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IMAGE SEGMENTATION USING FUZZY CLUSTERING ALGORITHM

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Abstract

In this paper, image segmentation is performed with the help of fuzzy clustering algorithms. Here fuzzy c-means algorithm and kernel weighted fuzzy c-means algorithm is used for clustering. After the segmentation of the image, comparison of the results will be done on the basis of execution time, number of clusters, mean absolute error and peak signal to noise ratio.

I. INTRODUCTION

Pattern analysis is considered as a very important science in the real world. Cluster analysis is found to be one of the useful tools for data analysis. It is a method for finding clusters of a data set with most similarity in the same cluster and most dissimilarity between different clusters. Image segmentation can be done with the help of fuzzy clustering Since Zadeh proposed fuzzy sets that introduced the idea of partial memberships described by membership functions; it has been successfully applied in various areas. Especially, fuzzy sets could allow membership functions to all clusters in a data set so that it is very suitable for cluster analysis. Ruspini first proposed fuzzy c-partitions as a fuzzy approach to clustering. Later, the fuzzy c-means (FCM) algorithms with a weighting exponent m = 2 proposed by Dunn, and then generalized by Bezdek with m > 1 became popular.

Image segmentation algorithm is a crucial step in image processing and analysis. It plays a vital role in many fields such as computer vision, pattern recognition and medical image processing numerical taxonomy, image processing, pattern recognition, medicine, economics, ecology, marketing, artificial intelligence, data mining, engineering systems, and gene expression. The goal of segmentation is to separate an image into some regions of feature and to pick up the interesting objects. Image segmentation is nothing but the grouping of pixels into individual clusters in such a way that the pixels from the same cluster are more similar to each other than pixels from different clusters. In non-fuzzy or hard clustering, data is divided into crisp clusters, where each data point belongs to exactly one cluster. Fuzzy clustering algorithm compares the intensity in a relative way and groups them into clusters. The grouped clusters are not with crisp boundaries.

Although a lot of works have been done, there is still not a general segmentation algorithm and a impersonality criterion to estimate the segmentation. According to concrete instances, many segmentation algorithms have been put forward. Among them, image segmentation algorithm based on fuzzy c-means is an important algorithm in the image segmentation field. It could retain much more information from the original image than hard segmentation methods.

In fuzzy clustering, the fuzzy c-means (FCM) algorithm plays an important role. Although the FCM algorithm is the best known, it has several drawbacks. For example, the points in the data set are supposed to be equally important, the number of points in the clusters is almost equal, nearly all points do not have a membership value of one, and the outliers always affect the clustering results. To overcome these drawbacks, many generalized FCM algorithms have been proposed. Gaussian kernel-based FCM (GKFCM) algorithm is one of them with a spatial bias correction.

I. II. FUZZY C-MEANS CLUSTERING

Fuzzy C-means Clustering (FCM) is also known as Fuzzy ISODATA. The FCM employs fuzzy partitioning such that a data point can belong to all groups with different membership grades between 0 and 1. FCM is an iterative algorithm. The aim of FCM is to find cluster centers (centroids) that minimize a dissimilarity function. Input and output detail are given as

Input:

(1) $X = \{x_1, . . .,x_n\}$, $x_i \in R^s$, the data set

(2) c, $2 \leq c \leq n$, the number of clusters

(3) $\varepsilon > 0$, the stopping criterion of algorithm

(4) $a^{(0)}=(a_1^{(0)},\ldots\ldots a_c^{(0)})$, the initials of cluster centers

Output:

$a = \{a_1, a_2. . .a_c\}$, the final cluster centers

FCM determines the cluster centers c_i and the membership matrix U using the following steps:

Step1: Initialize the membership matrix U with random values between 0 and 1 such that the constraints in following equation are satisfied.

$$\forall x \sum_{k=1}^{num.cluster} \mu_k(x) = 1$$

(2.1)

Step2: Calculate fuzzy cluster centers c_i , i =1.........c using the following equation.

$$center_k = \sum_x \mu_k(x)^m x \Big/ \sum_x \mu_k(x)^m$$

(2.2)

Step3: Compute the cost function according to following equation.

$$J_m = \sum_{i=1}^{C} \sum_{j=1}^{N} \mu_{ij}^m \left\| \emptyset(x_j) - \emptyset(v_i) \right\|^2$$

(2.3)

Where $\left\| \emptyset(x_j) - \emptyset(v_i) \right\|^2$ is the Euclidean distance between i^{th} cluster center and jth Data point and m ϵ [1, ∞] is a weighting exponent. Stop if either it is below a certain tolerance value or its improvement over previous iteration is below a certain threshold.

Step4: Compute a new U using following equation and go to step2

$$u_{ij} = 1/\sum_{k=1}^{c}\left(d_{ij}/d_{kj}\right)^{2/(m-1)}$$
(2.4)

Here $d_{ij} = ||\emptyset(x_j - v_i||$

By iteratively updating the cluster centers and the membership grades for each data point, FCM iteratively moves the cluster centers to the "right" location within a data set.

FCM does not ensure that it converges to an optimal solution. Because of cluster centers (centroids) are initialize using U that randomly initialized.(Equation 2.2).

Performance depends on initial centroids. For a robust approach there are two ways which is described below.

1-) Using an algorithm to determine all of the centroids. (for example: arithmetic means of all data points)

2-) Run FCM several times each starting with different initial centroids.

III. KERNEL WEIGHTED FUZZY C-MEANS CLUSTERING

An alternative kernel weighted fuzzy c-means (KFCM) algorithm is proposed to cluster incomplete data. Unlike the usual way utilizing kernel method in FCM, the proposed KFCM clustering algorithm is performed still in original data space, i.e., prototypes lie in data space. Furthermore, KFCM adopts a more robust kernel-induced metric different from the Euclidean norm in original FCM. KFCM has better outlier and noise immunity than FCM, it is especially suitable to dealing with incomplete data.

Define a nonlinear map as $\emptyset: x \rightarrow \emptyset(x) \in F$, where *x* ∈ X *X* denotes the data space, and *F* the transformed feature space with higher or even infinite dimension. KFCM minimizes the following objective function.

$$J_m(U,V)=\sum_{i=1}^{c}\sum_{k=1}^{n} u_{ik}^{m}\,||\emptyset(x_k) - \emptyset(v_i)||^2$$
(3.1)

The algorithm's input output parameters are given as follows:

Input:

(1) $X = \{x_1, . . ., x_n\}$, $x_i \in R^s$, the data set

(2) c, $2 \leq c \leq n$, the number of clusters

(3) $\varepsilon > 0$, the stopping criterion of algorithm

(4) The values of parameter

(5) $a^{(0)}=(a_1^{(0)},\ldots\ldots a_c^{(0)})$, the initials of cluster centers

Output:

a = {a_1,a_2, . . .,a_c}, the final cluster centers

Algorithm:

The image segmentation algorithm using fuzzy clustering based on kernel-induced distance

measure (KWFCM) can be summarized as follows:

Step1: Initialize the membership matrix U with random values between 0 and 1 such that the constraints in following equation are satisfied.

$$\forall x \sum_{k=1}^{num.cluster} \mu_k(x) = 1$$

(3.2)

Step2: Calculate fuzzy cluster centers c_i , i =1……….c using the following equation.

$$center_k = \sum_x \mu_k(x)^m x \Big/ \sum_x \mu_k(x)^m$$

(3.3)

Step3**:** Compute the cost function according to following equation.

$$J_m = \sum_{i=1}^{C} \sum_{j=1}^{N} \mu_{ij}^m \left\|\emptyset(x_j) - \emptyset(v_i)\right\|^2$$

(3.4) $\left\|\emptyset(x_j) - \emptyset(v_i)\right\|^2 = k(x_j, x_j) + k(v_i, v_i) - 2k(x_j, v_i)$ (3.5)

While using GRBF, $k(x_i, x_j) = \exp\left(-\frac{\|x_i - x_j\|^2}{2\sigma^2}\right)$ therefore

k (x ,x) = 1,then:

$$\left\|\emptyset(x_j) - \emptyset(v_i)\right\|^2 = 2\left(1 - k(x_j, v_i)\right)$$

(3.6)

$$J_m = 2\sum_{i=1}^{C} \sum_{j=1}^{N} \mu_{ij}^m \left(1 - k(x_j, v_i)\right)$$

(3.7)

Stop if either it is below a certain tolerance value or its improvement over previous iteration is below a certain threshold.

Step4: Compute a new U using following equation and go to step2

$$u_{jk} = 1 / \sum_{l=1}^{c} \left(E_j(x_k)/E_l(x_k)\right)^{2/(m-1)}$$

(3.8)

where $E_j(x_k) = \left\|\emptyset(x_k) - \emptyset(v_j)\right\|^2 = 2 - 2k(x_k, v_j)$

IV. EXPERIMENTAL RESULTS

This section explains the result obtained after performing FCM and KWFCM on the satellite images. For comparing the performance of the algorithm, we used an experimental database which consists of 30 satellite images and 20 SAR images in jpg format. The experiments are conducted on one of the satellite (or SAR) image using matlab platform, coded with FCM and KWFCM then comparison between the segmented results is performed based on number of cluster, execution time, mean absolute error and peak signal to noise ratio. Table 1 gives the comparison of FCM and KWFCM.

In the table, sat_canal.jpg image is taken as input for segmentation. The FCM and KWFCM output is compared for the clusters 3, 4 and 5. In this experiment, it can be observed that when the number of cluster increases then the execution time for image segmentation also increases, further it comes under observation that FCM algorithm faces local minima problem hence it takes more time for execution as compare to KFCM. Mean absolute error (MAE) values decreases, when there is increase in number of cluster. FCM algorithm gives noisy results hence FCM has more MAE as compare to KFCM results. Peak Signal to Noise Ratio (PSNR) values increases with increase in number of cluster. MAE is inversely proportional to PSNR hence FCM results are having lesser PSNR value as compare to KFCM results.

V.CONCLUSION

From the experimental results, it is seen that FCM algorithm is noise sensitive because of not taking into account the spatial information in the image. The KWCM algorithm overcomes the above problem. It includes a class of robust non-Euclidean distance measures for the original data space to derive new objective functions and thus clustering the non-Euclidean structures in data. The experiments on the Satellite images and SAR images show that KWFCM can segment images more effectively and provide more robust segmentation results than FCM. It is robust to noise and outliers and also tolerates unequal sized clusters. Comparison of KWFCM and FCM using PSNR, MAE, Number of clusters and Execution time as performance metric shows that KWFCM achieves better segmentation results than FCM for all test images.

REFERENCES

1. Xin-Bo Zhang And Li Jiang, " An Image Segmentation Algorithm Based On Fuzzy C-Means Clustering" Proceeding Of Ieee International Conference On Digital Image Processing, Vol. 29, Issue.24, Pp.:22-26,2009.
2. Yanling Li And Yi Shen, "Robust Image Segmentation Algorithm Using Fuzzy Clustering Based On Kernel-Induced Distance Measure" Proceeding Of The 2008 Ieee International Conference On Computer Science And Software Engineering, Vol. 26, Issue.54. Pp.:1065-1068, 2008
3. D.R. Chittajallu, G. Brunner, U. Kurkure R.P. Yalamanchili And I.A. Kakadiaris, "Fuzzy-Cuts: A Knowledge-Driven Graph-Based Method For Medical Image Segmentation", Proceeding Of The Ieee, Vol. 68, Issue.13, Pp.:715-722, 2009
4. B Sowmya And B Sheelarani, "Image Segmentation Using Reformed Fuzzy Clustering Technique" Proceeding Of Csi , Vol. 33, Issue 3, Pp.:14-18, 2009
5. Maryam Hasanzadeh, Shoreh Kasaei and Hadis Mohseni, "A New Fuzzy Connectedness Relation for Image Segmentation" proceeding of the IEEE, vol. 42, issue 4, pp.:453-458, 2004
6. J. K. Udupa, and P. K. Saha, "Fuzzy connectedness and image segmentation", Proceedings of the IEEE, vol. 91, issue.10, pp.:1649 –1669, 2003
7. Li Chunmao', Wang Lingzhi and Wu Shunjun "Ant Colony Fuzzy Clustering Algorithm Applied to SAR Image Segmentation" Proceedings of the IEEE, vol. 52, issue.34,pp.:69 –72, 2006
8. Martin Tabakov **"**A Fuzzy Clustering Technique for Medical Image Segmentation" 2006 International Symposium on Evolving Fuzzy Systems, vol.-74, issue.61, pp.:118-122, September, 2006

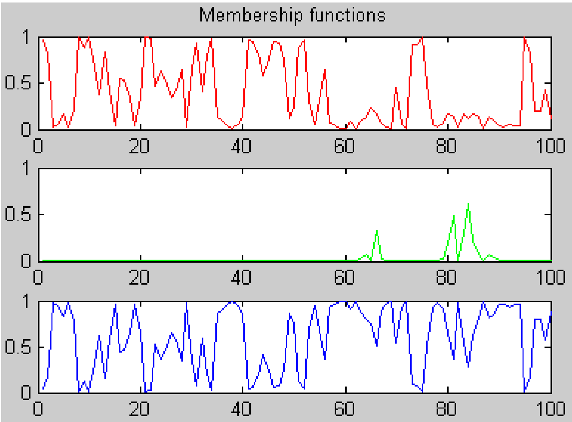
Image Name	Number of Clusters	Algorithm	Objective Function	Execution Time	MAE	PSNR
sat_canal.jpg	3	FCM	30.5013	2.484	84.87	57.68
		KWFCM	37.2405	1.296	24.04	68.64
	4	FCM	17.8688	5.015	72.83	59.01
		KWFCM	20.4224	2.796	24.07	68.62
	5	FCM	11.6155	7.171	63.85	60.15
		KWFCM	8.1353	2.765	24.11	68.61

Table 1. Comparison of FCM and KFCM algorithm

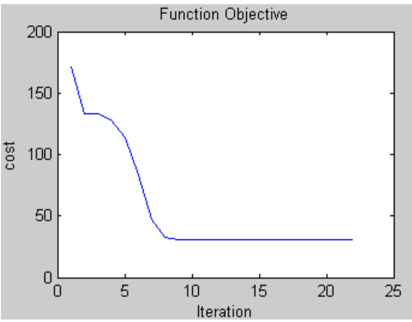
Table 1 is obtained with the help of the result given below.


(sat_canal.jpg)

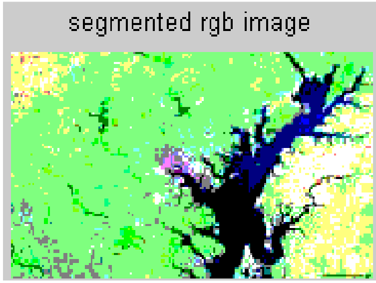
FCM: Number of clusters=3



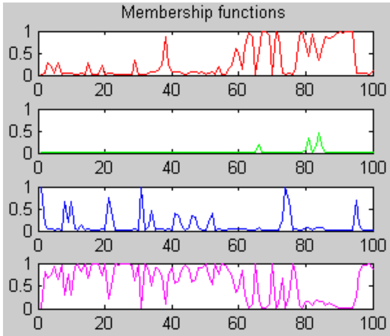
(partition matrix)



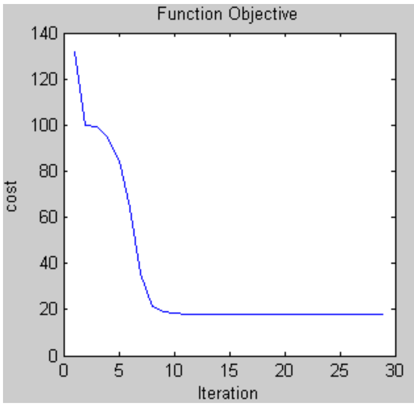
(Objective function plot)



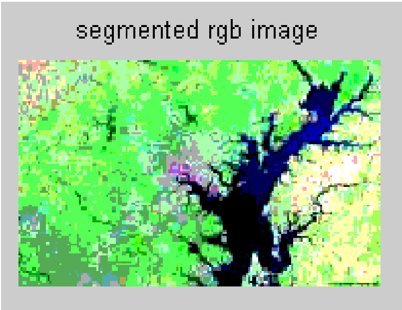
FCM: No of clusters=4



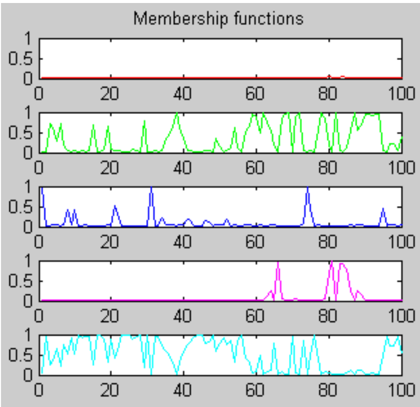
(partition Matrix)



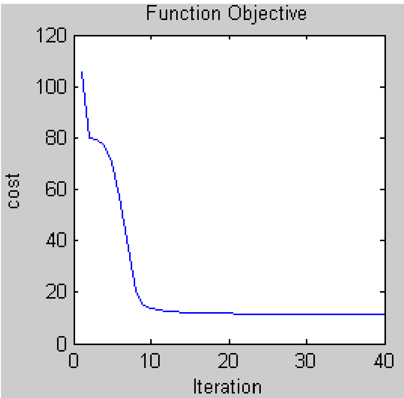
(Objective function plot)



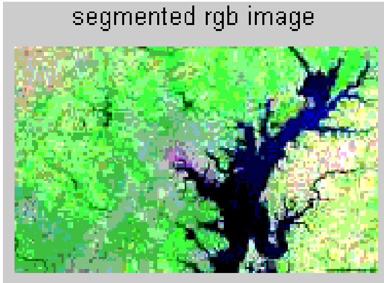
FCM: No of cluster= 5



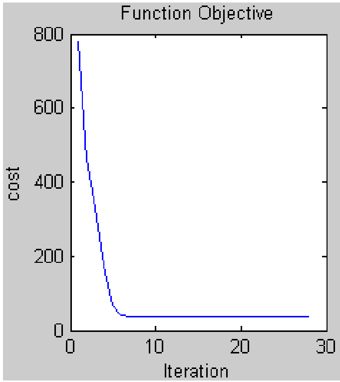
(partition Matrix)



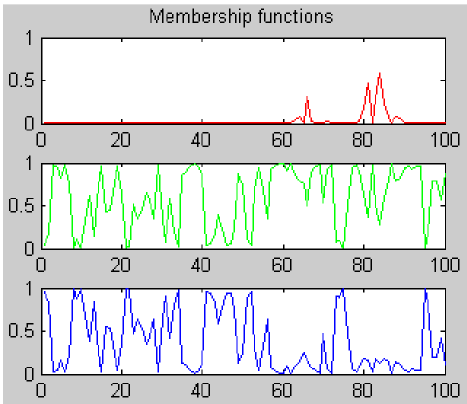
(Objective function plot)



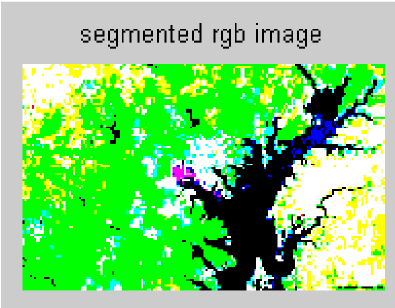
KFCM: No of clusters=3



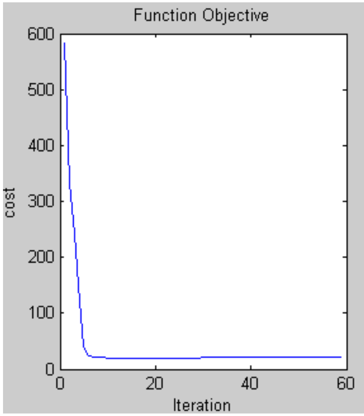
(Objective function plot)



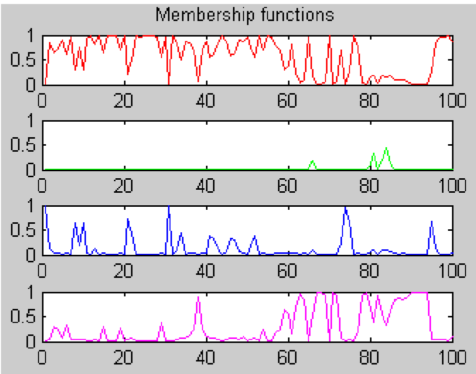
(partition Matrix)



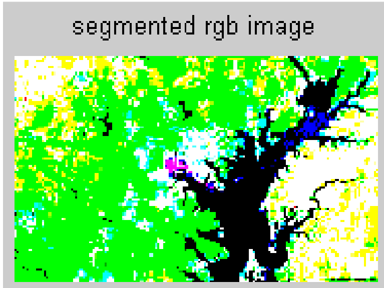
KFCM: no of clusters=4



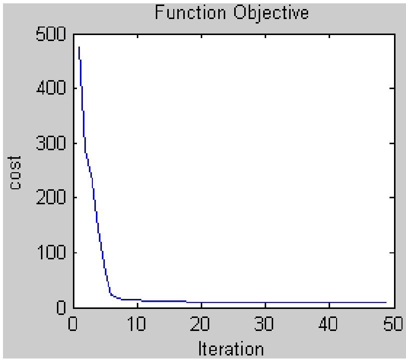
(Objective function plot)



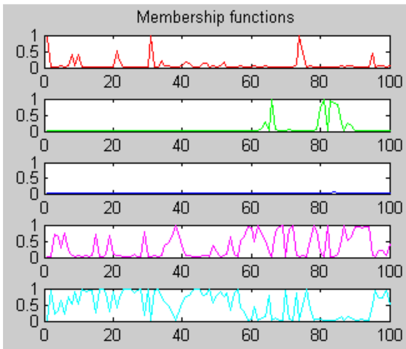
(partition Matrix)



KFCM: no of clusters=5



(Objective function plot)



(Partition Matrix)

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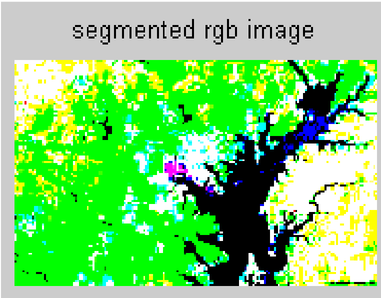
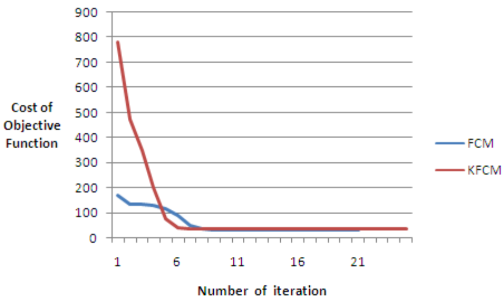


Comparison of results

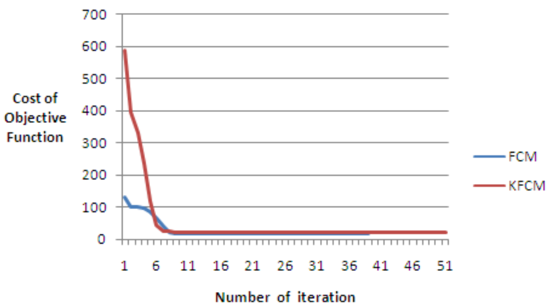
Objective function based:

Number of clusters=3



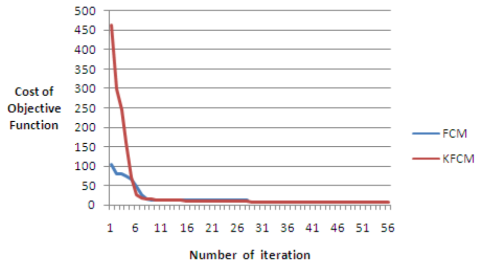
Objective function comparison for c=3

Number of clusters=4



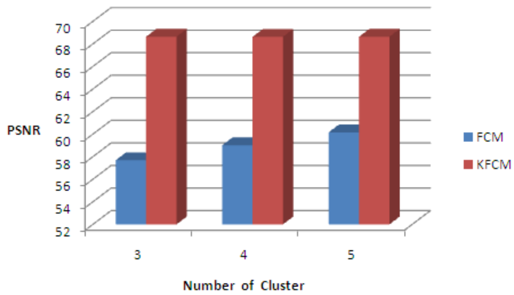
Objective function comparison for c=4

Number of Clusters=5



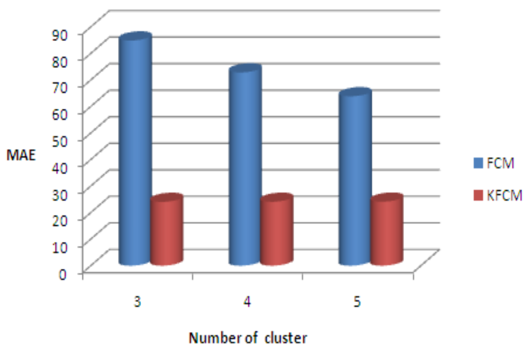
Objective function comparison for c=5

Peak Signal to Noise Ratio based



Comparison of Algorithms based on PSNR

Mean Absolute Error based



Comparison of Algorithms based on MAE

Execution Time based

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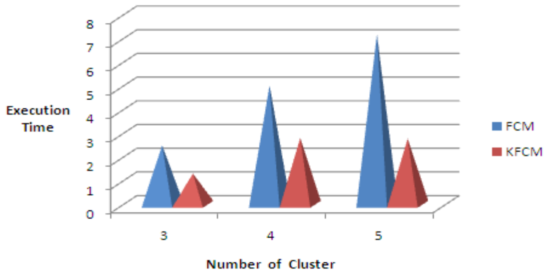

Comparison of Algorithms based on Execution time