals.org

Brain Tumor Segmentation and Extraction of MR Images Based on Improved Watershed Transform

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Abstract: *Brain tumor extraction in magnetic resonance imaging (MRI) has becoming an emergent research area in the field of medical imaging system. Extraction involves detection, localization, tracking, enhancement and recognition of the tumor from the MR brain images. Brain tumor extraction helps in finding the exact size and location of tumor. The watershed transform is a popular and has interesting properties that make it useful for many image segmentation applications. The intuitive description of this transform is quite simple, can be parallelized and always produces a complete division of the medical images. One of the important drawbacks associated to the watershed transform is the over segmentation that commonly results in brain images. We present an improvement to the watershed transform in this paper for the extraction of brain tumor based on segmentation and morphological operator. The tumor may be benign, pre-malignant or malignant and it needs medical support for further classification.*
Keywords: *Brain Tumor, Morphological Operators, MRI, Segmentation, Watershed*

I. Introduction

In medical imaging, segmentation of tissues and structures plays a vital role in many image analysis applications developed for medical diagnosis [1]. Image segmentation helps in diagnosis of brain diseases and helps in quantitative analysis of MR images such as measuring accurate size and volume of extracted portion. Exact measurements in brain diagnosis are difficult because of different shapes and sizes of tumor [2, 3]. Treatment plans and evaluation of disease progression of that disease affect specific tissues or structures, lead to loss and abnormalities. An accurate, reliable, and automatic segmentation of these tissues and structures can improve diagnosis and treatment of brain diseases [4, 5]. Manual segmentation is bias and usually accurate but is impractical for large datasets because it is tedious and time consuming. Automatic segmentation techniques can be useful for clinical applications if they have: ability to segment like an expert, excellent performance for diverse datasets and reasonable processing speed for large datasets because it is tedious and time Consuming [6, 7].

Brain tumor is one of the major causes for increasing mortality among children and adults. A tumor is a neoplasm which is formed by an abnormal growth of cells. Brain tumors can be separated into two general categories depending on the tumors origin, their growth pattern and malignancy. Tumors that arise from cells in the brain or from the covering of the brain are called primary brain tumors. Tumors occur when cancer cells spread to the brain from a primary cancer in another part of the body are called secondary brain tumors. It has been concluded from the research point of view that the number of people suffering and dying from brain tumors has been increased perhaps as much as 300 over past three decades. The best type of imaging to diagnose most types of brain tumors is MRI [8, 9]. This technique is basically used to detect the differences in the tissues which have a far better technique as compared to computed tomography. So this makes this technique a very special one for the brain tumor extraction. In this paper we purpose an improvement to the watershed transform for accurately detecting the location of brain tumor in MR images.

This research paper is organized as follows. In Section II, the proposed watershed transform is described. Experimental results and comparison with existing extraction algorithms are presented in Section III. Finally, conclusions and discussions come in Section IV.

II. Proposed Technique

The proposed technique for the extraction of brain tumor consists of the following processes, as shown in Fig.1. Pre-processing, improved watershed transform, morphological operations and resulting in the brain tumor designate confirmation. We now discuss the above mentioned steps in detail:

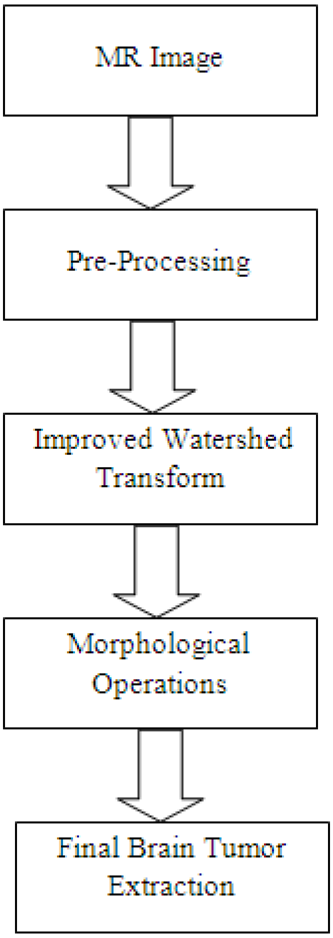


Fig.1. Flow Chart of Proposed Technique

2.1 Preprocessing

In this stage MR brain image is enhanced in the way that finer details are improved and noise is removed from the image. Commonly used enhancement and noise reduction techniques are implemented that can give best possible results[10]. Enhancement will result in more prominent edges and a sharpened image is obtained, noise will be reduced thus reducing the blurring effect from the image. In addition to enhancement, image segmentation will also be applied. This improved and enhanced image will help in detecting edges and improving the quality of the overall image. Edge detection will lead to finding the exact location of tumor [11].

In this work sobel edge-emphasizing filter is used to sharpen the MR brain image as we need the sharp edges because this will help us to detect the boundary of the tumor.

2.2 Methodology

2.2.1 Watershed Transform

Watershed transform [2] is a most efficient segmentation technique coming from the field of mathematical morphology. The intuitive idea of this transform is quite simple: if we consider the image as a landscape or topographic relief, where the height of each point is directly related to its gray level, and consider rain gradually falling on the terrain, then the watersheds are the lines that separate the “lakes” actually called catchment basins that form. The watershed transform is computed on the gradient of the original image, so that the catchment basin boundaries are located at high gradient points. This transform has been widely used in many fields of image processing, including medical MR image segmentation, due to the number of advantages that it possesses: it is quite simple, intuitive, fast, parallelized technique and produces a complete division of the image in separated regions even if the contrast is poor, thus avoiding the need for any kind of contour joining. Some important drawbacks associated to the watershed transform are the over segmentation and poor detection of significant areas with low contrast boundaries that commonly results in MR brain images.

2.2.2 Marker Controlled Watershed Segmentation

Touching objects separation in an image is one of the most difficult works in medical image processing. The watershed transform is often applied to this problem. The watershed transform finds catchment basins and watershed ridge lines in an image by treating it as a surface where light pixels are high and dark pixels are low. Segmentation using the watershed transform works better, if you can identify or mark foreground objects and background locations. Marker-controlled watershed segmentation follows this basic procedure [11]:

i. Compute a segmentation function. This is an image whose dark regions are the objects you are trying to segment.
ii. Compute foreground markers. These are connected blobs of pixels within each of the objects.
iii. Compute background markers. These are pixels that are not part of any object.
iv. Modify the segmentation function so that it only has maxima at the foreground and background marker locations.
v. Compute the watershed transform of the modified segmentation function.

2.2.3 Improvement of the watershed Transform

In medical images, the markers selection and extraction are not so easy. Some images may be very noisy and image processing becomes more and more complex. In some cases, the objects to be detected may be so complex and so varied in shape and size that it is very hard to find improved algorithm enabling their extraction. For that reason, we need to go a step further in the segmentation approach. We know that the initial watershed transformation of the gradient image provides very unsatisfactory results many apparently homogeneous regions are fragmented in small pieces. Fortunately, the watershed transform itself, applied on another level, will help us to merge the fragmented regions. Indeed, if we look at the boundaries produced by the segmentation, they do not have the same weight. Those which are inside the almost homogeneous regions are weaker. In order to compare these boundaries, we need to introduce neighborhood relations between them. The improved watershed transform presents some advantages: The watershed lines always correspond to the most significant edges between the markers and it always detects a contour in the area; where there are no strong edges between the Markers. This contour will be located on the pixels with higher contrast. In this work we first remove the noise from the image and pixel values are adjusted so that they will help to obtain the well segmented image.

2.3 Morphological Operations

Mathematical morphology [8, 11] commonly refers to a broad set of image processing operations that process images based on shapes. Morphological operations selects appropriate structuring element of the processed image and makes use of the basic theory of morphology including erosion, dilation, opening and closing operation and the operations of them to get clear MR image edge. In the process, the synthesized modes of the operations and the feature of structuring element decide the result of the processed image. Detailed saying, the synthesized mode of the operation reflects the relation between the processed image and original image, and the selection of structuring element decides the effect and precision and the result. Therefore, the keys of morphological operations can be generalized for the design of morphological filter structure and the selection of structuring element. In brain tumor extraction, we select disc shaped structuring element by texture features of the image and the size, shape and direction of structuring element must been considered roundly. By the operation features of morphology, erosion and dilation operations satisfy:

$$\mathbf{F} \ominus \mathbf{B} \subseteq \mathbf{F} \subseteq \mathbf{F} \oplus \mathbf{B} \qquad (\mathbf{1})$$

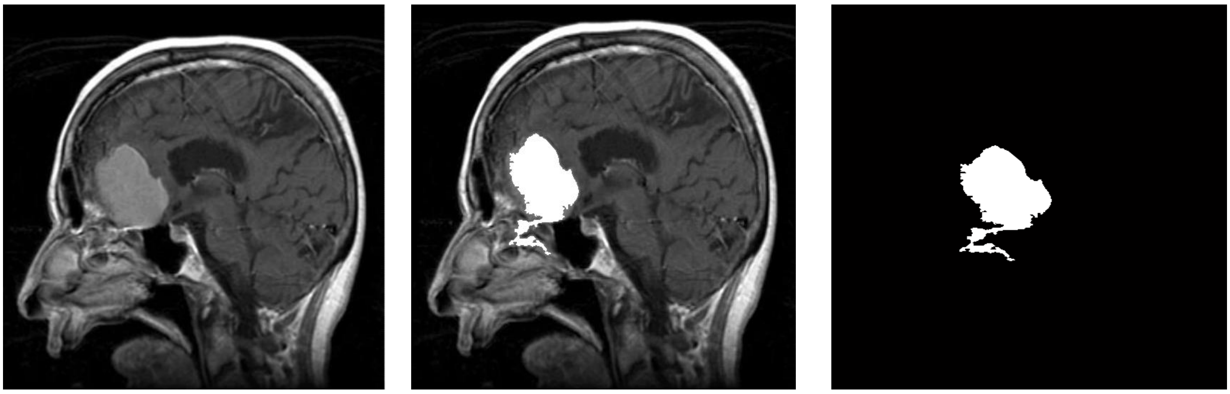
Where, F denote a gray scale brain image,B denote structuring element.Opening and closing operations satisfy:

$$\mathbf{F} \circ \mathbf{B} \subseteq \mathbf{F} \subseteq \mathbf{F} \cdot \mathbf{B} \qquad (\mathbf{2})$$

In this work morphological operations are applied on the converted binary image. The purpose of the morphological operators is to extract the tumor part of the MR images.

III. Experimental Results

A large data set consisting of a number of MR tumor images has been collected; all patients have ages ranging from 18 to 60.Their MRI scans were stored in database of images in JPEG format.

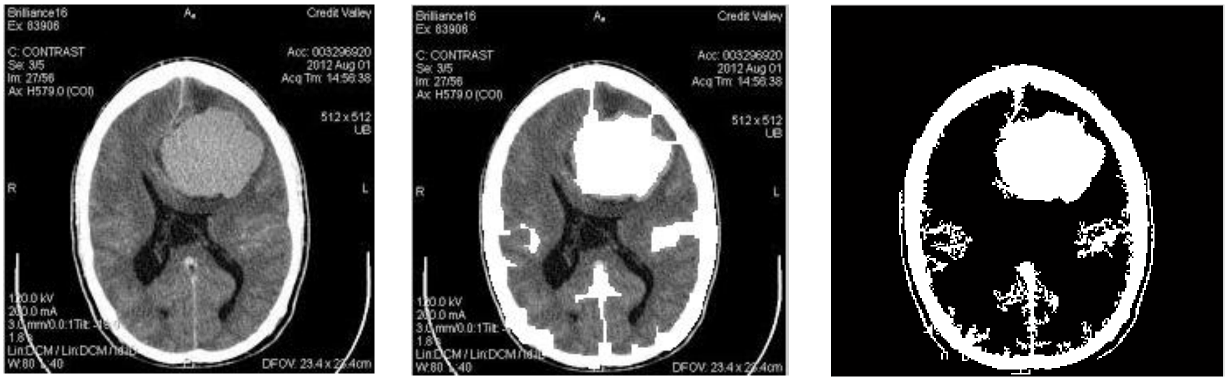


(a) (b) (c)

Fig.2 (a) Original MR Image , (b) Tumor detected as white portion, (c)Brain Tumor extraction

(a) (b) (c)

Fig.3 (a) Original MR Image , (b) Tumor detected as white portion, (c)Brain Tumor extraction



(a) (b) (c)

Fig.4 (a) Original MR Image , (b) Tumor detected as white portion, (c)Brain Tumor extraction

The proposed technique is tested on a large database consisting of 120 tumor images. Fig. (2) to Fig.(4) shows the tumor extracted from MR brain images. The tumor portion of the MR image is visible, shown as white color. This portion has the highest intensity than other regions of the image. The algorithm proposed in this paper is able to extract the brain tumor successfully with 98% accuracy in various age groups. Table 1 shows the comparison of proposed algorithm with [2].

Table 1.Comparision of proposed algorithm

Image set	**Proposed method**	**Method Proposed in [2]**
MR brain tumor Images	118/120	110/120
Success rate(%)	98.33%	91.66%

IV. Conclusions

This paper presented an improvement to the watershed transform for the extraction of brain tumor of MR images based on segmentation and morphological operator. Moreover, as contrast enhancement is employed, this technique is able to extract the brain tumors from the MR images in various age groups. The proposed technique gives more information about brain tumor and helps doctors in diagnosis, the treatment plan making and state of the tumor monitoring. The experimental results show that the proposed technique can provide close, smooth and accurate final contours with low computational complexity. The proposed work can be extended by adapting more segmentation algorithm to suit the different medical image segmentation.

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