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SEGMENTATION AND IDENTIFICATION OF MRI BRAIN SEGMENT IN DIGITAL IMAGE

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ABSTRACT:

Brain image segmentation is important in the area of clinical diagnosis. MRI Brain image segmentation is time consuming and there is always a chance of occurrence of error when the segmentation is done manually. It is always possible to detect the infected tissues easily in the current medical field. However, the accuracy and the characteristics of abnormalities of the tissues are not precise. In the past, many researchers have identified the drawbacks of manual segmentation and hence proposed the semiautomatic and fully automatic segmentation methods in the field of medical imaging. The amount of precision about the detection of defective tissues leads to acceptance of a particular image segmentation method. In this article three segmentation methods are hybridized to get the optimum extraction of the region of interest (ROI) in brain MRI image. Further, the region properties of segment is extracted and stored as knowledgebase. The proposed algorithm integrates multiple segmentation methods and identifies the Brain Outer layer in MRI image. This identification aids medical experts for optimum diagnosis of defective tissues in the brain.

Keywords: Pattern Recognition, Image Processing, MRI, Segmentation, Classification.

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1. INTRODUCTION

Image processing applies some mathematical operation for the input images and the output of this process will be an image or some parameters or characteristics related to the input images. Though image processing consist of methods like filtering, enhancement and restoration. It also does the analysis of images based on pattern recognition. Pattern recognition which includes various methods like feature extraction, classification, various pre-processing techniques and description of pattern from the input images. The images used for current study are the magnetic resonance images (MRI).Magnetic resonance imaging uses powerful magnetic field and radio frequency pulses to generate the images of the patients in the suspected area of their body. It is medical test which is highly prevalent in the field of medical science to detect certain medical conditions. The patient slides into a MRI scanner which is tunnel shaped equipment which uses strong magnetic field. These signals are read using the computer which helps the medical experts to diagnose the defects in the patients. The body which has abundant water and fat uses hydrogen protons for the purpose of imaging in strong magnetic field which in turn gives detailed about the internal organs of the body using MRI images. Under the presence of strong magnetic field, the hydrogen protons in the body lines up in its own axis. This alignment of the hydrogen protons creates a magnetic vector along the axis of the MRI scanner. The usual magnetic strength of the scanner is between 0.5 and 1.5 tesla. When the radio wave frequency is added to the magnetic field, the magnetic vector created gets fluctuated. It then creates a signal to be emitted. This signal is received by the receiver coil, which is read using the computer. This creates the MRI images of the internal organs of the body using the MRI Scanner.

2. BRAIN MRI IMAGE SEGMENTATION

MR Image Segmentation is an important area in the field of medical diagnosis. A study of MRI of brain is conducted for analysing various segmentation methods. MRI of brain is used for tumor detection. Early diagnosis of brain tumor helps in improving the treatment possibilities and further saves the life of the patients. Manual segmentation of brain tumor for diagnosing cancer from large amount of MRI images but it is not generally preferred as it is a time consuming task.

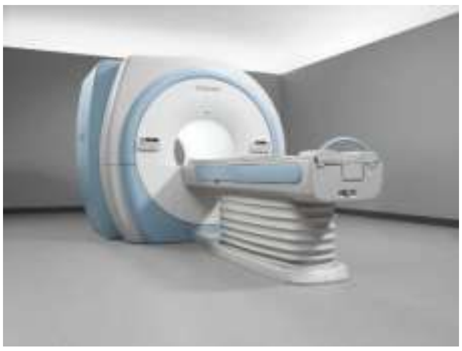
Hence there is a need for automatic brain tumor segmentation. The segmentation of regions in MRI images is an important task in the medical science. It has wide applications in the area of surgery, abnormality detection and so on. The semi-automatic and fully automatic image segmentation [2] which are currently used are still highly relevant. However most of the methods often leads to unknown noise, poor image contrast, hence it is not widely accepted. One of the drawbacks of these methods is the accuracy of detecting the region of interest such as the tumor or edema. The level of accuracy in detecting the presence of defective tissues is highly important for diagnosing the disease. The proposed algorithm is based on the segmentation methods like marker controlled watershed segmentation which is used to detect the presence of object in the image which is shown by study conducted by hiremath et al. [3] which is to identify the rotavirus particles in the image using marker controlled segmentation. Active contour method which is used in edge detection and the features are extracted from it, similar work is done by Micheals Kass [5].Watershed segmentation is a common method of segmentation which is shown by Hamarneh and Li,The objective of the proposed method gives a detailed study on shape and appearance using watershed and it is one of the most common method of segmentation [13].

This paper focuses on segmenting and identification of outer layer of brain MRI images on applying the segmentation methods. Organization of our paper Section I Deals with introduction, Section II presents the proposed methods of segmentation and the experimental results, Section III presents conclusion.

a) CareStream Health

b) Philips

(c) Toshiba



d) Siemens

Figure 1 Sample MRI devices from (a) CareStream Health (b) Philips (c) Toshiba (d) Siemens.

3. PROPOSED METHOD

For the current research work, A fusion of segmentation and feature methods are proposed. The figure 2 presents sample MRI brain Image.

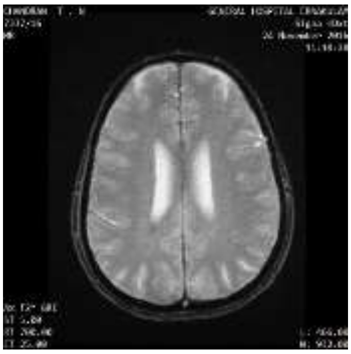


Figure 2 Sample MRI Brain Image

Manual segmentation

Manual segmentation involves manually drawing the region of interest such as the tumor, outer layer of the brain etc. and labelling in different ways. These methods are not using in the current medical field. Since the boundary of the region of interest is manually drawn [4], it is considered to be time consuming and tedious. When it comes to segmentation of MRI brain images, each of the slices of the MRI images are examined by the radiologist and other experts. They in turn labels the boundary of the region to be extracted, these are then studied and used in the proper diagnosis of the defects. Manual segmentation is done based on the intensity enhancement. Since these process is time consuming, hence the methods like semi-automatic and fully automatic segmentation methods are used. These methods overcome the drawbacks of the manual segmentation.

Semiautomatic segmentation

In semiautomatic brain segmentation, the segmentation results and the accuracy of the results are checked by human experts which are actually initialized by human experts, or the expert manually correct the segmentation result. It involves least human interaction compared to manual segmentation [14]. There is a chance of occurrence of variations between the observers in semi- automatic segmentation. Semi-automatic methods combine the computation and human experts' interpretation for segmenting any part from the MRI image. This method is better than that of the manual segmentation as the intervene of human experts is less. Fully automatic segmentation replaces this drawbacks, it removes the variations in the images and increases the standardization of protocols used in segmentation.

4. PROPOSED METHODOLOGY

The proposed algorithm as shown in fig 3 contains training phase and test phase. In training phase, the training set which contains the images of 19 subjects are given as input to the system. The system contains three segmentation methods like Marker controlled watershed segmentation method, Global threshold method and Active contour multigrid method which are explained below in this section. After applying each of these methods, features like area, eccentricity, compactness etc. are extracted from the images. In the test phase, single image is given as input to the system. The Features are then extracted, fused and are classified.

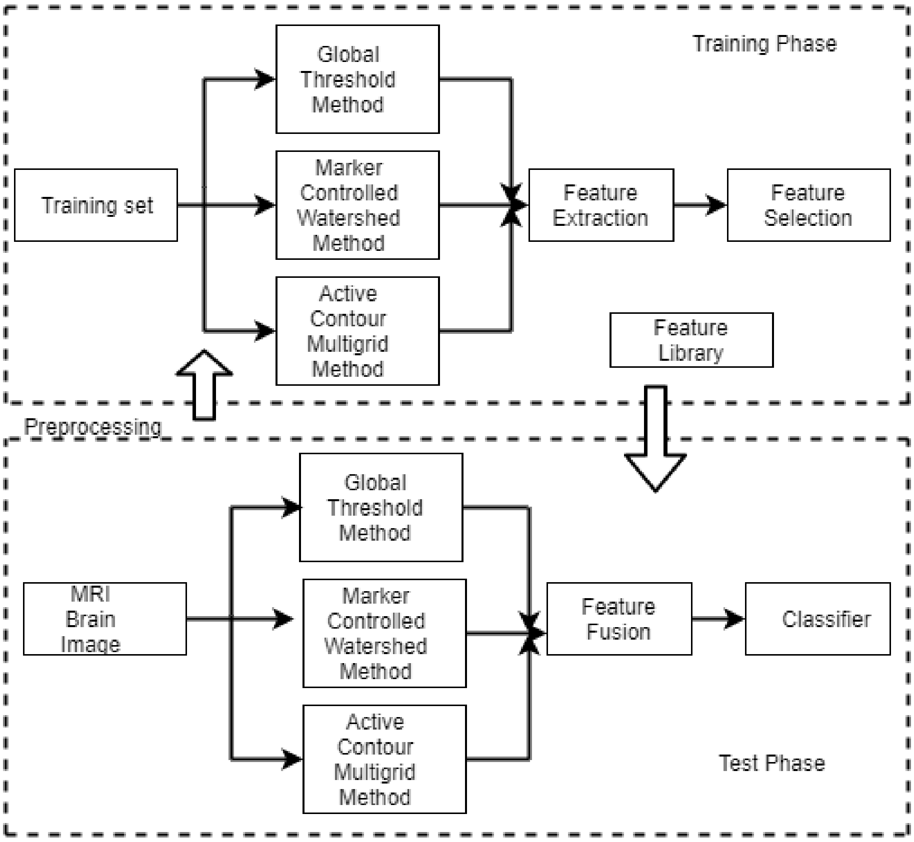


Figure 3 Block diagram of proposed method

Marker Controlled Watershed Method:

Marker controlled watershed segmentation is method based on morphological operations [12].It considers image as a surface or as catchment basins. It identifies the touching objects in an image based on the gradient magnitude of an image. The gradient magnitude transforms the image and identifies exactly the objects in it using the function watershed. The accuracy of the results is always degraded when there is external noise being added to the image, this will ultimately lead to over segmentation.

Similarly, the low contrast edges in the image generate changes in the gradient magnitude which results in under segmentation. This is due to the presence of local minima in the image. Marker controlled watershed segmentation prevents all these drawbacks. This method is robust and flexible for segmenting the objects with closed contours. It is based on internal and external markers which defines the presence of objects in the image. Even if the boundaries are not clear, they can be seen as ridges between the foreground marker and the background marker. Watershed segmentation method automatically combines the techniques like canny edge detection, thresholding and morphological operations.

The function in the algorithm is modified in order to determine the accuracy of the regions in the image using the watershed techniques [6].The ultimate goal is to impose the local minima using the marker function. The morphological reconstruction fills all the catchment basins which are not been marked and then it transforms into non-minima plateaus. This will not produce distinct regions when final watershed is calculated.

Marker controlled watershed segmentation follows some basic procedure, which is explained as below:

- Compute the segmentation function.
- Compute the foreground markers which are the connected blobs of pixels with in each of the objects.
- Compute the background markers which are the pixels which are not part of any object.
- The segmentation function should be modified in such a way that it should have minima at the foreground and background marker locations.
- Compute the watershed transform of the modified segmentation function.

Global thresholding:

Global thresholding is the simplest method and a popular method of image segmentation [8][9][10]. The threshold value is the global factor which converts the grey scale image into a binary image [7]. All the pixels above the threshold value turns into 1 and all the pixels below the threshold value is turns into 0. It separates the light and dark regions based on the intensity level. If g(x,y) is a threshold version of f(x,y) at some global threshold T[1],

$$g(x,y) = \begin{cases} 1 \; if\, (x,y) \geq \rho \\ 0 \; otherwise \end{cases}$$

Where 1 corresponds to the region of interest while 0 corresponds to the pixels in the background. It always works well with the images with the same intensity level. It also works well if the contrast between the object to be segmented and the background is high. The algorithm first applies the threshold to the region which is selected manually and segments the objects from their surroundings.

Active contour multigrid:

Active contour method is used for detecting the object boundary. It is extensively used in image processing and computer vision. Active contour method or snakes find the boundary of the object to be segmented based on the movement of curves, which moves under the influence of internal force within the object and external force from the image[11]. The internal and external forces depends on the boundary of the image. This method has wider applications in edge detection, shape modelling , object tracking etc. The curve starts from the object to be detected and it stops when it meets the boundary of the object.

Brain MRI Image Segmentation

For the purpose of experimentation, 19 subjects with 5 digital images of each subject are examined. Ax T2* GRE slices are studied for the experimentation. The images used for the experimental study are taken from General Hospital Ernakulum, Kerala. The implementation is carried on Intel core i5 processor @ 2.83GHz machine using MATLAB R2015a. The brain MRI image contains the description like ST, RT and ET.ST represents slice thickness of each slice seen on the screen in millimetres. RT represents the repetition time which is the time between the excitational pulses in the same slice in milliseconds and ET represents the echo time in milliseconds which is the time point at which the radiofrequency data is collected.

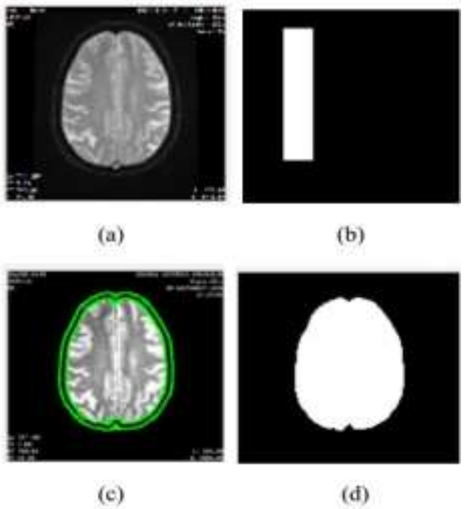


Figure 4 (a) Original Image of MRI Brain Image (b) Rectangular grid obtained at initialization. (c) Image which shows 1500 iterations (d) Segmentation of the image.

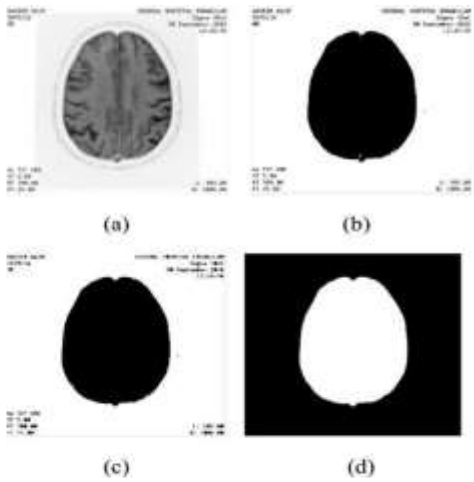


Figure 5 (a) Original Image (b) Grey Scale Image-1 (c) Grey Scale Image-2 (d) Segmented Image using Global thresholding method.

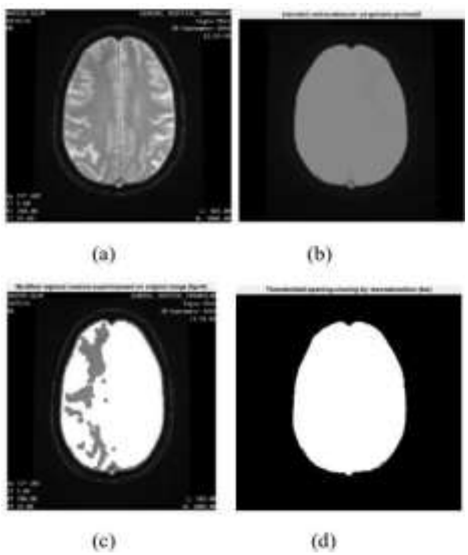


Figure 6 The subsequent outcomes of watershed Segmentation method;

In the training set, the enire data set is passed to three different segmentation model. For each execution of the segmentation method, the features are extracted and stored as knowledge base. After capturing all the features set of all the three methods, the feature fusion has to be made and average minimum and maximum features values are identified after integration.

This integration model provides an accurate segmentation of brain MRI image, which aids doctors to identify the brain section in the MRI image and particularly further it helps to identify the tumor part in it. The table 1,2 and 3 presents the average feature set of all the three segmentation methods.

5. CONCLUSION

Image processing is very active research area in the field of medical science. Segmentation techniques, to detect and analyse the defective tissues from clinical images, have already been proven promising. But the medical image analyses have to address the fact that the end-user of the program will be the physician. Since any result will have to be approved by the physician, applicable methods are limited. Major challengein segmenting the images in research is to differentiate defective tissues form others. Segmentation methods are tuned in order to satisfy this need. There are lot of segmentation methods such as threshold-based, region growing techniques, pixel based techniques which are employed for identification of defective from the normal tissues. Although the accuracy of the proposed segmentation is more compared to other methods, these approaches have still not gained wider acceptance due to the lack of standardized procedures in every day clinical practice.

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APPENDIX

Table 1 Geometric feature values of Active contour method

MRI Brain Images	Major Axis Length	Minor Axis Length	Area	Eccen-tricity	Perimeter	Roundns	Tortu-osity	Legth/ Width ratio	Compac tness
1	180.50	129.05	18209.00	0.70	510.31	0.88	0.35	1.40	1.14
2	184.14	132.59	18842.00	0.69	572.48	0.72	0.32	1.39	1.38
3	181.35	132.29	18704.00	0.68	517.60	0.88	0.35	1.37	1.14
4	176.99	154.12	21153.00	0.49	554.62	0.86	0.32	1.15	1.16
5	192.77	139.54	20717.00	0.69	611.51	0.70	0.32	1.38	1.44
6	188.84	134.96	19932.00	0.70	534.32	0.88	0.35	1.40	1.14
7	182.29	143.57	20294.00	0.62	581.79	0.75	0.31	1.27	1.33
8	178.74	151.22	19271.00	0.53	899.29	0.30	0.20	1.18	3.34
9	175.06	140.42	19049.00	0.60	538.15	0.83	0.33	1.25	1.21
10	176.08	153.27	20884.00	0.49	637.88	0.64	0.28	1.15	1.55
11	178.74	151.22	19271.00	0.53	899.29	0.30	0.20	1.18	3.34
12	173.60	131.19	17752.00	0.65	500.71	0.89	0.35	1.32	1.12
Geormetric values of active contour containing maximum and minimum									
Maximum	192.77	154.12	21153.00	0.70	899.29	0.89	0.35	1.40	3.34
Minimum	173.60	129.05	17752.00	0.49	500.71	0.30	0.20	1.15	1.12

Table 2 Geometric feature values of watershed method

MRI Brain Images	Major Axis Length	Minor Axis Length	Area	Eccen-tricity	Perimeter	Roundns	Tortu-osity	Legth/ Width ratio	Compac tness
1	367.07	260.09	74749.00	0.71	1083.15	0.80	0.34	1.41	1.25
2	375.18	265.22	77661.00	0.71	1097.98	0.81	0.34	1.41	1.24
3	366.30	265.41	75894.00	0.69	1104.57	0.78	0.33	1.38	1.28
4	360.12	307.81	86766.00	0.52	1107.28	0.89	0.33	1.17	1.12
5	396.97	277.64	86312.00	0.71	1110.93	0.88	0.36	1.43	1.14
6	383.24	271.20	81381.00	0.71	1080.44	0.88	0.35	1.41	1.14
7	369.02	288.30	82858.00	0.62	1102.99	0.86	0.33	1.28	1.17
8	375.03	309.12	90476.00	0.57	1119.91	0.91	0.33	1.21	1.10
9	354.95	282.28	77955.00	0.61	1103.79	0.80	0.32	1.26	1.24
10	362.24	305.92	86348.00	0.54	1122.15	0.86	0.32	1.18	1.16
11	375.03	309.12	90476.00	0.57	1119.91	0.91	0.33	1.21	1.10
12	351.79	263.24	72279.00	0.66	1061.15	0.81	0.33	1.34	1.24
Geormetric values of watershed method containing maximum and minimum									
Maximum	396.97	309.12	90476.00	0.71	1122.15	0.91	0.36	1.43	1.28
Minimum	351.79	260.09	72279.00	0.52	1061.15	0.78	0.32	1.17	1.10

Table 3 Geometric feature values of Global threshold method

MRI Brain Images	Major Axis Length	Minor Axis Length	Area	Eccen-tricity	Perimeter	Roundns	Tortu-osity	Legth/ Width ratio	Compac tness
1	365.95	259.52	74357.00	0.71	1047.03	0.85	0.35	1.41	1.17
2	374.71	264.89	77456.00	0.71	1095.07	0.81	0.34	1.41	1.23
3	365.72	265.25	75711.00	0.69	1124.82	0.75	0.33	1.38	1.33
4	359.77	307.61	86622.00	0.52	1102.28	0.90	0.33	1.17	1.12
5	396.46	277.44	86121.00	0.71	1141.53	0.83	0.35	1.43	1.20
6	382.67	270.97	81183.00	0.71	1108.56	0.83	0.35	1.41	1.20
7	368.43	287.99	82632.00	0.62	1101.04	0.86	0.33	1.28	1.17
8	374.37	308.91	90250.00	0.56	1130.50	0.89	0.33	1.21	1.13
9	354.06	282.02	77655.00	0.60	1142.67	0.75	0.31	1.26	1.34
10	361.84	305.87	86234.00	0.53	1121.11	0.86	0.32	1.18	1.16
11	374.37	308.91	90250.00	0.56	1130.50	0.89	0.33	1.21	1.13
12	351.16	263.11	72101.00	0.66	1058.36	0.81	0.33	1.33	1.24
Geometric values of global threshold method containing maximum and minimum									
Maximum	396.46	308.91	90250.00	0.71	1142.67	0.90	0.35	1.43	1.34
Minimum	351.16	259.52	72101.00	0.52	1047.03	0.75	0.31	1.17	1.12