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Image Segmentation using hybrid PSO-FCM

Rahul Kakar[1], Akansha Singh[2]

[1] Student, CSE- IT Department, ITM University,
Sector 23A, Gurgaon, Haryana 122017, India.
[2] Associate Professor, CSE- IT Department, ITM University,
Sector 23A, Gurgaon, Haryana 122017, India.

Abstract

In this paper, an image segmentation algorithm is proposed which is based on Fuzzy C means and Particle Swarm Optimization. This proposed method uses Xie Beni index and Fuzzy C means to evaluate the fitness function. The results on both the proposed algorithm as well as the simple Fuzzy c means have been calculated. The experimental results show that the image segmented using the proposed algorithm gave better results.

Keywords: *PSO, FCM, XieBeni Index, segmentation*

1. Introduction

Image segmentation is breaking up of an image into various parts which are known as segments. Here what we input is an image and what we get after segmentation as the output are the attributes of that image. We group the pixels with similar attributes together. The segmented image is more meaningful than the input image. Image segmentation is used in a wide variety of applications like face recognition, medical imaging, fingerprint recognition and many other fields.

A number of researchers are working in this area. In literature numerous methods are available for performing image segmentation.

Arbelaezetal explored outline detection as well as the segmentation of an image. The outline detector or the contour detector functions on the idea of spectral clustering. Spectral clustering is based on the technique of joining various cues. The segmentation algorithm discussed by the authors consists of generic equipment for changing the outcome of any outline detector into a hierarchical region tree. This conversion helps in reduction of the problem of image segmentation to that of outline detection [1]. Alpertetal used a process upward technique for image segmentation. In this method, the authors combined the pixels of an image to cause larger areas. After this, pairs of adjacent regions are verified on the basis of whether they should be present in the same segment or not. This checking is done by juxtaposing the intensity and texture distributions [2].

Tanetal used a method in which all suitable uniform regions in the color image are obtained by applying histogram thresholding technique. After this, FCM which stands for Fuzzy C-means algorithm is used to enhance the compactness of the group of these uniform regions [3].

Nguyenetal in their method reveal multiple advantageous properties of an effective interactive way for image segmentation. These include robustness, the capability to make a smooth and accurate boundary contour. It also covers the skill to hold topology changes [4].

Maetal defines a method in which starts with decomposition of the original image. After the decomposition is done, a filtered image is created by applying a noise reduction to the approximation image which was reconstructed with low-frequency coefficients. At the same time, a gradient image is reconstructed with some high-frequency coefficients. A co-occurrence matrix based on the filtered image and the gradient image is therefore constructed, and an improved two-dimensional grey entropy is defined. This grey entropy is defined to serve as the fitness function of ABC algorithm. Finally, by the swarm intelligence of employed bees, onlookers and scouts in honey bee colony, the optimal threshold is rapidly discovered [5].

Rotheretal defined a method in which they used the old energy function which an extra term having a scalar value. Segmentation is done using this, and the segmentation that is selected is based on an already mentioned criteria [6].

In this paper, a hypergraph-based image segmentation framework is formulated in a supervised manner for many high-level computer vision tasks. To consider short- and long-range dependency among various regions of an image and also to incorporate wider selection of features, a higher-order correlation clustering (HO-CC) is incorporated in the framework. Correlation clustering (CC), which is a graph-partitioning algorithm, was recently shown to be effective in a number of applications such as natural language processing, document clustering, and image segmentation. It derives its partitioning result from a pairwise graph by optimizing a global objective function such that it simultaneously maximizes both intra-cluster similarity and inter-cluster dissimilarity. In the HO-CC, the pairwise graph which is used in the CC is generalized to a hypergraph which can alleviate local boundary ambiguities that can occur in the CC. Fast inference is possible by linear programming relaxation, and effective parameter learning by structured support vector machine is also possible by incorporating a decomposable structured loss function. Experimental results on various data sets show that the proposed HO-CC

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outperforms other state-of-the-art image segmentation algorithms. The HO-CC framework is therefore an efficient and flexible image segmentation framework [7].

2. Background

PSO:

Particle Swarm Optimization (PSO) was invented by Edward and Kennedy. The main idea behind PSO is inspired by social behavior of bird flocking or fish schooling. The algorithm of PSO starts with random population. The smallest unit of the population is called a particle. In PSO, we initialize the particle with random position and velocity and then evaluate the fitness function for each of the particle in the population. The velocity vector for each particle is then updated and is then added to the particles position. Velocity updates are influenced by both the best global solution associated with the lowest cost ever found by a particle and the best local solution associated with the lowest cost in the present population. If the best local solution has a cost less than the cost of the current global solution,then the best local solution replaces the best global solution. PSO is easy to implement and there are few parameters to adjust. The PSO is able to tackle tough cost functions with many local minima.

FCM:

FCM stands for fuzzy c means. In this type of clustering, there exists for each segment a degree of belonging to each cluster. Greater the proximity of the segment towards the cluster, greater is the belonging of that segment to that cluster. In fuzzy c means, we first select a number of clusters. Then we compute the fuzzy belongingness which is represented by $\mu_{ij}$and is given as:

$$\mu_{ij} = \left(\sum_{l=1}^{k} \frac{(||z_i - x_j||)^{\frac{2}{\mu-1}}}{(||z_l - x_j||)} \right)^{-1} \quad (1)$$

For $1 \le i \le k$ and $1 \le j \le n$, where k is the number of clusters. $\mu_{ij}$is the membership of j^{th} pixel in the i^{th} cluster.

After calculating the membership, we calculate the center of the cluster which is represented by Z_i :

$$Z_i = \frac{\sum_{j=1}^{n} u_{ij}^{\mu} x_j}{\sum_{j=1}^{n} u_{ij}^{\mu}} \quad (2)$$

For $1 \le i \le k$, where n is the number of pixels.

We continue the above mentioned steps of the fuzzy c means algorithm, until we get the minimum value for the objective function J_m given by:

$$J_m = \sum_{j=1}^{c} \sum_{i=1}^{n} \mu_{ij}^{m} \, d_{ij} \quad (3)$$

3. Proposed method

Clustering using hybrid PSO-FCM:

In this paper, we propose a novel image segmentation algorithm based on PSO and FCM.

The image segmentation is done using Fuzzy C means clustering which is optimized by particle swarm optimization. The flow chart of hybrid PSO-FCM is shown in figure1.The following are the steps used in hybrid PSO-FCM algorithm.

Step1: Initial Population

The algorithm starts by choosing *n* particles with random position and velocity vectors. The number of particles decide the size of the population with which this algorithm is initiated.

Step2: Evaluating the fitness function

In this step, the fitness function for each particle of the population is evaluated. The fitness value is evaluated using FCM [3] and XieBeni index [8]. Once iteration of FCM is initially used to speed up the convergence. The cluster centers are computed using eq (1) and (2). In the next phase, the XieBeni index of these clusters is computed.

$$X_B = \frac{\sum_{i=1}^{k} \sum_{j=1}^{n} \mu_{ij}^{m} || X_j, Z_i ||}{n \, min_{i \neq j} || Z_i , Z_j ||} \quad (4)$$

Here ||, || is an operator denoting the square of Euclidean distance.

The XB index is minimized to obtain the optimal cluster centers.

Step 3: Selection

In this step, the best particles are selected from the entire population and is termed as.

gbest is the optimal solution. In the proposed algorithm, those particles that minimize the value of XB are chosen.

Step 4: Termination criteria

The termination cor (2) net when we get the gbest, which is the optimal solution.

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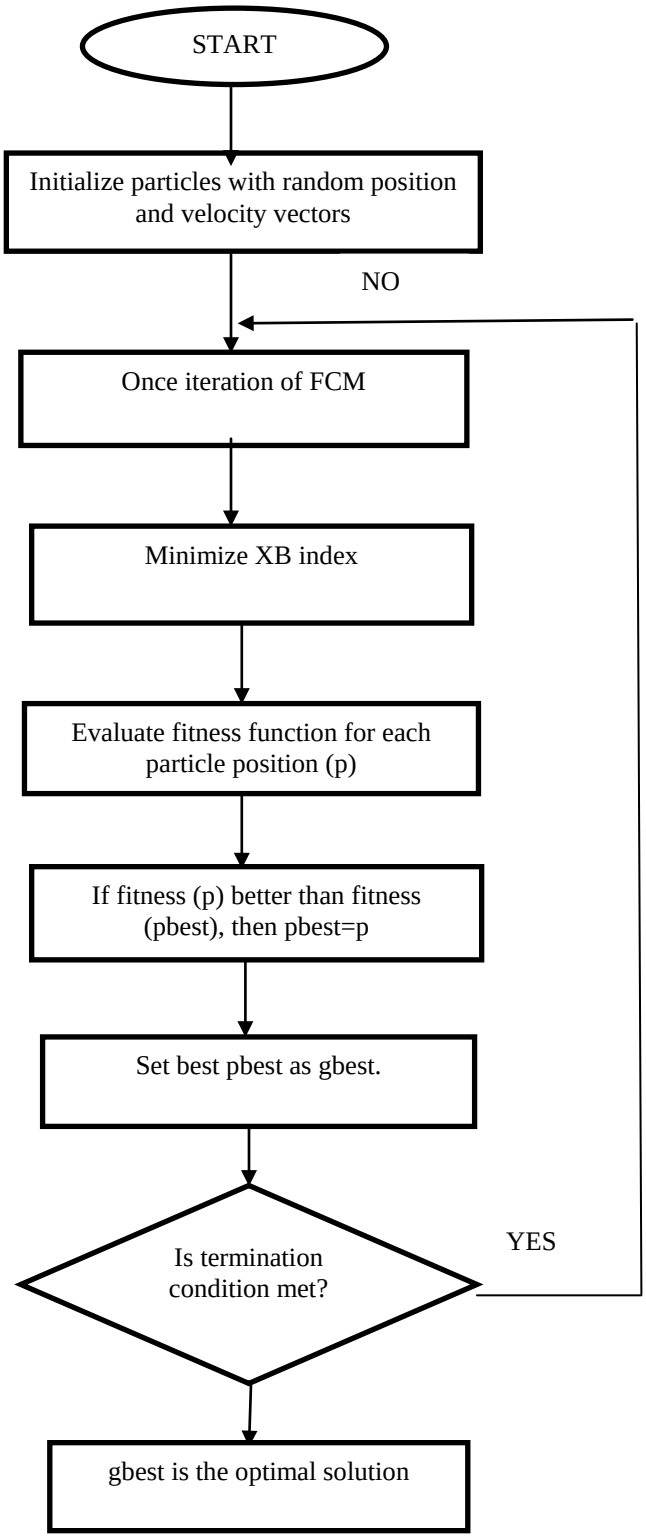

Fig. 1 Flowchart of hybrid PSO-FCM algorithm.

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4. Experiments and Results

The experiments were conducted on Matlab R2013a. Two test images were used to conduct the experiments. The first test image is a gray scale rice image of 188 × 188 pixels. The image was first segmented using simple FCM algorithm and then using the proposed algorithm. Fig. 1(a) shows the test image -1 and fig. 1(b) and (c) show the segmentation results. Similarly fig. 2 is an rgb image and the corresponding segmentation results are shown. It is seen the proposed method gives better results as compared to the conventional FCM.

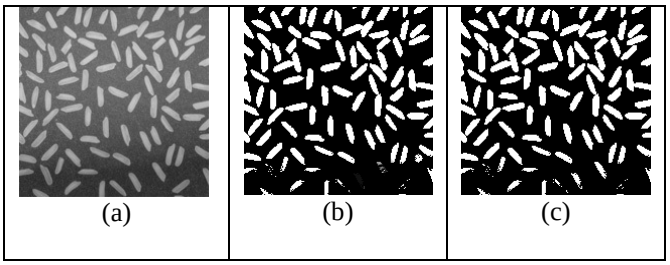

Fig.2 (a) Test image 1 (b) segmentation using FCM (c) Segmentation using proposed algorithm

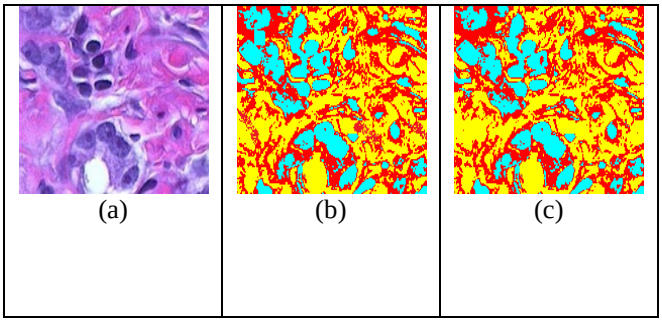

Fig.3 (a) Test image 2 (b) segmentation using FCM (c) Segmentation using proposed algorithm

5. Conclusion

In this paper, the author have proposed a novel image segmentation method based on Particle Swarm Optimization and Fuzzy C means. Results proved that the proposed method gave better results than the simple FCM algorithm. Thus, hybrid algorithm of PSO and FCM is a significant improvement over simple FCM

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