

Multi-object Recognition Algorithm based on Euclidean Feature Match in Fuzzy Remote Sensing Images

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Abstract. Remote sensing image target recognition is the use of artificial intelligence to distance non-contact sensing and remote sensing image recognition technology for surface covering, realizes the human of large scale surface macroscopic observation and monitoring for special purposes, to promote effective sense the state of human beings on the earth. Current remote sensing image target recognition technology mainly face the problem of low image segmentation precision and mixed primitive mass, this paper presents Multi-object recognition algorithm based on Euclidean Feature Match in fuzzy remote sensing images, firstly studied the relevant technology of the remote sensing image acquisition and image processing, analysis the current problems existing in the remote sensing image processing. By innovating the multi-objective recognition algorithm of fuzzy remote sensing image, the design of Euclidean feature matching operator is designed, and the manifold clustering processing is carried out for the feature of fuzzy image, so as to realize the optimization of multi-objective parallel recognition. The algorithm in this paper is validated by ERDAS simulation for target recognition accuracy and target recognition complexity performance.

1. Introduction

Remote sensing image target recognition is a technology that USES artificial intelligence to identify surface cover images with remote non-contact sensing and remote sensing, which realizes the macroscopic observation and monitoring of the special target of the super-large-scale surface and promotes the effective perception of the state of the earth.

By remote sensing image target recognition, the use of modern vehicle and sensors, get electromagnetic characteristics of the target object from a distance, through the information transmission, storage, loading, revisions, identify the target object, finally realize its function, timing, location, qualitative and quantitative), it will effectively promote the satellite load, sensing detection, image processing, visual navigation, data analysis, the development of related technology.

Countries all over the world attach great importance to the research of remote sensing image target recognition technology, which has strongly promoted the research and development of space remote sensing image target recognition. The United States has formulated and promoted the earth observation system plan, developed Modis sensors on TERRA and Aqua satellites, effectively realized the rapid broadcast of real-time observation data, and realized the ground resolution of 250m, 500m and 1000m using 36 discrete optical spectral bands. The U.S. institute of environmental systems has planned several Landsat systems, including enhanced cartography, operational land imager, and thermal infrared remote sensing devices, providing all-color resolution of 15m and thermal infrared resolution of 60m. France



has promoted the seven-generation SPOT satellite system, which was launched in 2014 with a panchromatic image resolution of 1.5m and a multispectral image resolution of 6m. The Italian space agency and the ministry of defense jointly developed the small satellite constellation system for observation around the Mediterranean. It is equipped with the SAR 2000 synthetic aperture radar, which provides radar data with resolution up to 1m. Japan has launched an advanced land observation satellite, equipped with all-color remote sensing stereoscopic mapping instrument, advanced visible light and infrared radiation instrument, which can achieve multi-spectral resolution of 10m, and can meet the requirements of surveying and mapping, regional environmental observation and disaster observation.

The application of remote sensing image target recognition has been extended to economic construction, social development, national security and people's livelihood, providing scientific basis and decision-making guarantee for major decision-making and sustainable social development of the state and departments, and visual military intelligence services for national defense construction and national security. Euroconsult, a European consultancy, reported in 2014 that it had invested \$8.7bn in global ground-to-ground observations in 2013. The total output value of China's geographic information industry reached 260 billion yuan in 2013, and the Chinese market is expected to exceed 800 billion yuan in 2020.

At present, target recognition technology of remote sensing image mainly includes neural network, cluster analysis and information fusion. Among them, the concept of deep learning is mainly used in the target recognition of remote sensing images by using neural network. The university of national defense science and technology has proposed the research of convolution neural network for the target recognition of optical remote sensing images. The university of Chinese academy of sciences has proposed a kind of application research of convolution neural network in remote sensing object recognition, which can effectively improve the recognition accuracy of flying objects. And remote sensing image target recognition based on clustering analysis, mainly is to reduce the target's characteristics, xi'an university of electronic science and technology is put forward based on the rotating extension and sparse representation of robust remote sensing image target recognition research, can make the test image approximation with sparse representation training set, under the condition of small samples, low sampling rate can maintain a good recognition performance; Nanjing university of aeronautics and astronautics proposed a remote sensing image target recognition method based on near neighbor propagation clustering and nuclear matching tracking, which has certain advantages in time cost and classification performance. However, the target recognition of remote sensing images based on information fusion is mainly to deeply explore the connection between information. Nanchang university of aeronautics and astronautics has proposed a remote sensing image aircraft target recognition combining feature points and invariant moments. A new remote sensing image processing method based on information fusion is proposed by northwest university of technology. By multi-source information fusion, the fuzziness of data in single sensor image can be overcome and the utilization rate of information can be improved.

In summary, the current remote sensing image target recognition technology mainly has the following two problems:

- 1) remote sensing image blurring results in insufficient segmentation precision of image pixels. Due to the distance of remote sensing image imaging, the blurred image makes it difficult to segment the pixel edge of the target linearly.

- 2) the target of remote sensing image is mixed, which affects the accurate recognition of the target image after superposition. Due to the dynamic nature of the target and the overlapping of the object, it is easy to be influenced by other objects when collecting the target information.

For remote sensing image target recognition in the face of low accuracy and image segmentation primitives mass mixed problem, this paper puts forward the fuzzy in the remote sensing image based on European feature matching algorithm of multi-target recognition, first studied the relevant technology of the remote sensing image acquisition and image processing, analysis the current problems existing in the remote sensing image processing. By innovating the multi-objective recognition algorithm of fuzzy remote sensing image, the design of Euclidean feature matching operator is designed, and the manifold clustering processing is carried out for the feature of fuzzy image, so as to realize the optimization of

multi-objective parallel recognition. The algorithm in this paper is validated by ERDAS simulation for target recognition accuracy and target recognition complexity performance.

2. Basic theories of remote sensing image acquisition and image processing

2.1 Research on technologies related to remote sensing image acquisition

Acquisition of remote sensing images is the basis and premise of remote sensing image processing. Its load platforms mainly include satellites, space shuttles and unmanned aerial vehicles. The basic components of the above remote sensing methods are shown in figure 1.

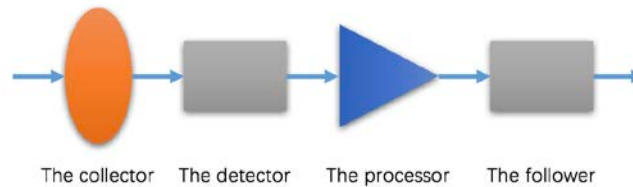


Figure 1. Basic principles of remote sensing

As shown in figure 1, it consists mainly of a collector, a detector, a processor, and an output. Here described by scanning imaging mechanism of remote sensing image, the airborne infrared scanner including rotating scanning mirror, mirror system, detectors, refrigeration equipment, electronic processing device and output device, the imaging process is made up of rotating prism scanning field ground radiant energy, in turn into the sensor, and the amplification and modulation, scenery image line on the negatives.

Assuming that the instantaneous field of view of the infrared scanner is β , the relation between it and the detector size d (diameter or width) and the focal length of the scanner is:

$$\beta = \frac{d}{f} \quad (1)$$

At this point, the spatial resolution of the infrared scanner pointing to the ground vertically α is determined by the instantaneous field of view and the height of navigation, which can be obtained

$$\alpha = \beta H \quad (2)$$

In the vertical direction observation, the scanning Angle $\theta = 0$, the navigation height H_0 , and the ground resolution are α_0 . When the scanning Angle is θ , the resolution is

$$\begin{aligned} H_\theta &= H_0 \sec \theta \\ \alpha_\theta &= \alpha_0 \sec \theta \end{aligned} \quad (3)$$

2.2 Researchs on image processing technology

The processing of remote sensing images is mainly to process the perceived geometric, physical and temporal features of images, which mainly correspond to four important parameters such as spatial resolution, spectral resolution, radiation resolution and time resolution of remote sensing images. Among them,

2.2.1 Spatial resolution. Spatial resolution refers to the size or size of the smallest unit of two adjacent ground objects that can be recognized on an image, which is used to represent the image's ability to distinguish the details of ground objects.

If the instantaneous field of view is used to represent it, it is the observation field of a single detection element in the remote sensing device

$$IFOV = \beta H = HS/f \quad (4)$$

Among them, S is the length of the detection element, H is the navigation height of the pseudo-remote sensing platform, and f is the focal length of the telescope system.

2.2.2 Spectral resolution. Spectral resolution refers to the minimum wavelength interval that the sensor can distinguish when receiving the target radiation spectrum. The spectral resolution is determined by the number of channels (the number of bands) selected by the remote sensor, the central wavelength and the bandwidth of each channel.

2.2.3 Radiation resolution. The radiation resolution reflects the sensitivity of the sensor to electromagnetic wave detection. The higher the radiation resolution, the more sensitive the electromagnetic energy is. It can be expressed as

$$R_L = (R_{max} - R_{min})/D \quad (5)$$

Where R_{max} is the maximum radiation value, R_{min} is the minimum radiation value, and D is the quantitative level. The smaller the R_L , the more sensitive the sensor.

2.2.4 Time resolution. The time resolution is the time interval between two adjacent observations of the same area on the ground. For satellite remote sensing, the time resolution is related to the design capability of satellites and sensors, the overlap degree of thin strips of ground swept by the field Angle of view of the satellite sensor, the latitude of the observation object and other factors.

2.3 Existing problems in remote sensing image processing

Because the ground resolution changes with the scanning Angle, the infrared scanning image is distorted. Since the observation line of the sensor is not perpendicular to the ground, the image resolution will change greatly, then equation (3) will become,

$$\alpha'_\theta = \alpha_\theta \sec\theta = \alpha_0 \sec^2\theta \quad (6)$$

Due to the image distortion in a single scan, there will be a problem of joint distortion along the mirror scanning, resulting in insufficient segmentation precision of image pixels.

Assuming that the time of a rotating prism scan is t and the ground resolution of a detector is constant, if the overlap degree of two scanning bands is zero, but no gaps are allowed, it is necessary

$$w = \alpha/t \quad (7)$$

Where, w is the speed of load, so it can be seen that when $wt > \alpha$, there will be scanning vulnerability, and when $wt < \alpha$, there will be partial overlap.

3. Multi-objective recognition algorithm for fuzzy remote sensing images

3.1 Design of Euclidean feature matching operator

In order to process the fuzzy remote sensing image effectively, it is necessary to classify image features and combine similar features. The key problem to be dealt with in object recognition is how to establish the standard of feature discrimination.

When calculating the distance between remote sensing image data samples, Euclidean distance can be selected as the similarity measurement between data samples.

Set the given remote sensing image data set as

$$X = \{x_m | m = 1, 2, \dots, \text{total}\} \quad (8)$$

The samples in X use d to describe attributes $A_1, A_2, \dots, A_d$ is represented, and d description attributes are contiguous. Data sample $x_i = (x_{i1}, x_{i2}, \dots, x_{id})$, $x_j = (x_{j1}, x_{j2}, \dots, x_{jd})$. Where, $x_{i1}, x_{i2}, \dots, x_{id}$ and $x_{j1}, x_{j2}, \dots, x_{jd}$ is the sample x_i and x_j respectively corresponding to d description attributes $A_1, A_2, \dots, A_d$. The similarity between sample x_i and x_j is usually expressed by the distance $d(x_i, x_j)$ between them. The greater the distance, the greater the difference between sample x_i and x_j . The Euclidean distance between remote sensing image data samples is,

$$d(x_i, x_j) = \sqrt{\sum_{k=1}^d (x_{ik} - x_{jk})^2} \quad (9)$$

3.2 Fuzzy image feature stream clustering processing

Based on the Euclidean distance above, the essence of Euclidean distance is to use the distance in the feature space to represent the similarity degree of image metadata and classification features, which can provide an important basis for the accurate segmentation of image features. Therefore, the classification method of image metadata on the category with the minimum distance (maximum similarity) can be used.

In the existing clustering algorithm, based on the distance between data points and class prototypes, the evaluation criteria of feature clustering results of remote sensing images are usually defined as a target function. Through manifold learning, its purpose is to explore the inherent regularity and distribution form of fuzzy remote sensing image feature data, and to find the essential information and internal regularity of things from the observed remote sensing image features.

The goal of fuzzy image feature manifold processing is to minimize the square Euclidean distance between all data points x_i and its nearest subspace Ω_i , and further convert it to minimize the following objective functions to solve the subspace parameters μ_j and B_j , then there are

$$\sum_{i=1}^N \sum_{j=1}^k w_{ij} |B_j^T (x_i - \mu_j)|^2 \quad (10)$$

Based on the above conditions, the algorithm designed consists of three steps:

A. Initialization

Randomly divide χ into k subset $\chi_1, \dots, \chi_k$, so that when i points belong to the j th subset $w_{ij} = 1$. The data points in each sub-set are recorded as $X_1, \dots, X_k$ by the data matrix formed by column stacking.

B. Clustering update

Given w_{ij} , the optimal solution of the subspace parameter B_j is the eigenvector corresponding to the minimum $D - d$ eigenvalues of $X_j(I - ee^T/N_j)X_j^T$, N_j is the number of sample points in the j th cluster, and the optimal solution of μ_j is $\mu_j = X_j e / N_j$.

C. Clustering assigned

Given the stator subspace parameters μ_j and B_j , the clustering assignment distributes or divides sample point x_i into the nearest subspace Ω_i according to the following reconstruction error criteria.

$$|B_j^T (x_i - \mu_j)|^2 = \min_{j=1, \dots, k} |B_j^T (x_i - \mu_j)|^2 \quad (11)$$

The result of feature clustering of remote sensing image is refined by iterating between cluster update and cluster assignment. Since the possible assignment of data points to subspace is limited, the algorithm can ensure that at least one local optimal solution can be convergent after the iteration of finite steps.

3.3 Multi-objective parallel identification optimization

In order to carry out the manifold clustering processing for the fuzzy image features, it is necessary to further realize the parallel identification optimization of multiple targets. In this paper, multiple targets will be identified in parallel using neural network, which mainly includes neural network cluster input layer design, dynamic hidden layer design, visual output layer design and other three parts, as shown in figure 2.

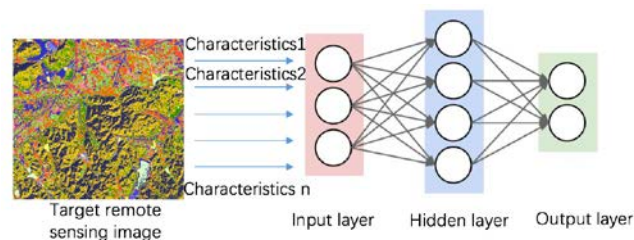


Figure 2. Multi-objective parallel recognition of fuzzy remote sensing images

The main design ideas are as follows:

(1)The input layer of neural network is mainly used to process a large number of non-linear input information. The input information is called input vector and is the original input data. In this paper, the target of remote sensing image is equivalent to the image pixel to form the original input matrix, then the heterogeneous factors such as time change, spatial change and causal change can be equivalent to the input unified element w . The uniform element w is a matrix of $i * j$, and the j th output of the current layer i is w_j^i .

(2)The hidden layer is the layer composed of many neurons and links between the input layer and the output layer, responsible for data processing. In remote sensing image object recognition, hierarchical features should be extracted from the influence factor matrix. The detailed features of clear remote sensing images are obtained in the shallow layer, and the general rules of fuzzy image objects are abstracted in the deep layer. Because the scope of each extraction is expanded during the extraction of layer features, the extraction results of the hidden layer are highly abstract, so it needs to be processed by regression again.

(3)In the neural network transmission, analysis, balance, the formation of output results. The output information is called the output vector. After the processing of input layer and hidden layer, the influence factors of remote sensing image target recognition were fitted and predicted in the output layer, and finally the output was completed. Among them, it is the key to establish the target recognition of remote sensing image which can be widely used and accurate.

4. Simulation and analysis

4.1 Establishment of simulation environment

In order to verify the performance of multi-target recognition in fuzzy remote sensing images, ERDAS IMAGINE was used to set up the simulation experiment. ERDAS has advanced image processing technology, friendly and flexible user interface and operation mode, product modules for a wide range of applications, model development tools for users at different levels, and high RS/GIS integration functions.

In this paper, remote sensing images provided in landsat-8 will be adopted, and then image import, image band synthesis, image cutting, image classification and data export will be carried out using ERDAS. The software interface is shown in figure 3.

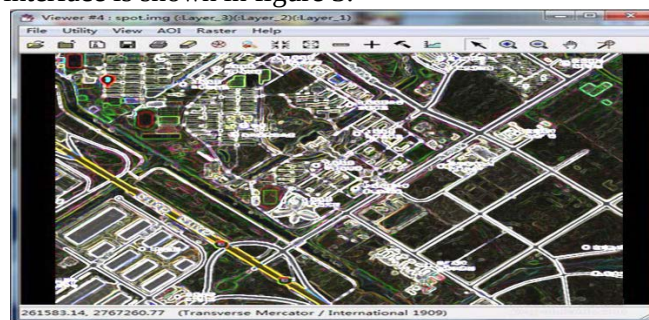


Figure 3. Image processing interface of ERDAS

The parameters set are shown in table 1.

Table 1. parameter Settings in ERDAS

Parameter	Numerical
Band	Band 1
Wavelength	0.45-0.52 micron
Cell	15mAll band
Sampling methods	GeoTiFF

4.2 Target recognition effect analysis

Through the processing of remote sensing images by ERDAS, the effects of the following different extraction methods can be obtained, as shown in figure 4.

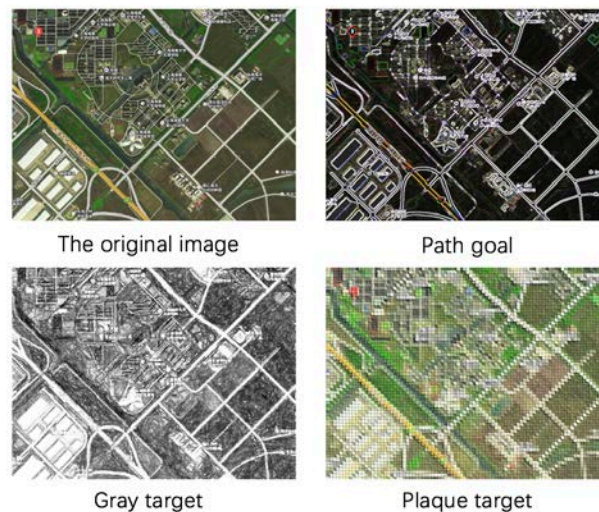


Figure 4. The processed image in ERDAS

As shown in figure 4, this method is suitable for using the original image, path target highlighting, grayscale target highlighting, and patch target. On this basis, different segmentation scale values are used to generate different scale image object layers, so that the image data with fixed resolution can be composed of different scale data structures, thus constructing a hierarchical structure similar to surface entities. It can be seen that the method designed in this paper can provide the ability to identify multiple targets simultaneously.

4.3 Precision analysis of target recognition

By using monte carlo method to carry out multiple experiments, the recognition accuracy of the proposed algorithm for the target pixel is obtained. Table 2 shows the error rate in different ERDAS experiments.

Table 2. Error rate in ERDAS experiment

The actual category	The percentage of test pixels(%)			Test as yuan	
	Category1	Category2	Category3		
1	84.3	4.9	10.8	100%	102
2	8.5	80.3	11.2	100%	152
3	6.1	4.1	89.8	100%	49

As can be seen in table 2, diagonal elements are the correct classification, and non-diagonal elements are the wrong classification.

According to the error matrix, the average precision can be calculated:

$$S = (84.3\% + 80.3\% + 89.8\%) / 3 = 84.8\%$$

Since the total number of different sample books is different, weighted average is often used:

$$S = (84.3\% * 102 + 80.3\% * 152 + 89.8\% * 49) / (102 + 152 + 49) = 83.2\%.$$

Therefore, the image recognition algorithm in this paper is maintained at a high level of about 83.2%.

5. Conclusion

By innovating the multi-objective recognition algorithm of fuzzy remote sensing image, the design of Euclidean feature matching operator is designed, and the manifold clustering processing is carried out for the feature of fuzzy image, so as to realize the optimization of multi-objective parallel recognition.

However, in the multi-object recognition algorithm, it is still possible to fully integrate various kinds of information provided by remote sensing images and eliminate the adverse factors that affect the classification accuracy.

6. Reference

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