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Fast processing method of high resolution remote sensing image based on decision tree classification

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ABSTRACT: In order to accurately distinguish the information of the nodes to be identified in remote sensing images and generate a global image processing strategy, a fast processing method for high-resolution remote sensing images based on decision tree classification is proposed. According to the classification principle of decision tree organization, the image data is preprocessed to complete the UAV remote sensing image coordination and registration, and the remote sensing image edge detection based on decision tree classification method is realized. On this basis, the convolution neural network is established, and the regularized constraint processing results are obtained by predicting the image scale. The fast processing method of high-resolution remote sensing image based on decision tree classification is successfully applied. The experimental results show that, compared with the traditional feature point matching principle, the average detection accuracy of the fast processing method is higher, and the node parameter matching accuracy is higher, which meets the practical application requirements of accurate resolution of the information to be identified in remote sensing images.

1. Introduction

Decision tree is a decision analysis method which is based on the known probability of occurrence of various situations. It can get the probability that the expected value of net present value is greater than or equal to zero, evaluate the project risk and judge its feasibility. It is a graphic method that intuitively uses probability analysis. Because this decision branch is drawn into a graph, it is very similar to the branches of a tree, so it is called decision tree. In machine learning, decision tree is a prediction model, which represents a mapping relationship between object attributes and object values [1-2]. Decision tree is a tree structure in which each internal node represents a test on an attribute, each branch represents a test output, and each leaf node represents a category. Classification tree (decision tree) is a very common classification method. It is a kind of supervised learning. The so-called supervised learning is given a pile of samples, each sample has a set of attributes and a category, these categories are determined in advance, then through learning to get a classifier, this classifier can give the correct classification of new objects. Generally, a complete decision tree organization consists of decision points, state nodes and result nodes.

In recent years, the rapid development of decision tree classification in the field of computer vision provides a new technical means for remote sensing image scene classification, target recognition, image segmentation and other fields. In the traditional feature point matching principle, firstly, feature points are extracted and matched, and then the survey area image is obtained by overall optimization iterative splicing. In the target classification of UAV remote sensing image, the database is constructed by manual annotation, and fast is used R-cnn and improved yolov3 convolutional neural networks train UAV remote sensing observation samples at typical nodes, generate recognition models of different types of data parameters, and carry out image processing and detection recognition, which can better identify a variety of different types of image information parameters. But the average detection accuracy level related to this method is low, so it is difficult to make the matching accuracy of node parameters reach the ideal value level. In order to solve this problem, a fast processing method of high-resolution remote sensing image based on decision tree classification is proposed. Under the support of remote sensing image registration principle, a complete convolution neural network is established, and then the final regularization constraint result is obtained through multiple prediction of image scale data.

2. Remote sensing image edge detection based on decision tree classification

Remote sensing image edge detection is the basic application of image fast processing method design. With the support of decision tree classification, the specific operation process can be carried out as follows.

2.1 Decision tree generation

For an image classification problem or rule learning problem, the generation of decision tree is a process from top to bottom and divide and rule, and its essence is greedy algorithm. Starting from the root node, an attribute (also known as test attribute) in the corresponding sample set is found for each non leaf node to test the training set. According to different test results, the training set is divided into several sub training sets, and each sub training set constitutes a new non leaf node. The above division process is repeated for each non leaf node, and the cycle is continued until the specific termination bar is reached And form a leaf node [3-4]. Among them, the selection of test attributes and how to divide the sample set are the key links in the construction of decision tree. The use of decision tree means that given an unknown class of image data object, the classification is determined by the classification rules of decision tree transformation. The first step is to generate "if……then", compare the attribute value of the image data object to be judged with the premise of the classification rule. If it is consistent with the premise of a rule, the classification of the rule is the category of the image data object.

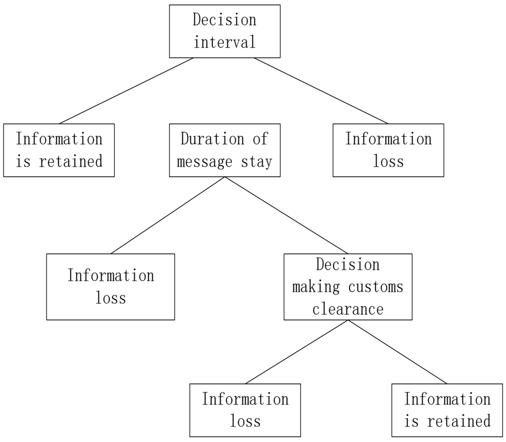

Figure 1. Structure of decision tree

How to quickly identify different types of ground objects, such as remote sensing landscape, and obtain their location, we need to use the classification and recognition technology based on decision tree. Remote sensing and remote sensing image is a form of electromagnetic information recorded by remote sensing image. Therefore, the main research direction of the application of remote sensing technology is to study the characteristics of the electromagnetic radiation of ground objects in remote sensing images, and further interpret and identify the types and distribution characteristics of ground objects. The most primitive method of image classification is to identify the types of ground objects in the image by visual interpretation. Visual interpretation requires the staff to have higher professional knowledge and be familiar with the distribution of ground features in the shooting area, and manual operation needs a lot of time and energy. With the development of computer technology, researchers began to use computer technology and image features for analysis and research, greatly improving the accuracy and efficiency of image discrimination. The early interpretation method is mainly through the statistical identification method, but this method needs a large number of training samples and expert knowledge, which is often difficult to meet in practical work, and its accuracy has been difficult to improve.

2.2 Image preprocessing

Due to the characteristics of UAV and sensors, remote sensing images need to be preprocessed before subsequent experimental analysis. The common pretreatment processes include radiation correction and geometric correction. Generally, the following standards can be used to preprocess the radiation correction direction of remote sensing images: pixel resolution, pixel overlap rate, angle between two adjacent edges of pixel coverage, image ground coverage, angle between ground coverage and flight direction corresponding to CCD direction, and mean square deviation. Geometric correction of remote sensing image includes spatial sampling distance evaluation, geometric positioning accuracy evaluation and multi band registration accuracy evaluation. The control point method is mainly used to test the spatial sampling distance [5]. According to the position of the point pair on the test image and the reference image, the number of pixels on the test image and the distance between the two points on the reference image are calculated. The pixel sampling distance between the two points is obtained by dividing the distance between the two points by the number of pixels between the two points. The sum of the spatial sampling distances of multiple point pairs is divided by the number of point pairs to obtain the mean value of spatial sampling distance. The specific implementation methods are as follows:

(1) 6-8 UAV image data of different flight belts and different regions are selected.

(2) Eight pairs of control points were selected by visual method in the direction parallel to the flight direction (along the orbit) and perpendicular to the flight direction (across the orbit). The distance between the control point pairs was greater than 300 pixels.

(3) For each control point pair, get the number of pixels (P_x and P_y) of the ground control point pair along the orbital direction, and calculate the number of pixels between the two points P :

$$P = \sqrt{P_x^2 + P_y^2} \quad (1)$$

(4) The reference distance between ground control points can be accurately measured by using the reference image map.

(5) By dividing the reference distance between the two control points by the number of pixels between the two points, the ground pixel resolution of the scene image, that is, the sampling distance, can be obtained.

(6) The average value of all selected images in each direction is calculated as the spatial sampling distance of the load.

2.3 UAV remote sensing image registration

Image registration is an important part of remote sensing image preprocessing. Its essence is to establish mapping relationship between two or more images, determine transformation parameters, and obtain two or more images with geometric consistency. An excellent registration method can improve the accuracy and speed of image registration. In general, there are two kinds of image registration methods based on gray information. Usually, the registration images are simultaneous interpreting images of the same scene at different time, different sensors or different viewing angles.

Image registration is based on some similarity between images to determine the transformation criteria, so that two or more images in the same scene obtained from multi-source, multi-scale and multi-phase can be converted to the same coordinate system through certain transformation criteria, so as to achieve the best matching of pixel level. The core of image registration is to find the best spatial transformation, and the first step is to determine the representative phase The first task is to find a certain number of control points, also known as homonymous points; the second task is to determine the coordinate relationship between images and correct them.

The method based on decision tree classification needs different remote sensing images to have the same gray value. However, because different sensors are used in different images, the gray levels of images are different. Therefore, the method based on image gray level can not be used between images with different gray values. The method based on image features is the invariant feature between the reference image and the image to be registered, which greatly reduces the amount of data used for processing and the amount of calculation [7]. But on the other hand, this method is often designed for a specific feature or problem, which needs stable and reliable features to register, otherwise it is prone to errors. The feature-based method has the adaptability and robustness to the change of gray level, and its speed is fast.

The traditional remote sensing image classification and recognition method is mainly based on the pixel image classification, the basic image processing unit is a single pixel. In this framework, many novel remote sensing classification methods have been proposed. The maximum likelihood method assumes that each training sample is normal distribution, and estimates the variance and covariance of the whole image through limited training samples. According to these parameters, the probability of each pixel belonging to each category is calculated, and then the pixel is classified into the category with the maximum probability. The general process of remote sensing image target recognition includes feature extraction, classifier training and classifier discrimination. The first step is to label the training samples and extract the features of the training samples; the second step is to design a classifier and train the classifiers; finally, the image is detected by using the form of active window.

3. Fast processing method of high resolution remote sensing image

Under the support of the principle of remote sensing image edge detection, according to the processing flow of convolution neural network construction, image scale prediction, data regularization constraints, the smooth application of high-resolution remote sensing image processing method based on decision tree classification is realized.

3.1 Convolutional Neural Network

Convolution neural network is generally composed of convolution layer, pooling layer, nonlinear layer and full connection layer. CNN follows the structure of ordinary neural network, that is, multilayer perceptron, but there are two main problems in MLP. One is that MLP is a fully connected network, which affects the maximum number of neurons in each layer, and also limits the number of layers of MLP, that is, the depth. The second is gradient divergence. Under the condition of increasing network depth, the residual error from back to front will be smaller and smaller, which will lead to less and less weight updating effect and lose the training effect, making the parameters of the front side layer tend to be randomized [8]. In order to solve the above problems, CNN proposed three solutions. One is the local receptive field. The connection between CNN neurons is incomplete. The other is weight sharing. The weights of the connections between some neurons in the same layer are shared. The third is pooling, which can be regarded as a special convolution process. Subsampling greatly simplifies the complexity of the model and reduces the parameters of the model.

In CNN, receptive field is the area size of the original remote sensing image mapped by pixels on the feature map output from each layer of convolution neural network. The regions mapped on the image are divided into global perception and local perception according to the size of the region. The region of local perception is also called local receptive field. In image cognition, the closer the spatial distance is, the stronger the correlation between pixels is, and the weaker the correlation is between the pixels with farther spatial distance, which indicates that the spatial relationship of image is closely related to the distance between pixels. Although local connection can effectively reduce the number of parameters, it contains more redundant information, which is prone to over fitting. In order to remove the redundant information, CNN adds pooling operation. Pooling is to aggregate the features of different positions in the image, as shown in Figure 2 (where "1" represents the high-resolution pixel space occupied by image nodes, and "0" represents the high-resolution pixel space not occupied by image nodes). Pooling not only has much lower dimensions, but also improves results. The common operations of pooling include average pooling or maximum pooling. Weight sharing means that the convolution kernel learns the information from the local region and applies it to other parts of the image, which is equivalent to a whole image filtering.

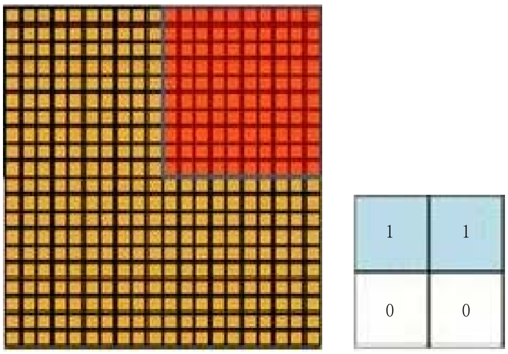

Figure 2. Remote sensing image processing based on convolutional neural network

3.2 Image scale prediction

The main function of neural network is to approximate some non-linear functions, especially some non convex functions, and to establish a complex model of human brain processing. One of the important means to introduce nonlinearity is to introduce nonlinear activation function. Sigmoid function is often used to constrain the pixel nodes in high-resolution remote sensing images and map variables to 0-1. This kind of function tends to be gentle at both ends, and is sensitive to the changes in the middle segment, and its output does not have sparsity. Therefore, unsupervised learning is needed to generate sparse data. This method makes the data processing process of convolution neural network converge slowly [9]. Its mathematical expression is as follows:

$$W_0 = \frac{P}{1+e^{-x}} \tag{2}$$

Among them, e represents the original resolution coefficient of remote sensing image, and x represents the classification authority of decision tree.

According to the relevant principles of decision tree classification, judging the transformation model between remote sensing images is the basis of perspective transformation model, which only needs to meet one of the following two conditions: (1) fixing the remote sensing imaging equipment at a point for shooting, the captured scene can be arbitrarily distributed, but the optical center of the imaging device can not be moved; (2) the depth of the scene captured by the remote sensing imaging device It is much larger than its focal length, so the imaging equipment can shoot the plane scene in any motion form. When the ground fluctuation in the shooting area is not particularly obvious, the shooting mode of the imaging equipment carried by the remote sensing equipment fully meets the requirements. In the process of practical application, each high-resolution remote sensing image uses a corresponding homography matrix to describe its deformation relative to the plane of the first image, so the deformation problem of each remote sensing image relative to the datum plane is transformed into the problem of solving the homography matrix of each image.

3.3 Regularization constraints

Remote sensing data is based on the change of observation objects detected by different remote sensors. It can be processed source data by identifying, separating and collecting the detected geographical entities and their attributes, which can be analog data or digital data. Remote sensing image regularization constraint is an important part of remote sensing image fast processing. Its essence is to establish mapping relationship between two or more images, determine transformation parameters, and obtain two or more images with geometric consistency. An excellent registration method can improve the accuracy and speed of image registration. Generally speaking, image registration methods can be divided into two categories. The first is image registration based on image gray information, the second is based on image features. Usually, the registration images are simultaneous interpreting images of the same scene at different time, different sensors or different viewing angles.

Image regularization constraint is to determine the transformation criteria based on some similarity between images, so that two or more images in the same scene obtained from multi-source, multi-scale and multi-phase can be transformed into the same coordinate system through certain transformation criteria, so as to achieve the best matching at pixel level. The core of image registration is to find the best spatial transformation. First of all, we need to determine the pixels with the same name that represent the same target, and then establish the mathematical transformation model through the pixels with the same name to further realize the conversion of other pixels. Image registration mainly completes two tasks: the first task is to find a certain number of control points, also known as the same name points; the second task is to determine the coordinate relationship between images according to a certain transformation method and correct [10].

After feature extraction, the feature space of high-resolution remote sensing image needs to be further established, which can express image features more accurately and easily. The establishment criterion of feature space is to retain the features with large similarity as far as possible and to maximize the difference of different features. Generally, the selection of feature space should consider the following factors: (1) the extracted features are similar, and the features should be of the same type; (2) the extracted features need to be one-to-one corresponding; (3) the extracted features are stable, and the parameters of different images will not change significantly; (4) the matching features should be evenly distributed in the geometric space as much as possible; (5) The selected features should be easy to extract. Let r represent the location information of decision tree classification nodes in high-resolution remote sensing image, u_r represent the original input of high-resolution information in remote sensing image, and u_r' represent the supplementary application conditions of information quantity. Under the support of the above physical quantities, the simultaneous formula (2) can define the regularization constraint criterion of remote sensing image based on decision tree classification as:

$$E=\frac{\sqrt{\left(u_r-u_r'\right)^2+(H_r-H_r')^2}}{W_0\cdot\left(v_r-v_r'\right)^2} \tag{3}$$

Among them, H_r represents the image processing coefficient based on convolution neural network, H_r' represents the supplementary explanation condition of image processing coefficient, v_r represents the information processing authority related to high-resolution remote sensing image, and v_r' represents the complement condition of authority. So far, the calculation and processing of each index parameter are completed, and the design of fast processing method of high-resolution remote sensing image is completed under the support of decision tree classification principle.

4. Practical testing

In order to verify the practical application value of the fast processing method for high-resolution remote sensing images based on decision tree classification, the following comparative experiments are designed. Through aerial photography, the remote sensing image information to be processed is obtained, and the image data are imported into the experimental group and the control group application host. The experimental group is equipped with a rapid image processing method based on decision tree classification, and the control group is equipped with traditional feature point matching In principle, under the same experimental environment, analyze the specific changes in the average detection accuracy value and the correct rate of node parameter matching according to various numerical recording indicators.

Figure 3 Remote sensing image information to be processed

Adjust the host display behavior, and put the remote sensing image information of the experimental group and the control group in the same interface, as shown in Figure 4. The left picture shows the import image of the experimental group, and the right picture shows the import image of the control group.

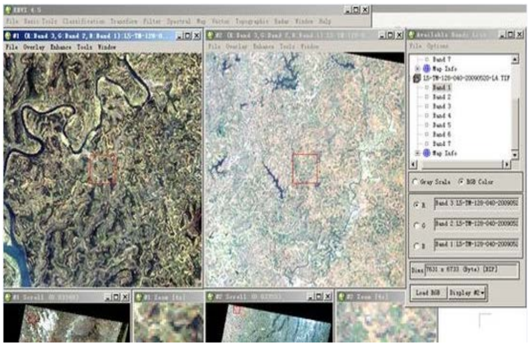

Figure 4 Remote sensing image processing interface

Keep increasing the number of input remote sensing images to be processed until the average detection accuracy value in the experimental host gradually stabilizes.

Table1. Comparison table of average detection accuracy values

Experimental group numerical record index				
method	Group number	Number of images/(piece)	Average detection accuracy / (%)	Total time spent / (s)
Fast processing method of high resolution remote sensing image based on decision tree classification	1	10	77	50
	2	20	75	54
	3	30	75	58
	4	40	74	62
	5	50	73	66
Control group numerical record index				
method	Group number	Number of images/(piece)	Average detection accuracy / (%)	Total time spent / (s)
Feature point matching principle	1	10	50	50
	2	20	45	54
	3	30	41	58
	4	40	37	62
	5	50	32	66

Analysis table 1 shows that with the increase of the number of input images, the detection time of remote sensing image processing accuracy in the experimental group and the control group has a rising trend, and there is no obvious difference between the two change forms. In the initial situation, the number of input images in the experimental group and the control group were 10, but the average detection accuracy of the control group was only 50%, which was 27% lower than that of the experimental group (77%). At the end of the experiment, the number of input images in the experimental group and the control group were 50. The average detection accuracy of the control group was only 32%, which was 41% lower than that of the experimental group (73%). To sum up, with the continuous increase of image input, with the application of high-resolution remote sensing image rapid processing method based on decision tree classification, the average detection accuracy value has a significant upward trend, which can not only promote the rapid generation of global image processing strategy, but also achieve the accurate resolution of the information of the nodes to be identified in the remote sensing image.

Table 2 records the actual numerical changes of the accuracy of node parameter matching in the experimental group and the control group.

Table2 Comparison of node parameter matching accuracy

Experimental time / (min)	Node parameter matching accuracy / (%)		
	Experience group	Control group	Ideal value
5	65	61	68
10	65	59	
15	65	57	
20	69	56	
25	69	54	
30	69	52	
35	74	51	
40	74	48	

45	74	47
50	80	47
55	80	47
60	80	47

It can be seen that the relative high resolution of the remote sensing node 2 is always high, and the accuracy of the image is always kept unchanged. In the experimental group, the matching accuracy of node parameters of high-resolution remote sensing images always keeps a rising trend, and the global maximum value reaches 80%, which is 12% higher than the ideal value. The matching accuracy of the high-resolution remote sensing image node parameters in the control group gradually tends to be stable after the periodic decline, and the global maximum value can only reach 61%, which is 19% lower than the extreme value of the experimental group. To sum up, with the application of image processing technology based on decision tree classification, the accuracy rate of node parameter matching of high-resolution remote sensing images has been significantly improved, which meets the actual processing needs of the application host for accurate resolution of the image to be processed.

5. Conclusion

Image processing based on decision tree classification can be well applied in the field of remote sensing monitoring, and it is one of the research hotspots of remote sensing image processing technology. At present, there is still a big gap between the accuracy of automatic recognition and the accuracy of manual interpretation. When the remote sensing information data to be processed is large, it is difficult to obtain the ideal average detection accuracy value by using the traditional image registration and splicing algorithm, which can not meet the application requirements of real-time. Therefore, it is necessary to determine the specific classification standard of decision tree organization according to the spatial region of high-resolution remote sensing image data, so as to obtain a higher level of node parameter matching accuracy value, and solve the practical application problem of low average image detection accuracy value.

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