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Analyzing MRI Segmentation Based on Wavelet and BEMD using Fuzzy C-Means Clustering

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***Abstract* - Segmentation of images means a great matter for the medical field treatment purpose. For the extraction of brain polyps, magnetic resonance image (MRI) processing contributes in a wide range. Usually it works in two ways: white matter and gray matter. The extraction of any type of issues helps in submissions of image segmentation like in medical report analysis, in preparation of radiotherapy, in formation of medical treatment etc. The main purpose of this paper is the Fuzzy C-Means (FCM) clustering exploitation by the help of Wavelet and Bi-dimensional Empirical Mode Decomposition (BEMD), as for the aim of improving the eminence of MR noisy images. To gain the best image segmentation method, in this paper the signal to noise ratio (SNR) rates were calculated by the data set of FCM clustering. As in the medical term of MRI segmentation, the experiment has done with synthetic WEB Images of brain that has verified the robustness and proved with efficiency with the applicable approach.**

Keywords - Image segmentation; Magnetic Resonance Imaging (MRI); Fuzzy C-means; SNR; Wavelet; BEMD

I. INTRODUCTION

In the area of image processing, joint space-spatial frequency illustrations have gained spatial consideration and it also happens in vision and pattern recognition sector. For medical image analysis purpose, Magnetic Resonance Imaging (MRI) segmentation is a very stimulating and substantial phase. This step helps in various medical treatment purposes. MRI is a nonintrusive process as it is functioned for identifying internal muscles and organs.MR images have very different nature and it doesn't have any linear features. Partial volume effect (PVE) is an issue which defines that a pixel can contain more than one tissue. MR images performance can be affected by PVE and this can occur as of blurred frontier between relic passions of the similar tissue as over the spatial domain it is not constant of image as well as geometric distortion [5].

With the aim of developing the requirements for the MRI segmentation, researchers and scientist have been developed many segmentation methods over past few years. Identification of tissues and organs from the MR images is the main problem in segmentation. To solve those problems some spontaneous works have been done and those are described in the literature review segment. The main objective of MR image segmentation is to define the measurements of lesions, tissues, as well as organs existent in an image obtained from the patient. The segmentation measurements and the changing of those results with respect to time may help in the phase of patient treatment. It also helps to analysis and diagnosis forecasting of patients over exploration.

In a precise image segmentation process also helps to identify region of concern. The foremost approach of segmentation is to make image supplementary simple and expressive.

There remain many classification techniques in medical image segmentation but there is not any standard classification technique. On the basis of commonly used technique, the classification is done into various attitudes like as region based segmentation techniques which are sight for region recognition from the particular properties [6], another basis of physical evidence for irregular as well as regular tissues [2]. The Edge base segmentation techniques that are identified the edges among the sections of the image with the various features [7]. The knowledge based methods i.e., artificial neural networks. Other methods are based on data fusion method [1][9], based on Hybrid Method [4] and Random Markov method [10].

In some times the FCM is being used for the image segmentation. This is a multi-resolution process employed by the discrete wavelet transform (DWT). It is one of the good methods used for image segmentation in real time. By this process firstly the features are extracted from image, and then perform the selection, and finally segmentation is performed using the K-means clustering algorithm.

Fuzzy C-Means (FCM) based on image segmentation method had been applied in [11]. There proposed an algorithm which defined the size of window dynamically as for mining apposite inclusive spatial data from images. Moreover, without adding any penalty term there used the standard objective function of FCM. For describing one of each pixel clearly there used an n-dimensional feature. That method showed satisfactory results on real images but it failed in classification of five classes (i.e. background, cortical bone, malleable jawbone, adipose flesh and muscle) in the MRI of thigh.

Empirical Mode Decomposition (EMD) image function is operated in [12]. Bi-dimensional Empirical Mode Decomposition (BEMD) usually used in image segmentation of MRI and CT scans. By using the simple fusion rules, the fusion of the generated Bi-dimensional Intrinsic Mode Functions (BIMFs) are done. They had done comparison of the BEMD based fusion results by two efficient synthesis

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techniques: wavelet fusion and curve let fusion. BEMD performance had been calculated by using three well known synthesis image quality matrices; i.e., Peak Signal-to-Noise Ratio (PSNR), Mutual Information Parameter (MIP) and Structure Similarity Index Metric (SSIM).

In [13], worked on the image processing technique that is Wavelet for MR and CT scan image decomposition. That method involved de-noising of the images. For that, there used wiener filter that removed salt and pepper noise. Their main aim of image de-noising was noise reduction and feature preservation. In there, wavelet transformation was done by wavelet filters. They used different wavelet transformations i.e. Daubechies, Symlets, and Coiflets for gaining optimal results from the input images. But for noisy MR images this method didn't worked so well as like for CT scan images.

Work on brain tumor segmentation by using improved FCM has been done in [14]. In the paper, for decreasing noise ratio and to increase the contrast level there had preprocessed the test input images. Then the work was done on the segmentation of brain images by improved Fuzzy C-Means (FCM) algorithm to display the abnormal activity like growth of tumor. After that, texture features (GLCM) had removed from the images. In that extraction phase, for various distances and directions the calculation of statistical measurements had been done by gray level co-occurrence matrix. But there main disadvantage occurred in the edge detection of tumor as they can't sharpen every single pixel at a high contrast.

In [15], proposed a method for MR image segmentation by using the Wavelets and FCMs. The work is based on the image segmentation obtained by MRI is a challenging task as for the inherent signal noises and in homogeneity. Discrete Wavelet Transform has been applied to MRI image to excerpt great details and after some dispensation on high pass image. Their proposed method includes the FCM dissection algorithm functional to the Kirch's edge detection mask wavelet transformed image that used to increase the edge feature in the image. In the paper, authors are worked with hybrid method with help of wavelets and Fuzzy C-means. They extracted the high filtered image with the help of wavelets and Kirch's edge detection mask that had been applied to intensify extra brink specifics that afford satisfactory edge facts. Usually MR images are dispersed; incorrect brink collection can cause absconding polyp portion or tab a lot in decent physical forms as polyps. These types of methods are not that much dependable. For human body, it provides improved imagining of soft muscles. But only along the Discrete Wavelet transformation (DWT) is not much effective because the discrete value can miss some important value which may be useful for the survey.

For the segmentation of MRI, clustering is the most functioning or exploitable technique. Clustering used to classify pixels into curriculums and it does not have any idea of previous evidence or exercise. It categorizes pixels interested in the same class with maximum possibility. It may discover unsystematic pixels which do not have any class probability. The working out of clustering techniques has done by means of pixel structures with possessions of every session [16].

In this paper proposed a method to determine the best technique from the two decomposition techniques i.e., Wavelet and BEMD. These techniques are used before applying the image clustering technique i.e. FCM on MR images. For that, firstly apply the decomposition technique on the input MRI image. After that, FCM clustering technique is used on the outcomes of the decomposition techniques. Finally, calculate value of SNR to select the best segmentation technique from the segmentation approaches.

The paper is arranged as follows. The proposed framework is explained step by step in Section II. In Section III, the experimental results are described. Finally, the conclusion is given in Section IV.

II. PROPOSED METHOD

In this section describes the proposed method which is about the segmentation of MRI brain images with signal noise ratio. In the proposed methodology two important phases have involved i.e., extraction of features and clustering techniques. Extraction of feature process has done by Wavelet decomposition (2D) and BEMD. The working criterion of wavelet decomposition has divided into two segments i.e. outputs in low pass and outputs in high pass. The low pass values are the estimated elements and the high pass values are the exhaustive elements. In images Dubechies-1 (DAUB1) Wavelet is employed to acquire the wavelet features. The extraction of the feature has done in both Wavelet as well as BEMD decomposition. The results from the decomposition techniques are given into FCM which is functioned as a vector of the feature. That result was gained from the previous clustering step. The outputs of the MR images are divided into white and gray matter segments. After that, the value of the SNR is calculated for segmented output. Finally, determines the best segmentation technique based on the SNR value of the MR image. Fig. 1 shows the proposed method.

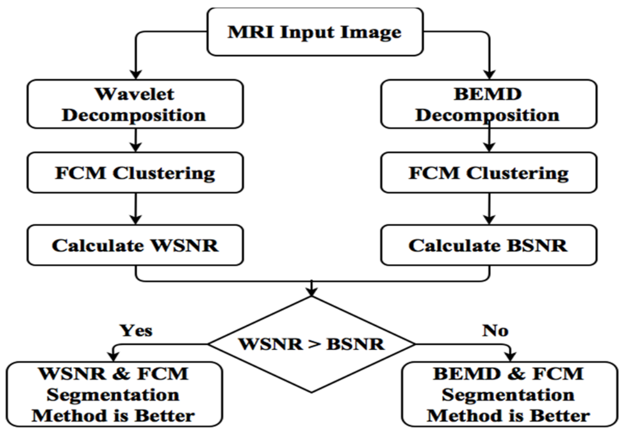
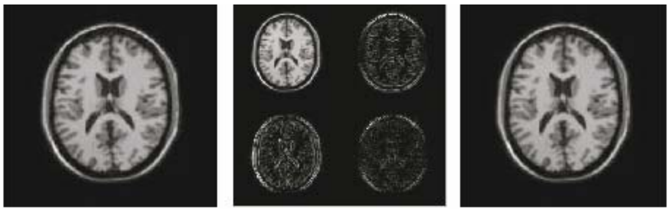


Fig. 1. The proposed method.

A. *Wavelet Decomposition*

The wavelet transform which is based on the Fourier transform is used in the image processing. This technique is becomes even more easy to transfer and analyze and also easier to compress the MR images. Wavelet Transformation (WT) characteristics share properties which is the basic functions of the family, mostly limited provision for the frequency domains and unique domains as well as scalability. In this family, there provides Haar, Coiflets, Biorthogonal, Daubechies, Reverse Biorthogonal, and Symlets. In this research paper, the family of Daubechies is used functionally. In the signal and image processing applications like segmentation, classification, de-noising and compression, Daubechies family is widely used.

The input MR image, wavelet decomposition of input image, and wavelet reconstruction to input image from decomposition image are shown in Fig. 2(a), 2(b), and 2(c) respectively.



(a) (b) (c)

Fig. 2. Processing experiment of wavelet decomposition and construction: a) Input MR image, b) Wavelet decomposition of MR image, and c) wavelet reconstruction of MR image.

B. Bi-dimensional Empirical Mode Decomposition(BEMD)

The EMD method has been established in [17], it is an algorithm of signal processing which has been recognized to be capable of perfectly exploring adaptive, non-stationary, and non-linear data by gaining regional structures as well as time-frequency distribution (TFD). For that, firstly decomposition of data/signal has done perfectly into its intrinsic mode function (IMF), in the next step finds the TFD of the signal/data from each intrinsic mode function with the help of utilization of the instantaneous frequency and Hilbert transform. The Hilbert-Huang transform (HHT) [17] is known by that process of above. The Bi-dimensional EMD (BEMD) technique is the process of two-dimensional (2D) data/images in a decomposition method.

The BEMD method is used in this paper based on IMFs to de-noise and decompose the MRI with the weighted threshold value of IMFs. After applying this method in the MR image the image noises are distributed in the different frequencies mainly high as well as intermediate frequency. The shifting procedure is used to attain the frequency elements in the image.

A sampled signal decomposes the selecting method by the EMD. This process is created by two obligations. The IMF has equal quantity of zero crossings as well as extrema in first process. In second process, respect to the local mean, IMF is symmetric. Also, it accepts those have two extrema at least. In the final stage, de-noising is achieved by reconstruct the source image. It is also mentioned that the segmentation quality is influenced by smoothness of the image data. Fig. 3 shows the experimental example of BEMD on MR images. Here, 48 iterations are performed for IMF to achieve the required response.

C. Fuzzy-C Means (FCM)

In image segmentation, FCM procedure is an unsubstantiated technique of clustering. FCM idea depends on two or more clustering data classes only by recognized amount of courses.

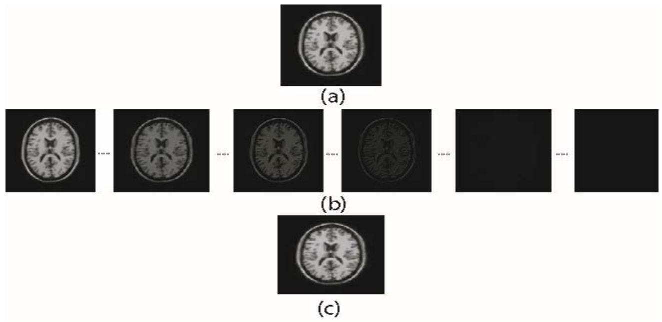


Fig. 3. Processing experiment of FCM: a) Input MR image, b) IMF (1,...,6,…,12,…,20,…,48),…, residue image, and c) reconstructed MR Image.

FCM algorithm is based on the minimization objective function shown in bellow.

$$J(U, c_1, c_2, \dots, c_c) = \sum_{i=1}^{c} J_i = \sum_{i=1}^{c}\sum_{j=1}^{n} u_{ij}^{m}\, d_{ij}^{2} \qquad (1)$$

here, the value of u is within 0 and 1. The value of the cancroids cluster I is define as C_i , the distance of the Euclidean between i^{th} and j^{th} cancroids data point is d_{ij}. The weighting function is m[1,∞]. The identified data sample of Fuzzy portioning is approved by optimization objection function which is the iterative process shown in bellow.

$$u_{ij} = \frac{1}{\sum_{k=1}^{c}\left(\frac{d_{ij}}{d_{kj}}\right)^{2/(m-1)}} \qquad (2)$$

$$c_{ij} = \frac{\sum_{j=1}^{n} u_{ij}^{m} x_j}{\sum_{j=1}^{n} u_{ij}^{m}} \qquad (3)$$

The stopping moment of this iteration is

$$max_{ij}\left\{\left|u_{ij}^{(k+1)} - u_{ij}^{(k)}\right|\right\} < \in \qquad (4)$$

where, the value of the termination criterion within 0 and 1, the iteration step is k. The local minimum is J_m.

(a) (b) (c)

Fig. 4. Processing experiment of segmentation: a) Input MR image, b) segmented MR image using Wavelet & FCM, and c) segmented MR image using BEMD & FCM.

III. Experimental Results

The experimental results of some stair images are explained in this section. The experiments were instigated on MRI web images in MATLAB environment. The MRI generated by various percent of noise that are 0%, 2%, 4%, 6%, 8%, 10% and with different parity of INU that are 0%, 30% and 50%. All the experimental MR images are taken from the Brain Web Database.

The Database is at the McConnell Brain Imaging Centre of the Montreal Neurological Institute, McGill University. Fig. 5(a), Fig. 5(b), and Fig. 5(c) are shown the example the brain MR images.

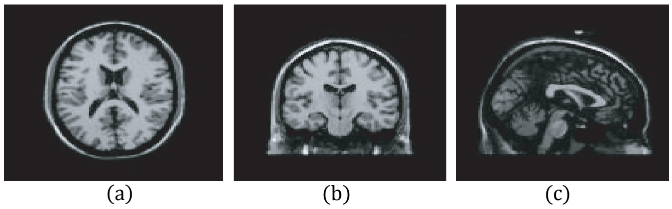


Fig. 5. T1 simulated brain web images: (a) MR sample 1 image, (b) MR sample 2 image and (c) MR sample 3 image.

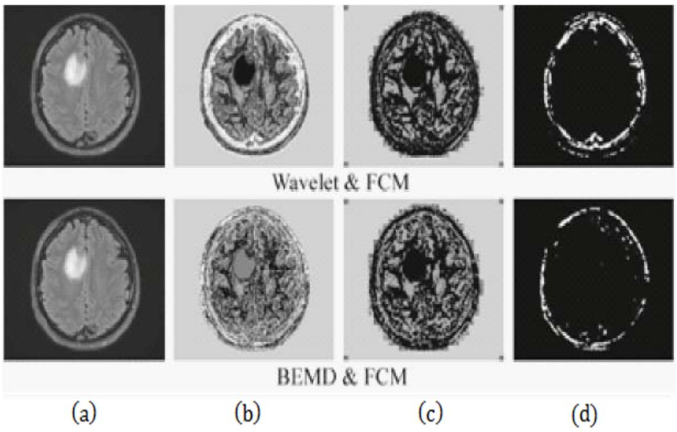


Fig. 6. Processing experiment of smooth MR image for sample 1: a) original MR image, b) segmented MR image, c) Gray Matter, and d) White Matter.

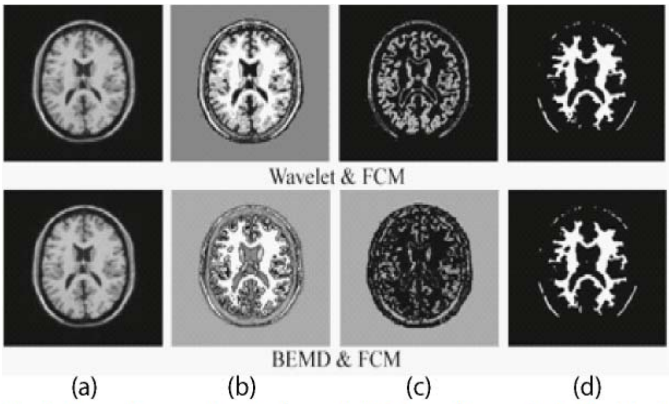


Fig. 7. Processing experiment of smooth MR image for sample 2: a) original MR image, b) segmented MR image, c) Gray Matter, and d) White Matter.

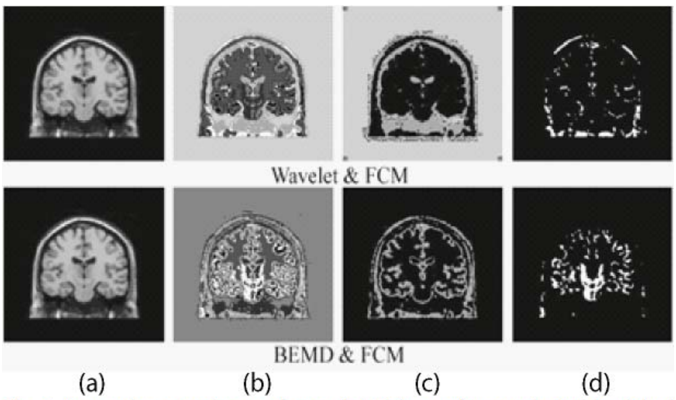


Fig. 8. Processing experiment of smooth MR image for sample 3: (a) original MR image, (b) segmented MR image, (c) Gray Matter, and (d) White Matter.

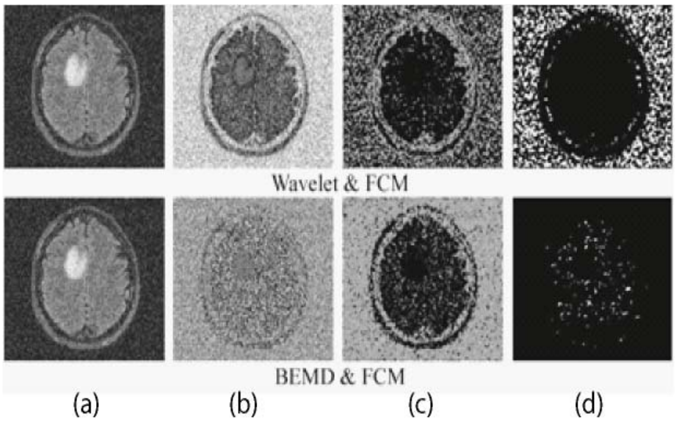


Fig. 9. Processing experiment of noisy MRI image for sample 1: (a) original MR image, (b) segmented MR image, (c) Gray Matter, and (d) White Matter.

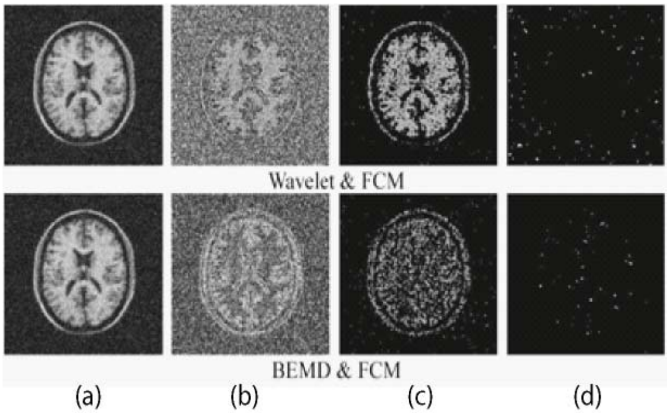


Fig. 10. Processing experiment of noisy MR image for sample 2: (a) original MR image, (b) segmented MR image, (c) Gray Matter, and (d) White Matter.

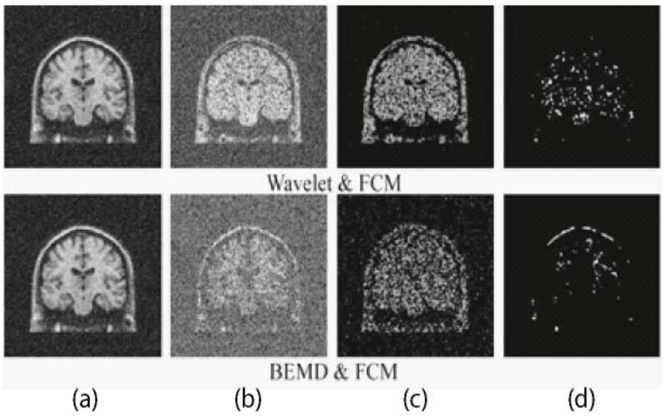


Fig. 11. Processing experiment of noisy MRI image for sample 3: (a) original MR image, (b) segmented MR image, (c) Gray Matter, and (d) White Matter.

The processing experimental example of smooth MRI sample image 1, sample image 2 and sample image 3 are shown in Fig. 6, Fig. 7, and Fig. 8 respectively. Another processing experimental example of Gaussian noisy MRI sample image 1, sample image 2, and sample image 3 are shown in Fig. 9, Fig. 10, and Fig. 11 respectively. In the all processing experiments apply the wavelet and BEMD with the FCM clustering.

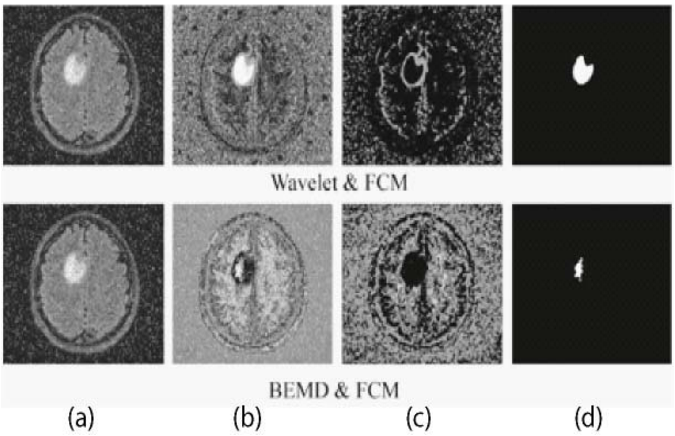


Fig. 12. Processing experiment of 10% Salt & Pepper noisy MR image for sample 1: a) original MR image, b) segmented MR image, c) Gray Matter, and d) White Matter.

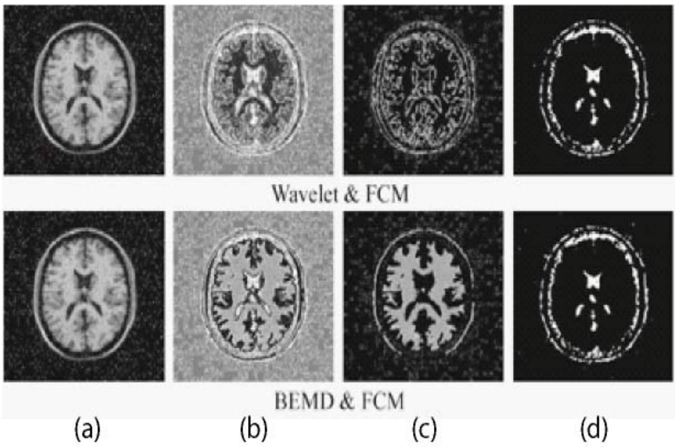


Fig. 13. Processing experiment of 10% Salt & Pepper noisy MR image for sample 2: a) original MR image, b) segmented MR image, c) Gray Matter, and d) White Matter.

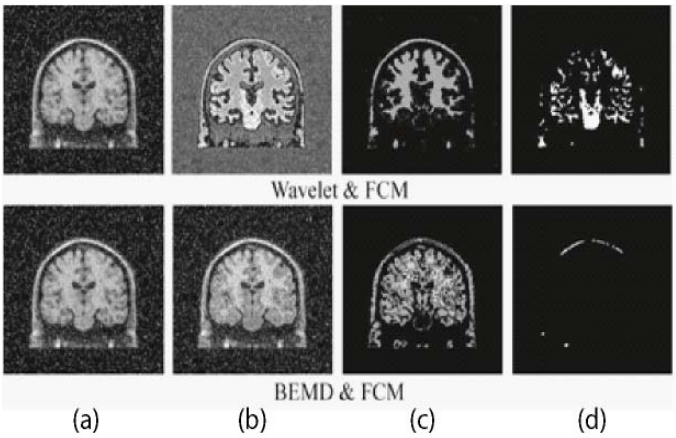


Fig. 14. Processing experiment of 10% Salt & Pepper noisy MR image for sample 3: a) original MR image, b) segmented MR image, c) Gray Matter, and d) White Matter.

The processing experimental example of 10% Salt & Pepper noisy MRI sample image 1, sample image 2, and sample image 3 are shown in the Fig. 11, Fig. 12, and Fig. 13 respectively. In these experiments apply the wavelet and BEMD with FCM clustering.

The segmentation presentation of evaluation in this paper is dignified with the Eq. (5).

$$SNR = \frac{\sum_{x=1}^{M}\sum_{y=1}^{N} f(x,y)^2}{\sum_{x=1}^{M}\sum_{y=1}^{N} s(x,y)^2} \quad (5)$$

Where, the input image is defined as $f\ (x,y)$ and the segmentation image is defined as $s(x,y)$.

In this paper the best segmentation method is computed through the value of the SNR which is calculated by the Eq. (5). The value is calculated both for the wavelet and FCM as well as BEMD and FMC. The SNR value is calculated for the MRI smooth image as well as for the MRI image by adding 10% salt & Pepper noise and Gaussian noise. The value of the SNR for the sample MR image 1, sample MR image 2, and sample MR image 3 is shown in Table I.

TABLE I: SNR OF THE INPUT IMAGES

Sample MRI image	**Input MRI with Smooth, Adding Gaussian and 10% Salt & Pepper noise**	**SNR**	
		Wavelet & FCM	**BEMD & FCM**
1	Smooth	1.0175	1.0977
	mean= 0 and variance =0.025	0.7749	0.7789
	10% Salt & Pepper noise	0.8692	0.8731
2	Smooth	0.4249	0.4259
	mean=0 and variance =0.025	0.6588	0.6654
	10% Salt & Pepper noise	0.5042	0.5241
3	Smooth	0.3992	0.3997
	mean= 0 and variance =0.025	0.6452	0.6472
	10% Salt & Pepper noise	0.4955	1.0011

Fig. 15 shows the value of SNR for smooth MRI sample image 1, MRI sample image 2, and MRI sample image 3. Fig. 16 and Fig. 17 shows the SNR value for these MRI images which are added by the noise of Gaussian and 10% Salt & Pepper respectively.

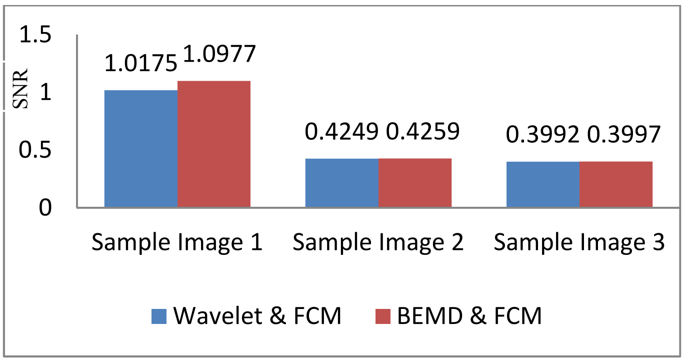


Fig. 15. SNR values of Wavelet & FCM and BEMD & FCM for smooth images.

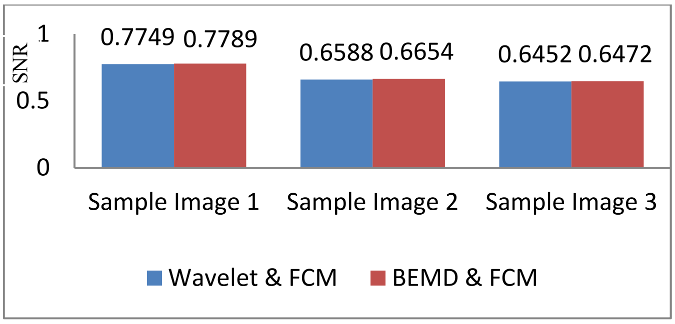


Fig. 16. SNR values of Wavelet & FCM and BEMD & FCM for noisy images (Gaussian noise).

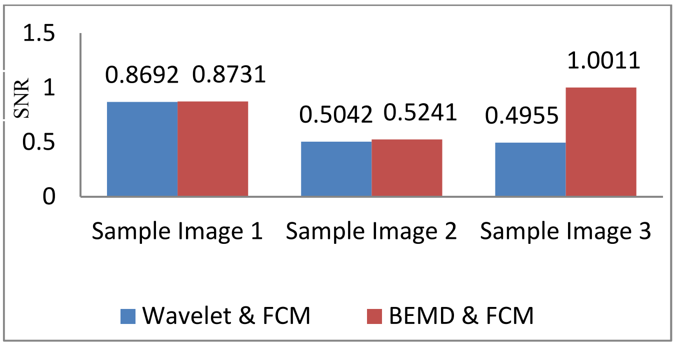


Fig. 17. SNR values of Wavelet & FCM and BEMD & FCM for noisy images (10% Salt & Pepper noise).

From the Fig. 15, Fig. 16, and Fig. 17 it has been seen that the SNR value for the BEMD and FCM i.e. BSNR shows the superior value for smooth and noisy i.e., Gaussian, 10% Salt & Pepper noise MRI image. According to this SNR value it can be mentioned that BEMD decomposition method is better with respect to wavelet method.

IV. CONCLUSIONS

The paper represents an efficient approach and strong evidences for MR image segmentation. For that, firstly decomposition method i.e. BEMD as well as wavelet are employed on the MR images for extracting the MR image features. After that, decomposition image is clustered by using the FCM algorithm. By this process the MR image is converted to segment image. Then, the SNR value is calculated from the segmented image both for BEMD and FCM as well as wavelet and FCM. By this SNR value better approach is detected. The best method has founded robust beside the various MR images. The processing examples with unreal Brain Web image which validated effectiveness as well as forcefulness of the superior methodology for the noisy and smooth MR images. In future, the research work will be extended through enhancing the segmentation performance by different version of segmentation technique for various types of noisy (white noise) MR images.

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