Segmentation of tumor tissue in gray medical images using watershed transformation method

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Abstract

The new imaging techniques for organic body tissue give more details and information about the normal and abnormal tissue that help to distinguish the overlapping in margin of each organ.

In this paper a new method of tumor line detection and segmentation is used to separate the abnormal from the normal surrounding tissue to get a real identification of involved and noninvolved area that help the surgeon to distinguish the involved area precisely.

The method used in this paper is watershed method and image processing by using MatLab 7.1 to detect the tumor boundaries in MRI and CT image for different cases.

Our result in this study is very clear for physician to distinguish the area of tumor for surgical planning.

Keywords: *Watershed, MRI image, CT image, gray level, tumor, segmentation*

1. Introduction

One of the most difficulties in tumor excisions and tissue differentiation is the border and cells overlapping between normal and abnormal tissues in gray level of the medical images and that are the challenge of the surgeon or physician to distinguish that.

The difficulties are summarized by image gray level overlapping between two or more different parts in the same image. And that very clear when the image of MRI and CT scan were taken to a patient. As shown in figure (1) its image of MRI for patient with brain tumor; there is an overlapping between the boundaries of tumor in the cerebellum part and tissue surrounded; the surgeon must be very accurate and carful to remove that tumor without cause a damage for the surrounding tissue. If the surgeon has the accurate dimensions of the involved tissue he can do his job with more flexibility; there are a new medical instrument used to remove the tumor specially in the brain without opening a large area in the scalp depending on the image only, like Brainlab instrument (Navigator) **[1]**, as well as Linear accelerator (LINAC) **[2]** these devices need well defined dimensions of abnormal tissue for extraction.

Figure 1. MRI image for brain tumor in cerebellum (Acoustic Neuroma).

There are many methods used in many researches to differentiate biological tissue boundaries in the images like Matei Mancas et al, they used a novel method called iterative watersheds is then used in order to segment the tumors for CT image of the neck **[3]** and then they used Fuzzy logic for tumor segmentation in another research **[4]**. Fuhui Long et al **[5]** they present a method based on 3D watershed algorithm of segmentation using both the intensity information of the image and the geometry information of the appropriately detected foreground mask of biological nuclei images. Regina Pohle et al **[6]** they developed a region growing algorithm that learns its homogeneity criterion automatically from characteristics of the region to be segmented for MRI and CT images. Rune Petter Sørlie **[7]** used the watershed with snake method to study the speckle noise and edge detection of the liver tumor image. Kathleen Marty **[8]** used watershed algorithm for brain cortical surface meshes. The function used is curvature measures inherent in the geometry of the mesh with four different curvature measures are compared: mean, Gaussian, absolute, and root mean square.

In this paper, our algorithm is used which depend on watershed method with marking the region of interest as well as the background in gray image. This method was supported by morphological techniques called "opening-by-reconstruction" and "closing-by-reconstruction" to "clean" up the image.

1. 1. Watershed method

The term watershed is mean that the area of land where all of the water that is under it or drains off of it goes into the same place [9]; and this meaning is used in image processing as a method of solving problems.

The principle of watershed [10, 11, 12, 13] in image processing as shown in figure (2) summarized by suppose the lower point in the image are B_1 ,B_2, …, B_z to be coordinate of these points for the image $I\ (i,\ j)$ and CB_m refers to the points of catchment basins associated with minimum region $B_z\ (x,\ y)$ represented by $X\ [n]$ accordingly $I(x,\ y) < n$.

$$X[n] = \{(x, y) \mid I(x, y) < n\} \tag{1}$$

$X[n]$ is the coordinate of points in $I\ (i,\ j)$ geometrically lying under the plain $I\ (i.j) = n$. Topographically the image filled with water in integer filling increments begin from $n = t_{max-1}$ to $n = t_{min+1}$.

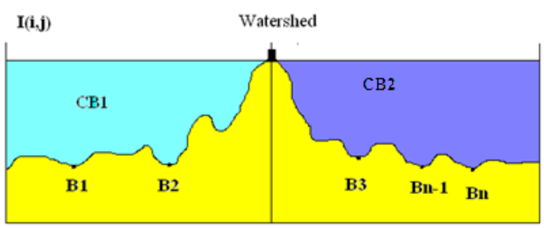


Figure 2. Shows the watershed principle method.

The number of points under the fluid is necessary, due to that marker will used in black color for the coordinates in $X[n]$ which are below the level $I(i,j)=n$ and the other point in white color.

$$C_n B_m = CB_m \cap X[n] \tag{2}$$

where $C_n B_m$ represents the coordinates in catchment basins related to B_m, which are fluid filling at the level n. Then let $C[n]$ refer to the union of the filling fluid of the points of catchment basins of level n:

$$C[n] = \cup_{m=1}^{z} C_n B_m \tag{3}$$

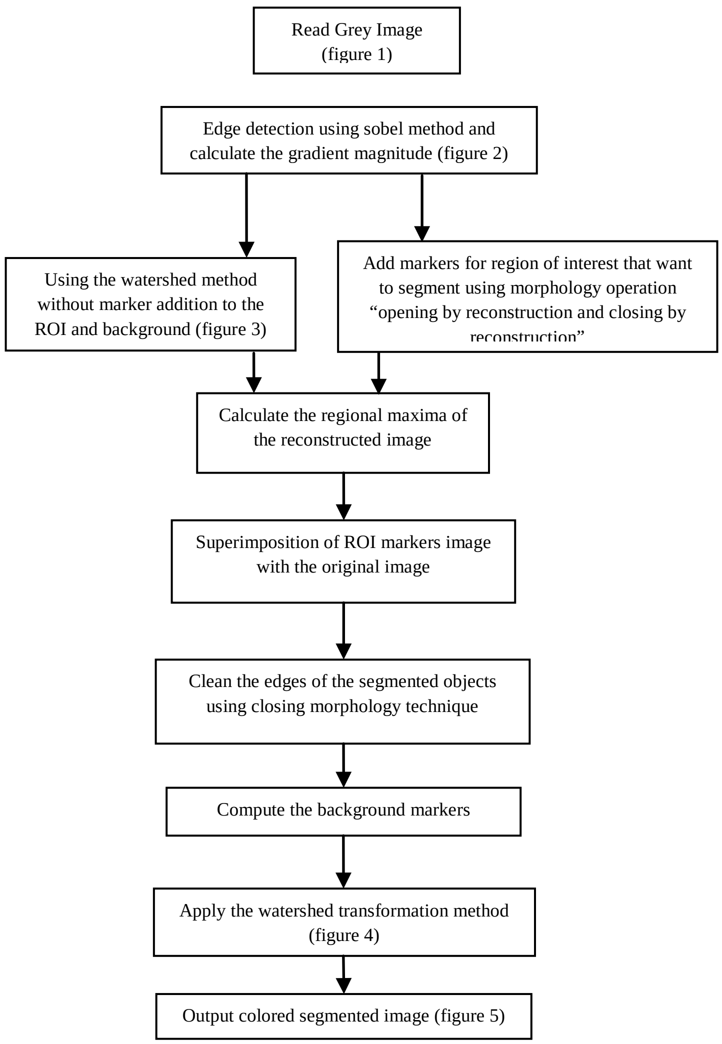
Finally C_{tmax+1} refer to all catchment basins union.

$$C_{tmax+1} = \cup_{m=1}^{z} CB_m \tag{4}$$

From equation 2 and 3, $C[n]$ is a subgroup of $X[n]$ accordingly; then watershed lines is prepared when $C\ [t_{min+1}] = X\ [t_{min+1}]$. Then the procedure follows to reconstruct $C\ [n-1]$ at level n.

$C[n]$ can be obtained from $C[n-1]$ by assuming S as the set of the connected component in $X[n]$, at $s \in S[n]$ there are three assumption **i)** $s \cap C[n-1]$ is empty and the assumption is verify at a new minimum is encountered, in this case **s** is incorporated into $C[n-1]$ to produce $C[n]$. **ii)** $s \cap C[n-1]$, contains more than one connected component of $C[n-1]$ and this lead to s is incorporated in to $C[n-1]$ to produce $C[n]$. **iii)** In last case $s \cap C[n-1]$ contains more than one connected component of $C[n-1]$ and this verify at all or part of rim separating two or more catchment basins in encumbered.
Additional water filled lead to merge the water at these catchment basins. According to that one or more than one dam must reconstruct to prevent overflow between catchment basins within s.

2. The Proposed Algorithm



3. Result

The watershed transformation method considered as a difficult segmentation operation comparing with other image segmentation techniques. This method is useful in medical field because it is solve the overlapping between the closest grey levels in medical images. In this section we will explain the obtained results. Starting with figure (3) which represents the input images for some cases that are processed in the proposed algorithm. Firstly the gradient magnitude was obtained and the edges of the input images were determined as shown in figure (4). We compared the application of watershed method with and without marking the ROI and background. The watershed method is useful only when making markers for background and ROI. The effect of marking is clarified in figure (5) of the over segmented image which represent the application of watershed method without marking and this result considered as useless result in medical imaging and figure (6) which represent the application of watershed transformation after marking each ROI and background.

From the above method the markers is necessary for each ROI and background to be useful special in medical field. The markers computation was done by using the morphology operation technique called opening by reconstruction and closing by reconstruction to clean up the image from stem and dark spats and removing the small blemishes without affecting the overall shape of the segmented objects.

The marking step required to calculate the regional maxima and minima to get good markers for ROI as well as background. After making markers we were applied the watershed transform to segment the ROI in the image as shown in figure (6). Figure (7) represent the output superimposed images between the markers of ROI and background and the boundaries of the segmented object on the original images.

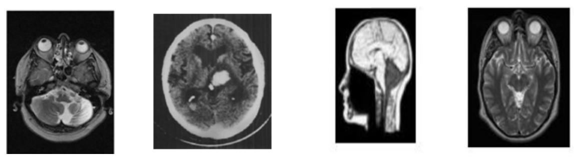


Figure 3. Input Image

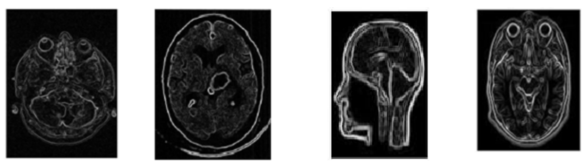


Figure 4. computing the gradient magnitude and edge detection using sobel technique

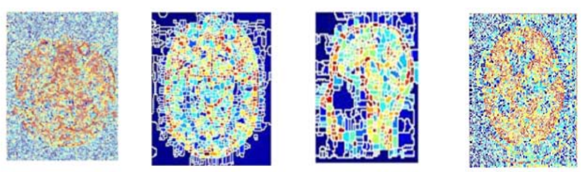


Figure 5. Oversegmented image (Apply watershed transform without marking objects)

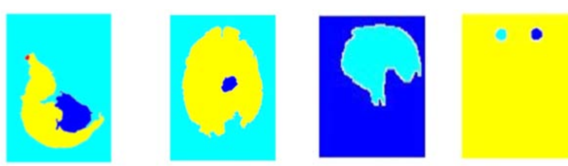


Figure 6. apply watershed transform after marks the ROI and background

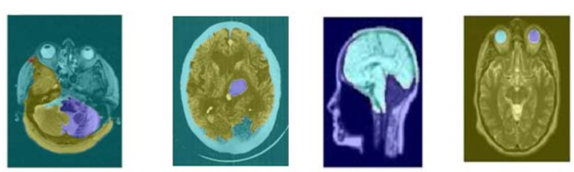


Figure 7. final colored image after superimposition between watershed and original images

4. Discussion

The reason that lead to this work is to separate the infected area in a gray image from the surrounding tissue by identification the boundaries as well as give a colour for the image. All that assist the surgeon and physician to diagnose the infected area or remove the tumour form the brain without damaging the surrounded tissue.

The algorithm used in this paper is one of the new methods that depend on the watershed theory with morphology to detect the involved regions in whole image with more flexibility.

As shown in figure (4) edge detection used to detect the involved region like tumour in gray level as the first step then watershed theory used to detect the minimum regions from the other values in the same image as shown in figure (5) in this figure there are many regions selected by watershed that give more flexibility to discover more zones compares when using morphology only as example.

In figure (6) the watershed method applied with using marker for the region of interest and the background and that give minimum probability to identify the background and the infection regions in CT or MRI images.

Final step is super imposed between the original image and the image obtained by watershed algorithm to get the final image differentiable and coloured as shown in figure (7)

From the above we can find the result is very clear and useful for differentiating abnormal regions for many purposes like surgery or treatment by gamma camera.

5. References

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