IJCSN International Journal of Computer Science and Network, Volume 5, Issue 1, February 2016
ISSN (Online) : 2277-5420 www.IJCSN.org
**Impact Factor: 1.02**



# Enhancing Spatial FCM using Intuitionistic Fuzzy Sets

**Prabhjot Kaur**

Maharaja Surajmal Institute of Technology (MSIT)
New Delhi, 110058, INDIA

**Abstract - A conventional fuzzy c- means (FCM) clustering algorithm did not use the spatial information of the data and is very much sensitive to noise. To improve the noise sensitivity of FCM, Spatial FCM (SFCM) incorporates the spatial information to improve the results. Intuitionistic fuzzy sets introduce hesitation factor in the fuzzy sets to enhance the performance of fuzzy sets and also added entropy to maximize the good points in data. This paper proposed a variant of SFCM by using intuitionistic fuzzy sets. The algorithm is tested on the CT scan images and after comparison it is observed that SIFCM outperformed SFCM and IFCM in case of images.**

**Keywords -** *Intuitionistic Fuzzy Set, Hesitation Degree, Fuzzy Clustering, Intuitionistic Fuzzy Generator, Spatial Information, Image Segmentation, FCM.*

## 1. Introduction

Segmentation is the initial step towards analysis in case of many applications such as object recognition, pattern recognition. Its aim is to partition the images into various parts. Every region must have some homogeneous feature like color, texture and so on. Clustering can be crisp or fuzzy. Crisp clustering is where image boundary is defined. In case of fuzzy clustering, there is some overlapping in defining the clusters.FCM clustering classifies the image by dividing it into similar regions based upon some common property like color, texture etc. FCM is based upon fuzzy sets. In 1983, Atanassov gave the concept of intuitionistic fuzzy sets (IFS). IFS has the concept of hesitation degree. In 2011, T. Chaira proposed a variant of FCM based upon IFS known as intuitionistic FCM (IFCM) [4].The spatial relationship of neighboring pixels can provide important information in dividing the image into clusters.

This paper proposed an algorithm which incorporates the spatial information into IFCM and is known as Spatial Intuitionistic Fuzzy C-Means (SIFCM). This scheme reduces the noise and biases the algorithm towards homogeneous clustering.

## 2. Background Information

This section briefly discuss FCM, IFCM, and SFCM.

### 2.1. The Fuzzy C- Means Algorithm

Fuzzy CMeans is the most popular algorithm proposed by Bezdek in 1981[3]. This algorithm works well with noiseless data but if even a single noise point is added to the data. FCM's performance deteriorates. The disadvantages of FCM are that it does not tolerate noise and another point is that it does not work with non-linear data. Many algorithms have been proposed by researchers to tackle these problems. So FCM become a base problem for many researchers to think about.

### 2.2 The Intuitionistic Fuzzy C-Means Algorithm (IFCM)

The IFCM algorithm is based upon the intuitionistic fuzzy set theory [1, 2]. It modifies FCM algorithm by using the concept of intuitionistic fuzzy sets proposed by Atanassov [2]. It has modified the FCM objective function by adding a new term known as intuitionistic fuzzy entropy. Intuitionistic fuzzy entropy deals with noise points and helps to maximize good points in the data. It has also added another term known as hesitation degree, which is there to define lack of knowledge, when membership of any points is defined. It works well with medical images [4].

### 2.2 The Spatial Fuzzy C-Means (SFCM) [10]

In an image, the points in the neighborhood carry very important information. In case of corrupted image, the neighborhood information is very critical and important to regenerate the image. The author of SFCM has used this concept in the algorithm to deal with noisy images. It is also a variant of FCM in which the author has incorporated the spatial information to modify the objective function of

FCM. SFCM uses a square window around the point to regenerate the membership of point in consideration.

## 3. The Proposed Algorithm, Spatial Intuitionistic Fuzzy C-Means(SIFCM)

This paper proposed a technique wherein to enhance the IFCM algorithm, spatial information is incorporated. The membership of every point is modified to encorporate the neighborhood membership. It is a variant of IFCM where the spatial characteristics of the image is added into the objective function of IFCM to enhance the results.

For an efficient analysis of SIFCM we calculate 3 functions: objective function (OF), membership function (MF), clusters center.

$$\text{SIFCM} = \sum_{i=1}^{c}\sum_{j=1}^{n} U_{ij}^{SIFCM}\, d_{ij}^{2} + \sum_{i=1}^{c} \pi_i^{*}\, e^{1-\pi_i^{*}} \tag{1}$$

$U_{ij}^{SIFCM}$= Spatial intuitionistic fuzzy membership function.

M = Represents fuzziness, it is user defined. Generally its value is 2.

$d_{ik}$ = Euclidean distance i.e. used to find the distance between cluster center and the data points.

The second part denotes IFE that represents the degree of intuitionistic in fuzzy set. It is defined as:

$$\text{IFE (A)} = \sum_{i=1}^{n} \pi_A(x_i) e^{[1-\pi_A(x_i)]} \tag{2}$$

Where, $\pi_A(x_i)$ = hesitation degree
= 1- $u_A(x_i)$ $-v_A(x_i)$

$u_A(x_i)$ = membership degree (MD) of each element.
$v_A(x_i)$ = non-MD of each element
.

The MF of SIFCM is given by:

$$U_{ij}^{SIFCM} = \frac{(U_{ij}^{IFCM})^{p} h_{ij}^{q}}{\sum_{k=1}^{c}(U_{kj}^{IFCM})^{p} h_{kj}^{q}} \tag{3}$$

Where, $U_{ij}^{IFCM}$ = Intuitionistic fuzzy membership function.
$h_{ij}$ = Spatial function

$$= \sum_{k\in NB(x_j)} u_{ij}^{IFCM} \tag{4}$$

p and q= Parameters containing positive values
Intuitionistic fuzzy membership function ($U_{ij}^{IFCM}$) is further elaborated as:

$$u_{ij}^{IFCM} = u_{ij}^{FCM} + \pi_i^{*} \tag{5}$$

Here $u_{ij}^{FCM}$ represents the fuzzy membership degree of each pixel in a cluster region and is further elaborated as:

$$u_{ij}^{FCM} = \frac{1}{\sum_{k=1}^{c}\left(\frac{\| x_j - v_i \|}{\| x_j - v_k \|}\right)^{\frac{2}{m-1}}} \tag{6}$$

Where $v_i$ is the ‘i[th]’ cluster center and is defined as:

$$v_i = \frac{\sum_{k=1}^{n}(u_{ik}^{m} x_k)}{\sum_{k=1}^{n}(u_{ik}^{m})} \tag{7}$$

And $\pi_i^{*} = \frac{1}{N}\sum_{k=1}^{n}\pi_{ik}$ and $\pi_{ik}$ is the hesitation degree of the k[th] element in cluster ‘i’ and is defined as.

$\pi_{ik}$=1-$u_{ik}$–(1-$u_{ik}^{\alpha}$)$^{\frac{1}{\alpha}}$,α>0

The cluster center $v_{ik}$ is modified as

$$v_i^{SIFCM} = \frac{\sum_{k=1}^{n}(u_{ik}^{SIFCM} x_k)}{\sum_{k=1}^{n}(u_{ik}^{SIFCM})} \tag{8}$$

Using this above equation the center of the cluster is updated and simultaneously the membership matrix is updated at each iteration and the algorithm stops when the difference between updated membership matrix and the previous matrix is less than∈ i.e.

$$max_{ik}|(U_{ik}^{SIFCM})^{new} - (U_{ik}^{SIFCM})^{pre}| < \in, \tag{9}$$

Here ∈ is user defined value and is selected as 0.03.

**ALGORITHM**

Step1. Convert the input image into matrix form.

Step2. Calculate membership matrix using equation .

Step3. Obtain the center of cluster using equation.

Step4. Repeat steps 4-6 to update membership values and cluster centers.

Step5. Calculate the objective function using the equation.

Step6. Algorithm stops, when the stopping criteria is met.

## 4. Simulation and Result

This section presents empirical calculations to compare the segmentation performance of SIFCM with IFCM and SFCM. Matlab version R2008a is used for simulating and implementing the experiments.Core2duo, dual core, corei3, corei5, corei7 Intel processor was the configuration of the computer with at least 2.4GHz.The installed RAM of 2GB was considered with a 32 bit operating system. For the evaluation process, paper has assumed certain parameters: value of fuzziness index i.e. m=2, ε=0.3 the value at which the iteration stops; α=0.85 [10].

Uniform noise is added to the image to study the efficiency of SIFCM algorithm in comparison to IFCM and SFCM. Analysis and results are based upon two criterions:

1. Qualitative Analysis
2. Quantitative Results

**Qualitative Analysis**

Tests are performed on medical images. Images are downloaded from medical image gallery. Following Fig. 1 shows a CT scan image, which is segmented into four classes. Experiment is repeated for different values of α=0.45, 0.5, 0.6, 0.7, 0.85, and 0.9. From the results, it is clear that good results are obtained with α=0.9.

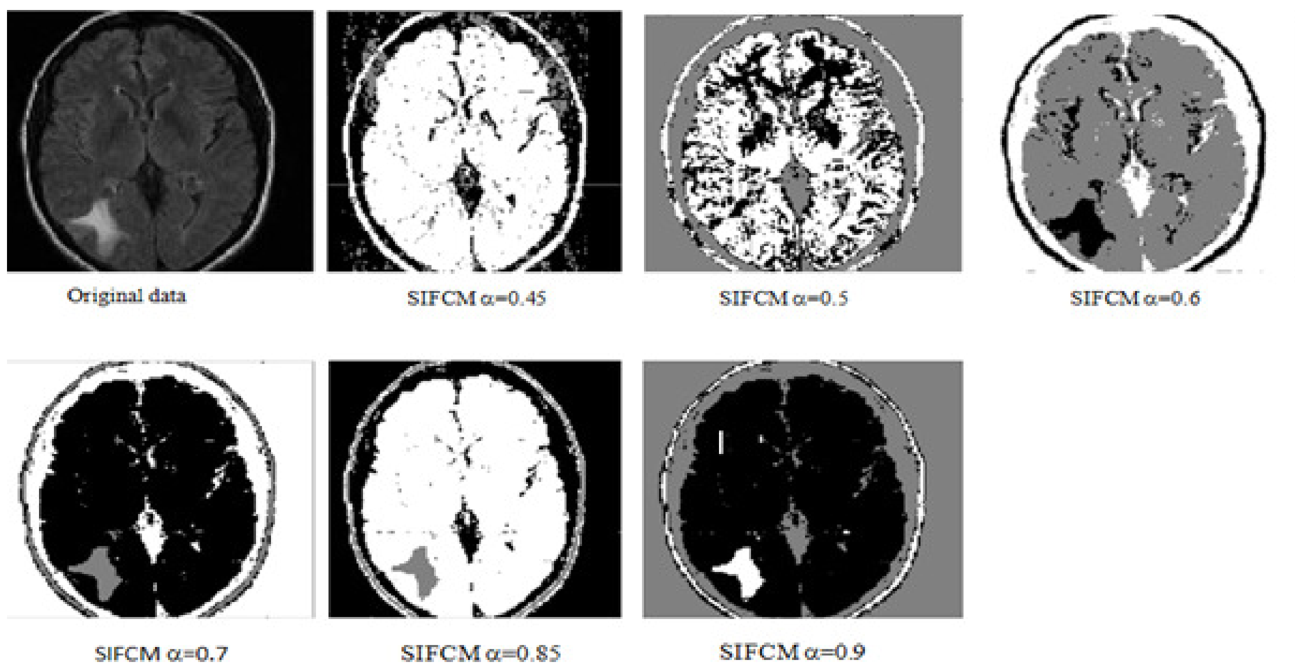


Fig. 1 Clustered Image at different values of 'α' using SIFCM

The proposed method of incorporating the spatial information through the spatial function in IFCM is compared with IFCM and SFCM. The conventional FCM classifies the MRI into six clusters successfully but the spurious blobs of the gray matter(GM) that is overlapping the white matter(WM) do appear in the final results of image segmentation with IFCM. These overlapping and spurious blobs are still reduced to a certain extent in case of SIFCM. SFCM detected the tumor but still some noise is present in the GM and the WM. SIFCM classify the image accurately with no noise present with its highest level of efficiency as shown inFig.2. When comparing IFCM,SFCM,SIFCM the first two algorithms clusters the tumor region with little noise present inside the tumor and also the region surrounded by the tumor is not clearly detected. SIFCM clearly detected the tumor region without noise

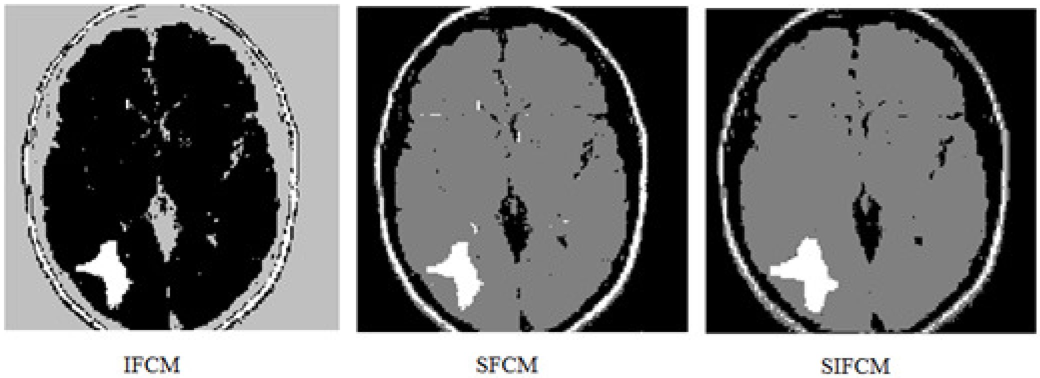


Fig. 2 Segmented Images of MRI using IFCM, SFCM and SIFCM

**Quantitative Results**

Based upon misclassification in the three algorithms IFCM, SFCM, and SIFCM, this paper verify their performance by quantitative index $r_{ij}$. [11, 12]

$$r_{ij} = \frac{A_{ij} \cap A_{refj}}{A_{ij} \cup A_{refj}} \quad (16)$$

Where $A_{ij}$the set of pixels belonging to jth class is founded by the i[th] algorithm and $A_{refj}$ represents the set of pixels belonging to j[th] class in reference segmented image. In our case $A_{refj}$ represents the pixel of ground truth image.

The following table shows the misclassification and the comparison scores using the three methods.

Table 1: Misclassification of an image using various techniques

| IMAGE | IFCM | SFCM | SIFCM |
|---|---|---|---|
| Tumor image | 2477 | 2386 | 2569 |

Calculating $r_{ij}$ for IFCM, SFCM, and SIFCM using (16).

Table 2:Comparison Scores of the Techniques

| IFCM | SFCM | SIFCM |
|---|---|---|
| 0.867 | 0.88 | 0.89 |

From the Table 2, it is observed that results of SIFCM are better than the other two algorithms IFCM and SFCM, as the value of $r_{ij}$ is considered moreefficient and accurate as it comes towards one. Soconsidering these points, we can say that SIFCM has outperformed the other two algorithms.

## 5. Conclusion

This paper proposed an intuitionistic approach of clustering by adding the spatial information into IFCM. It combined the advantages of IFCM and SFCM to enhancethe image segmentation process. The algorithm is tested with CT brain scan image and from the results, it is clear that SIFCM gives better results compared to other two methods.

## References

[1] K.T. Atanassov's, Intuitionistic fuzzy sets, VII ITKR's Session, Sofia, 983 (Deposed in Central Science – Technology Library of Bulgaria Academy of Science – 1697/84).

[2] K.T. Atanassov, Intuitionistic Fuzzy Sets Theory and Applications Series in Fuzzinessand Soft Computing, Phisica-Verlag, 1999.

[3] J.C. Bezdek, L.O. Hall, L.P. Clark, Review ofMRsegmentation technique in patternrecognition, Medical Physics 10 (20) (1993) 33–48.

[4] T. Chaira, A.K. Ray, O. Salvetti, Intuitionistic fuzzy c means clustering in medical image segmentation, in: Proc. of ICAPR, ISI Calcutta, India, 2007.

[5] L.A. Zadeh, Fuzzy sets and systems, in: Proc of Symposium on systems theory, Polytechnic Institute of Brooklyn, NY, USA, 1965.

[6] A. Kaufmann, Introduction to the Theory of Fuzzy Subsets: Fundamental Theoretical Elements-1, Academic Press, New York, 1980.

[7] R.R. Yager, On the measures of fuzziness and negation part II lattices, Information and Control 44 (1980) 236–260.

[8] Pedrycz W, Waletzky J. Fuzzy clustering with partial supervision. IEEE Trans Syst Man Cybern Part B Cybern 1997;27:787–95.

[9] Ahmed MN, Yamany SM, Mohamed N, Farag AA, Moriarty T. Amodified fuzzy c-means algorithm for

bias field estimation and segmentation of MRI data. IEEE Trans Med Imaging 2002;21:193–9.

[10] Chuang Keh-Shih, Tzeng Hong-Long, Chen Sharon et al.(2006),"Fuzzy C-means clustering with spatial information for image segmentation,",Computeried Medical Imaging and graphics, 30(2006) 9-15.

[11] Masulli, F., Schenone, A., 1999. A fuzzy clustering based segmentation system as support to diagnosis in medical imaging. Artif. Intell. Med. 16 (2), 129–147.

[12] W.A. Yasnoff, et al. (1977), "Error measures for scene segmentation", Pattern Recognition 9, 217–231.

**Prabhjot Kaur** is working as a Reader in maharaja Surajmal Institute of Technology. She has done her Ph.D. in Computer Science. She is the member of IEEE, CSI and ISTE.