MRI Image Segmentation using Stationary Wavelet Transform and FCM Algorithm

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ABSTRACT

Image segmentation is one of the vital steps in Image processing. It is a challenging task in segmenting MRI(Magnetic Resonance Imaging) images because these images have no linear features. But MRI images provide high quality when compared to any other imaging techniques, so it is best suited for clinical diagnosis, biomedical research, etc. This paper presents a novel approach for segmenting MRI brain images using Stationary Wavelet Transform (SWT) and Clustering Technique. The clustering technique used here is Fuzzy c-means (FCM) clustering because it provides better segmentation for medical images. The obtained result using Stationary wavelet transform and Clustering Technique is compared with the existing method. The quality of segmentation is evaluated with deviation ratio as performance measure and the performance comparison for Discrete Wavelet Transform and Stationary Wavelet Transform in segmenting MRI images has been performed and the deviation ratio values are tabulated.

General Terms

Medical Imaging,image processing,image segmentation.

Keywords

Deviation ratio, Fuzzy C-means clustering, Magnetic Resonance Imaging, Segmentation, Stationary Wavelet Transform.

1. INTRODUCTION

Image analysis is one of the most significant key steps in image processing and computer vision applications. Image segmentation is one of the most essential and challenging task. Image segmentation means dividing an image into multiple regions. Medical image segmentation finds applications in clinical diagnosis, tumour detection, etc. Segmentation can be classified into several categories such as clustering methods, edge detection methods, region based segmentation techniques. Wavelet transform is a useful tool that is used to describe the image in multiple resolutions. Wavelet decomposition allows a perfect reconstruction of the original image. There are different wavelet transform available like discrete wavelet transform and stationary wavelet transform. Discrete wavelet transform (DWT) decimates the wavelet coefficients. Thus the results half the size of the original sequence. The output of each level of Stationary Wavelet Transform (SWT) contains the same number of samples as the input. SWT is similar to DWT but the signal is never subsampled. In existing method [1] an algorithm for segmenting MRI brain images using DWT and Fuzzy C-means (FCM) clustering is proposed[7]. Our approach is based on applying SWT and FCM algorithm for segmenting MRI brain images.

An overview of this paper is as follows. In section 2 and 3 analysis of DWT and SWT is discussed. In section 4, the procedure for image segmentation using Fuzzy C means clustering is explained. In section 5, the proposed methodology is explained with flowchart. In section 6, the experimental results are shown. In section 7,conclusion is given.

2. DISCRETE WAVELET TRANSFORM

The Discrete Wavelet Transform is based on subband coding. In this transform, wavelets are sampled discretely and there is convolution followed by decimation. The most important information in the signal appears in high amplitudes and the least important information in the signal appears in very low amplitudes. The basic idea is simple. Appropriate high pass and low pass filters are applied to the data at each level and also there is down sampling done at each level. The image is divided in to four subbands (LL,LH,HL,HH) by using DWT. The subbands will have half of the size of the original image[2]. The LL subbands can be regarded as the approximation component of the image, while the LH,HL,HH subbands can be regarded as the detailed components of the image. The advantages of Discrete Wavelet transform are as follows: It provides fast computation. It can be implemented easily and also reduces the computation time and resources required. The Discrete wavelet transform provides sufficient information for the analysis and synthesis of the signal. The Discrete Wavelet Transform also suffers from the following drawbacks: Poor directionality, Translational invariant and Lack of phase information. The filter bank structure of DWT is shown in figure1.
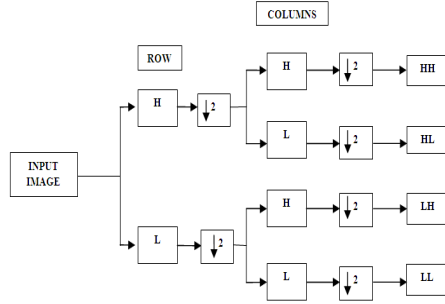
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Figure.1 Filter bank structure of DWT

3. STATIONARY WAVELET TRANSFORM

In order to overcome the translational invariant of the Discrete Wavelet transform, Stationary Wavelet Transform is designed. In this transform, there is no downsampling occurs between levels. They provide better time-frequency localization and the design is simple. The basic idea is simple. Appropriate high pass and low pass filters are applied to the data at each level and it produces two sequences at the next level. There is no decimation step in SWT as in DWT therefore the new sequences have the same length as the original sequence and it provides redundant information. The advantages of Stationary wavelet transform are: No subsampling of input, Translation invariant, providing better time frequency localization, providing freedom to carryout design. There is no downsampling and therefore there is no loss of information and hence suitable for feature selection[4]. The filter bank structure of SWT is shown in figure 2.
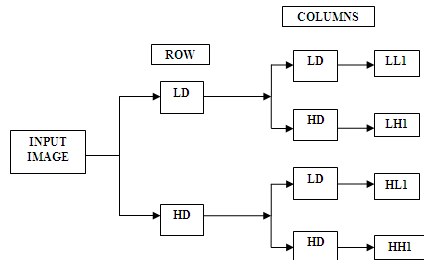

Figure.2 Filter bank structure of SWT

4. FUZZY C-MEANS CLUSTERING

It is one of the unsupervised clustering techniques used in image segmentation. The idea is simple, clusters the data into two or more classes by known no of classes that the image cluster to it.FCM was first demonstrated by DUNN and later it was improved by BEZDEK[12].This algorithm works by assigning membership to each data point corresponding to each cluster center on the basis of distance between the cluster center and the data point. More the data is near to the cluster center more is its membership towards the particular cluster center. Clearly, summation of membership of each data point should be equal to one.

After each iteration membership and cluster centers are updated according to the formula:

$$\mu = 1 / \sum_{k=1}^{c} (d_{ij} / d_{ik})^{2/m-1} \qquad (1)$$

$$v_j = \frac{\sum_{i=1}^{n} (\mu_{ij})^m x_j}{\sum_{i=1}^{n} (\mu_{ij})^m}, \forall j = 1, 2, \ldots, c. \qquad (2)$$

where,

'n' is the number of data points.

'vj' represents the jth cluster center.

'm' is the fuzziness index m € [1, ∞].

'c' represents the number of cluster center.

'µij' represents the membership of ith data to j^{th} cluster center.

'dij' represents the Euclidean distance between i^{th} data and j^{th} cluster center.

Main objective of fuzzy c-means algorithm is to minimize:

$$J(U,V) = \sum_{i=1}^{n} \sum_{j=1}^{c} (\mu_{ij})^m \| x_i - v_j \|^2 \qquad (3)$$

where,'$//x_i - v_i//$' is the Euclidean distance between i^{th} data and j^{th} cluster center.

The major advantages of Fuzzy c-means clustering are: 1) Gives best result for overlapped data set and comparatively better then k-means algorithm[8].2) Unlike k-means where data point must exclusively belong to one cluster center here data point is assigned membership to each cluster center as a result of which data point may belong to more than one cluster center[5].Eventhough,It has more advantages it suffers from few drawbacks like:1) Apriori specification of the number of clusters.2) With lower value of β we get the better result but at the expense of more number of iteration[9].3) Euclidean distance measures can unequally weight underlying factors.

5. PROPOSED METHODOLOGY

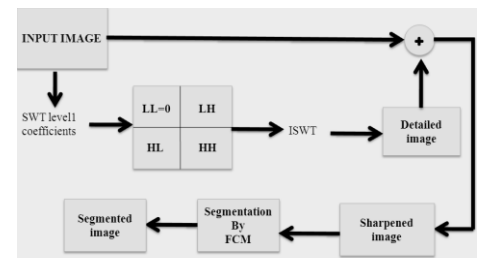The block diagram of the proposed algorithm is shown in Figure 3.

Figure.3 Block diagram for the proposed algorithm

5.1 STEPS INVOLVED:

1. Stationary Wavelet transform is applied to an input image to obtain stationary wavelet decomposed image resulting in four subbands. we obtain LL, LH, HL and HH sub bands representing approximation ,horizontal, vertical and diagonal components in the form of coefficients, respectively. LL sub band contains low level and the other three (LH, HL, HH) contain high level details[6].

2. Set approximation coefficients in LL equal to zero and apply inverse SWT is applied to obtain a high pass image from the remaining (horizontal, vertical and diagonal) subbands. We call the resultant image level-1 (L1) detail image. We obtain an images by using Inverse SWT.

3. Apply the images obtained in step2 to FCM clustering algorithm, to segment the image that partition the data set in to an optimal number of clusters[6].

4. Finally we obtain the segmented image by using SWT with FCM algorithm and also Performance Evaluation is done.

6. EXPERIMENTAL RESULTS

The input images and their segmented results using proposed algorithm and DWT with FCM algorithm is shown in figure4.   .
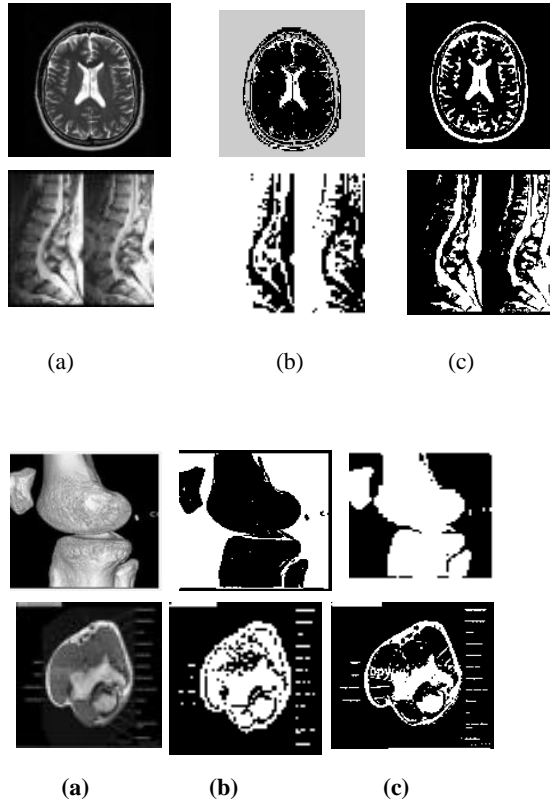

(a)   (b)   (c)

(a)   (b)   (c)
Figure.4 (a) Input image (b) Segmented image using DWT-FCM(c) Segmented image using SWT-FCM

The quality of segmentation results of different MRI images are evaluated using deviation ratio[11][4]. The deviation ratio is given as,

$$D_r = N_{ms} / N_{Tot} \qquad (4)$$

Where,

N_{ms}-Number of misclassified pixels
N_{Tot}-Total Number of pixels.

The results of the segmentation using proposed algorithm is compared with DWT based FCM and the corresponding deviation ratio values are tabulated for different images as shown in Table .1

Table 1: comparison of performance of the proposed segmentation algorithm with dwt based fcm algorithm

Input images	Deviation ratio	
	SWT	DWT
	0.1522	0.9893
	0.0438	0.6445
	0.0434	0.5027
	0.0524	0.8789

7. CONCLUSION

In this paper, image segmentation using SWT with FCM is compared with the segmented image using DWT with FCM. The output obtained using SWT with FCM is found better than the output obtained using DWT with FCM. Hence, we conclude that, SWT with FCM can be used for segmenting MRI Images. In future, the performance can be further improved using hybrid approach combining both FCM and Fuzzy rules.

8. REFERENCES

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