# Fuzzy Clustering Segmentation Algorithm Research on Flame Image

**LIU Bin, ZHANG Xin, QIE Jianmin, GAO Yuehua, HUANG Yali**

*College of Electronic and Informational Engineering, Hebei University, Baoding, 071002, China*

*e-mail*: *wllbin@sina.com*

**Abstract:** In this paper, linking with the basic principle of FCM (Fuzzy c-means clustering) algorithm, on the basis of theory research, a method of the cluster analysis of FCM is proposed. Firstly, the approximate optimal solution obtained by the improved FCM algorithm is taken as the original value of the FCM algorithm, then carrying on the local search to obtain the global optimal solution. The final segmentation result is achieved at last. The experiment results prove that in the view of the flame image segmentation, this method shows the good clustering performance and fast convergence rate, and has the widespread serviceability, so it is the practical method in image segmentation.

**Keywords:** image segmentation; FCM; flame image

## 1 Introduction

In the image research and the application, people are often interested in the certain parts of the image, which are called the target or the foreground (the other parts are called background) and generally, they are corresponded with the specific region that have the unique nature in the image. In order to recognize and analyze the target, the relevant region are needed to be separated, and only based on this step, the target may be used further ,such as carrying on the feature extraction and the measurement. Image segmentation is the technology and the process that dividing image into region that each one has the characteristics and extracting the interesting target [1].Image segmentation is one method of the image information pre-processing, whose basic principle is extracting the meaningful characteristic or the features that needs to be applied from the image. These features can be the primitive features in image field, such as the pixel grey values of the object occupying area, the object profile curve or the texture feature and so on, and may also be the spatial spectrum or the histogram characteristic, the target may be the single region and also be many regions.

At present, there have many kinds of classic segmentation algorithm in the image segmentation technology area, and the following are several kinds: (1) the segmentation methods based on pixels classifi cation , including the threshold segmentation, the feature space clustering, the fuzzy clustering and so on;(2) the segmentation methods based on edge detection, including Sobel operator, Marr operator, Robert operator, Prewitt operator, Canny edge detector and so on;(3) the segmentation methods based on regions, including the region-growing method, the splitting and merging method, the watershed algorithm, and the method based on graphic theory;(4) the segmentation methods based on multi-scale. In spite that many kinds of image segmentation methods are quite mature in theoretical, but in application, the characteristics of the image, the processing speed and hardware realizing must be considered. The practical application often takes the effect as the basis. Several methods are used simultaneously or the slight improvements are made to the method before it is used. In our design, adopting an image segmentation method based on the fuzzy clustering reduces the information content sharply and makes full preparation for system automatic recognition.

## 2 Algorithm Analysis

### 2.1 Fuzzy C-Means Clustering Algorithm

In 1969, Ruspini applied the fuzzy set theory in the cluster analysis for the first time, and the fuzzy c-means clustering algorithm was proposed (FCM), which is still used commonly in image segmentation. Standard FCM



978-1-935068-06-8 

is the non-surveillance clustering algorithm, and its success is mainly due to that in order to solve the membership of each image pixel, the fuzzinessis introduced. Compared with the crisp or the hard segmentation method, FCM can retain more information of the primitive image[2] .The steps of FCM:

① Input training samples prior known, $n$ is the number of the samples. $x_i = (x_{i1}, x_{i2}, ..., x_{ip})$ , $i = 1,2,...,n$ .

② Using the immune network algorithm to obtain the clustering center $M_j$ , $j = 1,2,...,c$ , and the corresponding cluster are supposed as follows: $A_1, A_2, ..., A_c$ .

③ $i = 1$ ,calculate the membership degree that $x_i$ to the $c$ classifications prior known:

$$\mu_j(x_i) = (1/\left\|x_i - M_j\right\|^{2/(b-1)}) / \sum_{k=1}^{c} \left\|x_i - M_k\right\|^{2/(b-1)}$$

Where $b$ is the measurement constant of clustering fuzzy degree.

④ Get $c$ membership degree values $\mu_j(x_i)$ , the maximum is $\mu_{\max i}$ , try to find the classes which make $\mu_j(x_i) = \mu_{\max i}$ established ,and the classes are supposed as: $A_1, A_2, ..., A_{c_0}$ .

⑤ If $c_0 = 1$ , $x_i$ is converged to $A_{c_0}$ ,else if $c_0 > 1$ ,go to next step.

⑥ According to the fuzzy regulation, $A_{ik}$ is chosen from $A_1, A_2, ..., A_{c_0}$ , making $x_i$ and $A_{ik}$ are most close to fuzzy condition, then $x_i$ is converged to $A_{ik}$ .

FCM has been applied widespread because of its unique advantages in the image segmentation. But when clustering the big data set, FCM algorithm is extremely time-consuming, moreover, regarding to the image of low signal-to-noise ratio and the segmentation result is not very ideal. Seeing this, an improved FCM algorithm is put forward (M-FCM).

## 2.2 Improved FCM Algorithm (M-FCM)

To further enhance the operating performance of the FCM clustering algorithm, and reduce the time complexity, an improved FCM image segmentation algorithm is introduced (M-FCM).

The region from which the flame image signal is gained[3]:

$$Y_K = X_K G_K \qquad \forall k \in \{1,2,...,N\} \tag{1}$$

where $X_K$ 、$Y_K$ and $G_K$ respectively are the real intensity, the observational intensity ,the region gained from $kth$ pixels, $N$ is the total number of pixels.

The permitting bias during the process of the image transforming:

$$y_k = x_k + \beta_k \qquad \forall k \in \{1,2,...,N\} \tag{2}$$

where $x_k$ 、 $y_k$ and $\beta_k$ respectively are the real value , the value represented in $kth$ pixels after in logarithmic transformation, the bias in $kth$ pixels. If the region has been known, adopting the common segmentation methods based on the intensity can evaluate the flame region easily, thus the correct data is gained.

The following are the improvement for the algorithm. The influence of the flame edge and the determine factors of the flame intensity are also discussed[4].

$$J_m = \sum_{i=1}^{c} \sum_{K=1}^{N} u_{ik}^{p} \left\|y_k - \beta_k - v_i\right\|^2 + \sum_{i=1}^{c} \sum_{k=1}^{N} u_{ik}^{p} \left(\sum_{y_r \in N_K} w(y_k, y_r) \left\|y_r - \beta_r - v_i\right\|^2\right) \tag{3}$$

where $w(y_k, y_r)$ is the weight function, satisfying the condition below:

$$\sum_{y_r \in N_k} w(y_k, y_r) = \alpha \quad , \quad 0 \le \alpha \le 1 \quad , \quad \forall k \in \{1,2,...,N\}$$

when the equality holds: $w(y_k, y_r) = \alpha / N_R$ , $J_m$ is the optimum solution to the problem of BCFCM （Bias-corrected fuzzy c-means）, the following several factors can effect obtaining the optimum parameters:

$$\min_{u_{ik}, v_i, \beta_k} J_m \tag{4}$$

That is $u_{ik}$ 、 $v_i$ and $\beta_k$ ,according to the BCFCM algorithm, correlation parameters are calculated out, then the optimum solution are obtained.

A. Membership Evaluation

$$u_{ik}^{*} = \frac{1}{\sum_{j=1}^{c} \left(\frac{D_{ik} + \gamma_{ik}}{D_{ij} + \gamma_{ij}}\right)^{1/(p-1)}} \tag{5}$$

where $D_{ik} = \left\|y_k - \beta_k - v_i\right\|^2$ , $\gamma_{ik} = \sum_{y_r \in N_k} w(y_k, y_r) \left\|y_r - \beta_r - v_i\right\|^2$

B. Cluster Prototype Updating

$$v_i^{*} = \frac{\sum_{k=1}^{N} u_{ki}^{p} ((y_k - \beta_k) + \sum_{y_r \in N_k} w(y_k, y_r)(y_r - \beta_r))}{\sum_{k=1}^{N} u_{ki}^{p} (1 + \sum_{y_r \in N_k} w(y_k, y_r))} \tag{6}$$

C. Bias-Field Estimation

$$\beta_k^* = y_k - \frac{\sum_{i=1}^{c} v_i (u_{ik}^p + \sum_{y_r \in N_k} w(y_k, y_r) u_{ir}^p)}{\sum_{i=1}^{c} (u_{ik}^p + \sum_{y_r \in N_k} w(y_k, y_r) u_{ir}^p)} \quad (7)$$

D. Discussion of the cluster

If $w(y_k, y_r) \geq 0$ and $\sum_{y_r \in N_k} w(y_k, y_r) = \alpha$ , $0 \leq \alpha \leq 1$ , $\forall k \in \{1,2,..., N\}$ $N_k$ is 4 or 8,

Using the equation above to calculate $u_{ik}$ , $v_i$ and $\beta_k$ ,the optimum solution $J_m$ can be obtained.

E. M-FCM Algorithm

The image is divided into many different clusters, using the M-FCM algorithm to revise the bias, the step as follows[5,6]:

① choose the weight function

$$w(y_k - y_r) = \alpha e^{\frac{\|y_k - y_r\|^2}{\sigma^2}} \quad , 0 \leq \alpha < 1, \sigma \geq 1 \quad (8)$$

We set the initial class model as $\{v_i\}_{i=1}^{c}$,for example: $\{v_i = \log(255 * (2i-1)/2c)\}_{i=1}^{c}$

② Suppose $\{\beta_k\}_{k=1}^{N}$ is a very small value that is close to zero(such as 0.01)

③ Using equation(5) to update dividing matrix

④ Using equation(6) to calculate the clustering model under the condition of mean-weighted pattern

⑤ Using equation(7) to calculate the bias field

Repeat steps③-⑤,until equation (9)is satisfied.

$$\|V_{new} - V_{old}\| < \varepsilon \quad (9)$$

where $V$ is the clustering centre vector, $\varepsilon$ is a very small value that is close to zero (such as 0.01).

This improved FCM algorithm increases the effect of image segmentation, but regarding to the big data sets, the algorithm is still time-consuming and the image segmentation effect needs to be improved.

## 3 Experiment result and analysis

The experiment is carried out to confirm the different of the two algorithms of traditional FCM algorithm and the M-FCM algorithm. Table 1 and Figures 1,2 shows the result:

Table1. Experiment result

| Algorithm | Reduction number of the wrong classification | The Surpassing proportion to FCM |
|---|---|---|
| FCM | 15 | |
| M-FCM | 5 | 20% |

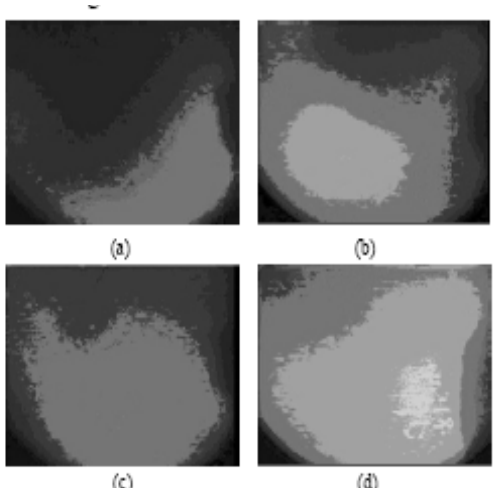


**Figure 1. The original flame images in different condition**

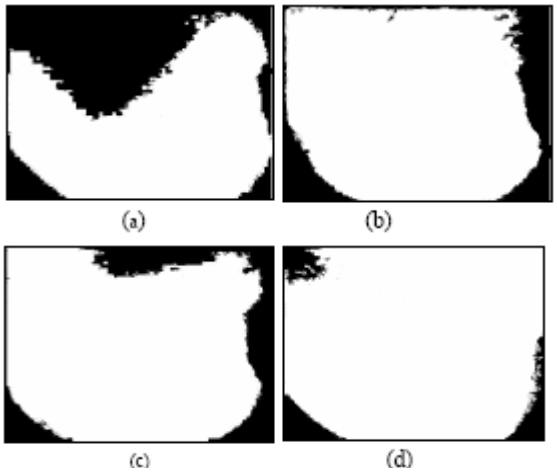


**Figure 2. The image segmentation result of the M-FCM**

## 4 Conclusions

The image segmentation is the important content of the mode recognition, image understanding, and the computer vision. FCM and its improved methods havethe characteristics of describing simply, realizing eas ily, the good segmentation effect and so on, but the segmentation time are often excessively long. On the premise of guarantee segmentation quality, the approach of the M-FCM algorithm which is introduced in this paper raises the FCM image segmentation speed greatly, and it has certain application value.

## Acknowledgements

This paper is supported by Natural Science Foundation of Hebei Province and project of science and technology of Hebei Province



978-1-935068-06-8 © 2009 SciRes.

## References

[1] Yujin ZHANG. Image Processing and Analysis [M], Beijing: Tsinghua University Press, 1999.
[2] Thitimajshima, P.“A new modified fuzzy c-means algorithm for multispectral satellite images segmentation ”[C]. Proceedings of Geoscience and Remote Sensing Symposium. Honolulu, H I, 2000,4: 1684-1686.
[3] Bezdek J C, Hathaway R J. “Progressive sampling schemes for approximate clustering in very large data sets”[C]. Proceedings of 2004 IEEE International Conference on Fuzzy Systems, 2004,1:15-21.
[4] Lu WANG,Zixing CAI. Improved rapid FCM algorithm [J]. Mini-Micro Computer Systems. 2005,10：1774-1777.
[5] Chuang K S, Tzeng H L , Chen S, etal. Fuzzy c-means clustering with spatial information for image segmentation [J]. Computerized Medical Imaging and Graphics, 2006,30:9216.
[6] Eschrich S. et. al. “fast fuzzy clustering of infrared images”[C]1 Proceedings of IFSA World Congress and 20th NAF IPS International Conference, Vancouver, 2001,2:1145-1150.