Augmentation of Segment Accuracy of Medical Images Using FCM with Spatial Probability and De-Noising

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Abstract – This paper utilizes histogram based FCM clustering algorithm [1] for segmentation of images with 3-D transform. The spatial probability of neighboring pixels is incorporated in the objective function of FCM to increase the robustness against noise. The proposed approach makes use of histogram based Fuzzy C-Means clustering with de-noising & spatial probability for the segmentation of noisy images, which will give better segmentation accuracy. The experimental result at the end shows that this approach achieves consistent segmentation accuracy regardless of noise levels.

Keywords- Image Segmentation, Fuzzy Logic, De-Noising, Clustering and Spatial Probability.

I. INTRODUCTION

Segmentation is an objective analysis on images [7].Image segmentation refers to the process of partitioning a digital image into non overlapped multiple segments. It is typically used to locate objects & boundaries in images. It is the process of assigning a label to every pixel.The segmentation is based on measurements taken from the image and might be grey level, colour, texture, depth or motion.Segmentation is unsupervised learning that involves identifying objects in a scene for object-based measurements such as size and shape.Image segmentation has a wide application in areas such as robot vision, geographical imaging, object recognition and imaging. Result of image segmentation is a set of segments that collectively cover the entire image or set of contour extracted from the image. Clustering based approaches have been widely selected for extensive investigation and thereby utilized for image segmentation.

II. PROPOSED APPROACH

The proposed approach as shown in figure 1isto be Carried out in 5 stages:

Stage1:- Image De-noising
Stage2:- Histogram Analysis
Stage3:- Fuzzy-Clustering
Stage4:-Spatial Transformations
Stage5:- Execution in MATLAB

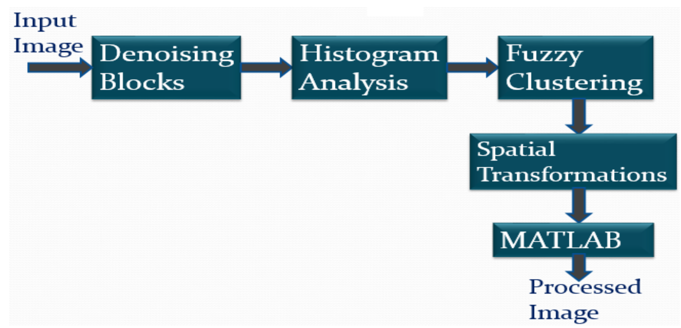

Fig.1. Block Diagram Depicting the Proposed Approach

A. Image De-noising

It refers to the recovery of a digital image that has been contaminated by Additive White Gaussian Noise (AWGN).We have used image de-noising strategy based on an enhanced 3D sparse representation in transform domain. The enhancement of the sparsity is achieved by grouping similar 2D image fragments (e.g. blocks) into 3D data arrays which we call "groups" shown in figure2. A significant improvement is obtained by a specially developed collaborative Wiener filtering.

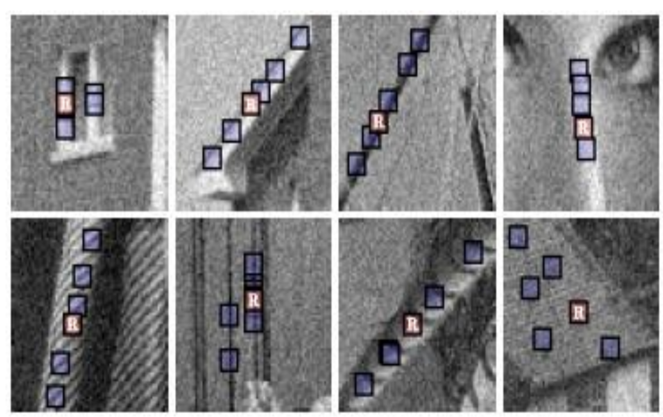

Fig.2. Illustration of grouping blocks from noisy natural images corrupted by White Gaussian Noise with standard deviation 15 and zero mean. Each fragment shows a reference block marked with “R” & a few of the blocks matched to it.

a). Formulae used:

Block Distance,

$$d(Z_{xR}, Z_x) = \left\|\gamma(T_{2d}^{ht}(Z_{xR}) - \gamma(TT_{2d}^{ht}(Z_x))\right\|_2^2 / (N_1^{ht})$$

Block Matching Set,

$$S_{xR}^{ht} = (x \epsilon X : d(Z_{xR}, Z_x \leq T_{match}^{ht})$$

3D Array of Block-Wise Basic Estimates,

$$\hat{Y}_{S_{xR}^{ht}}^{ht} = T_{3D}^{ht^{-1}}(\gamma(T_{3D}^{ht}(Z_{S_{xR}^{ht}})))$$

Coordinates of Matched Block,

$$S_{xR}^{wie} = (x \epsilon X : \left\|\hat{Y}_{xR}^{basic} - \hat{Y}_{x}^{basic}\right\|_2^2 / (N_1^{wie}) < T_{match}^{wie})$$

Wiener Group Estimates,

$$\hat{Y}_{S_{xR}^{wie}}^{wie} = T_{3D}^{wie-1}(W_{xr}^{wie} T_{3D}^{wie}(Z_{xr}^{wie}))$$

Aggregation weight,

$$w_{xR}^{ht} = \begin{cases} 1/(\sigma^2 N_{har}^{xR}) & \text{,if } N_{har}^{xR} \geq 1 \\ 1 & \text{,Otherwise} \end{cases}$$

Global Estimate,

$$\hat{Y}^{basic}(x) = \sum_{xR \epsilon X} \sum_{xm < S_{xR}^{ht}} w_{xR}^{ht} \hat{Y}_{x_m}^{ht,xR}(x) / \sum_{xR \epsilon X} \sum_{xm < S_{xR}^{ht}} w_{xR}^{ht} X_{x_m},(x) \forall x \epsilon X$$

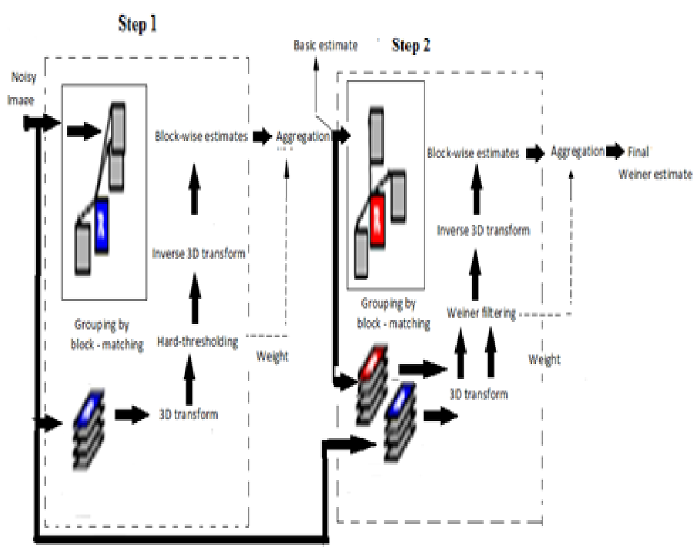

Fig. 3. Flowchart of the Proposed Image De-Noising Algorithm. the Operations Surrounded By Dashed Lines Are Repeated For Each Processed Block (Marked With R)

B. Clustering

Clustering algorithms attempt to partition the input data into groups i.e., clusters such that patterns within a cluster are more similar to each other than to the patterns in other cluster. Fuzzy clustering has advantages over crisp & probabilistic clustering especially when there are significant overlaps between clusters. In fuzzy clustering, affinity to an input vector to the considered cluster is modeled by a membership function whose range is [0, 1] rather than either/or (0/1) as shown in figure 4(a) & 4(b).

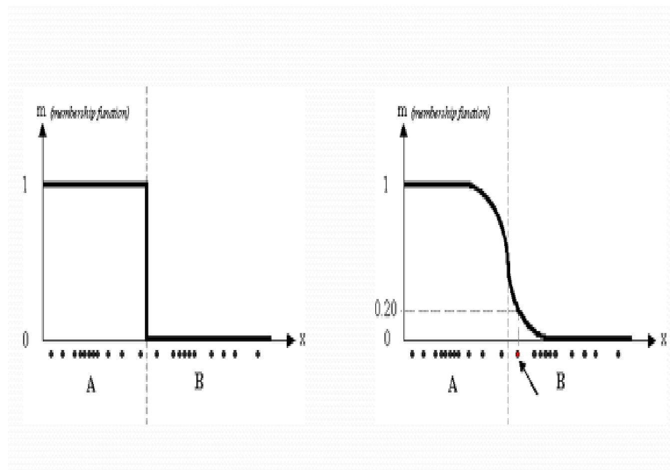

Fig. 4(a) – Hard Membership Function, Soft Membership Function.

$$U_{NxC} = \begin{bmatrix} 1 & 0 \\ 0 & 1 \\ 1 & 0 \\ .. & .. \\ 0 & 1 \end{bmatrix} \qquad U_{NxC} = \begin{bmatrix} 0.8 & 0.2 \\ 0.3 & 0.7 \\ 0.6 & 0.4 \\ .. & .. \\ 0.9 & 0.1 \end{bmatrix}$$

Fig. 4(b) – Hard Clustering and Soft Clustering.

C. Fuzzy C-Means Clustering

Fuzzy C-Means (FCM) is a method of clustering which allows one piece of data to belong to two or more clusters [3]. This method is frequently used in pattern recognition [5] [6]. Its objective function:

$$Jm = \sum_{i-1}^{N} \sum_{j-1}^{C} Uij^m \left\|xi - cj\right\|^2$$

D. Spatial Transformation

The originality of spatial transformation is based on the fact that FCM based algorithm considers no spatial context information which makes it sensitive to noise.The new algorithm is formulated by incorporating by priori probability and histogram based FCM algorithm.The probability indicates the spatial influence of the neighboring pixels on the center pixel plays a key role in this algorithm.

III. PROPOSED METHODOLOGY

FCM algorithm functions well on the majority of noise-free images. It possesses a major drawback, and it is highly sensitive to noise. The incorporation of spatial information into the histogram-based FCM makes it robust against noise and blurred edges. The objective function O (u,l) is given by

$$O(u,l) = \sum_{k-1}^{n} \sum_{i-1}^{v} (u_{kt}^{m}) d^2(x_k, c_t)$$

Two types of spatial informationare incorporated in the membership function of FCM algorithm:

- Apriori Probability: Assigns noise pixel to a cluster, which contains a majority of noise pixel's neighbourhood as its members.
- Fuzzy Spatial Information: A pixel gets higher membership value to a cluster when its neighborhood pixels have high membership value to that cluster.

IV. EXPERIMENTAL RESULTS AND DISCUSSION

NOISE LEVEL dB	FCM (%)	Accuracy of previous method (DFCM)[11]	Accuracy of proposed method (DFSCM)
0	100	97.8027	97.6001
10	96.4294	97.3023	97.6013
20	94,2429	97.229	97.3339
30	86.04	92.339	97.189

Table 1: Segmentation Accuracy of Conventional FCM, FCM with Spatial Probability and FCM with Spatial Probability and De-Noising.

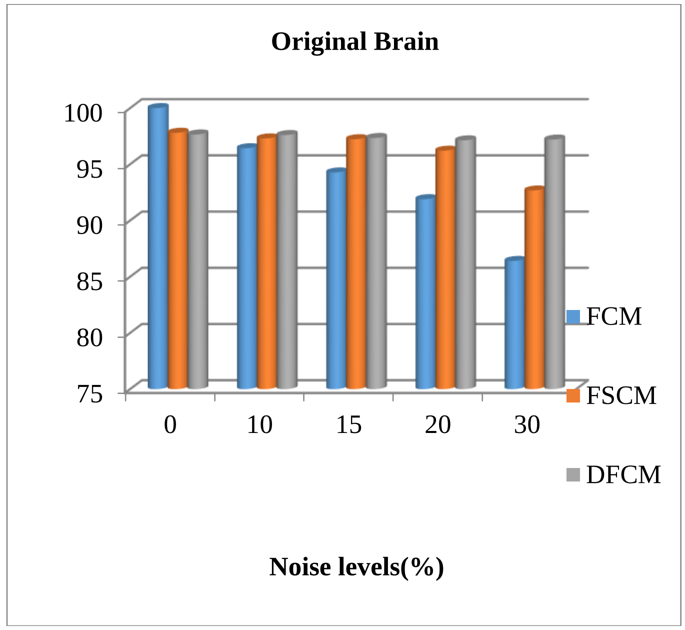

Fig. 5. Graphical Representation of Various Methods

It can be seen from the above table, the method developed by the authors are more consistent at higher noise levels as compared to methods developed previously. [11]

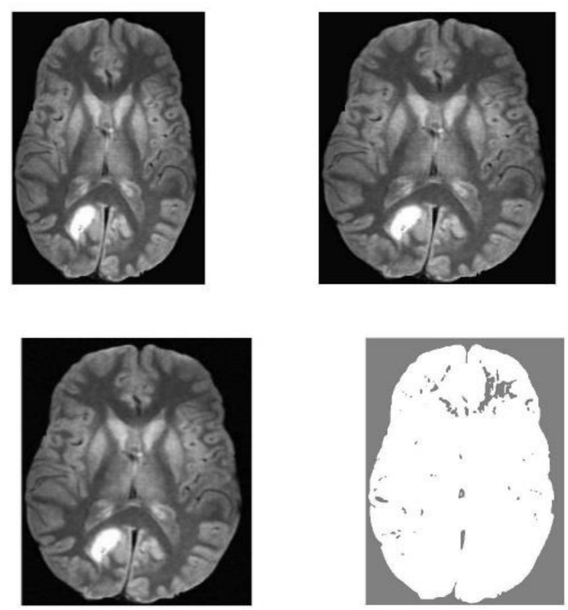

Fig. 6. Segmentation Result of Brain Image At 5% Noise Level. (Clockwise From Top Left) Original Brain Image, Image with Noise, Conventional FCM, FCM with De-Noising and Spatial Probability.

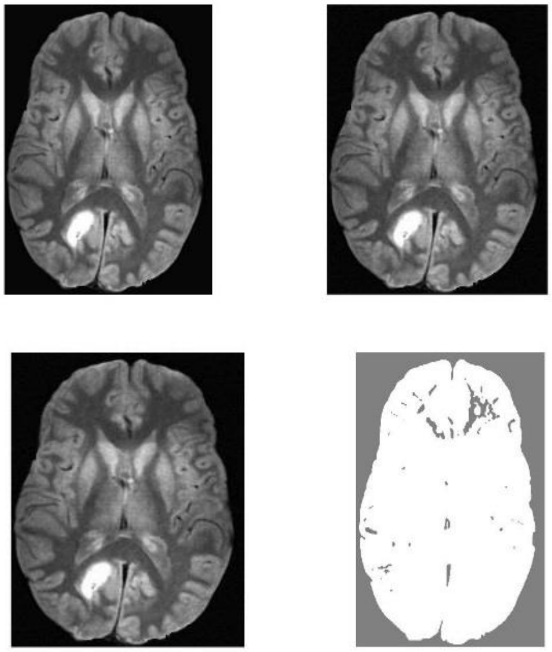

Fig. 7. Segmentation Result of Brain Image At 10% Noise Level. (Clockwise From Top Left) Original Brain Image, Image with Noise, Conventional FCM, FCM with De-Noising And Spatial Probability.

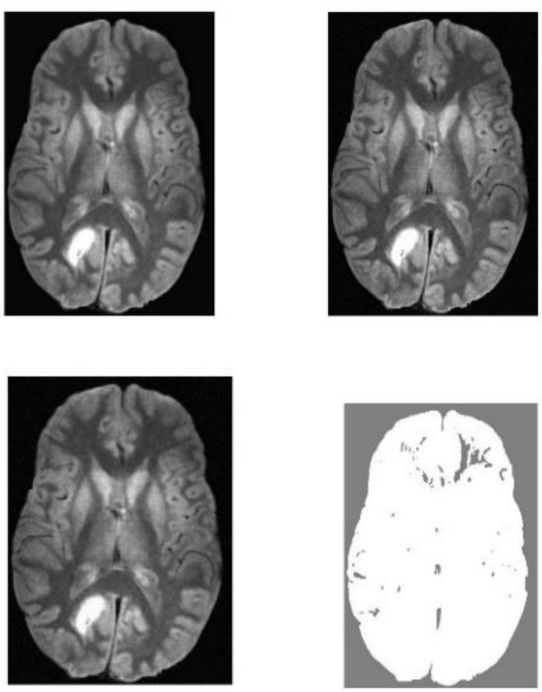

Fig. 8. Segmentation Result of Brain Image At 15% Noise Level. (Clockwise From Top Left) Original Brain Image, Image with Noise, Conventional FCM, FCM with De-Noising and Spatial Probability.

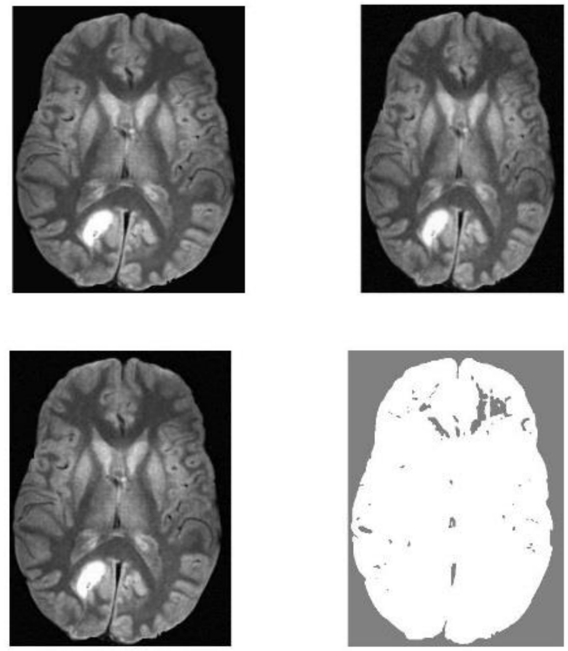

Fig. 9. Segmentation Result of Brain Image At 20% Noise Level. (Clockwise From Top Left) Original Brain Image, Image with Noise, Conventional FCM, FCM with De-Noising And Spatial Probability.

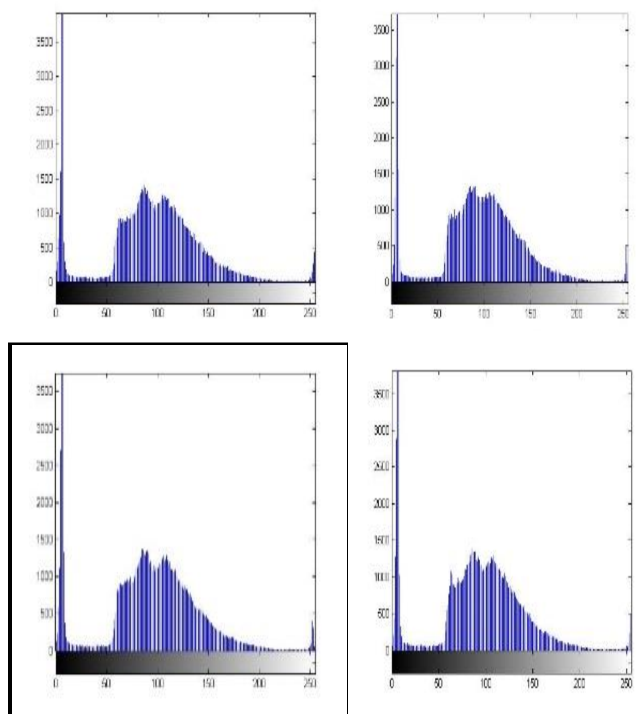

Fig. 10. Histogram of Output Image (Clockwise From Top Left) At 5% Noise Level, 10% Noise Level, 15% Noise Level And 20% Noise Level.

V. RESULT

The results obtained from the experimentation on the proposed segmentation approach are presented. The proposed segmentation approach has been programmed in MATLAB. Since the objective function of the proposed segmentation approach is initialized with parameters obtained from histogram of the image, it converged very quickly. The experimentation has been performed with three kinds of images namely, synthetic brain MRI images, original brain MRI images and real world images.

VI. CONCLUSION

This paper presents an efficient approach for the segmentation of noisy images. The proposed approach made use of histogram based Fuzzy C-Means clustering with de-noising & spatial probability for the segmentation of noisy images, which will give better segmentation accuracy. The de-noising of noisy images before to segmentation has been found robust against various noise levels. The experimentation with synthetic and real images has demonstrated the efficiency and robustness of the proposed approach in segmenting noisy images.

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