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Hybrid Image Segmentation Model using KM, FCM, Wavelet KM and Wavelet FCM Techniques

A.H.M. Jaffar Iqbal Barbhuiya[1*], K. Hemachandran[2]

[1]Dept. of Computer Science, Assam University, Silchar, India
[2]Dept. of Computer Science, Assam University, Silchar, India

[*]*Corresponding Author: jaffar.iqbal84@gmail.com, Tel.: +91-7002375667*

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***Abstract*—** An attempt has been made to study the DWT (Discrete Wavelet Transform) based K-Means (KM) clustering and DWT based Fuzzy C-Means (FCM) clustering methods for the segmentation of digital images. The segmentation results of Wavelet KM clustering and Wavelet FCM clustering are compared with the conventional KM clustering and FCM clustering techniques used for the segmentation. The images are split-up into identical areas using KM, FCM, wavelet KM and wavelet FCM algorithms. The algorithms are tested on different image formats available in the literature. The proposed methods are analyzed using discrete wavelet transform (DWT) for enhancing the digital images and various image features like regions, colors and shapes are considered to validate the proposed work. The segmentation results exhibit that the objects in various image clusters of wavelet KM and wavelet FCM performs better as compared to traditional KM and FCM clustering algorithm with respect to CPU execution time, sensitivity analysis, segmentation accuracy and PSNR(Peak Signal to Noise Ratio).

***Keywords*--** Image segmentation, Clustering, K-Means (KM), Fuzzy C-Means (FCM), Wavelet KM, Wavelet FCM, Discrete Wavelet Transform (DWT), CPU execution time, sensitivity analysis and segmentation accuracy

I. INTRODUCTION

Image clustering has been widely used in digital image processing for image segmentation, face detection, fingerprint recognition, object recognition, medical imaging and many more. Different authors have used clustering methods for image segmentation [1, 2, 3, 4, 5] and K-means (KM) and Fuzzy C-means (FCM) are most popular techniques [6, 7, 8, 9, 10, 11, 12]. The objective of wavelet based image segmentation is to extract the image features from the original image. The extracted image features are then classified into number of clusters by employing the K-means (KM) clustering and fuzzy C-means clustering (FCM) method. These methods are concisely presented in this section.

I.A. Segmentation using K-Means (KM) Clustering Algorithm

K-means clustering algorithm was first introduced by MacQueen in 1967 [13]. The method proceeds with a simple manner to categorize a specified data set via definite number of clusters which draws an attention. The basic concept is to derive k centroids for each and every cluster. The objective of the KM algorithm is to reduce objective function or a squared error function. The objective function, X may be represented as [14]:

$$X = \sum_{y=1}^{n} \sum_{z=1}^{k} ||Iy - Jz||^2 \qquad (1)$$

In the above equation, n is the number of pixels in an image, k is the total number of clusters, , I_y means the yth pixel data in an image, J_z represents the centroid of the zth cluster and $||I_y\text{-}J_z||$ is called the Euclidean distance between data points I_y and the cluster centroids J_z. In the preliminary steps of K-means clustering, first the computation of number of clusters k should be carried out and after that the task for the centroid of those clusters should be observed.

The conventional KM algorithm can be stated that [14]

Step 1: Choose k randomly as initial centroid.

Step 2: Generate k clusters assigning each data points to the closest centroid.

Step 3: Compute the cluster centroids J_z, where $z = 1, 2, 3, \ldots\ldots, k$, according to equation (1).

Step 4: Compute the Euclidean distance, $||I_y\text{-}J_z||$ between data points and clusters, where $y = 1, 2, 3, \ldots., n$ and $z = 1, 2, 3, \ldots\ldots, k$.

Step 5: Compute k new centroid by averaging data points in each cluster.

Step 6 : For each value of *k*, recomputed the Euclidean distance between data points and clusters and find the closest centroid.

Step 7: Repeat step 1 to 6 until centroid for each cluster will not be computed.

The image segmentation based on KM clustering is simple and easily executable and the performance is better compared to hierarchical clustering algorithms [14, 15, 16, 17, 18, 19, 20, 21, 22, 23]. The KM clustering process enables faster execution on large datasets but it is not always sufficient to provide enhanced cluster objects with good sensitivity, accuracy, execution time and PSNR compared to Wavelet KM and Wavelet FCM clustering algorithm.

I. B. Segmentation using Fuzzy C-Means (FCM) Clustering Algorithm

Fuzzy clustering or soft clustering is a strong unsupervised technique for data analysis and creation of models. The primary goal of fuzzy clustering is the non-identical division of data into a collection of clusters. Fuzzy c-means (FCM) is a clustering technique that permits one portion of image data be connected with two or alternatives clusters. The FCM clustering algorithm introduced by Dunn in 1973 [24] and enhanced by Bezdek in 1981 [25] and the method is often applied in pattern recognition. The FCM uses fuzzy partitioning with non-similar membership functions between *0* and *1* [26]. The data points allocate the membership values for each cluster. Fuzzy clustering algorithm enables the clusters to originate their natural form [27].

The objective of FCM algorithm is to segment a finite group of n elements $A= \{a_1, a_2, \ldots\ldots, a_n\}$ towards a group of fuzzy c clusters with reference to certain specified condition. A finite set of data is stated, the algorithm return a list of *c* cluster centroids $B= \{c_1, c_2, \ldots\ldots, c_n\}$ as well as a partition matrix [28].

The FCM clustering can be acquired by reducing an objective function *X*, presented in equation (2) [29]

$$X = \sum_{y=1}^{n} \sum_{z=1}^{c} \mu_{yz}^{f} \, ||Iy - Jz||^2 \qquad (2)$$

In the above equation, *n* is the number of pixels in an image, *c* is the total number of clusters, μ is the fuzzy membership matrix ,*f* indicates the fuzziness factor, I_y means the *yth* pixel in an image, J_z represents the centroid of the *zth* cluster and $||I_y-J_z||$ is called the Euclidean distance.

The conventional FCM algorithm can be stated that [7]

Step 1: Choose *m*. where $m>1$.

Initialize the fuzzy membership function values $\mu^{f}_{yz,}$ where, $y=1, 2, 3, \ldots, n$ and $z=1,2,3,\ldots,c$. *f* indicates fuzziness factor.

Step 2: Compute the cluster centroids J_z, where, $z=1,2,\ldots\ldots,c$. according to equation (2)

Step 3: Compute the Euclidean distance, $||I_y-J_z||$ between data points and clusters. Where, $y=1, 2, 3,\ldots\ldots,n$ and $z=1, 2, 3,\ldots\ldots,c$.

Step 4: Repeat the process from step 1 to step 3 to obtain more results.

FCM clustering algorithm depicts the membership correlation into distinct objects and the framework applying mathematical process besides the soft computing result is more reliable and logical [30]. FCM algorithm is easily affected by noise and to execute any FCM algorithm which takes more time compared to KM and Wavelet FCM algorithm. FCM clustering algorithm has enough information of the original image to detect the ground truth of an image compared to KM clustering algorithm but it takes too much time to execute compared to KM and other clustering methods [6, 12].

This paper structure comprises of the following sections: section I contains the introduction to image segmentation and segmentation using KM and FCM algorithm, section II describes the previous work done by different authors in the field of KM and FCM clustering, in section III, the proposed methodology of image segmentation techniques based on Wavelet KM and Wavelet FCM is presented, section IV demonstrates the experimental results and discussion followed by a brief performance analysis and eventually section V concludes the paper.

II. RELATED WORK

Considerable amount of work has been done by many researchers in the image segmentation. An image segmentation algorithm using wavelet based multiresolution and Expectation Algorithm (EM) has been introduced. But the main disadvantage of this algorithm is that it is based on identical and independent distribution of pixel intensities which may not be possible in case of noisy images [31]. A wavelet based image segmentation method for feature extraction connected with various pixels of an image with their categorization in contrast to the watershed transform has been recommended [32]. In another work, Haar wavelet was used to compress an image and to extract the image features. The proposed method was compared with simulated images and applied in biomedical image processing in the MATLAB platform. A wavelet based image segmentation technique was also described by using an unsupervised method called fuzzy K-means clustering algorithm [4]. But the major drawback of their algorithm is that it is based on general fuzzy K-means algorithm. They have not shown any output regarding Wavelet KM or FCM algorithms with respect to time consumed by each model. The disadvantage of KM algorithm is that if the initial cluster centers are selected incorrectly, the KM algorithm may not converge. It occurs in case of noisy images. An unsupervised image segmentation algorithm proposed which merges wavelet transform and improved fuzzy c-means clustering (FCM) taking neighboring pixels [33]. They first used the conventional FCM algorithm and then used the wavelet FCM algorithm and the results were shown on real noisy medical images. An image segmentation model was suggested based on FCM algorithm which is integrated with wavelet transform noise filtration. Moreover, the filtering technique was extended to FCM algorithm into the membership function for clustering [7]. The analytical results of their method showed its necessity for reducing FCM clustering noise sensitivity in an image. The suggested method was compared with other existing FCM algorithms on the basis of quantitative performance measure and the visual quality of the image.

An image segmentation technique to partition and detect the cancer affected areas in the prostate's infrared images has been proposed [8]. They described two segmentation techniques called KM and FCM algorithm which were discussed and differentiated and established that the KM algorithm is better than FCM in context of accuracy to extract the original shape of tumor. The work was demonstrated using NIRF (Near-infrared Fluorescence) images to detect prostate cancer disorder. An image segmentation technique using fuzzy clustering algorithms and their applications for denoising the digital images has been introduced [9]. The objective of their paper was to remove speckle noise from the input image using DWT and compare with the various clustering algorithms like Mean Shift, Crisp (k-Means), Fuzzy c-Means (FCM), Spatial Fuzzy c-Means (SFCM) and Possibilistic Fuzzy c-Means (PFCM) to perform the experimental analysis. To evaluate the performance of their proposed algorithm, various evaluation measures like accuracy, elapse time, MSE, PSNR and SSIM was considered and found that FCM algorithm shows better performance as compared to others. An innovative clustering-based image segmentation technique was introduced called ICDP algorithm [34]. They presented few advantages of their algorithm as compared to other existing algorithms. (1) The input image shows the integral channel attributes which automatically combining the heterogeneous source of information. (2) Number of clusters can be computed immediately and cluster centroids are able to identify automatically. (3)Using ICDP algorithm, hierarchical segmentation can be attained simply. The variable measures like PSNR and MSE has been used to measure the performance of the proposed algorithm. A new tissue segmentation algorithm that fragments the brain MR images towards the gray matter (GM), white matter (WM), cerebrospinal fluid (CSF), tumor and edema was developed [12]. They merged k-means (KM) clustering algorithm with Fuzzy c-means (FCM) clustering algorithm for segmentation of the brain MR images because the KM clustering takes less execution time and FCM clustering has facilities with respect to accuracy in the soft tissues. At first they fragmented the abnormal area from T_2-weighted FLAIR modality based on KM clustering along with FCM algorithm and in the second step, they segmented the tumor from T_1-weighted variance enhancement modality T_{1ce}. To evaluate the performance of the proposed algorithm, the evaluation measures such as specificity, sensitivity and dice similarity index were used and showed better performance as compared to the existing methods. An image segmentation technique of brain MR images on edema and tumor on the basis of skull stripping and kernel based fuzzy c-means method was developed [11]. Graph cut algorithm was also applied to detect the specific cut point between edema and tumor in order to remove edema from the tumor. The analytical results were shown that the proposed algorithm performs better as compared to other existing models for absolute tumor and edema segmentation. Different dependent variables like segmentation accuracy, sensitivity, specificity, execution time, number of iterations, PSNR and Jaccard coefficient have been considered to evaluate the validity of the proposed algorithm. An image segmentation technique was proposed on brain MRI images to detect tumor region and the affected part of brain [35]. They introduced a hybrid method for information retrieval from brain MRI images based on k-means (KM) and artificial neural network (ANN). Gray level co-occurrence matrix (GLCM) applied for feature extraction. They also employed Fuzzy Inference System (FIS) to extract the feature of MR images succeeded by thresholding, morphological operator and watershed segmentation for brain tumor detection and classification. To validate their work, the analytical results were compared with the simple KM and neuro-fuzzy system. An efficient method based on cluster segmentation in the wavelet domain was also introduced which analyzes texture features of an image in high frequency coefficients [36]. To validate the proposed algorithm, different evaluation measure were considered and compared with the existing methods.

III. A. Proposed Image Segmentation Techniques using Wavelet KM and Wavelet FCM algorithm

We are proposing Wavelet KM and Wavelet FCM clustering algorithm and applied for image segmentation and comparing with conventional K-means (KM), Fuzzy c-means (FCM) clustering algorithm. The accuracy and performance of the conventional KM, FCM, Wavelet KM and Wavelet FCM algorithms for segmentation for the same images with image quality, sensitivity, execution time and PSNR value of each image is measured. Fuzzy C-means (FCM) is a method of clustering which allows one piece of data to belong to two or more clusters. The proposed approaches initially emphasizes on preprocessing of the image for image refinement. The use of Discreet Wavelet Transform (DWT) and statistical parameters for extracting the features in an image is investigated. The image is then subdivided into similar areas using the KM, FCM, Wavelet KM and Wavelet FCM clustering approaches.

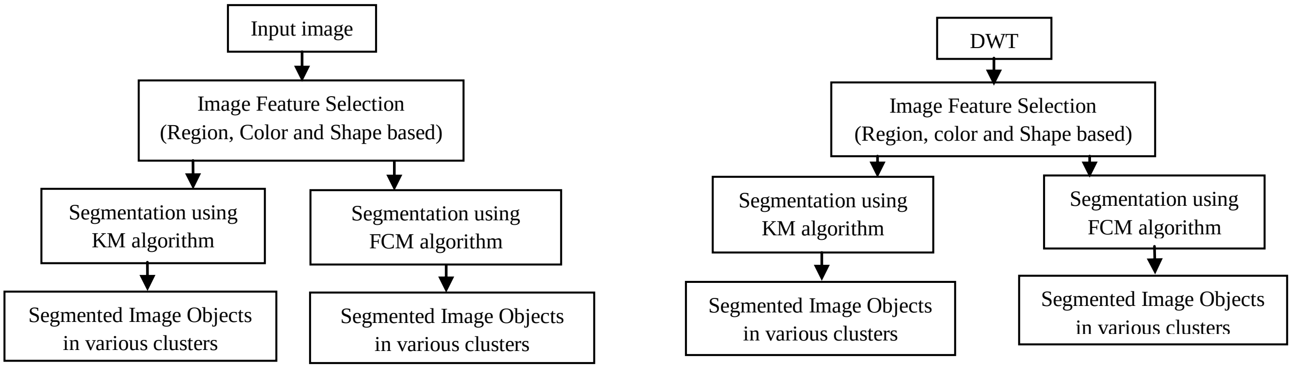

Figure 1: Block diagram of the existing and proposed segmentation model a) Segmentation using KM and FCM algorithm and b) Segmentation using Wavelet KM and Wavelet FCM algorithm

Fig. 1 describe in details the model for image segmentation using K-Means and FCM algorithms and the wavelet transform is applied, we call it as Wavelet K-Means and Wavelet FCM respectively. In Fig. 1, at first we take a 24 bit color image of any resolution and of any image format as original image. Subsequently, we decompose the original image using DWT into four subbands namely *LL*, *LH*, *HL* and *HH* respectively. Here, only the *LL* subband contains the low frequency of an image holding highest pixel information of an image after decomposition and the other three subbands contains high frequency of an image. The *LL* subband represents the approximation coefficients, *LH* subband represents the horizontal coefficients, *HL* subband represents the vertical coefficients and *HH* subband represents the diagonal coefficients of a decomposed image.

The feature selection of an image is the first step of image segmentation which is used for the development of feature space. It consists of computing the values of different features for each pixel or block of pixels in the image. Each and every feature of an image should have somehow analyze the visual representation of some regions encircling the pixels. These features are made up of feature vector in such a way that each pixel is represented in a multidimensional feature space. The main objective of image clustering is to identify the objects based on features and to arrange the image pixels properly. The sensitivity analysis and segmentation accuracy is eventually based on the types of features we used. So, feature selection process is significant which identify the characteristics of the image on which the segmentation to be done. Image consists of number of highly regions, colors and shapes are optimal if it is segmented using frequency based features. Many natural images are composed of all three types of regions and hence it requires different features to be used in different areas of images. The proposed algorithm focuses on the use of DWT to detect the features correlated with each pixel or block of pixels. DWT is used to interpret the image before segmenting the image and after enabling the features based on colors, regions and shapes. Regions of an image can be detected from the low level frequency subband whereas the colors and shapes of an image can be detected from both low level and mid level frequency subband. So, colors, regions and shapes can be easily detected by analyzing their DWT decomposition properties. Hence, to extract the colors, regions and the shapes of an image, it is essential to decompose an image using DWT into its constituent subbands.

In the next section of the proposed model, we try to show the application of conventional K-Means clustering algorithm on the decomposed image to obtain partition of an image into *c* clusters and *k* centroid for each cluster described in section (I.A) of the proposed research work.

Again, we apply the conventional FCM clustering algorithm described in section (I.B) of the proposed research work to partition the image that divides the data set into an optimal number of clusters. These two algorithms detect the variations in cluster shapes, cluster regions and cluster edges. The human based segmentation is used to compute ground truth images from the original images. The KM and FCM algorithm has a common disadvantage that it is unable to give good results in case of noisy natural images. So, the hybridization of wavelet and KM as well as FCM gives better results as wavelet transform based methods are robust to noise. This hybridization method also assists to reduce inhomogeneity and pixel intensity variations produced in natural images during the segmentation process.

In this research work, the DWT is used to natural images as wavelets supply both frequency and time-space localization information. The multiresolution nature of wavelet transform allows us to represents images at different scales and resolutions. We consider the level 1 decomposition only because due to over-decomposition, the possibility of loss of pixel information is more and *LL* subband frequencies may become part of the high frequency subbands and distortion may occur.

III. B. Proposed Algorithm using Wavelet KM

Step 1: Read an input image *I*.

Step 2: Decompose the input image, *I* using DWT into four subbands *LL*, *LH*, *HL*, and *HH* respectively which represents approximation, horizontal, vertical and diagonal components as coefficients.

Step 3: Apply the conventional K-Means clustering algorithm described in section (I.A) of the proposed research work into the *LL* subband to segment the image and to partition the dataset into optimal number of clusters and to obtain partitioning of image pixels into *c* clusters and *k* centroid for each cluster based on image features like colors, regions and shapes.

Step 4: Repeat the steps from 1 to 3 and from section (I.A) of the proposed research work until the equation (1) converges.

III. C. Proposed Algorithm using Wavelet FCM

Step 1: Read an input image, *I*.

Step 2: Decompose the input image, *I* using DWT into four subbands *LL*, *LH*, *HL*, and *HH* respectively which represents approximation, horizontal, vertical and diagonal components as coefficients.

Step 3: Apply the conventional FCM clustering algorithm described in section (I.B) of the proposed research work into the *LL* subband to segment the image and to partition the dataset into optimal number of clusters and to obtain partitioning of image pixels into *c* clusters and *k* centroid for each cluster based on image features like colors, regions and shapes.

Step 4: Repeat the steps from 1 to 3 and from section (I.B) of the proposed research work until the equation (2) converges.

IV. RESULTS AND DISCUSSION

The efficiency of the proposed wavelet KM and Wavelet FCM based image segmentation method is observed and the outcome acquired from the various observations is analyzed in this section. We have proposed an algorithm on a large set of natural images used for testing and training purposes available in open literature. The fifty natural test images are taken from the SIPI image database and thirty segmentation images are taken from Berkeley segmentation of color images database to perform the experiments.

The input images of various formats like JPEG, PNG, BMP and TIFF are taken randomly and DWT is applied for each input images to decompose the image into four subbands such as *LL*, *HL*, *LH*, and *HH* respectively. The segmented input images are using four algorithms like KM, FCM, Wavelet KM and Wavelet FCM to compare the results. In each case, the outputs are shown with a segmented image as well as its corresponding objects in various clusters. The proposed segmentation method is carried out in MATLAB 7.12 environment with signal and image processing toolboxes.

To show the efficiency and effectiveness of the proposed algorithm, the various evaluation measures such as sensitivity, segmentation accuracy and the execution time taken to perform an operation are computed and compared with the identical clustering based methods. To assess the quality of the images, the measures like Peak Signal to Noise Ratio (PSNR) is considered. Here, the PSNR is used to examine the noise level in order to check any kind of reduction in the image quality can be observed.

The *PSNR* can be computed using the following formula [11].

$$PSNR = 10 \log \frac{255^2}{MSE} \qquad (3)$$

Where, *MSE* means Mean Square Error.

The sensitivity analysis can be defined as [12]

$$Sensitivity = \frac{TP}{TP+FN} \times 100 \qquad (4)$$

The segmentation accuracy can be defined as [11]

$$Accuracy = \frac{TP+FN}{TP+TN+FP+FN} \qquad (5)$$

Where, True Positive (TP) indicates that the number of true pixels in the ground truth accurately identified as segmented pixels.

True Negative (TN) means the number of false pixels in the ground truth accurately detected as segmented pixels.

False Positive (FP) indicates that the number of true pixels in the ground truth is not observed in the segmented area.

False Negative (FN) indicates that the number of false pixels in the ground truth which are absent in the segmented area.

Table 1 provides the segmentation results of different formats. Total 80 images are tested to carry out the proposed research work but the outputs of only 5 different images have been considered in the table.

Table 1: Segmentation Results of Five input images with respect to Execution Time

Image Name	Image resolution	Original Image size (KB)	Execution time taken by different Algorithms (in seconds)			
			KM	FCM	Wavelet KM (Proposed)	Wavelet FCM (Proposed)
Lena.jpg	512X512	99.50	12.4558	47.6115	1.6948	10.0641
Baboon.png	512X512	243	1.3464	40.0547	0.7531	4.0176
Barbara.bmp	512X512	768	3.3561	33.7156	0.8208	5.8510
Airplane.tif	512X512	535	23.9105	36.5948	2.1655	6.5820
Sunflower.jpg	256X256	39.90	0.8034	10.6969	0.5542	2.5285

From Table 1, it is seen that the execution time taken by each images using Wavelet KM and Wavelet FCM is better for almost all the input images as compared to KM and FCM algorithm.

Table 2: Segmentation Results of Five input images with respect to PSNR (dB)

Image Name	Image Size (KB)	PSNR (KM)	PSNR (FCM)	PSNR (Wavelet KM)	PSNR (Wavelet FCM)
Lena.jpg	99.50	39.4561	43.1284	52.9326	52.9814
Baboon.png	243	46.9824	48.7642	53.0722	54.1169
Barbara.bmp	768	40.3466	49.6458	51.5438	53.5438
Airplane.tif	535	49.7856	44.8541	48.9345	51.9865
Sunflower.jpg	39.90	38.8843	46.1156	67.8619	81.6317

Table 2 provides the segmentation results of 5 input images with reference to PSNR value. From Table 2, it is observed that the PSNR value is better using Wavelet KM and Wavelet FCM as compared to KM and FCM algorithms.

Table 3: Segmentation Results of Five input images with respect to Sensitivity Analysis (%)

Image Name	Image Size (KB)	Sensitivity Analysis (KM)	Sensitivity Analysis (FCM)	Sensitivity Analysis (Wavelet KM)	Sensitivity Analysis (Wavelet FCM)
Lena.jpg	99.50	86.83%	89.62%	94.71%	98.92%
Baboon.png	243	76.98%	87.95%	97.47%	99.08%
Barbara.bmp	768	73.26%	84.53%	91.66%	95.18%
Airplane.tif	535	79.64%	81.68%	96.87%	99.81%
Sunflower.jpg	39.90	67.45%	74.19%	88.91%	93.76%

Table 3 shows the segmentation outcome of 5 input images with reference to sensitivity analysis. Similarly in Table 3, it is observed that the percentage of sensitivity analysis is better in case of Wavelet KM and Wavelet FCM algorithm as compared to KM and FCM algorithm.

Table 4 represents the segmentation outcome of 5 input images with reference to segmentation accuracy. In Table 4, it is noticed that the percentage of segmentation accuracy is better in case of Wavelet KM and Wavelet FCM algorithm as compared to KM and FCM algorithm.

Table 4: Segmentation Results of Five input images with respect to Segmentation Accuracy (%)

Image Name	Image Size (KB)	Segmentation Accuracy (KM)	Segmentation Accuracy (FCM)	Segmentation Accuracy (Wavelet KM)	Segmentation Accuracy (Wavelet FCM)
Lena.jpg	99.50	88.75%	90.33%	95.63%	99.43%
Baboon.png	243	79.31%	89.62%	93.67%	99.31%
Barbara.bmp	768	78.06%	88.51%	96.51%	96.69%
Airplane.tif	535	81.88%	84.07%	91.06%	99.09%
Sunflower.jpg	39.90	70.36%	79.66%	93.96%	95.15%

IV. A. Performance Analysis

The performance of the proposed algorithm is measured using the evaluation measures like sensitivity analysis, accuracy, execution time and PSNR. Table 5 represents the outcome of the proposed method compared to the existing methods. The sensitivity analysis and the execution time for each observation signify a competitive achievement of the proposed method. The best result on the basis of run time shown by the proposed method for Wavelet KM is 0.55 seconds and the percentage of sensitivity analysis is 97.47%. Again, the best result on the basis of run time shown by the proposed method for Wavelet FCM is 2.53 seconds and the percentage of sensitivity analysis is 99.81%.

Table 5: Quantitative Evaluation of the Proposed Method with the existing Methods with respect to Time and Sensitivity Analysis

Authors	Algorithms Used	Elapsed Time (s)	Sensitivity (%)
Shanker and Bhattacharya (2017)	KM	2.90	64.35
	FCM	18.62	70.62
ShanmugaPriya and Valarmathi (2018)	MKFCM+GC	32.40	96.81
Proposed Method	Wavelet KM	0.55	97.47
	Wavelet FCM	2.53	99.81

Similar to Table 5, Table 6 represents the outcome of the proposed method compared to the existing methods. The segmentation accuracy, PSNR value and execution time for each observation signify a competitive achievement of the proposed method. The best result on the basis of segmentation accuracy shown by the proposed method for Wavelet KM is 97.47% and the best PSNR value is 67.8619 dB. Again, the best result on the basis of segmentation accuracy shown by the proposed method for Wavelet FCM is 99.43% and the best PSNR value using the same method is 81.6317 dB.

Table 6: Quantitative Evaluation of the Proposed Method with the existing Methods with respect to Time, Accuracy and PSNR

Authors Name	Algorithms Used	Elapsed Time (s)	Accuracy (%)	PSNR(dB)
Sibina and Raj (2016)	KM	0.28	77.98	60.3130
	FCM	1.08	98.63	79.6450
ShanmugaPriya and Valarmathi (2018)	MKFCM+GC	32.40	96.81	51.98
Proposed Method	Wavelet KM	0.55	96.53	67.8619
	Wavelet FCM	2.53	99.47	81.6317

So, analyzing the above all research works, our work shows better performance with respect to Sensitivity, Accuracy, PSNR, image quality and execution time.

Figure 2 depicts the segmentation of lena.jpg image representing its original image, cluster index image of Lena, segmented image object in cluster 1 representing L*a*b based color regions of Lena using KM algorithm and segmented image object in cluster 2 showing shapes of Lena based on L*a*b* color space using KM algorithm. Human based segmentation of ground truth image of Lena is also shown in figure 2. Each figure also shows the CPU execution time taken by each algorithm to execute a process.

Similarly, figure 3 depicts the segmentation of lena.jpg image representing its cluster index image based on original image, segmented image object in cluster 1 representing L*a*b based color regions of Lena using FCM algorithm and segmented image object in cluster 2 showing shapes of Lena based on L*a*b* color space using FCM algorithm.

Furthermore, figure 4 depicts the segmentation of lena.jpg image representing its cluster index image based on original image, segmented image object in cluster 1 representing L*a*b based color regions of Lena using wavelet KM algorithm and segmented image object in cluster 2 showing shapes of Lena based on L*a*b* color space using Wavelet KM algorithm.

Finally, figure 5 depicts the segmentation of lena.jpg image representing its cluster index image based on original image, segmented image object in cluster 1 representing L*a*b based color regions of Lena using wavelet Wavelet FCM algorithm and segmented image object in cluster 2 showing shapes of Lena based on L*a*b* color space using Wavelet FCM algorithm.

V. CONCLUSION

In this research work, an attempt has been made to study the DWT based KM and FCM clustering methods for the segmentation of digital images. The proposed work is validated considering the different attributes like elapsed time, image quality, sensitivity analysis, segmentation accuracy and PSNR value. The proposed method demonstrates that the wavelet KM and wavelet FCM accomplished better results as compared to traditional KM and FCM algorithms. On the other hand, due to wavelet and fuzziness features of FCM, the proposed wavelet FCM algorithm is more successful as compared to the other three algorithms except execution time. The selection process of initial centroid in KM and FCM is time consuming and sometimes due to wrong selection of initial centroid the whole process may show the wrong outputs. In future, the proposed work can be extended using Wavelet PFCM and Wavelet MKFCM algorithms and compare the analytical results with the conventional PFCM and MKFCM algorithms.

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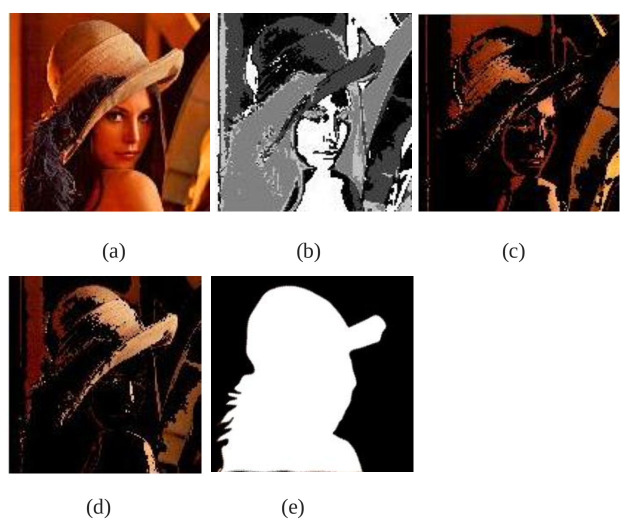

Elapsed Time: 12.4558 seconds

Figure 2: a) Original Image Lena b) Cluster Index image of Lena using KM algorithm c) Segmented Image object in Cluster 1 showing various color

regions (L*a*b* based) of Lena using KM algorithm d) Segmented Image object in cluster 2 showing shapes of Lena based on L*a*b* color space using KM algorithm and e) Ground Truth image of Lena.

(a) (b) (c)

Elapsed Time: 47.6115 seconds

Figure 3: a) Cluster Index Image of Lena using FCM algorithm b) Segmented Image object in Cluster 1 showing various color regions (L*a*b* based) of Lena using FCM algorithm and c) Segmented Image Object in Cluster 2 showing shapes of Lena based on L*a*b* color space using FCM algorithm.

(a) (b) (c)

Elapsed Time: 1.6948 seconds

Figure 4: a) Cluster Index Image of Lena using proposed Wavelet KM algorithm b) Segmented Image object in Cluster 1 showing various color regions (L*a*b* based) of Lena using proposed Wavelet KM algorithm and c) Segmented Image Object in Cluster 2 showing shapes of Lena based on L*a*b* color space using proposed Wavelet KM algorithm.

(a) (b) (c)

Elapsed Time: 10.0641 seconds

Figure 5: a) Cluster Index Image of Lena using proposed Wavelet FCM algorithm b) Segmented Image object in Cluster 1 showing various color regions (L*a*b* based) of Lena using proposed Wavelet FCM algorithm and c) Segmented Image Object in Cluster 2 showing shapes of Lena based on L*a*b* color space using proposed Wavelet FCM algorithm.

Author Biographies:

1) Mr. A.H.M. Jaffar Iqbal Barbhuiya received his Master of Science in Computer Science (5 years integrated course) degree with first class in 2008 from the Department of Computer Science, Assam University, Silchar, where he is currently pursuing his Ph.D. He is also working as a Lecturer from 2008 to till date in the Dept. of Computer Science, M.H.C.M. Science College, Hailakandi, Assam, India. His research interest includes Digital Image Processing and Wavelet Analysis in Image and Signal Processing.

2) Prof. K. Hemachandran is associated with the Department of Computer Science, Assam University, Silchar, since 1998. Currently he is serving as the Head of the Department in the Department of Computer Science, Assam University, Silchar. He obtained his M.Sc. Degree from Sri Venkateswara University, Tirupati and M.Tech and Ph.D Degrees from Indian School of Mines (ISM), Dhanbad. His areas of research interest are Image Processing, Software Engineering and Distributed Computing.