IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology
ISO 3297:2007 Certified
Vol. 4, Issue 2, February 2017

Brain MRI Segmentation using Canny Edge Detection Technique

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Abstract: Image segmentation is a very tough technical process in the field of image processing. It is mandatory to go for the pre-processing before actual identification and segregation of ROI in MRI. Edge detection is based on the identification of the bounadries on the basis of similar brightness level and continuity of some pattern in the pixels. It is not possible to separate the some segment without applying the pre-processing of the image. . The applications of medical image segmentation are 3D reconstruction and quantitative analysis. Our experiment uses the MRI because this type of images give the most reliable image of the internal human organs like brain.. In this paper, the common problems of the image segmentation are explored and a novel method of image detection has been used.The classical image segmentation methods have been discussed for example gradient based operators were used usedfor edge detection, but these methods could deliver in the noisy surroundings. In the medical applications, the precision cannot be compromised with. To overcome these difficulties, we have proposed Canny edge detection technique prior to Non-Local Fuzzy C-Means Clustering technique for the segmentation. Quantifying brain structures in such large databases cannot be practically accomplished by expert neuroanatomists using hand-tracing. Rather, this research will depend upon automated methods that reliably and accurately segment and quantify large number of brain regions. At present, there is little guidance available to help clinical research groups in choosing such tools. This work is targeted to find out and establish more reliable segmentation technique as compared to expert hand tracing. The proposed approach consistently gives better results for various noise levels in the image compared to the reference schemes. This method is used for detecting brain region based on their energy function. In order to compare between them, one slice of MRI image tested with these methods. The traditional and proposed edge detection algorithms are implemented in MATLAB and results of proposed method are presented and compared with traditional approach. [1]

Keywords: Edge detection, Brain MRI images, Canny edge detector, manual tracing, neuroanatomists, Segmentation, Robust Fuzzy C-means clustering (RFCM), image segmentation, non-local, brain tissue.

1. INTRODUCTION

Image segmentation is one of the fundamental approaches of digital image processing. Image segmentation is the process of partitioning a digital image into multiple segments (sets of pixels also known as super-pixels). The goal of segmentation is to simplify and/or change the representation of an image into something that is more meaningful and easier to analyze. Image segmentation is typically used to locate objects and boundaries (lines, curves, etc.) in images. More precisely, image segmentation is the process of assigning a label to every pixel in an image such that pixels with the same label share certain characteristics. This part deals with the formation, acquisition and processing of images.

During past few years, brain tumor segmentation in magnetic resonance imaging (MRI) has become a popular research area in the field of medical imaging system. MRI is used in radiology for analyzing internal structures and makes easy to extract the required region. The method used in this paper is a hybrid approach i.e. combination of watershed method and edge detection method by using MATLAB as a tool to detect the tumor boundaries in MRI image for different cases of brain. The result of this method makes very clear for physician to distinguish the tumor portion for surgical planning. The efficiency and accuracy of the hybrid method is demonstrated by the experiments on the MRI brain images. Experimental results presented in this paper are obtained by using MATLAB.

2. CANNY EDGEDETECTIONMETHOD

Canny detector is optimal edge detector. This method can be put to use where the different stages are possible. The salient stages of the Canny Edge method are listed as under:

(a)The Canny edge detection starts with the application of Gaussian Filter.It smoothens the image.
(b)The second step is to calculate gradient magnitude
(c)The third step is marked by Non-maxima suppression
(d)The final step is following thresholding.[17]

The non- maxima removal includes, edge strength of current pixel is compared with pixel in +ve and –ve direction. If it is found that magnitude the pixel found to be larger than other pixels, the value of the magnitude is

IARJSET

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maintained otherwise the value is removed.The double threshold algorithm is used to identify the edges. If we use only low threshold, noisy maxima will get added and if we use high threshold, there is a possibility of true maxima might be missed. This the reason why double threshold is used in canny edge detection method. The strong edge points than high threshold are set as strong and points weaker than low threshold are suppressed and points between thresholds are set as weak.
In order to remove the noise, filtering the image is the step which cannot be ignored. Gaussian filter is convolved with image to obtain smooth image. Followed by the application sobel or prewitt operator to find gradient magnitude and orientation.Aftercalculating gradient magnitude we get blurred edges in the image. To convert the blurred edges into sharp edges we [17]

3. IMPROVED NON-LOCAL FUZZY CLUSTERING SEGMENTATION ALGORITHM (NLFCM)

Defining the neighbor of pixel j is a neighbor patch Pj, then the similarity of pixel i and j is the gray-similarity of patch Piand Pj, the weight value wijcan be calculated by the following equation:[1]
The distance between patch Pi and Pjis calculated as following:

$$\left\|y(P_i)-y(P_j)\right\|_2^2=\sum_{p=1}^{|P_i|}\left(y^{(p)}(P_i)-y^{(P)}(P_j)\right)^2 \quad \text{---- (1)}$$

Among formula (8) and (9), Ziis and regularized constant, h is a smooth parameter, vector y(Pi)contain gray information of neighbor of pixel i, $y^{(p)}$(Pi) is the p^{th} value of the vector.

Because non-local algorithm can get more space information of pixels without need for additional priori knowledge, we combined it with FCM algorithm, to get better ability to suppress noise. First, we assume that the pixels in the same tissue have similar neighborhood patch, we define the objective function with NL penalty term is as follows:[3]

$$J_{RFCM}=\sum_{j\in\Omega}\sum_{k=1}^{C}u_{jk}^q\left\|y_j-v_k\right\|^2+\frac{\beta}{2}\sum_{j\in\Omega}\sum_{k=1}^{C}u_{jk}^q\sum_{n\in N_j^R}w_{jn}\sum_{l\in L_k}u_{nl}^q \quad \text{----- (2)}$$

Compare with formula (6), we find that formula (1) can adjust the influence of neighborhood pixels around affecting on it automatically by a weight parameter Wij. That is to say, if the neighbor of pixel i and n is similar, they may belong to a same tissue, and the weight Wijwill increase. Otherwise, if two pixels are different, the influence of penalty term will reduce, i.e. pixel n will have small effect on current pixel i.

Us Lagrange multiplier method, we can get the final membership function and cluster centers: [4]

$$u_{jk}=\frac{\left(\left\|y_j-v_k\right\|^2+\beta\sum_{n\in N_j^R}w_{jn}\sum_{l\in L_k}u_{nl}^q\right)^{-1/(q-1)}}{\sum_{i=1}^{C}\left(\left\|y_j-v_k\right\|^2+\beta\sum_{n\in N_j^R}w_{jn}\sum_{l\in L_k}u_{nl}^q\right)^{-1/(q-1)}})$$

$$v_i=\frac{\sum_{k=1}^{n}(u_{ik})^m x_k}{\sum_{k=1}^{n}(u_{ik})^m} \quad \text{----------- (4)}$$

The flow step of NLFCM is as follows:

Step1: Initial the clustering parameters: class number C cluster center v(t), and membership function u(t), set error value to break iteration £>0 , iteration initial value t=0;
Step2: Calculate the weight value wijby formula (8);
Step3: Calculate the membership function u(t+1) by formula (11);
Step4: Calculate the cluster center v(t+1) by formula (12);
Step5: Calculate the iteration condition, if ||v(i+1)-v(i)||≤ £, stop the iteration; Otherwise, t=t+1 and go to step2.

4. PROPOSED APPROACH

The proposed approach applies canny edge detection before applying the segmentation. The advantage of the proposed approach is we can get the better segmentation result for the noisy image. As the canny edge provides the better edges in noisy environments, edge information can be used in the non-local fuzzy c-means segmentation. [5]
Defining the neighbor of pixel j is a neighbor patch Pj, then the similarity of pixel i and j is the edge-similarity of patch Piand Pj, the weight value wijcan be calculated by the following equation:

$$w_{ij}=\frac{1}{Z_i}e^{-1/h^2\left\|y(p_i)-y(p_j)\right\|_2^2} \quad \text{--- (5)}$$

The distance between patch Pi and Pjis calculated as following:

$$\left\|y(P_i)-y(P_j)\right\|_2^2=\sum_{p=1}^{|P_i|}\left(y^{(p)}(P_i)-y^{(P)}(P_j)\right)^2 \quad \text{---- (6)}$$

Among formula (13) and (14), Ziis and regularized constant, h is a smooth parameter, vector y(Pi)contain edge information of neighbor of pixel i, $y^{(p)}$(Pi) is the p^{th} value of the vector.

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[1]

$$J_{RFCM} = \sum_{j\in\Omega}\sum_{k=1}^{C} u_{jk}^{q}\left\|y_j - v_k\right\|^2 + \frac{\beta}{2}\sum_{j\in\Omega}\sum_{k=1}^{C} u_{jk}^{q}\sum_{n\in N_j^R} w_{jn}\sum_{l\in L_k} u_{nl}^{q} \quad \text{----(7)}$$

Compare with formula (6), we find that formula (14) can adjust the influence of neighborhood pixels around affecting on it automatically by a weight parameter Wij. That is to say, if the neighbor of pixel edge i and n is similar, they may belong to a same tissue, and the weight Wijwill increase. Otherwise, if two edges are different, the influence of penalty term will reduce, i.e. edge pixel n will have small effect on current pixel i.

Use Lagrange multiplier method, we can get the final membership function and cluster centers:[1]

$$u_{jk} = \frac{\left(\left\|y_j - v_k\right\|^2 + \beta\sum_{n\in N_j^R} w_{jn}\sum_{l\in L_k} u_{nl}^{q}\right)^{-1/(q-1)}}{\sum_{i=1}^{C}\left(\left\|y_j - v_k\right\|^2 + \beta\sum_{n\in N_j^R} w_{jn}\sum_{l\in L_k} u_{nl}^{q}\right)^{-1/(q-1)}} \quad \text{---- (8)}$$

$$v_i = \frac{\sum_{k=1}^{n}(u_{ik})^m x_k}{\sum_{k=1}^{n}(u_{ik})^m} \quad \text{----------- (9)}$$

The flow step of proposed approach is as follows:[1]

Step1: Initial the clustering parameters: class number C cluster center v(t), and membership function u(t), set error value to break iteration £>0 , iteration initial value t=0;
Step2: Calculate the weight value wijby formula (13);
Step3: Calculate the membership function u(t+1) by formula (16);
Step4: Calculate the cluster center v(t+1) by formula (17);
Step5: Calculate the iteration condition, if ||v(i+1)-v(i)||≤ €, stop the iteration; Otherwise, t=t+1 and go to step2.

5. EXPERIMENT RESEARCH AND ANALYSIS

The experimental MATLAB codes were run on Intel core i3-50054 CPU, @2 GHz, 4GB Ram, the operating system used was Windows 10.The standard NLFCM are tested and before this Canny Edge Detection Method is applied. The brain images are obtained from Brain webwebsite. The Gaussian noise 5, 10,15,20,25,30 is added to the original images. The results of this experiment are shown in fig.1. and fig.2.[16]

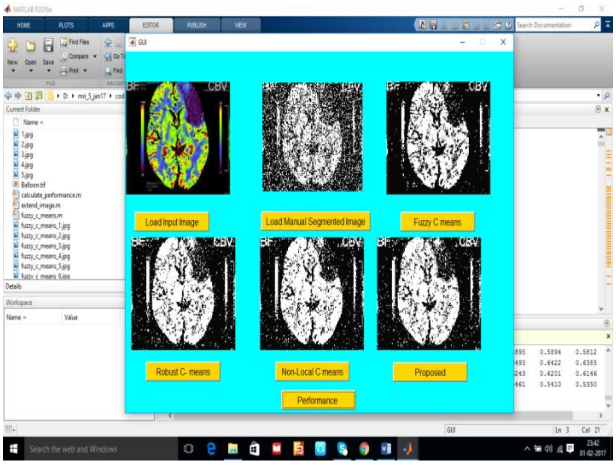
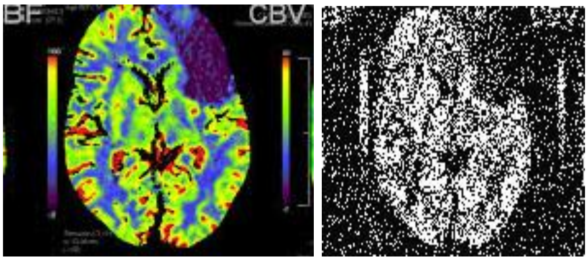
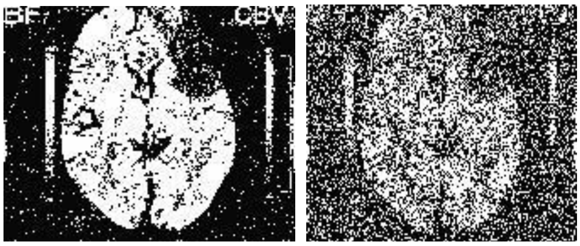


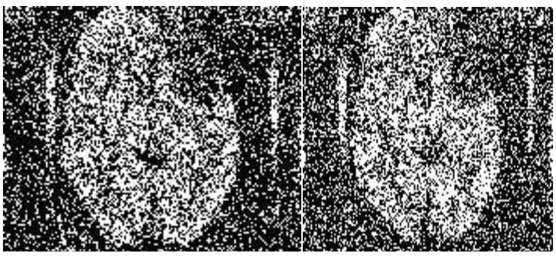
Fig1. showing the segmented images



(A)ORIGINAL IMAGE (B)IMAGE WITH NOISE



(**C**)FUZZY C-MEANS(D) ROBUST C-MEANS



(E)NLFCM (F)PROPOSED

FIG.2. COMPARISION OF THE RESULTS OF BASE ALGORITHMS AND PROPOSED ALOGORITHM

IARJSET
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ISSN (Print) 2394-1588
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ISO 3297:2007 Certified
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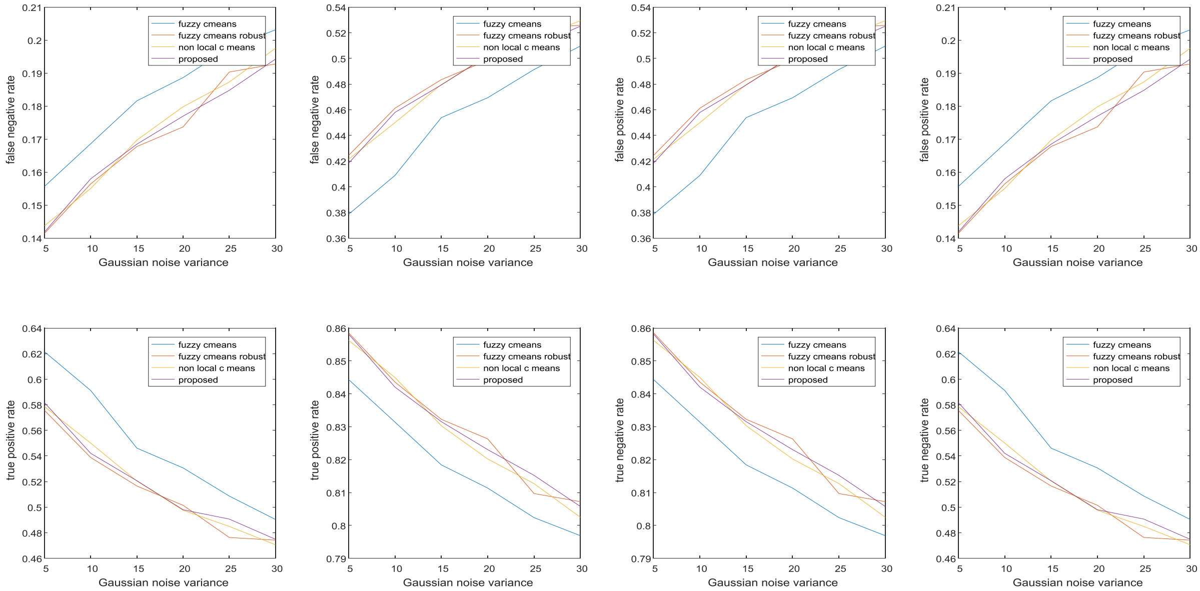

FIG.3. COMPARISON OF VARIOUS SEGMENTATION SCHEMES

TABLE 1. FALSE NEGATIVE RATE FALSE NEGATIVE RATE

	Variance=5	Variance=10	Variance=15	Variance=20	Variance=25	Variance=30
Fuzzy cmeans	0.1557	0.1686	0.1816	0.1886	0.1976	0.2031
Fuzzy cmeans robust	0.1415	0.1564	0.1678	0.1737	0.1903	0.1928
Non local cmeans	0.1437	0.1550	0.1697	0.1798	0.1873	0.1975
Proposed	0.1419	0.1580	0.1685	0.1770	0.1848	0.1942

TABLE 2. FALSE POSITIVE RATE

	Variance=5	Variance=10	Variance=15	Variance=20	Variance=25	Variance=30
Fuzzy cmeans	0.3786	0.4088	0.4539	0.4694	0.4914	0.5096
Fuzzy cmeans robust	0.4244	0.4612	0.4835	0.4986	0.5237	0.5258
Non local cmeans	0.4215	0.4500	0.4796	0.5025	0.5151	0.5294
Proposed	0.4184	0.4579	0.4794	0.5020	0.5093	0.5251

TABLE 3. TRUE POSITIVE RATE

	Variance=5	Variance=10	Variance=15	Variance=20	Variance=25	Variance=30
Fuzzy cmeans	0.6214	0.5912	0.5461	0.5306	0.5086	0.4904
Fuzzy cmeans robust	0.5756	0.5388	0.5165	0.5014	0.4763	0.4742
Non local cmeans	0.5785	0.5500	0.5204	0.4975	0.4849	0.4706
Proposed	0.5816	0.5421	0.5206	0.4980	0.4907	0.4749

TABLE 4. TRUE NEGATIVE RATE

	Variance=5	Variance=10	Variance=15	Variance=20	Variance=25	Variance=30
F Fuzzy cmeans	0.8443	0.8314	0.8184	0.8114	0.8024	0.7969
Fuzzy cmeans robust	0.8585	0.8436	0.8322	0.8263	0.8097	0.8072
Non-local cmeans	0.8563	0.8450	0.8303	0.8202	0.8127	0.8025
Proposed	0.8581	0.8420	0.8315	0.8230	0.8152	0.8058

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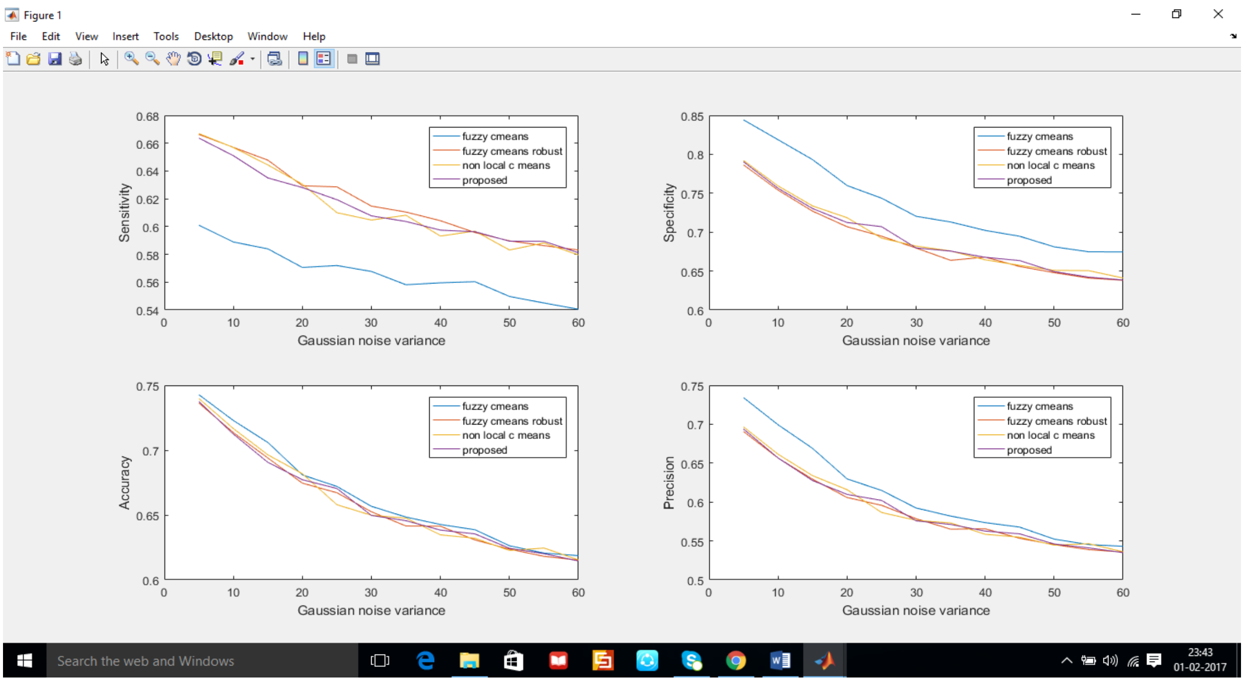

FIG.4. The Comparison Of Different Schemes Showing Sensitivity, Specificity, Accuracy And Precision

The graphs showing sensitivity, Specificity, Accuracy and Precision and can used in medical diagnosis. The presence of some signs of ailment suggest the the person may be sick. There are two possibilities the person may or may not have the disease. Physician and surgeons depend upon the diagnostic test to arrive at the conclusion about the diagnosis. Test result is either positive (diseased) or negative (healthy). False Positive: Healthy person incorrectly receives a positive (diseased) test result. False Negative: Diseased person incorrectly receives a negative (healthy) test result.[9]

6. PERFORMANCE COMPARISON

Fig.1 shows the performance comparison of true positive rate (TPR), true negative rate (TNR), false positive rate (FPR), and false negative rate (FNR) between the various approaches (fuzzy c-means, fuzzy c-means robust, non-local c means and the proposed approach). The FPR is high for fuzzy c-means and low for the proposed approach at high Gaussian noises for the foreground which have the same pattern for false positive. FNR and FPR is high for the proposed approach for the background and the foreground. TPR for foreground and TNR for the background for the proposed approach and the fuzzy c-means robust is nearly same whereas it is high for the fuzzy c-means. TPR for background and TNR for the foreground for the proposed approach is high and low for the fuzzy c-means. [15]

7. CONCLUSION

Segmentation is the one of the important problem in medical image processing to analyze the characteristics of the different regions. In this work, we implemented various approaches and proposed edge based non-local c-means approach for segmentation. The proposed approach consistently gives better results for various noise levels in the image compared to the reference schemes.[1]

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IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

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ISO 3297:2007 Certified
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