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Satellite Image target Detection Method Based on Multi Agent and Depth Neural Network and Fuzzy Clustering Camera

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Abstract. Remote sensing images are valuable in civil and military applications. In this paper, we propose a remote sensing image target detection method based on a multi-agent system and the deep neural network. The proposed method extracts and fuses the intensity, texture, edges, and the structures in collaboration and parallization, and it provides theoretical and technical supports for real target detection applications.

1. Introduction

Satellite remote sensing is a technique that was put forward in the last century in 60s, which can remote and non-contact access to surface dynamic information [1]. On the basis of the further research on the technology of computer and graphics, remote sensing technology has been developed rapidly, it plays an increasingly prominent role in the national economic construction and national defense construction. 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 [2].

Satellite remote sensing image target detection is a kind of image interpretation technology, which is based on the characteristics of remote sensing image and combined with the target attribute [3]. The satellite remote sensing image is influenced by the type and location of sensors, weather, wave band and resolution, so there will be geometric distortion and noise interference in remote sensing image, the key problem in the field of remote sensing image interpretation is the design of the algorithm with good robustness and adaptability. In the field of target detection, the effective application of edge, texture and structure features can significantly improve the accuracy of detection results, but extraction and fusion of these features are difficult [4]. Image feature synergistic extraction and fast parallel implementation is a goal of remote sensing image target detection.

Multi-Agent is a kind of technology which can intelligently utilize the multiple features of the target and realize the feature fusion [5]. It uses multiple operators to extract multiple features in the same image, then respectively get detection result of the multiple features, finally, the fusion criterion is used to get higher accuracy of target detection. Because of its intelligence, autonomy and parallelism, the multi-agent system has certain advantages to improve the recognition accuracy.

2. 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 Agent 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 [6]. Therefore, the most important feature of the multi Agent system is the interaction between various Agents. MAS system works as shown in Fig. 1.

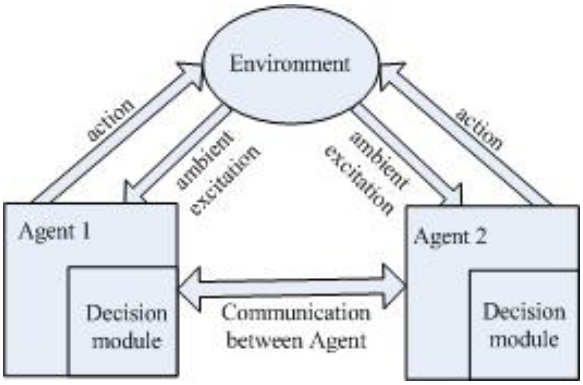

Fig. 1 MAS system working mode

In MAS, each Agent in the process of completing their own goals, not only affected by the constraint of environment, but also affected by other Agent [7]. 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.

3. Design of Target Detection System Based on Multi-agent

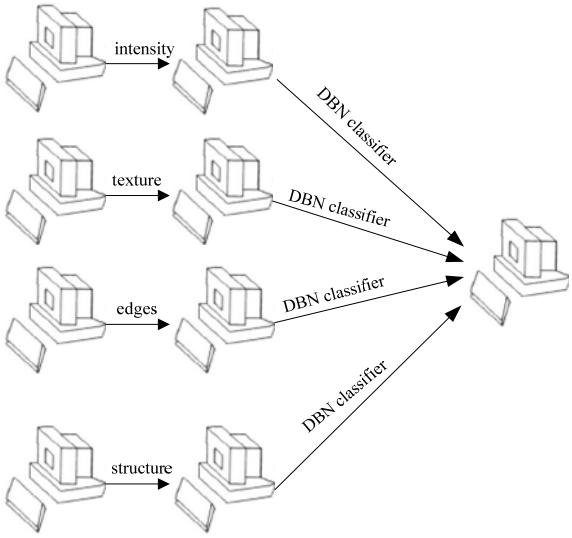

Fig. 2 Structure of target detection system based on MAS

The design scheme of target detection system based on MAS and depth neural network is shown in Fig. 2. It mainly consists of three parts: the first part is the feature extraction layer, which is composed of 4 Agent systems, they respectively realize the extraction of target intensity, texture, edge and structure features in remote sensing images, among them, the texture feature extraction is based on anisotropic Gauss kernel model, edge extraction is based on the high frequency signal of Gabor filter, structure features are obtained through the linear segment detection, polygon detection, angle detection and so on; the second part is the target detection layer, which is composed of 4 Agent based on DBN(DBN: Deep belief network), they respectively achieve the target detection based on intensity, texture, edge and structure; the last part is the fusion layer of detection results, which is used to fuse the advantages of different features in the detection results to achieve a better detection 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.

4. Design Based on DBN Agent

In the target detection layer, four DBN-Agent modules are designed, they obtain the target detection results of image intensity, texture, and edge and structure characteristics respectively. DBN is a generative model, which is different from the traditional neural network model, and can get the joint distribution between the classification results and the observed data. DBN is composed of RBM: Restricted Boltmann Machine and BP: Back Propagation, its structure is shown in Fig. 3.

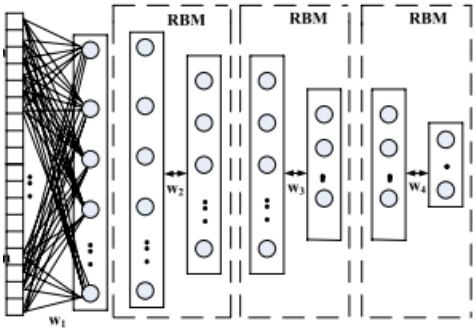

Fig. 3 DBN structure

In this system, DBN is composed of 3 layers of RBM, each which is an independent unsupervised clustering, while each RBM consists of two layers of neurons, that is, the explicit and hidden neurons. The display layer is the input image feature, and the hidden layer is the feature detection. In the DBM, non-supervised greedy method is generally adopted to get the weights that need to be trained through the pre-training. The DBN training model mainly includes two parts: pre-training and fine tuning. In the first part, each layer of RBM network is trained separately, and the weight parameters of each layer of RBM are obtained, which can keep the characteristic information as far as possible. In the second part, the BP network is set to the last layer of the DBN, the front part of the multi-layer RBM training model is as the initial weights of BP network, and error information is transmitted to each RBM layer by using back propagation from top to bottom. The entire DBN network is adjusted to ensure that the weight of each layer of RBM network for the entire DBN network to achieve the best.

Agent classifier based on DBN, extracts image features on a higher level through the multi-layer structure effectively, has a good performance in the target detection and recognition.

5. Design of Agent Based on FCM

In the split sublayer, we need to design 2 FCM-Agent modules, which are used to get the segmentation result based on image texture and intensity. 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:

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

Constraint conditions are:

$$\sum_{c=1}^{c}u_{ic}=1 \tag{2}$$

Fuzzy C-Means clustering algorithm is a simple iterative algorithm. FCM use the following steps to determine the cluster center Ci 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 ci, i=1, ... ,C:

$$v_c=\frac{\sum_{i=1}^{N}u_{ic}^{m}x_i}{\sum_{i=1}^{N}u_{ic}^{m}} \tag{3}$$

Step 3: update degree of membership:

$$u_{ic} = \frac{1}{\sum_{c=1}^{C} \left(\frac{d(x_i, v_c)}{d(x_i, v_c')} \right)^{m-1}} \tag{4}$$

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.

6. Design of Fusion Layer Agent

Fusion Layer Agent is used to achieve the effective adaptive fusion of multiple features, in order to get better results of the target detection. Fusion layer takes the voting strategy, the fusion process is shown in Fig. 4.

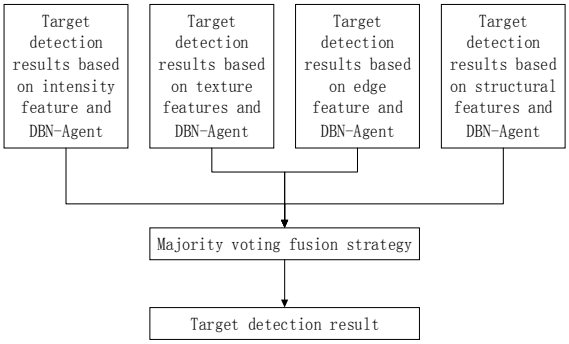

Fig. 4 Fusion Layer Agent

7. Experimental Results and Analysis

This experiment aims at the effective detection of ship targets in satellite images, the image near the Boston port is captured by the GeoEye-1 satellite from the Godeyes. The target detection method of satellite images based on multi Agent and deep neural network is validated and analyzed by using 9 sets of memory of 2G computer. Image size of 3000 x 3000 pixels, the resolution is 0.5 meters. There are 12 boats in the picture, including boats and ports connected, ships and the port non-connected, cases of the ships parking side by side and ship berth alone. The ship targets with red rectangular box marking can be detected by our method.

(a)original im (b)detection results

Fig. 5 Target detection results

It can be found that the methods in this paper can effectively detect most of the ship targets, mainly including 10 ships that its hull parallels with port. The structure characteristic is obvious, because of large ship size, and the detection effect is good. In this paper, the target of ground vehicle is detected by mistake, which is small in size and not obvious in feature. In addition, the method of this paper misses 2 ships, because the characteristic is not obvious. Method of the MAS structure realize the target detection in multi-feature space quickly and in parallel and can integrate the advantages of different characteristics effectively. Therefore, the algorithm in this paper has a higher detection accuracy and better detection efficiency.

8. Conclusion

This paper proposes the method of the satellite image target detection based on a multi-Agent system, multi-level Agent is used to realize extraction, detection and fusion of image features, and gets a better target detection results. In addition, the key Agent design for the target detection task is realized based on the deep belief network that uses multi-layer structure and feedback learning to improve the accuracy of target detection in the feature space. The multi-level Agent system proposed in this paper has achieved very good results in improving the accuracy of target detection and detection efficiency.

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References

[1]. Aeronautics and Space Engineering Board, National Research Council. National Academies Press. 2002
[2]. Z. Xi, T. Hesketh. Discrete time integral sliding mode control for overhead crane with uncertainties [J]. IET Control Theory and Applications, 2010, 4(10): 2071-2081.
[3]. WEICKER T J. Efficient image segmentation using partial differential equations and morphology [J]. Pattern-Recognition 2001, 34 (9): 1813-1824.
[4]. Anil K. Jain, Robert P. W. Duin, JianChangMao. Statistical Pattern Recognition: A Review [M]. IEEE Transactions on Pattern Analysis and Machine Intelligence, 2000.
[5]. RA. Schowengerdt. Remote sensing, third edition: models and methods for image processing [M], Academic Press, 2006.11.
[6]. Foster I. The grid: A new infrastructure for 21st century science[C]. In proceedings of Grid Computing: Making the Global Infrastructure Reality, 2003, pp. 51 – 63.
[7]. Zhang Yajuan, multi Agent system in the remote sensing image target recognition system in the application of research, development and application of computer, 20 (11): 20-23.
[8]. Bansal N, Blum A, and Chawla S. Correlation clustering[C]. In Proceedings of the 43rd Symposium on Foundations of Computer Science, 2002, pp. 238 – 247.