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Composite Fuzzy C Means Image Segmentation

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Abstract*: *In this paper synthetic image segmentation is carried out by Possibilistic Rough kernel intuionistic Fuzzy c means (PRIKFCM) technique which is proposed in this paper. The results obtained through the proposed method is compared with FCM, PFCM, RKFCM segmentation techniques. The segmentation accuracy is more than the segmentation accuracy yielded by other methods. PRIKFCM is a hybrid technique incorporate in it the concepts of kernelized distance,rough ses,possibilistic and intuionistic concepts in it.the advantage of the proposed method is more due to the hybridization approach.

Keywords* :. *PCM - Possibilistic c means clustering, PFCM-Possibilistic Fuzzy c means clustering, RCM-Rough c means clustering.

I. INTRODUCTION

Segmentation is the process of extracting the region of interest from an image . the images may contain gaussian noise , speckle noise, salt and pepper noise or combination of any of the noise.Fcm results are getting degraded by the presence of noise or other artifacts in the unsegmented image. Possibilistic approach of segmentation yields cluster prototypes having very less deviation. PFCM yields non overlapping cluster prototypes and it is less affected by noise. an object is assigned to a single cluster in K means method of clustering. fuzzy c means clustering is a soft clustering technique which assigns an object to all the clusters with varying degrees of membership and it can handle data sets with outliers or noises to a certain extent. FCM [3] yields fruit full results even when the image contains overlapping clusters. PCM is used to achieve better clustering even when the number of clusters are unknown. To enhance the performance of fuzzy clustering rough set concepts are merged with fuzzy clustering and this integrated approach (RFCM) [11] can handle incomplete data information..similar to RFCM many more hybrid methods such as rough intuionistic fuzzy c means clustering(RIFCM)[9],possibilistic rough fuzzy c means clustering(PRFCM)[10]. Anindya Halder[11] incorporated kernel concepts with RFCM and optimized the different algorithm's parameter by particle swarm optimization. A hybrid technique in which kernelized distance measure is incorporated in PRIFCM to obtain PRIKFCM was also proposed in our previous work.

To achieve non overlapping clusters the Gaussian kernelized distance is used to find the member ship values and spatial information is considered in Kernel induced spatial FCM [7]. In FCM_S [1] the surrounding pixel intensity values in a 5X5 window are considered in addition to the Euclidean distance measure of FCM. FLICM[6]considers spatial information and gray level information and it is free from parameters.

Intuionistic Fuzzy set [4],[5]takes in to account of the measure of the uncertainity in assigning a pixel to a particular cluster. merging.of Intuionistic concepts to FCM yields IFCM which can handle vague data.

RCM can group data patterns whose boundaries are uncertain. an object which is assigned to one lower approximation then it lies in its own upper approximation. an object which is not assigned to any of its lower approximation then it belongs to two or many upper approximations. The distance between the consideredt pixel and the centers of different groups are found. A picture element is linked to the lower approximation of the cluster if the differences of distances is more than the threshold. we made a survey on the various Fuzzy c means clustering techniques with or without optimization techniques and proposed a novel technique. In [8] the PRIKFCM method is proposed and in this paper that method is modified and implemented in matlab . we made a survey on the various Fuzzy c means clustering techniques with or without optimization techniques and proposed a novel technique. In [8] the PRIKFCM method is proposed and in this paper that method is modified and implemented in matlab R2014a .

The remaining part of the paper is organized as follows section I deals with the earlier segmentation techniques available in the literature.In section II the algorithm of PRIKFCM method is specified.section III deals with the experimental results and evaluative measures of segmentation.

II. SECTION -I

A. *FCM*

In this method a pixel is assigned to a particular cluster if the degree of membership of the picture element to it is more than the degree of membership of the pixel to any other cluster. the membership value depends on the distance between the pixel and the cluster center i.e the Euclidean distance d_{ij} . the membership value of the picture element u_{ik} is updated in each iteration . The cluster center v_{ij} is found using equation (1). This approach yields better results only when the input image is free from noise and other artifacts.

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The performance deteriotates as the noise level increases in the image.The expression for distance and membership is given in equation (2) and (3).

$$v_{ij} = \frac{\sum_{k=1}^{n} u_{ik}^{m} x_{kj}}{\sum_{k=1}^{n} u_{ik}^{m}} \quad (1)$$

$$d_{ij} = \left[\sum_{j=1}^{m} \left(x_{kj} - v_{ij}\right)^2\right]^{1/2} \quad (2)$$

$$u_{ik} = \frac{1}{\sum_{j=1}^{c} \left(\frac{d_{ik}^{2}}{d_{jk}^{2}}\right)^{1/m-1}} \quad (3)$$

B. PFCM

Typicality value is calculated in addition to membership value calculated by FCM .Based on those two values membership degree is found in PFCM method.The cons of FCM and PCM methods are overcome in this method.

C. RKFCM

In RKFCM the membership is found using kernelized distance instead of Euclidean distance as in FCM method. Image consisting of Incomplete data can even be segmented by the use of rough set concepts.if the difference between membership value of picture element is greater than the roughset threshold then it is said to be lying with in the inner boundary of that cluster. if the difference of membership value of picture element is less than the threshold then it lies in the upper approximation of many clusters. The cluster center is updated in each iteration using the following equation (10) .

D. Intuionistic FCM

In addition to membership and non membership value,hesitation degree is considered in this method.the hesitation degree represents how far the pixel is deviated from its cluster,if hesitation degree is more then the belongingness of a pixel to that cluster is more. the hesitation degree is calculated using equation (5).

III. SECTION-II –PROPOSED ALGORITHM

The membership function is found with Kernel induced distance measure instead of Euclidean distance in PRIKFCM so that the classification is done in the kernel space. The amount of noise in the output is reduced by considering hesitation degree of assigning a pixel to a cluster..The boon of possibilistic approach, Intuionistic method ,kernel distance measure and that of rough sets are obtained in the proposed method.The proposed method produces significantly improved results even when the input image is noisy. The algorithm of proposed work is given below

Possibilistic Roughl Intuionistic kernel FC M Algorithm

1. Assign initial cluster centers v_i for c clusters.
2. Calculate the kernel induced distance $k(x_i, v_i^{(l+1)})$ between the pixel x_i and the cluster centroid v_i.

$$\mu_{ik} = \frac{1 - k(x_i, v_i^{(l+1)})^{1/m-1}}{\sum_{k=1}^{c} (1 - k(x_i, v_i^{(l+1)})^{1/m-1}} \quad (4)$$

3. Compute the hesitation degree π_{ik} using the expression given below

$$\pi_{ik} = 1 - \mu_{ik} - \frac{1-\mu_{ik}}{1+\lambda\mu_{ik}} \quad (5)$$

4. Find membership values of object x_k to cluster centroids v_i using the following equation

$$\mu_{ik}' = \mu_{ik} + \pi_{ik} \quad (6)$$

5. compute δ ,The average of differences between the two highest memberships of all the pixels in the image .

$$\delta = \frac{1}{n}\sum_{j=1}^{n}(u_{ij} - u_{kj}) \quad (7)$$

6. if μ_{ij}-$\mu_{ik} > \delta$ then $x_j \in A(\beta_i)$ and $x_j \in \bar{A}(\beta_i)$
Else $x_j \in \bar{A}(\beta_i)$and $x_j \in \bar{A}(\beta_k)$

7. For each data point belonging to the cluster a typicality value t_{ik} is calculated by using the following equations

$$t_{ik} = \frac{1}{1 + \frac{\mu_{ik}^2}{\zeta_i}} \quad (8)$$

$$\zeta_i = \frac{\sum_k \mu_{ik}^2}{|Ax_i - Ax_i|} \quad (9)$$

8. Find the novel center by using the equation (10).

9. Redo from step 2 till termination condition is satisfied or till there are no more assignment of objects.

IV. SECTION-III -RESULT & DISCUSSION

The segmentation accuracy (SA) is defined as the ratio of number of correctly classified pixels to the total number of pixels in an image.SA used as the evaluative measure.The coding is written and outputs are obtained by executing them in Matlab R2014 a.The segmentation is carried out on synthetic images .The speckle , Gaussian and salt & pepper noise is added to the image and segmentation is carried out on noisy image.The number of
is initialized as 2 and noise is added to the image using imnoise function in matlab.

A. Noise Analysis of PRIKFCM method

A synthetic image of size 128x128 is considered,salt & pepper noise (0.02) and Gaussian noise (0.03) is added to the image. A 3x3 portion of the image is taken from the noisy image to analyse the performance of PRIKFCM algorithm. Fig 1 shows the 3x3 portion of the noisy image .

$$v_i = \begin{cases} \dfrac{w_{low} \sum_{x_k \in \underline{B}x_i} \vec{x_k}\, \mu_{ik}^m\, k(\vec{x_k}, \vec{v_i})}{\sum_{\vec{x_k} \in |\underline{B}x_i|} \mu_{ik}^m\, k(\vec{x_k}, \vec{v_i})} + \dfrac{w_{up} \sum_{x_k \in \overline{B}x_i} \vec{x_k}\, \mu_{ik}^m\, k(\vec{x_k}, \vec{v_i})}{\sum_{\vec{x_k} \in |\overline{B}x_i|} \mu_{ik}^m\, k(\vec{x_k}, \vec{v_i})} & if\ \underline{B}x_i = \emptyset\ and\ (\overline{B}x_i - \underline{B}x_i) \neq \emptyset; \\ \dfrac{\sum_{x_k \in \overline{B}x_i - \underline{B}x_i} \vec{x_k}\, \mu_{ik}^m\, k(\vec{x_k}, \vec{v_i})}{\sum_{x_k \in \overline{B}x_i - \underline{B}x_i} \mu_{ik}^m\, k(\vec{x_k}, \vec{v_i})} & ,if\ \underline{B}x_i = \emptyset\ and\ (\overline{B}x_i - \underline{B}x_i) \neq \emptyset; \\ \dfrac{\sum_{x_k \in \underline{B}x_i} \vec{x_k}\, \mu_{ik}^m\, k(\vec{x_k}, \vec{v_i})}{\sum_{x_k \in \underline{B}x_i} \mu_{ik}^m\, k(\vec{x_k}, \vec{v_i})} & ,otherwise \end{cases} \tag{10}$$

0.9838	1	1
0.9881	1	0.9894
0.9688	1	0.8372

Fig 1: 3X3 window of the image considered for segmentation.

U1

0.7551	0.0333	0.4193
0.6872	0.4701	0.1451
0.2838	0.4842	0.4772

U2

0.2443	0.3667	0.5807
0.3108	0.5223	0.8543
0.7162	0.5158	0.5228

Fig 2: Initial membership values of pixels lying in 3X3 window of the image

0.5555	0.5555	0.5555
0.5555	0.5555	0.5555
0.5554	0.5555	0.5554

0.5556	0.5556	0.5556
0.5556	0.5556	0.5556
0.5557	0.5556	0.5556

Fig 3: Membership values of pixels lying in 3X3 window of the image after first iteration.

0.3973	0.3721	0.5293
0.3973	0.4552	0.3973
0.3973	0.3973	0.3565

0.7061	0.725	0.5815
0.7033	0.6489	0.7033
0.7033	0.7033	0.7382

Fig 4: Membership values of pixels lying in 3X3 window of the image after first iteration

In the Fig 1 pixel with values 1 are not corrupted due to noise and other pixels with values less than one are corrupted by noise.Initially centers and membership function is assigned some random values. Initial centers are 0.0587 and 0.5156 and random values of membership function is specified below.since the number of clusters is 2, U1 and U2 are the initial random membership values of pixel to cluster 1 and cluster 2 respectively. Initial membership values are shown in Fig 2.

During the first iteration of the PRIKFCM algorithm, the membership values of pixel to the clusters are given below The values of centers after first iteration are 0.0306 and 0.9490. From the Fig 2 it is found that the membership values of pixel corrupted by noise is same as that of the pixel which is not corrupted by noise. Hence the noise is effectively handled by the PRIKFCM method.During the second iteration of the PRIKFCM algorithm, the membership values of pixel to the clusters are given below The values of centers after second iteration are 0.0315 and 0.9487.the centers after the final iteration are 0.0298 and 0.9566. The value of the parameters are specified in table 1.

the kernel distance measure provides good classification rate.The segmented image by proposed method is less affected by noise.the segmentation accuracy is greater in the proposed method than the FCM,PFCM and RKFCM methods. Table 1 shows the SA values obtained through different segmentation methods for synthetic image containing different amount of Gaussian and salt and pepper noise. Table 2 shows the values of final centroids obtained from FCM,PFCM ,RKFCM and the proposed PRIKFM method for synthetic image containing different amount of Gaussian and salt and pepper noisethe non overlapping final centroids are obtained by proposed method and by PFCM methods. . The centroids obtained from PRIKFCM method is very much close to the unaffected pixels of original noisy image. Figure 5 and Figure 6 shows the original synthetic image with noise and the cameraman image with noise and the segmented images by FCM,PFCM,RKFCM and PRIKFCM respectively. Figure 7 shows the original mri brain image and its segmented results by PRIKFCM.

Table-I: Values of the parameters used in the algorithm

parameters	values
w_{low}	0.92
w_{up}	0.08
rst	0.7
lambda	0.25
iter	30
eps	2e-10

V. CONCLUSION

In this paper synthetic image of size 128*128 is considered and to that image Gaussian noise and salt and pepper noise at different level is added to it. As the noise level increases in the image the segmentation obtained through the proposed method yields better performance than other methods. The noisy image is segmented by the proposed PRIKFCM method .the performance of the

Table- II: Segmentation Accuracy values obtained by FCM,PFCM,RKFCM,PRIKFCM method with different values of noise added to the image

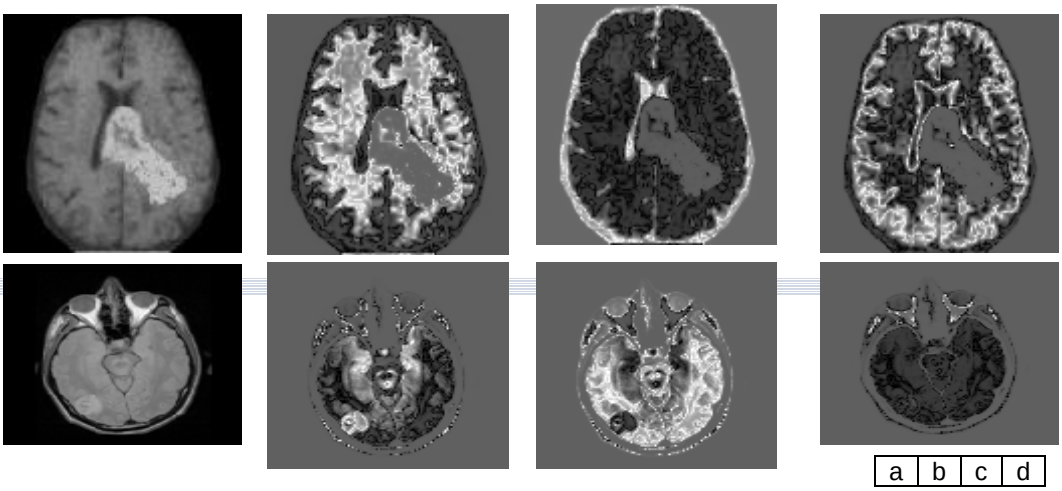
Gaussian noise	Salt & pepper noise	FCM	PFCM	RKFCM	PRIKFCM
0.01	0.01	99.6	99.6	99.11	99.61
0.01	0.02	99.13	99.11	99.06	99.2
0.02	0.01	99.65	99.6	99.48	99.67
0.01	0.03	98.65	98.67	98.45	98.71
0.03	0.02	98.17	99.11	98.97	99.17
0.03	0.01	99.55	98.58	99.49	99.65

Table- III: Final Centroids of FCM,PFCM,RKFCM,PRIKFCM method with different values of noise added to the image

Gaussian noise	Salt & pepper noise	FCM	PFCM	RKFCM	PRIKFCM
0.01	0.01	< 0.5076,0.5039>	<0.0585, 0.9490>	<0.9368,1.0792>	<0.9803,0.0131>
0.01	0.02	< 0.5033,0.5045>	<0.0678,0.9405 >	<0.9369,1.0470>	< 0.9261,0.1214>
0.02	0.01	<0.0624,0.9572 >	<0.0624,0.9572 >	<0.9280,1.0939>	< 0.9315,0.0453>
0.01	0.03	<0.0756,0.9307 >	<0.0756,0.9307 >	<0.9411,0.9648>	< 0.0600,0.1062>
0.03	0.02	< 0.5147,0.5138>	<0.0746,0.9509 >	<0.9395,0.9564>	<0.0298,0.9566>
0.03	0.01	< 0.5154,0.5142>	< 0.9595,0.0699>	<0.1085,0.1198>	<0.0305,0.9649>

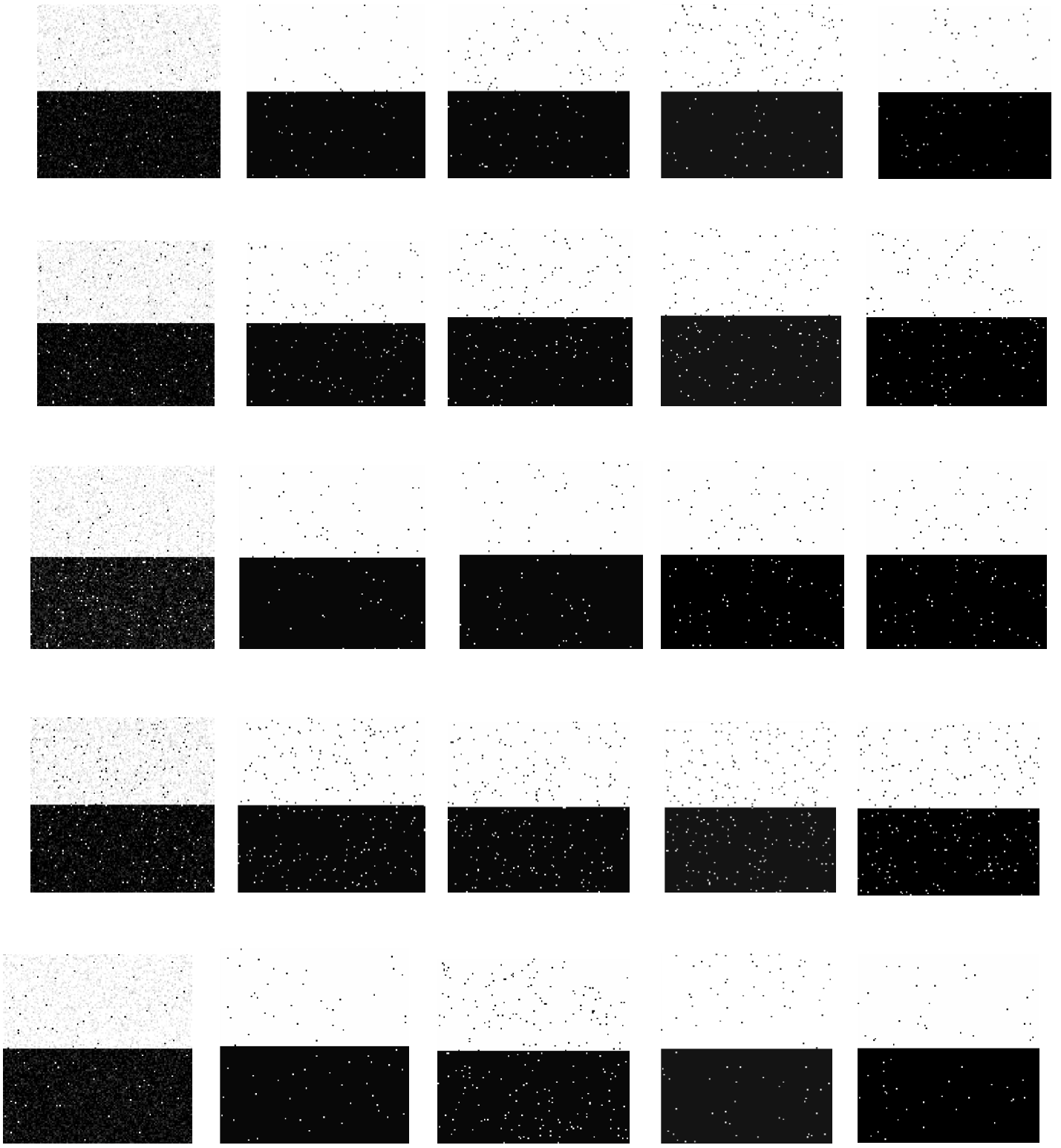
a b c d e

Fig:6 : a. Gaussian,salt and pepper noise added cameraman image b. FCM output c. .PFCM output d. .RKFCM output e. PRIKFCM output



a b c d

Fig:7 : a. original mri brain image b-d . segmented images by PRIKFCM



a	b	c	d	e

Fig:5 : a. Gaussian,salt and pepper noise added synthetic image Amount of Gaussian noise= 0.01 Amount of salt and pepper noise=0.01 is added in row1.,Amount Gaussian noise= 0.01 Amount of salt and pepper noise=0.02 in row2,Amount of Gaussian noise= 0.02 Amount of salt and pepper noise=0.01 in row3, Amount of Gaussian noise= 0.01 Amount of salt and pepper noise=0.03 in row4, Amount of Gaussian noise= 0.01 Amount of salt and pepper noise=0.02 in row5. b. FCM output c. .PFCM output d. .RKFCM output e. PRIKFCM output

algorithm is judged by comparing it with existing FCM,PFCM,RKFCM methods.The experimental results indicates that segmentation accuracy is high in the case of PRIKFCM method.the centroids obtained in the proposed method is not over lapping as in the case of PRIKFCM method.In the future this method can be applied to segment medical image and natural images.

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