Remote Sensing Image Segmentation Algorithm Based on Multi-agent and Fuzzy Clustering

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Keywords: Remote sensing image, Segmentation, Multi-Agent system, Fuzzy clustering.

Abstract. Remote sensing is a technology for monitoring surface information in real time, remote sensing image interpretation has important application value in military and civil fields [1]. In this paper, aiming at the design of remote sensing image segmentation algorithm, we propose a remote sensing image segmentation method based on multi-Agent system and fuzzy clustering. The proposed method extracts and fuses the intensity, texture and edge information in collaboration and penalization, and it provides theoretical and technical support for remote sensing image segmentation.

Introduction

Remote sensing (RS) is a technology which can be used to obtain the dynamic information of the earth surface remotely and without contact from the last century in 60s. On the basis of the further research on the technology of computer and graphics[2], remote sensing technology has been developed rapidly, its role in the national economic construction and national defense construction is becoming more and more prominent[3]. The remote sensing technology is built on the interaction of electromagnetic waves with ground objects, by receiving and processing features of electromagnetic waves reflected or radiated back to obtain ground object information.

Satellite remote sensing image target detection is a kind of image interpretation technology, which is based on the features of remote sensing image, and combined with the image distribution and characteristics[4]. The type and location of sensors, weather, wave band and resolution has a great effect on satellite remote sensing image, therefore, there will be geometric distortion and noise interference in remote sensing image, the design of the algorithm with good robustness and adaptability is a key problem in the field of remote sensing image interpretation[5]. In the field of image segmentation, the effective application of target edge and texture information can significantly improve the accuracy of segmentation results, but extraction and fusion of these features are difficult. Image feature synergistic extraction and fast parallel implementation is a goal of remote sensing image segmentation[6].

Multi-Agent is a kind of technology which can intelligently utilize the multiple features of the target and realize the feature fusion. It uses multiple operators to extract multiple features in the same image[7], then respectively get segmentation result of the multiple features, finally, the fusion criterion is used to get higher accuracy of segmentation. Because of its intelligence, autonomy and parallelism, the multi-Agent system has certain advantages to improve the recognition accuracy[8].

Organization of the Text

Multi-Agent System

Agent system is a kind of intelligent computing entity that can sense the environment and affect the environment, and has a high degree of autonomy. multi-Agent System (MAS) is a distributed solution system which is composed of two or more Agents through consultation, cooperation and competition to realize the common goal. Single Agent's ability is not enough to solve the whole problem, they
must interact with each other in order to achieve the purpose of solving problems, planning, searching, decision-making and learning. Therefore, the most important feature of the multi-Agent system is the interaction between various Agents. MAS system works as shown in Fig. 1.

In MAS, each Agent in the process of achieving its own goals, not only by the constraints of the environment, but also by other Agent. This effect may be directly accomplished through the interaction between Agents, it may also be achieved through changing the environment of the common Agent. The goal of MAS is to achieve the goal of a single Agent cannot be accomplished through the cooperation between Agents with a common goal.

**Design of Segmentation System Based on Multi-Agent**

The design scheme of target detection system based on fuzzy clustering and multi-Agent is shown in Fig. 2. It mainly consists of three parts: the first part is the feature extraction layer, which is composed of 3 Agent systems, they respectively realize the extraction of target intensity, texture and edge feature in remote sensing images; the second part is the segmentation layer, which is composed of 3 Agent based on FCM (Fuzzy C-Means clustering), they respectively achieve the image segmentation based on intensity, texture and edges; the last part is the fusion layer of segmentation results, which is used to fuse the advantages of different features in the segmentation results to achieve a better segmentation accuracy.

Each Agent module is based on the reaction model proposed by Brooks, mainly includes three parts: sensor, decision-making, action, under the guidance of the environment these three parts are cyclic to achieve, the single Agent model does not need to use programming to realize complex reasoning planning and knowledge representation, which is easy to implement.
Feature Extraction Layer

The first part is feature extraction layer, which is used to extract the intensity, texture and edge feature of remote sensing image. Where the intensity feature is the gray value of image pixel, texture feature extraction based on the model of gray level co-occurrence matrix, and edge extraction based on Canny operator.

Gray level co-occurrence matrix is a common method to describe texture by studying the spatial correlation of gray level. First define a direction and a gray level co-occurrence matrix $T(N \times N)$ with pixel as unit step for the image, where $M(I, J)$ is defined as the frequency at which the gray level $i$ and $j$ pixels appear simultaneously at a same point and the point which is a step distance along the defined direction, $N$ is the number of gray level division. The contrast, inverse difference moment, entropy and autocorrelation can be defined by gray level co-occurrence matrix, and it can be used to measure the feature of image texture in brightness change, homogeneity and consistency.

Canny edge detection algorithm based on a multi-order boundary operator, where the four filters are used to detect the horizontal, vertical and diagonal edges of the image, the edge detector returns a value $G_x$ of horizontal component and a value $G_y$ of vertical component, according to the edge gradient and direction, we can determine the boundary feature of the image:

$$G = \sqrt{G_x^2 + G_y^2}$$  \hspace{1cm} (1)

$$\Theta = \arctan\left(\frac{G_y}{G_x}\right)$$  \hspace{1cm} (2)

Design of Agent Based on FCM

In the split sublayer, 3 FCM-Agent modules need to be designed, which are used to obtain segmentation results based on image intensity, texture and edge feature respectively. FCM is a kind of clustering algorithm based on partition, its idea is that the similarity between objects divided into the same cluster is the largest, and the similarity between different clusters is the smallest. The objective function of FCM is:

$$J(U, V) = \sum_{i=1}^{N} \sum_{c=1}^{C} u_{ic}^m d^2(x_i, v_c)$$ \hspace{1cm} (3)

Constraint conditions are:

$$\sum_{c=1}^{C} u_{ic} = 1 \hspace{1cm} \forall i$$ \hspace{1cm} (4)

Fuzzy C-Means clustering algorithm is a simple iterative algorithm. FCM use the following steps to determine the cluster center $c_i$ and membership matrix $U$ of pixel points:

Step 1: initialize the membership matrix $U$ with random numbers between 0 and 1;
Step 2: calculate $c$ cluster centers $c_i$, $i=1, \ldots, C$:

$$v_c = \frac{\sum_{i=1}^{N} u_{ic}^m x_i}{\sum_{i=1}^{N} u_{ic}^m}$$ \hspace{1cm} (5)

Step 3: update degree of membership:
Since FCM converges to an optimal solution is not able to ensure, and the performance of the algorithm depends on the initial clustering center. Therefore, we can either use another fast algorithm to determine the initial cluster center, or start the algorithm with different initial cluster centers for each time, do several experiments.

**Design of Fusion Layer Agent**

Fusion layer Agent is used to realize effective adaptive fusion of segmentation results under multiple features, in order to get better results of the segmentation. Fusion layer takes the voting strategy, the fusion process is shown in Fig. 3.

![Fusion layer agent](image)

**Experimental Results and Analysis**

This experiment aims at the effective segmentation of remote sensing image, the image of Munich, Germany is captured from the God eyes. The segmentation method of remote sensing image based on multi-Agent and FCM is validated and analyzed by using 7 computers with 2G memory. Image size is 512 * 512 pixels, the resolution is 0.5 meters, we use different gray level display segmentation results obtained.

![Segmentation results](image)

It can be found that the image is seriously polluted by noise. This method can effectively segment most of the region, the segmentation result is complete, the effect is also good, but the smoothness and anti-noise performance of the segmented area need to be further improved.

**Summary**

This paper proposes the method of the Remote sensing image segmentation based on a multi-Agent system and FCM, multi-level agent is used to realize extraction, detection and fusion of image
features, and gets a better segmentation results. In addition, the key agent design for the segmentation task is realized by the method based on fuzzy clustering that uses fuzzy learning and unsupervised clustering to improve the accuracy of segmentation results and noise immunity. The multi-Agent system proposed in this paper has achieved good results in the field of remote sensing image segmentation.

Acknowledgement

This work was supported by the National Natural Science Foundation of China (Grant No. 41302261).

References


