

OBJECT RECOGNITION BASED ON TEMPLATE CORRELATION IN REMOTE SENSING IMAGE

Jun Zhang^{a,b,*}, Xiyuan Zhou^b

^aDept. E.E., Beijing Institute of Technology, Beijing 100081

^bCommunication Telemetry & Telecontrol Research Institute, Shijiazhuang 050081
junzhang@fescmail.net

KEY WORDS: Correlation, Matching, Extraction, High resolution, Object Recognition

ABSTRACT:

In recent years, the spatial resolution of remote sensing image becomes much more higher than ten years ago. There are more information reflected by modern remote sensing image. The research of image processing and analyzing based on traditional low resolution image has already not satisfied the need for people to get more accuracy information from high resolution remote sensing image. People want to get information about some particular objects and the change about a particular area from remote sensing image, this is particularly important to the urban plan and disaster surveillance. On the base of analysis of the conventional methods for information extracting from the remote sensing image, a method of extraction particular object in remote sensing image based on feature template correlation is proposed. The method includes three parts: building the template, image match and template correlations, and object recognition. The methods are applied to several high-resolution example images, and vehicles as example object in the image are extracted and recognized. Those examples illuminate that the method proposed in this paper is effective and accuracy.

1. INTRODUCTION

With the increasing improvement of spatial resolution of remote sensing image, we can acquire more information about object on the earth. Based on conventional remote sensing image processing method, we can classify different type of large terrain, such as city and farmland. When the resolution of remote sensing image approaches to 1 meter or even less, we can see most small objects on the ground clearly, such as houses, vehicles, and so on. It is difficult to distinguish those small objects from image background by conventional remote sensing image processing methods. Now there are many studies on man made object (roads, houses, vehicles) recognition in the high-resolution image (Rucklidge, 1997; Rensheng, 1997; Ballard, 1981; Selvarajan, 2001).

Object recognition algorithm in optical camera image processing are applied to the remote sensing image because the improvement of the spatial resolution of image. but there are several different problem faced to remote sensing image processing and optical camera image processing, 1) the spatial resolution of remote sensing image is relatively low although much improved; 2) the remote sensing image are acquired with different viewpoint angle and view field; 3) the SNR of the image is relatively low; 4) the object in remote sensing image usually has scale, translation and distortion; 5) the ratio of the number of object pixel and whole image pixel is quite small. Because the object on the earth are quite variety, from a large city to a small vehicle, and one object has different appearance on the remote sensing image because of different view point, view field, view angle and different climate condition. The algorithm based on supervised or unsupervised methods have good performance to classify large terrain objects. But for small objects in the remote sensing image, the algorithm for recognition should be paid more attention to study.

In this paper, to get accuracy classification of objects, hierarchical object template database should be built. A wavelet transform and morphological processing is used to extract the feature of image and to find the interested object region. Second, template-matching methods are discussed based shape feature template, template-correlation is a time-consuming, the template and the image are never the same, so the method for correlation should be robust to matching noise and time-saving.

Section 2 gives profile of the approach and section 3,4,5 present the detail description; Section 6 concludes the object recognition processing.

2. OUTLINE OF THE APPROACH

In this section a coarse description of the algorithm is presented. The whole process is summarized in the flowchart of Figure 1. In section 3, the single steps are explained in detail.

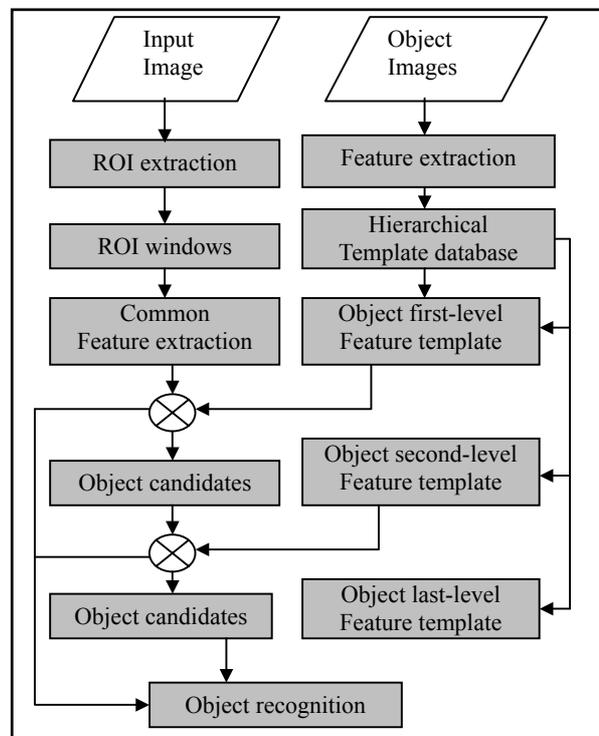


Figure 1. Flowchart of the algorithm that is used to recognize the object in the remote sensing image based on hierarchical template

In this paper, ROI of the input image are extracted by wavelet transform and morphological processing to reduce the object search region, after that, the ROI is divided into several windows to facilitate the feature extraction. From template image, a hierarchical template database is built for hierarchical feature template correlation to recognize the interested object. the process of the object recognition begin from the correlating with the most common feature(i.e. first level template), and possible object candidates are acquired. Then after the further processing by the detail template (second-level and to last), we can get the more accuracy object that we want to find.

3. ROI EXTRACTION BASED ON WAVELET TRANSFORMS

It is a difficult thing to find a small object in a large remote sensing image, and it is also a tedious work to search the object by matching the object template image to the input image, Even we know there is a object in the image, it is still difficult to find this object for computer itself. To avoid consuming long time to search large image. It is necessary to find where are the most possible parts in which the object exists. We can find that the regions in which have man-made objects has abrupt variety of intensity because man-made object has outstanding edge feature. Transform methods convert raw data to transform coefficients in order to obtain a more efficient representation of the data for feature extraction Wavelet transform just provide a tool for detect this kind abrupt variety feature. Wavelet methods provide several advantages over the Fourier-based methods. One of the most important advantages of the wavelets is that wavelet bases have local support in the space and frequency, other advantages of the wavelet methods are the availability of fast algorithms. Daubechies wavelet is used to transform the input image to detail parts which reflects the gray values variety of the images. Binarizing the detail image we can acquire an image that reflects the abrupt gray variety regions which are our interested region, but may be in the image there are several discrete edges, the morphological processing is used to deal with this problem, by dilation, removing spur pixel and so on, the morphological processing transform the detail image to a region, we can get the parts in the image that possibly object exists in.

4. ESTABLISHING THE HIERARCHICAL FEATURE TEMPLATE OF OBJECT

The object template is a representative of object that is built based on analysis of the properties of object. There are two kinds of object template used in image processing. One is geometric template of object based on the real gray values of object image, such as the object image cut from the large example image, and searching the whole input image based on this geometric template. This is the simplest class of object recognition methods (Brown, 1992), a survey of matching approaches is given in (Brown, 1992). The template and input image can get a good match when there are no distinct change in view point, view angle and climate condition during the time image acquired. But we can't ensure we can get two images with little change at two different time, especially in remote sensing image, and to match the two image, the computation is also time consuming. Those drawbacks (huge Time-consuming and unrobust to change) limit the application range of this method.

Another more complex method for building the template for object recognition is a abstract feature template based on te description of object feature properties. There are several kind of feature that can be used to describe the object. Figure 2 lists the feature we can acquire in remote sensing imageries.

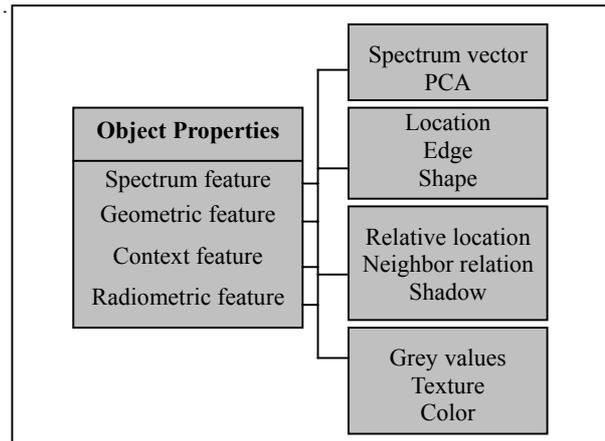


Figure 2. The features for object properties in remote sensing

The features for representing the object are variety because there are so many different objects. Recognizing different object from remote sensing image can't get a good result if we just use one kind of feature. But we can get a good distinction just by threshold when the ratio of gray intensity between objects and background, we can think it is a vehicle with low false probability when there is a oblong shape on the highway in the remote sensing image. So, we should choose the most obvious feature in the image that can reflect the properties of object to build the object feature template.

From the process that a people recognizes another person who walks near from far (figure 3), we can know that recognition is a process from fuzzy to accuracy, from coarse to detail. And this process is a hierarchical recognizing process.

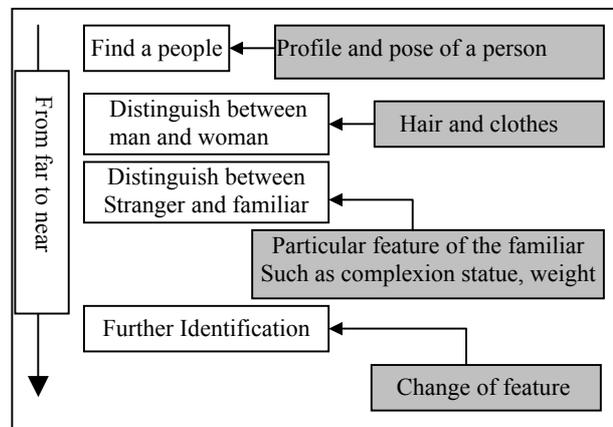


Figure 3. The process of recognizing a person from far to near, the shadow parts are the feature used at different recognition stage

In the process above, we use different features at different recognition stage. Emulate the process what we do in recognizing a person. We should build a hierarchical feature template database to adapt to the different stage of recognition. The first level is the basic object feature template that reflects the common features of the same class object. This level feature should satisfy three assumption: 1) the selected feature can be acquired in remote sensing image, 2) they are obvious features can be relatively extracted, 3) those feature represent the most common properties of this object class not a certain one. Other levels feature templates represent gradually object from coarse feature to detail one. The principle of determining the levels is

according to the difficulty of extracting the features and complexity of the correlating computation for searching those features in the input image. The easier and simpler one is used in the lower levels. We think the last level template is the object image template. Here we have an example for explaining the establishing process of feature template for a simple object, ground vehicles in remote sensing image. We study vehicle image in several remote sensing image and we get the primary feature of vehicles.

The profile of vehicle reflects the main feature of ground vehicle especially when we see ground vehicle from space or air. The background behind the vehicles also provide strong information for discriminate the vehicle. So we can think an object is a vehicle since it is on the road. Hierarchical vehicle templates can be formed as figure 4.

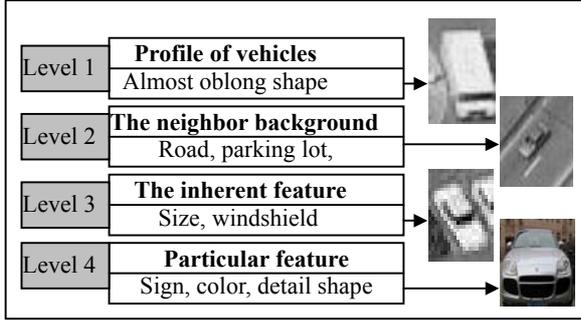


Figure 4. The hierarchical feature template for vehicles in remote sensing image

We use the profile of the vehicles as the first level template, the width of most of the vehicles is near 1.5-2meter, but the length is quite different, so we form several oblong shape templates with different ratio of width to length. Other level templates can be described by extracting corresponding features. In this paper, we focus on the first level template especially on the shape profile feature of the object, because the profile features are the most common features of objects.

5. CORRELATION PROCESSING

What we focus here is the template correlation based on the object shape template (most common used feature in object recognition). Because of the reason mentioned in the first sections, object recognition based on GHT(Ballard 1981) or Hausdorff distance (Rucklidge,1997) require rigid model representing the object to be found and do not meet the demands: robust to occlusions, clutter, arbitrary illumination changes and sensor noise, but in remote sensing image the assumption of a rigid model is not fulfilled the correlation match based on the distance between profile to shape center (DPC) is presented for recognizing the object with protruding profile in this paper.

5.1 The definition of DPC of object image

When we acquire the profile of the object image, firstly the location of shape center of the profile is computed. Assume that the profile point set is $T(x_i, y_i) \quad I=1,2,3,\dots,N$, where N is the number of points in set T . the shape center $C(x,y)$ can be computed by equation (1):

$$x = \left(\sum_{i=1}^N x_i \right) / N \quad y = \left(\sum_{i=1}^N y_i \right) / N \quad (1)$$

Then we can get the distant set S of DPC

$$S(i) = \sqrt{(x_i - x)^2 + (y_i - y)^2} \quad I=1,2,3,\dots,N \quad (2)$$

Where (x_i, y_i) = the coordinate of profile points
 (x, y) = the coordinate of shape center

Normalized $S(i) = S(i)/S_{max}$,

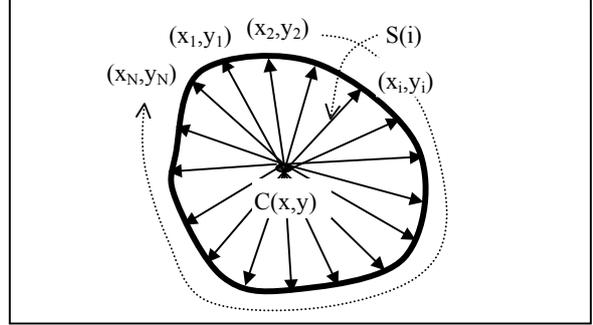


Figure 5. The DPC set of object template

The DPC set reflects the distance change process of the profile related to the shaper center. So there are two advantages when the DPC set is used as the feature for correlation process: 1) this processing has the characteristic of translation invariant because the shape center is used as a reference points; 2) this processing has the characteristic of rotation invariant due to the method for computing the DPC.

5.2 Correlation processing

DPC convert the two dimension edge profile to one dimension feature, it is convenient to choose a correlation method for template matching. The DPC mean square difference (MSD) between the object profile acquired from input image and template is proposed as template correlation criterion. And a threshold is set to decide object image is similar to template or not. Assume that $S_r(n)$ is DPC set of object in input image and $S_m(n)$ is the DPC set of template, $n=1,2,3,\dots,M$, if $N < M$, $S_r(n)$ will be expanded to M by interpolating processing. Here we think $N=M$. the correlative conjunctions based on MSD can be written as equation (3):

$$R(n) = \sum_{i=1}^N (S_r(i) - S_m(i+n))^2 \quad (3)$$

$$R = \min(R(n) / N)$$

Where $R(n)$ is the correlative conjunctions
 R is the correlative degree between object and template

$$R = \begin{cases} \leq \sigma & \text{Accept} \\ > \sigma & \text{Refuse} \end{cases} \quad (4)$$

Where σ is the threshold for making decision that the object is similar to template or not.

From this process we can see that the rotation direction difference between object image and template does not affect the result of correlation. Table 1 list the simulation correlation results of multi basic shape, where row direction are the template, and column parts are simulated objects which have some change with template. The number parts represent the correlation degree.

From the table 1 we can see that correlation based on DPC set has good discrimination to basic shape, at the same time we can

also get that the algorithm is robust to partly distortion from table 2. In table 2, the object images are the transform of the template images, but are distorted 5% in horizon and vertical respectively.

Template \ Object	Circle	Square	Oblong (1:2)	Triangle
Circle	0.1052	3.4109	7.7127	9.9295
Square	3.4109	0.0539	3.7840	4.4781
Oblong (1:2)	7.7127	3.7840	0.1038	6.6609
Triangle	9.9295	4.4781	6.6609	0.3828

Table 1. Correlation results of multi basic shape based on DPC

	Circle	Square	Oblong(1:2)	Triangle
Circle	1.939			
Square		1.9394		
Oblong (1:2)			1.9109	
Triangle				1.3482

Table 2. Correlation results of distorted images and templates

5.3 Vehicle extraction and recognition

Here we give an example to show vehicle extraction and recognition from remote sensing image based on hierarchical template, figure 7 is the wavelet and morphological transform result of figure 6. From image in figure 7 We acquire the interested region in the input image, we choose a small window (figure 8) to do the further processing. first we extract feature of the vehicles in the window image in two steps: 1) edge detection using canny algorithm (figure 9), 2) edge tracking to find the profile of the vehicles by combining the gradient and gradient direction (Hang, 2000; Shaoqing, 2002). Secondly, we correlate the profiles with vehicles profile template by DPC sets and most the profiles extracted from the image has good correlation with the vehicles oblong template although the image profiles have some distortion. From this we can get a whole concept where the vehicles most possibly are. In those profiles that has good correlation with the templates we try to find the further features such as windshield, and the size of the profiles according to the resolution and number of the pixels contained in the profile. Then we can get a further recognition of the vehicles in the image. The results show that we can recognition almost all the vehicles in the input image.



Figure 6. Input example image that contain highways, vehicles, airplanes and so on.

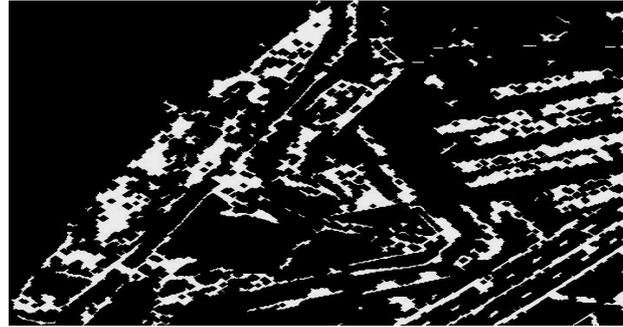


Figure 7. The transform image of input image



Figure 8. Small parts of input image



Figure 9. Canny edge detection results of left image

6. CONCLUSIONS

Objection recognition in remote sensing image is a challenging work. In this paper, we try to establish a hierarchical template for the object to recognize the objects from common features to particular features. it is time-saving method since it avoids searching whole input image with complex features. A method for template correlation based on DPC set is also presented in this paper and the experiments show that it is effective for correlation between the profile of the object template and image.

7. REFERENCES

- Ballard, D.H., 1981. Generalizing the Hough transform to detect arbitrary shapes. *Pattern Recognition*, 13(2), pp.111-122.
- Brown, L.G., 1992. A survey of image registration techniques. *ACM Computing Surveys*, 24(4), pp.325-376.
- Hang, D., Yu, Y. Jun, S. Songyu, Y., 2000. Snake Model for Edge Detection , *Journal of Shang Hai Jiao Tong University*, Vol.34, No.6.
- Rensheng, W., Xiaoguang, J., Jianlin, Z., 1997. A Studyon Detecting Man-made Objects from Natural Background in Space Sensing Imagery, *Journa lof Image and Graphics*.Vol.2 No.7.
- Rucklidge, W.j., 1997. Efficiently locating objects using the Hausdorff distance, *International Journal of Computer Vision*, 24(3), pp. 251-270.
- Selvarajan, S. and Tat, C.W., 2001. Extraction of man-made features from remote sensing imageries by data fusion techniques. In: *The 22nd Asian conference on remote sensing, Singapore*.
- Shaoqing, Y. and Chuanying, J., 2002. Image edge connection based on fuzzy logic, *Optical Technique*, Vol.28, No.2.