

AUTOMATIC RECOGNITION AND EXTRACTION OF OIL TANKS FROM HIGH-RESOLUTION REMOTELY SENSED IMAGES

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ABSTRACT:

Nowadays, recognition of oil storage tanks that are crucial targets is vital. Making use of remote sensed images becomes more and more important in the field of targets recognition. In recent twenty years, numerous achievements in the field of object recognition^{[1][5]}, such as roads, buildings, planes and oil storage tanks. There are plentiful kinds of algorithms presented in target recognition and extraction, with the development of computer-assistant recognition and extraction, such as neural networks, wavelet transform, image segmentation, mathematical morphology and genetic algorithm, most of which are based on low-resolution remote sensed images. In recent years, high-resolution remote sensed images have become one of the most important products, because they become not so expensive as before and they have some characteristics such as tremendous data, complex feature details and dependence on scale. Thus algorithms based on high-resolution remote sensed images are necessary and helpful in extraction. However, there lacks general algorithm aim at recognizing oil storage tanks, especially making use of high-resolution remote sensed images. Furthermore, high-resolution images still have some disadvantages, such as too many information to find a particular object. So we bring forth a new technique for information extraction and target recognition from high resolution remote sensing image.

This paper brings forward an automatic target recognition algorithm which is based on the knowledge-driven strategy combined with the data-driven strategy. Firstly, we introduce the up-down strategy that collecting large amount data of oil tanks to customize a knowledge database^[3] aim at our target, based on the analyze of their size, texture, color, distribution and other features information. Secondly, we utilize data mining method, taking spatial relationship among them and GIS into account as well, to get special priori knowledge at last. Thirdly, we present a new automatic down-up strategy inherited from template matching method and watershed algorithm with adaptive parameters, in order to get a primary segmentation result. Last but not the least, based on the supervisory learning method combining with the primary result, we get precision result of oil tanks extraction and recognition from high resolution remote sensing images. The primary test result shows that this new automatic algorithm has excellent performance in pertinence and speed.

1. INTRODUCTION

High resolution satellite image is a kind of remote sensing images that pixel spatial resolution within 10 meters^[2]. At the very beginning, the research and application of high resolution sensor are mainly applied in the field of military, in order to map with large scale, analyze geographical objects and monitor human activities. It has been developed since 90s in 20th century. What does high resolution image mean? It means a revolution of data collection and data refresh.

In the traditional course of map data collection, we use manual manner which costs many manpower and material resource. Moreover, it has a long refresh period. However, high resolution remote sensed images sensed by satellites can help us gain refreshed data a few weeks even a few days before rapidly, which are more precise and lower cost.

Nowadays, high resolution remote sensed images are widely used, such as statistic of country resource, disaster evaluation, environment monitor, civil layout, etc.

Compared with low resolution satellite images, high resolution images have characters as follows:

1. obviously more data in one image;
2. less imaging spectrum band;
3. more obvious information about geometry structure and texture of geographical objects;
4. three-dimensional information instead of planar information;
5. high temporal resolution.

The information of High resolution satellite image is multiplex, various and even complex, which brings forward a series of problems in related fields. Thus, traditional image process of remote sensing image is no longer fit and we can not use only one kind of technique to solve all problems. Thus, new techniques are required.

At present, there are two kinds of object recognition system^[3]. One is data driven which is down-to-up, while the other is knowledge driven which is up-to-down.

As to the first one, no matter what kind of object, it use a general low level process to make segment, tag and feature extraction of the original image firstly. Then register the feature set of segmented area with tags to the object model. The course of object recognition includes low lever process and high level register and explanation, which are two different unrelated courses. This method is widely used, which is suitable for single object recognition and complex scene analysis system. However, it lacks knowledge guiding and has too much blindness, which leads to huge workload and complex algorithm. While as to the other one, bringing forward a hypothesis aiming at possible feature of object in images, based on knowledge about object. Secondly we do segment, tag and feature extraction purposefully according to the hypothesis. Then we get precise register based on the prior result and object model. Because of the low level process guided by knowledge, it can avoid extract redundant feature set, so that improve process efficiency. Moreover the precise registration process can be simpler and more pertinence thanks to the shrinked area. However, its disadvantage is lacking of substitute and compatibility that is its knowledge, model and hypothesis should be changed with object.

Considering advantages and disadvantages mentioned above, this paper brings forward an automatic target recognition algorithm which is based on the knowledge-driven strategy combined with the data-driven strategy.

2. IMAGE SEGMENTING

Remote sensing images have some differs from other images. High resolution remote sensing images include plenty information of surface objects^[3]. Furthermore, gray feature is different from different region or different time. First of all, we should preprocess the image in order to get more precise recognition result.

Image preprocess is that process on the lowest abstract level. Preprocess of image won't increase information to the original image. It can be divided into three kinds method according to pixel neighborhood when calculating new pixel gray, that is: 1)pixel brightness exchange, such as histogram equalization; 2)geometry exchange, such as coordinate transform and gray interpolation; 3)partial preprocess, such as image smoothness and edge detection; 4)Image recovery.

According to the feature of test image, we need to enhance contrast. In this article, the author brings forward mathematical morphology that is combined Top-Hat with Bot-Hat algorithms to enhance the image. This method is a partial preprocess that is output new gray of pixel according to a small neighborhood. Top-Hat transform is different from original image to opened image which can extract higher gray area considered as object area. Bot-Hat transform is different from original image to closed image which can extract lower gray area considered as background area. We use original image add Top-Hat image, and then minus Bot-Hat image, we get enhanced image at last.

$$\begin{aligned} Top &= f - (f \circ b) \\ Bot &= (f \bullet b) - f \\ I &= f + Top - Bot \end{aligned} \quad (1)$$

where f = original image
 b = unit template
 I = result image

3. KNOWLEDGE DRIVEN(UP-DOWN) STRATEGY

After the segmentation, we need to get further object recognition^{[5][7]}according to geometry feature of object. In this article, the interesting object is oil tank in remote sensed images. In remote sensed images, oil tanks have obviously different gray value from scenery around. Most oil tanks are round, so that oil tanks look like round light speckles. Their sizes are generally between 10 to 110 pixels. Furthermore, there is no single oil tank and oil tanks are arranged tightly and in order. All those mentioned above are important criterion in recognition.

3.1 Size

Statistic the bi-value image threshold segmented, then get the acreage of each connected domain, and omit the connected domain whose acreage is less than 10 or bigger than 110^[3].

3.2 Shape

There are three morphological characteristics to describe the round's approximation of the connected domain, which are on the basis of the acreage and perimeter calculating.

3.2.1 Shape factor: The shape factor is used to describe departure quantity between X image and round, which is defined as:

$$FQ(X) = U(X) / 2\sqrt{\pi A(X)} \quad (2)$$

If X is a standard round and its radius is r , its perimeter $U(X)$ is $2\pi r$ and its acreage $A(X)$ is πr^2 , and then $FQ(X)$ equals 1. Generally, the bigger X and deflection quantity are the bigger $FQ(X)$ is.

3.2.2 Undulance quantity: The undulance quantity is used to measure departure degree between X image and ellipse, which is defined as:

$$UQ(X) = 2A^2(X) / \pi^2 (D_{\max}^2 \bullet D_{\min}^2) \quad (3)$$

where D_{\max} , D_{\min} =maximal ,minimum value of X projection in each direction.

When X is round or ellipse, undulance quantity is 1 the minimum value.

3.2.3 Elongation quantity:Elongation quantity is defined as:

$$EQ(X) = D_{\max} / D_{\min}$$

It is obviously that X is more threadlike, the $EQ(X)$ is bigger. When X is round, $EQ(X)$ equals 1.

We take these three shape features as criterion estimating round's approximation of connected area. We omit connected areas with low round's approximation after inspecting each connected area.

3.3 Space Relationship

As we all know, there is no single oil tank and oil tanks are arranged tightly and in order. Thus, we could calculate Euclidian distance between each object centre^{[3][9]}. When there are less than 4 objects around a certain object in a particular range, we should omit current object, or else current object is an oil tank.

4. DATA DRIVEN(DOWN-UP) STRATEGY

We have already recognized oil tanks primarily. Then we could take next step to classify segmented objects. These oil tanks might belong to different tank areas^[4], so we should classify these tanks.

We get 27 features such as mean, variance, slope quantity, pinnacle value, organization density^[8], etc from 20 images after preprocess and feature extraction. We set these feature as input of our system which is designed by Matlab 6.5^[6].

The result shows that the precise of oil tank classify in remote sensing images is between 67% and 80%.

5. RESULT



Figure 1. The Original image



Figure 2. The image processed by mathematical morphology



Figure 3. The Result image

Figure 1 is the original image which is bi-valued. Then we process the original image with mathematical morphology algorithm: Top-Hat and Bot-Hat, we get figure 2.

After processed by mathematical morphology method, we take classify to the image, then we get the result image figure 3.

6. DISCUSSION

Knowledge driven strategy is aim at particular object which is not general to all kinds of small objects.

The result of the experiment indicates that knowledge driven combined with data mining algorithm is much better than single method.

However, we cannot get the oil tank as exactly its real round shape, which need further experiment and better algorithm is required.

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