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Histon based Combined Clustering Approach for Brain Tissue Segmentation

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Abstract-In this paper, MR Brain image segmentation technique based on Modified Gaussian Kernelized Fuzzy C- Means (MGKFCM) clustering approach has been presented. Moreover, in FCM the cluster centroids are selected in a random manner, which may affect the process sometime. Hence, In this proposed method, instead of selecting the cluster centres in a random manner, Histogram technique along with K- Means clustering was used. In general, the MR images are suffered by noise, intensity inhomogeneity and Partial Volume Effect (PVE), primarily the noise has been removed by applying median filtering process. The Fuzzy C-Means (FCM) clustering technique has been proposed to deal with the problem of PVE. The intensity inhomogeneity problem has been handled by modifying the Objective function of the standard Fuzzy C- Means by applying a Gaussian radial basis function with the additive bias field. The result analysis has been carried out with the addition of impulsive and Gaussian noise.

Key words - Histon formation, K-means clustering, Modified Gaussian Kernelized FCM, Magnetic Resonance (MR) Brain Image, Noise Analysis.

I. INTRODUCTION

The Clustering strategies are Hard clustering and Fuzzy clustering. Hard clustering methods, force the pixels to belong to one class, but Fuzzy clustering allows pixels to belong to multiple clusters with varying degrees of membership, which is needed to analyze the medical images without any loss of information. In Fuzzy clustering, Fuzzy C- Means clustering plays an important role [1]. This could retain much more information from the original image than hard segmentation techniques [2].

In Histogram and Histon, the distributed values are used to initialize the centroid for every cluster [3]. Such initialization fails, if the image is suffering from noise, or any other disturbances. Moreover, the probability of getting the number of

centroids is more if the image is having high contrast, and it may be less with low contrast. To overcome this drawback, In this proposed method based on the maximum values of the Histon of the input images, the cluster centres for K-Means clustering were selected [4]. The output from each cluster of the K- Means was given to modified Gaussian kernelized FCM as the initial value of centroid for making clusters. Hence, a new technique has been introduced to select the initial centroid value for Fuzzy clusters. In fuzzy clustering three clusters are created to segment the brain tissues into White matter (WM), Gray matter (GM) and Cerebro-Spinal fluid (CSF) [5]. The following figure1 depicts the proceeding steps for the proposed method.

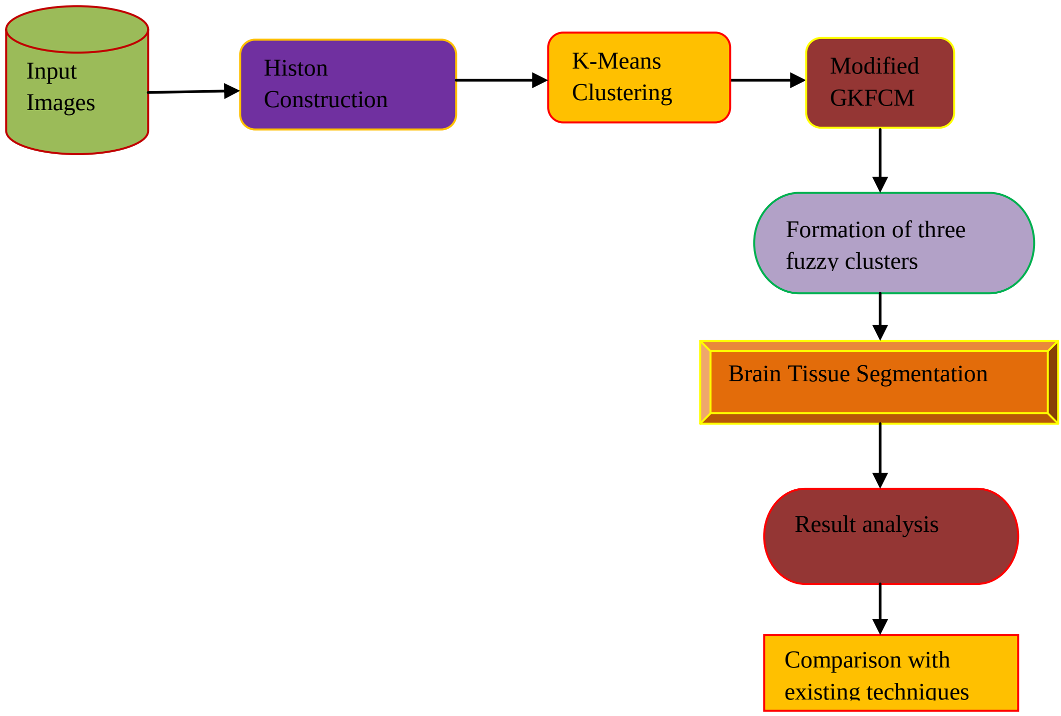


Figure. 1. Schematic diagram for the proposed method.

II. CLUSTERING TECHNIQUES

A. Centroid Selection

Let ‘I’ be a MR Brain image of size ‘MxN’ and it is converted into grayscale image (I’) of size ‘M xN’. The distance (d) between the image pixels with their neighbourhood pixels is computed as,

$$d(m,n) = \sqrt{\sum_{x\in X}\sum_{y\in Y}\left(I'(m,n) - I'(x,y)\right)^2} \tag{1}$$

Where, I’(x, y) is the neighbouring pixel of the image pixel I’(m, n). The computed value d(m,n) is compared with the Threshold value (Th) to form a new matrix ‘A’ of size ‘mxn’. The matrix element A(m,n) is given by,

$$A(m\times n) = \begin{cases} 2, & d(m,n) > Th \\ 0, & otherwise \end{cases} \tag{2}$$

The Threshold value ‘Th’ is computed by,

$$Th = \frac{1}{M' \times N'} \sum_{m=1}^{M'}\sum_{n=1}^{N'} d(m,n) \tag{3}$$

$$H(t) = \sum_{m=1}^{M'}\sum_{n=1}^{N'} (1 + A(m,n))\delta(I'(m,n) - t), \;\; 0 \le t \le S-1 \tag{4}$$

Where, ‘$\delta(.)$’is the impulse function and ‘S’ is the total number of intensity levels in the image. The maximum values from the constructed Histon are given to K- Means clustering technique.

It is a well-known Hard clustering technique and the main advantages of this algorithm are its simplicity and low computational cost. Here, ‘k’ number of clusters must be selected randomly and the resulting clusters depend on the initial assignments of centroids. The K- Means algorithm aims at minimizing an Objective function [6].

$$J_{k-means} = \sum_{r=1}^{R}\sum_{i=1}^{S} \left\| s_i - C_r \right\|^2 \tag{5}$$

Where, ‘s_i’ represents data points and ‘C_r’ is the cluster centre. The result of the K-Means clustering process has ‘r’ number of clusters.

B. Modified Gaussian Kernel Objective Function

In the proposed method, the regularizer term includes the spatial neighbourhood information which is useful in segmenting the images distorted by noise and intensity inhomogeneity. (6)

The Modified Gaussian Kernel based FCM (MGKFCM) Objective function includes the performance of both Gaussian Kernel function and additive bias field which is given by the equation (6), [7].

$$J_{Mgkfcm} = 2\sum_{i=1}^{c} \sum_{j=1}^{n} u_{ij}^{m}\left(1 - \exp\left(\frac{\left\| y_j - w_j\beta_j - c_i \right\|^2}{\sigma^2}\right)\right) +$$

$$\frac{2\alpha}{N_R}\sum_{i=1}^{c} \sum_{j=1}^{n} u_{ij}^{m} \sum_{y_r \varepsilon N_j}\left(1 - \exp\left(\frac{\left\| y_r - w_r\beta_r - c_i \right\|^2}{\sigma^2}\right)\right)$$

Modified Algorithm

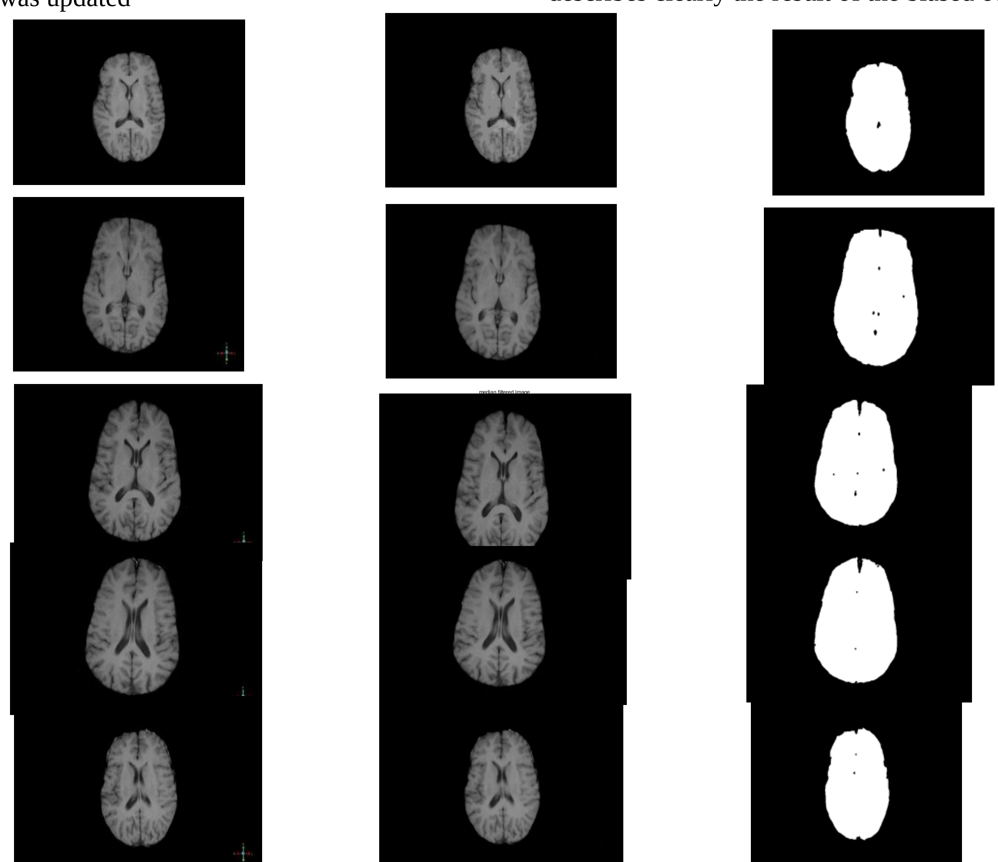
1. The image dataset was collected.
2. The number of clusters was decided and the centroids were initialized.
3. The membership function was updated
4. The cluster centroids were updated
5. The bias field was updated
6. Repeat the steps 3-5 until the following termination criterion is satisfied:

$$\left\| u_{ij}^{t+1} - u_{ij}^{t} \right\| < \varepsilon$$

Where $\|.\|$ is the Euclidean norm and ε is a small number (0.01) which can be fixed during the initialization process. The parameters of the modified algorithm, are tuned with the values of σ=6.0, α=0.85, N_j= 9, ε=0.01 [8]. W_j=0.008 which increases with the value of 0.001for each iteration [9].

III. DISCUSSION

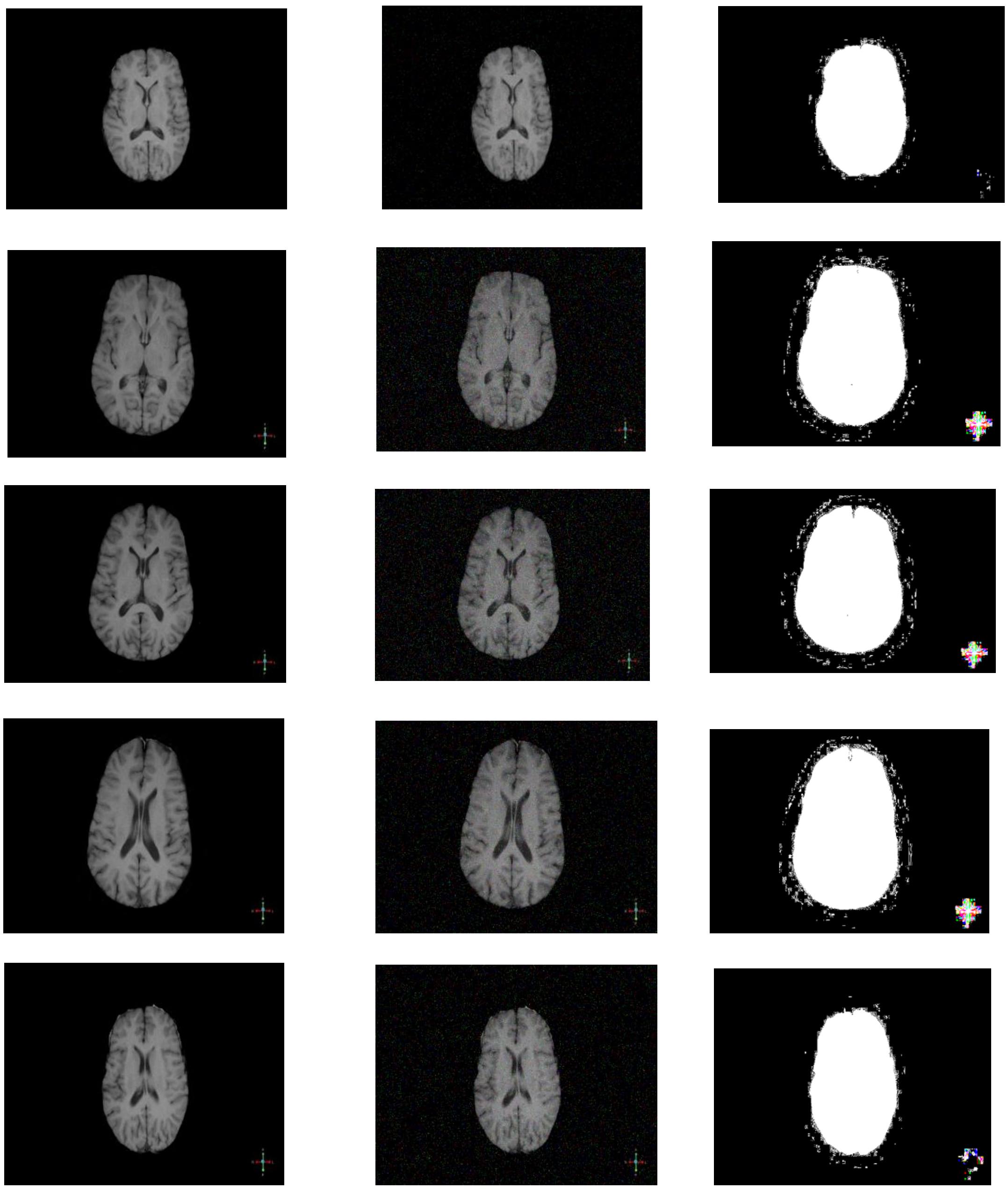
As a starting step, the images were converted into gray scale images and pre-processed with the help of the median filter [10,11,12]. The proposed Modified Gaussian Kernel based Fuzzy C- Means technique (MGKFCM) has been applied to the images in order to segment the MR Brain images into White Matter, Gray Matter and Cerebro-Spinal Fluid [13,14,15]. The following Figure 2(i) gives the details about the input real Brain images, Figure 2(ii) shows the result of median filtered images, Figure 2(iii) describes clearly the result of the biased output.



(i) **(ii)** **(iii)**

Figure 2 Segmentation using Proposed MGKFCM without Noise (i) Five Real Input MR Brain Images, (ii) Median Filtered Images (iii) Biased Output

The following Figure 3(i) gives the details about the input real Brain MR images, Figure 3(ii) shows the set of images added with impulsive noise of 0.03 level and Figure 3(iii) describes clearly the results for the corresponding biased image. Figure 4(i) gives the details about the input real Brain MR images, Figure 4(ii) shows the set of images added with Gaussian noise of 0.03 level and Figure 4(iii) describes clearly the results for the corresponding biased images. Figure 5(i) gives the details about the segmented results of the proposed MGKFCM technique, Figure 5(ii) shows the segmented results for the set of images added with impulsive noise of level 0.03 and Figure 5(iii) describes clearly the segmented results for the Gaussian noisy images of level 0.03.



(i) **(ii)** **(iii)**

Figure 3. Segmented Results for MGKFCM with 0.03 Impulsive Noise (i) Five Real lnput MR Brain Images (ii) Images with Impulsive Noise (iii) Corresponding Biased Output

Figure 6(i) gives the details about the convergence of the proposed Objective function without noise. Figure 6(ii) describes clearly the convergence of the proposed Objective function added with Impulsive noise of level 0.03. Figure 6(iii) describes clearly the convergence of the proposed Objective function added with Gaussian noise of 0.03 level. Table 1 depicts the number of iterations to run the proposed algorithm without noise, with the addition of Impulsive noise of level 0.03 and with the inclusion of Gaussian noise of level 0.03. Table 2 gives the details about the elapsed time to run the proposed algorithm in seconds without noise, with the addition of impulsive noise and Gaussian noise.

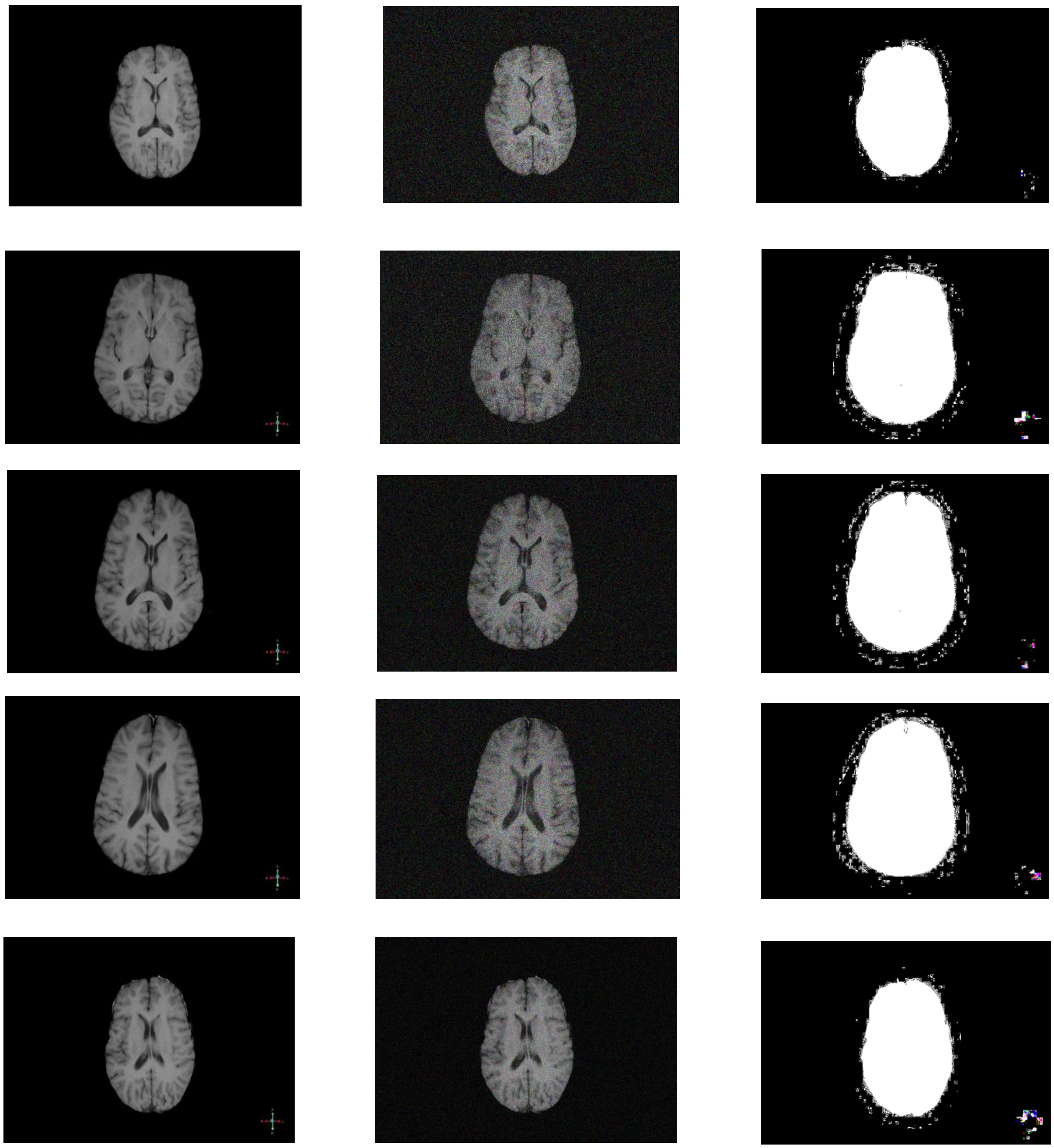


Figure 4 Segmented Results for MGKFCM with 0.03 Gaussian Noise (i) Five Real Input MRI Brain Images, (ii) Images with Gaussian Noise (iii) Corresponding Biased Output

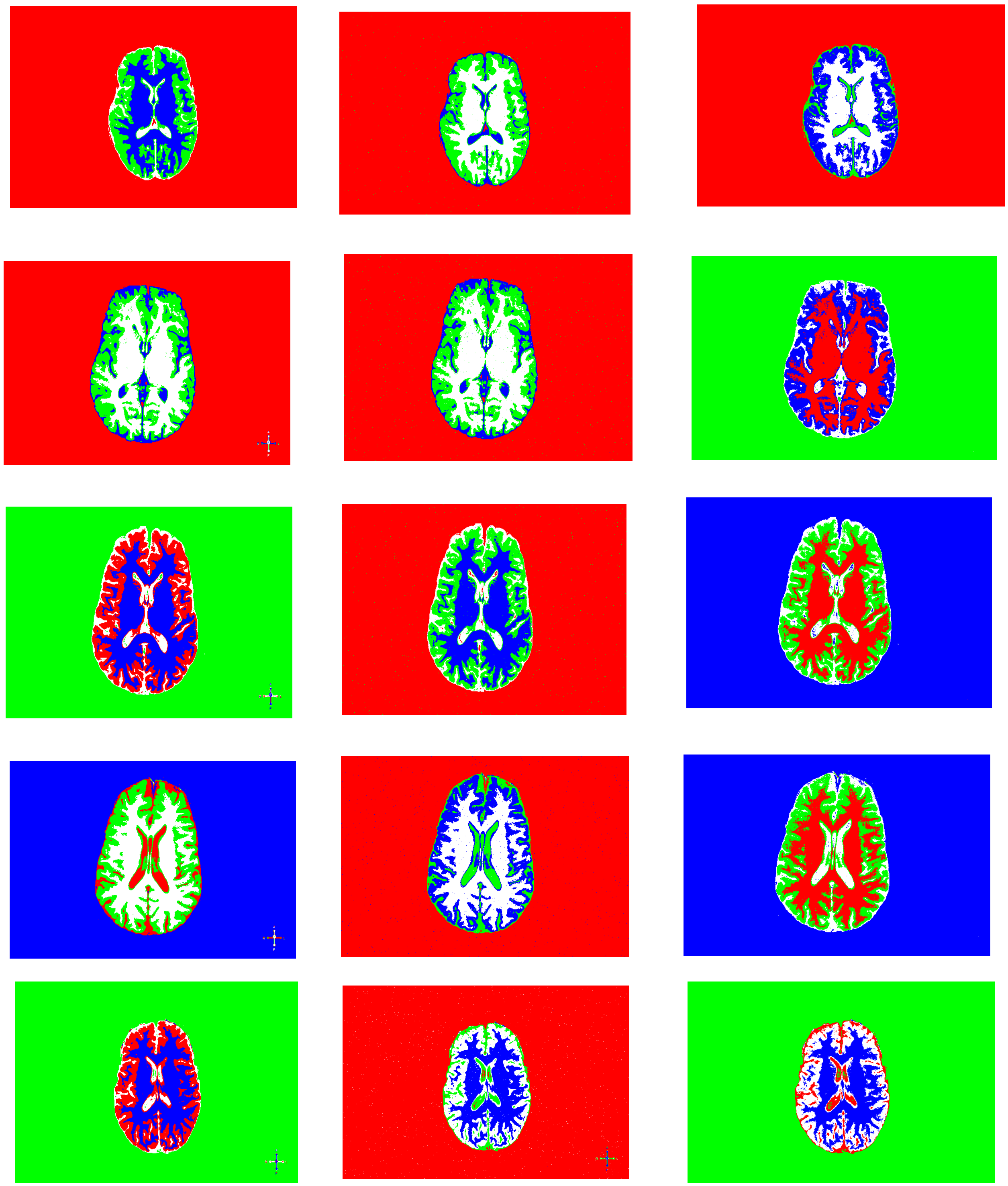


Figure 5 Segmented Result Analysis of Proposed MGKFCM (i) Segmented Images without Noise (ii) Segmented Images with Impulsive Noise (iii) Segmented Images with Gaussian Noise

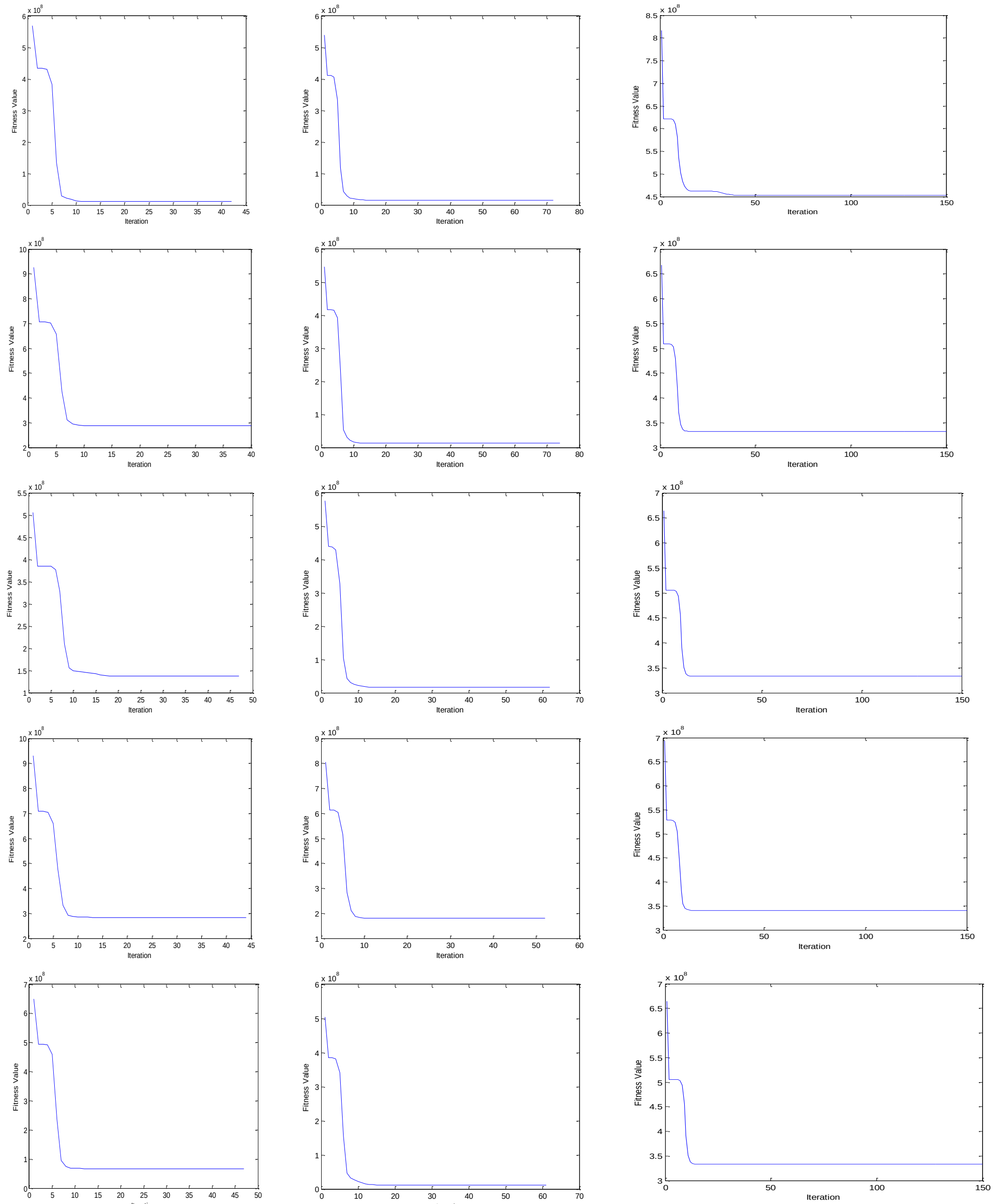


Figure 6. Convergence Plot for the Proposed MGKFCM (i) without Noise (ii) with Impulsive Noise (iii) with Gaussian Noise

Table 1. Number of Iterations for the Proposed MGKFCM Technique

Input Images	MGKFCM without Noise (Iterations)	With Implusive Noise of 0.03 Level (Iterations)	With Gaussion Noise of 0.03 Level (Iterations)
1	42	70	150
2	40	72	150
3	47	62	150
4	44	52	150
5	46	61	150

Table 2. Running Time in Seconds for the Proposed MGKFCM Technique

Input Images	MGKFCM without Noise	With Implusive Noise of 0.03 Level (Iterations)	With Gaussion Noise of 0.03 Level (Iterations)
1	7.702733 s	12.132221 s	26.082380 s
2	7.722577 s	12.635773 s	25.985121 s
3	8.872127s	11.071735 s	25.964520 s
4	8.376691 s	9.855340 s	26.104916 s
5	7.752558 s	10.874325 s	25.984215 s

IV. CONCLUSION

This paper deals with the concept of modified Fuzzy C-Means algorithm. To overcome the effect of intensity inhomogeneity and to maintain a constant bias field the Objective function of standard Fuzzy C-Means was modified by including the penalty term. It includes five stages (i) Pre-processing (ii) Centroid selection (iii) Tissue segmentation (v) noise analysis. It also summarizes the quantitative evaluation of the results of the proposed Fuzzy segmentation method without noise and with the addition of impulsive noise and Gaussian noise. This work can also be extended to diagnose a number of diseases in multi spectral MR Brain images and CT Liver images using a hybrid combination of meta-heuristics algorithm.

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Balan. Thamaraichelvi received her B.E. degree in Electrical and Electronics Engineering (EEE) in the year 1994 from Thiagaraja College of Engineering, Madurai, TamilNadu, M.E., degree in Process control and Instrumentation Engineering (PC&I) in the year 2004 and ph.D., degree in Electrical Engineering in the year 2017, from Annamalai University, Chidambaram, TamilNadu,. She has 15 years of teaching experience and she is currently working as an Assistant Professor in the Department of Electrical Engineering at Annamalai university. She has published and presented papers in National and International conferences and journals in the area of Image processing. Her research interest includes Digital signal processing, Image segmentation, Medical Imaging and soft computing.

