Fine Tune Watershed Using Embankment To Extract Tumor From Human Head Scan

S.JOSEPHINE, S.MURUGAN

Abstract— New computer aided methods require in the field of brain tumor analysis for diagnosing, surgical planning and tele-medicine. This paper proposes a Fine tune watershed algorithm by using embanking approach. The embankment approach produces thick walls around objects of an image. Then easy the job of flooding in watershed algorithm and the thick walls avoids the over-segmentation. The results of proposed Fine tune watershed algorithm are compared over the existing watershed algorithm in terms of qualitative and quantitative measures. The proposed method outperforms the existing method in 18% of Dice score and 1% of false positive and true positive results.

Index Terms— MRI, brain tumor, watershed, embankment, morphology operations

1 INTRODUCTION

Brain is the hidden area of human body, the abnormal growth of brain tissues called brain tumor. CBTRUS reported that 69720 new brain tumor cases were diagnosed in 2014. In the cases, 35% of patients are afflicted by malignant [CBTRUS] [Sivakumar P]. The malignancies are diagnosed with the help of medical imaging. Subsequently, medical images help to differentiate the diseased tissue from, normal healthy tissue, bones and fluid. The Magnetic Resonance Image (MRI) is preferred by the physicians due to its multi modality and multi plane option of the scanner which produces a high quality of brain images [Stefan Baur]. Image processing techniques such as enhancement, segmentation and denoising take part in automatic tumor detection and quantification [Thirumurugan P]. Segmentation is a process of dividing an image into multiple distinct regions. In brain image processing, tumor segmentation helps to analyze, interpret and understand the various tissues. Generally, segmentation process is done by 3 ways such as thresholding, edge-based or region-based approach. Recently, a semi automatic method proposed for tumor segmentation. The work requires user interaction to initialize the level set function. Further, level set and region based active contour method is employed to attain good results [Lefohn A]. Simple edge detection methods are employed before segmentation. The methods only base the concept of edge instead of using edge detectors such as watershed. The earlier watershed segmentation results over segmentation. For resolving the problem, morphology was employed in marker control watershed segmentation [Parvathi, 2008]. Texture based region merging was employed with watershed approach to get better segmentation results [N g, H.P, Huary, 2008]. Nickam et al. Combined region growing and watershed algorithm for brain tumor segmentation [Nikam, 2013]. Subsequently, Fuzzy C-means and watershed algorithm was established for brain tissue segmentation [Benson, 2016]. Recently, a combination of watershed transformation and the expectation-maximization technique was suggested for brain tumor extraction [Kwon, 2016]. The above methods use another one approach to perfectly extract the required brain component. Hence, proposed method aims to fine tune watershed method alone. Generally, brain tumor does not surrounded by a well defined border that is a big barrier in brain tumor extraction from MRI image. Hence, embankment approach which raises the wall of canal to avoid a change in level required by the terrain as shown in Fig.1. Morphological operators dilation and erosion employed to enhance the edges. This remaining part of this paper organized into three sections. Section 2 explains the proposed method and evaluation measures, section 3 discusses about the performance of the proposed method and marker controlled watershed algorithm and section 4 concludes the results.

2. PROPOSED METHOD

The proposed method pass up the over segmentation by using the approach of Embankment. The method consists of 3 stages. The first stage strengthens the walls of the object by using embankment. The second stage detects the minima by using singularity detection and the last stage floods the minima until to reach the walls of the object.

Stage 1: Embankment
Stage 2: Catchment Basin detection
Stage 3: Flooding

Embankment is the process of strengthening the walls of canal by eroding the canal and dilating the wall of the canal. The high grade tumor does not have well defined boundary as given in Fig.2 which is obtained by the canny edge operator. Canny edge operator is more sensitive even though it lacks in tumor boundary detection [Debosmit Ray]. Hence, the proposed method follows the embankment approach and applies morphological operators. The basic operations dilation and erosion processes are employed which expands the object and shrink the objects [Gonzalez, R.C.] [Senthilkumaran, N.]. They are defined as follows,

\[ R_I = I \otimes e \]

\[ (1) \]
The subtraction of eroded image from dilated image results thick wall of the tumor as shown in Fig.3. Fig. 3 shows the dilated and well defined boundary of the tumor.

2.1 Catchment Basin detection
The human brain has millions of neurons and different types of tissues. So it contains more edges and no singular region except tumor portion [Kalaiselvi]. Such singular area is detected by convoluting an edge operator ‘h’ with the image.

\[ h = \begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix} \]  \hspace{1cm} (4)

\[ f = I \ast h \]  \hspace{1cm} (5)

Where ‘\( \ast \)' represents convolution operation. Eqn. (5) results more singular area as shown in Fig.4. It shows more catchment basins due to the complex structure of brain. The larger catchment basin fc is selected to extract the tumor.

2.2 Flooding
The general method of flooding in watershed algorithm is to find the minima Mi e f(x, y) from the catchment basin and merges the minima regions. The proposed method uses the similar method, first observes the Mi from fc and treated as a catchment basin C. Then observe the next minima from current flood border (xi, yi) and merge with the catchment basin C, repeat the process until it reaches the wall obtained by using embanking max(R). The process is represented as follows,

\[ f_c = \bigcup_{i=1}^{n} C(M_i) \]  \hspace{1cm} (6)

Where \( n \geq 100 \in R \). The minima and R are given in Fig.5 (a) and Fig.5 (b). Fig.5 (a) shows region of spatial coefficients in R and Fig.5 (b) shows the similar spatial coefficients in C.

2.3 Evaluation Measures
Similarity measure gives the comparison study between the ground truth and the segmented results. Among several similarity measures, Dice is common and most frequently used measure. It ranges between 0 and 1, where '0' indicates the poor result and '1' indicates the significant result. The equations is defined as follows,

\[ \text{Dice} = 2 \times \frac{|A \cap B|}{|A| + |B|} \]  \hspace{1cm} (7)

Where A and B are the ground truth and the segmented image respectively. |A \cap B| represents the number of pixels common in ground truth and segmented result, |A| and |B| are the number of abnormal pixels in the ground truth and segmented result.

The performance of the segmented results is validated using True Positive (TP), True Negative (TN), False positive (FP) and False Negative (FN) extremely. The tumor pixels correctly obtained by the segmentation method is represented by using TP, The normal pixels correctly discarded by the segmentation method is represented by using TN, the FP counts the normal pixels segmented along with the tumor pixels and the FN counts the tumor pixels are missed as normal pixels by the segmentation method [1].

3. Results and Discussion
The proposed method is coded by using Mat lab 2013a and Dual core 2 systems. The experiments were carried out on some MRI images collected from web resources and clinics. The results are compared against with the results of the marker controlled watershed (Existing) which is in Mat lab 2013a. toolbox. Some sample images are shown in Fig.6. In Fig.6, column 1 shows the input image, column 2 shows the catchment basins, column 3 shows the embankment results, column 4 shows the segmented tumor portion and column 5 shows the ground truth images. The experiments were carried on contrast less images and complex structured tumor images. In row 1 image, some normal pixels besides tumor region are as bright as tumor. In the watershed segmentation, the normal pixels are also considered as tumor and merges with the minima. It leads over segmentation. But the proposed method builds a thick wall on the boundary of the tumor as given in column 3 image and avoids the over segmentation. In Fig.6, row 2 and row 3 images, some pixels inside the tumor are in different intensity. Hence, the earlier watershed method considers the pixels as normal pixels and misses the regions. The embanking approach used in the proposed method fits the border pixels exactly. Hence, the tumor portion was extracted perfectly in the given images. The quantitative measures Dice, TP, TN, FP and FN of Marker controlled watershed and proposed method were calculated for the comparative performance analysis. Dice indicates the similarity index between the segmented results and the ground truth. The Dice measures are listed in Table 1. For the given sample images, the proposed method gives good result than existing. For the first case, the proposed method gives 18% better result than the Existing method. Further average value of TP, TN, FP and FN were calculated and given in Fig.7 for better visual analysis. The both methods extract 93% of normal pixels sensitively and the proposed method obtained 1% more tumor pixels than the existing method. The FP indicates the over segmentation and FN indicates the under segmentation results. The proposed method reduces 1% of under segmentation than the existing one and results 0% of over segmentation. The results proved that the proposed Fine tune watershed algorithm outperforms the existing marker controlled watershed algorithm.
4. CONCLUSION

In this paper, a Fine tune water shed algorithm is proposed to segment brain tumor from MRI images. Experiments were carried over some clinically available and open database images. The proposed method is compared against the existing marker controlled watershed algorithm. The experiments results show that the existing method gives over-segmented results. But the proposed embanking approach fine tune the flood flow and restrict the over flow in weak edge portions. The results were analyzed against the existing watershed algorithm in terms of Dice, TP, TN, FP and FN. The results ensure that the outstanding performance of the proposed method. The proposed method gives 1% of over segmentation it will be avoided in future.

![Figure 1. Embankment in a cannel](https://en.wikipedia.org/wiki/Embankment_(transportation))

**Figure 1. Embankment in a cannel**

*Courtesy: https://en.wikipedia.org/wiki/Embankment_(transportation)*

![Figure 2. Edge detection by using 'Canny'](image)

**Figure 2. Edge detection by using ‘Canny’**

![Figure 3. Embankment of brain tumor image](image)

**Figure 3. Embankment of brain tumor image**

![Figure 4. Catchment Basin detection using singular points detection](image)

**Figure 4. Catchment Basin detection using singular points detection**

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**Figure 5. Coefficients of R and C. (a) Shows the spatial coefficients of R and (b) shows spatial coefficients appear in the similar region of C**
Figure 6. Output of the proposed method. Column 1 shows the input image, column 2 shows the catchment basins, column 3 shows the embankment result and column 4 shows the output of the proposed method and column 5 shows the ground truth image.

**TABLE 1. DICE MEASURE**

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Figure 7. Quantitative measures TP, TN, FP and FN of the proposed and existing methods. (a) Quantitative measures of the proposed method and (b) Quantitative measures of the existing method.

**REFERENCES**


