Detecting Airports in TM Satellite Images Based on Edge Tracing and SURF

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Abstract: Most studies on automatic airport recognition from remote sensing images focus on extracting straight lines to identify airport runways, and then determine the airport target. However, straight line not only is an indicator of airport runways, but also indicates presence of highways, railways, and external walls of large-scale plants, marginal lands, mountains, formations, and other structures. Furthermore, these methods work well mainly on a single and large airport instead of small ones. Few of them have studied multiple targets. In this paper, TM satellite imagery is used as source to detect airports. Traditional spatial filter and edge-detection methods tend to fail in airport detection because of noise and false edges. This paper presents a new method that combines edge tracing and SURF to extract airports from images. Firstly, Gaussian filter is applied to suppress noise. Then, gradient magnitudes and gradient directions are calculated. Large local variations of gradients detected by improved non-maximum suppression (NMS) method are removed to obtain a single-pixel edge image. A contour line is extracted from this edge image. Finally, airports are detected through line detection and SURF. Airports in TM images are successfully recognized using the presented method. The airport detection method proposed in this paper is suitable not only for remote-sensing data of TM satellites but also for application on day-painting satellites, such as other remote-sensing satellite data.

1 INTRODUCTION

Detecting and identifying artificial targets such as airports, bridges, ports, roads from remote sensing images has been an important research field. Many researchers at domestic and overseas have devoted themselves to this research. Among these targets, airport is an important one. The identification of airport can be used to applications such as automatic navigation, aircraft safety landing, etc. On the one hand, in military applications, airports are considered as strategic targets. And on the other hand, the effective identification of airport targets can help to improve guidance accuracy. The airport is a large, well-formed structure that consists of airplanes, runways, and airport exterior walls, forming unique image features on the image. For example, the US Department of Defense funded Delft University of Technology to complete the SPOT image-based road automatic extraction system in 1990 (Gunst, 1991). In 1994, Hevenor et al. proposed an algorithm for automatically extracting an airport runway from a radar image. The main purpose of this work is to extract the runway structure for a known airport. The algorithm focuses on edge extraction (Hevenor and Chen, 1994). Michel (Michel, 1994) used georeferenced multi-source images and simple models to detect the airports. Deng et al. (Deng and Peng, 2002) established an airport runway model based on characteristics of the runway in SPOT images, such as geometric properties and grayscale properties. Airport runway models were used to detect the presence or absence of airports, and ROI was initially used to determine the airport in an area, and finally the airport area is determined by human-computer interaction. Chen (2005) used the SPOT4 satellite image with a resolution of 10 m to do the fuzzy enhancement, and then segmented the image and labeled the maximum connected area as

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candidate airport, after that recognized the candidate airport area through a ROI algorithm, then the Canny operator was used to extract the edge of the image, and an improved Hough transform was combined with the previously candidate airport to extract the straight line segment from the edge image, airport runway was identified, and finallythe airport was determined. According to the characteristics of the airport runway, Long et al. (2006) firstly detected edges of an image, and then used a line-based search method to quickly extract the straight line from the edge image. Since the airport runway should be one of these straight lines, a reasonable search was designed. The criterion was to detect the runway as a straight line fitting method to determine the airport area. Based on the improved mathematical morphology method, Yang et al. (2006) firstly extracted straight lines with an improved and extended Freeman chain coding method, and finally completed the automatic recognition system for airport runways in SAR images by using Hough transform. Wang (2012) firstly used the Hough transform to initially screen whether there was an airport target in a remote sensing image, and then used an improved image-based visual saliency model to extract saliency regions, extracted scale-invariant features in the region and applied a multiple-layer classification tree to complete the identification of airports.

Most of the above mentioned extraction methods first extract the runways and then determine the airports according to the extracted runways. However many targets with straight lines that being not the runway will be extracted, such as roads, railways, farmland, external walls of large factories and mines, mountains, strata, etc. there will be over detections based on only the presence of the straight lines. In addition, this kind of method has better performance if there is only one and large airport in the image. However, if there are multiple airports across different scales or only small airports in the image, then the existing methods may fail to detect airports and should be improved.

Nowadays, the commonly used airport extraction method is to perform image down-samplefirstly, conduct edge detection, and then recognize airport runways based on Hough line detection. The deficiencies of this extraction method are: 1) Considering that computers have limited resource such as memory and CPU frequency, down-sampling is applied to the image firstly, which can speed up the processing and reduce the memory usage. However, this will remove many details of the image and may only extract large airports. When there are small airports in the image, it will detect these airports incorrectly. With the development of computer technologies, the processing speed and capacity of computers have been greatly improved. There is no need to reduce the resolution of images. Directly applying image filtering can achieve the purpose of reducing the amount of calculation; 2) For edge detection, traditional non-maximum suppression is used. Traditional non-maximum suppression only compares the gradient values of four directions of pixels and proposes the local maximum value of pixels. The extraction accuracy is poor; 3) Only using Hough transformation to identify straight lines may make it difficult to determine airport targets because many targets in the image may contain lines.

In this paper, taking the TM (LANDSAT_SCENE_ID: LC81230322017303LGN00) image as an example, an airport target detection method based on edge extraction tracking model and SURF detection are proposed. Firstly, the TM image is filtered to reduce the noise, then the gradient of the image is obtained and the normal direction of the gradient is calculated, and the local maximum of the gradient image is located by using an improved non-maximum suppression method. A single-pixel edge image is obtained, edge contour tracing is performed on the edge image to extract edge contours, and straight lines are detected by using Hough transform. Since the method may detect multiple straight lines in the image, the SURF detection method is finally used. Areas with straight lines and many feature points are identified as airport areas. The results prove that this method is applicable for TM remote sensing images.

2 THE PROPOSED TM IMAGE AIRPORT DETECTION METHOD

2.1 Improved Non-Maximum Suppression Edge Detection

Edge detection can greatly reduce the amount of data processed by subsequent; image analysis steps thus can speed up the detection process. The steps for edge detection are:

The image is smoothed by convolving the image with a 2-dimensional Gaussian filter. Gaussian functions are considered to be optimal for image smoothing, which can remove noise and preserve most of the image features (Figure1 and Figure2).

Figure 1: TM image after Gaussian smooth (4500×3500 pixels).

Figure 2: Beijing airport, shown in Yellow box for the next view of the area, (950 × 500 pixels).

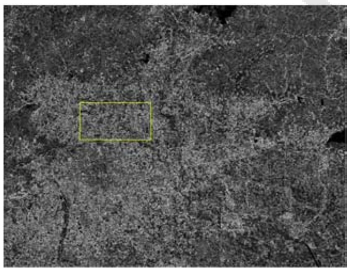

Figure 3: Gradient results of TM Satellite image (4500×3500 pixels).

Figure 4: Beijing airport, shown in Yellow box for the next view of the area,(950 × 500 pixels).

Calculating gradient and angle in each pixel. The edges of the image indicate strong change of pixels. The intensity of the edge of the pixel is used to find the edge intensity, which is calculated using the first-order partial derivative of the 3×3 neighborhood(Figure3 and Figure4).

Improved non-maximum suppression is used to extract the edges of gradient images. The goal is to change the “fuzzy edge” to “clear edge” in the gradient value image, which is also called edge refinement. The maximum values of the local variation in the gradient image actually are found and other values are deleted.

The entire edge with double threshold is connected. The result of the non-maximum suppression processing in the previous step includes false edges, and it is also necessary to perform threshold processing to reduce false edge points. If the single-threshold processing is used and the threshold is set low, there will be a false edge. If the threshold is set high, the effective edge will be deleted. The double threshold algorithm of CANNY (Canny, 1986) is used. Two thresholds selection method in edge detection is: First image histogram statistics is performed. Then the maximum 80% of the gray value is selected. The ratio of high and low thresholds is 2:1. Points above the threshold are connected to the edge. When the edge is reached. points low the threshold are found in the 8 neighborhood points of the breakpoint. New edges based on this point are collected until the entire edges of image are closed.

2.2 Edge Contour Tracking Extraction and Straight Line Extraction

Edge contour tracking extraction. Before the straight line extraction is performed, it is necessary to extract the continuous edge contours of image that edge extraction has been completed. These contour lines may be straight lines or curves, and they are required to be extracted as long as they are continuous (Figure5 and Figure6). This article has designed a method for quickly extracting edge contours (Han, 2016).

Straight line extraction. After completing the edge profile recognition, performing image Hough transforming can significantly speed up image processing. At the same time, the improved HOUGH transformation can obtain the linear endpoint coordinates, which can easily determine the positional relationship between the straight lines.

The HOUGH parameter is defined according to the default value of the HOUGH function in the opencv2.4.6 tutorial (Opencv2.4.6 tutorials.pdf. http://docs.opencv.org/2.4/doc/tutorials/tutorials.html.).

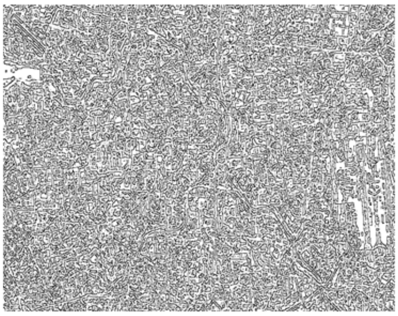

Figure 5: TM image(Inverting)NMS edge extraction result (950×500 pixels).

Figure 6: TM image(Inverting) edge contour Tracking extraction result (950 × 500 pixels).

2.3 SURF Detection Identifies Airport Targets

SURF is a robust local feature detection algorithm. It was first proposed by Herbert Bay et al. (2006) in 2006 and completed in 2008. Satellite image extracted from the straight line segments is used for SURF detection. SURF algorithm includes 4 steps: Integral image processing, DOH approximation, Scale space representation, SURF feature point generation. Specific algorithm sees the literature of Bay (Han, 2016).

Two airports have been detected in the scene. For this scene, a large number of detection points were found in the airport area after SURF detection was completed. The feature points on the airport mostly fall at the intersections within the airport. In the image, the entire map is searched according to the position of the straight line segment coordinate point. The area in the image where there are both straight line segments and a large number of feature points is defined as the airport area(Figure 7 and Figure 8). There are two areas with two features in the image. Therefore, there are two airports detected in the image(Figure 9 and Figure 10). It can be seen that the SURF feature can better reflect the characteristics of the airport.

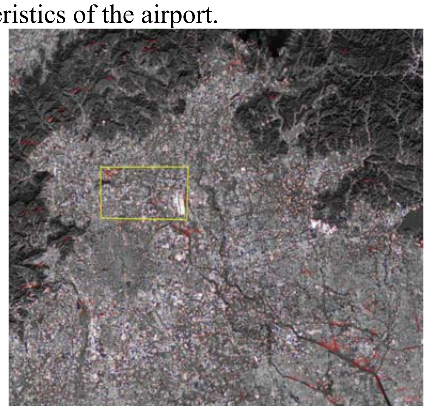

Figure 7: TM image Airport detection result (4500×3500 pixels).

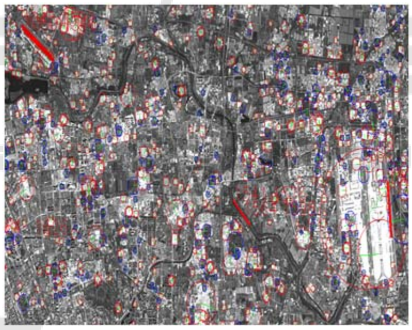

Figure 8: TM image Airport detection result (950 × 500 pixels).

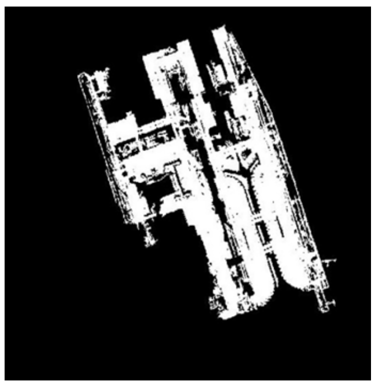

Figure 9: TM image Airport detection result-Beijing Capital International Airport.

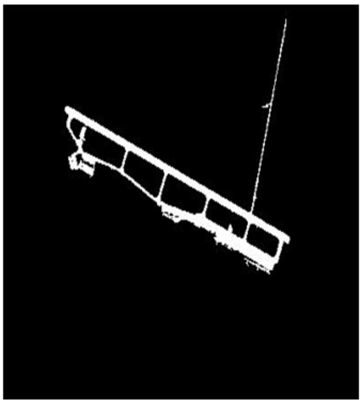

Figure 10: TM image Airport detection result- small Airport.

3 CONCLUSIONS

Experimental results show that TM images can be used for edge extraction and target recognition, and have achieved good results. The author (Bay et al., 2006) used the same method to identify Chinese Mapping satellite image. Mapping satellite image resolution is 10 meters. Therefore, the recognition effect of several images is better. Now author uses only one scene TM image to identify. In the future, more TM images can be used to do the same recognition. At the same time, other types of satellite images can also be used for identification and extraction.

This paper proposes an improved edge extraction method that can extract a variety of different types of airport targets, with the advantages of fast extraction and accurate extraction. If being coupled with an appropriate interface, it can become a standard airport automatic extraction procedure that can directly and accurately detect the presence of airport targets in remote sensing images. At the same time, the method can be modified appropriately, and other large-scale artificial targets such as ports, bridges, etc., can also be detected.

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REFERENCES

Bay H, Tuytelaars T, Van Gool L 2006 SURF: speeded up robust features[C] *Processing of the 9th European Conference on Computer Vision* Berlin Heidelberg: Springer 404-417

Canny J 1986 A computational approach to edge detection[J] *IEEE Transactions on Pattern Analysis and Machine Intelligence* **PAMI-8(6)** 679-698

Chen X G 2005 Study on Airport Region Recognition in Satellite Remote Sensing Image[D] *Nanjing: Nanjing University of Science and Technology*

Deng X J, Peng H L 2002 An airport detection method based on remote sensing imagery[J] *Journal of Test and Measurement Technology* **16(2)** 96-99

Gunst M ED 1991 Automatic extraction of roads from SPOT images[R] Technical Report,Delft: Delft University of Technology

Xiaoqing Han 2016 Detecting airports in high--resolution Mapping Satellite using edge tracing--SURF method[J] *JOURNAL OF IMAGE AND GRAPHICS* **21(10)** 1337—1347

Hevenor R A, Chen P F 1994 Automated extraction of airport runway patterns from radar imagery: US 5335298[P] 08-02

Michel A 1994 Airport detection using a simple model,multisource images, and altimetric informations[C]//*Proceeding of the SPIE 2315, Image and Signal Processing for Remote Sensing. Rome, Italy*: *SPIE* 2315: #604.

Opencv2.4.6 tutorials.pdf. http://docs.opencv.org/2.4/doc/tutorials/tutorials.html.

Wang X, Wang B, Zhang L M 2012 Airport detection based on salient areas in remote sensing images[J] *Journal of Computer-Aided Design & Computer Graphics* **24(3)** 336-344

Yang S L, Lu L, Du Z G, et al. 2006 Automatic recognition of airport runways in SAR images[J] *Journal of Wuhan University of Technology: Transportation Science &Engineering* **30(1)** 56-59

Ying L, Song H N, Su Y. 2006 A fast algorithm to detecting runway fromremote sensing images[J]. *Computer Applications and Software* **23(3)** 94-97.