A SHIP TARGET AUTOMATIC DETECTION METHOD FOR HIGH-RESOLUTION REMOTE SENSING

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ABSTRACT

With the increasement of spatial resolution of remote sensing, the ship detection methods for low-resolution images are no longer suitable. In this study, a ship target automatic detection method for high-resolution remote sensing is proposed, which mainly contains steps of Otsu binary segmentation, morphological operation, calculation of target features and target judgment. The results show that almost all of the offshore ships can be detected, and the total detection rates are 94% and 91% with the experimental Google Earth data and GF-1 data respectively. The ship target automatic detection method proposed in this study is more suitable for detecting ship targets offshore rather than anchored along the dock.

Key words: ship target, automatic detection, high resolution, remote sensing

1. INTRODUCTION

Remote sensing plays a critical role in ship target detection and monitoring, which has numerous applications for both civil and military purposes [1].

When the spatial resolution of remote sensing is relatively low in the early age, the ship targets are detected using methods like CFAR [2], GLRT [3], et al., which treat ship targets more like point targets and search targets by traversing the image. As increasement of the spatial resolution, high spatial resolution remote sensing images are used more and more widely [4].

Considering that the ship targets of high-resolution remote sensing images have the characteristic of detailed texture and relatively large area [5], ship targets should be treated as area targets rather than point targets, which is not widely considered yet. Therefore, in this study a ship target automatic detection method for high-resolution remote sensing is proposed.

2. SHIP AUTOMATIC DETECTION METHOD

The ship target automatic detection method mainly contains the following steps: Otsu segmentation, morphological operations, calculation of target features and target judgment.

The processing flow is shown as Fig.1.

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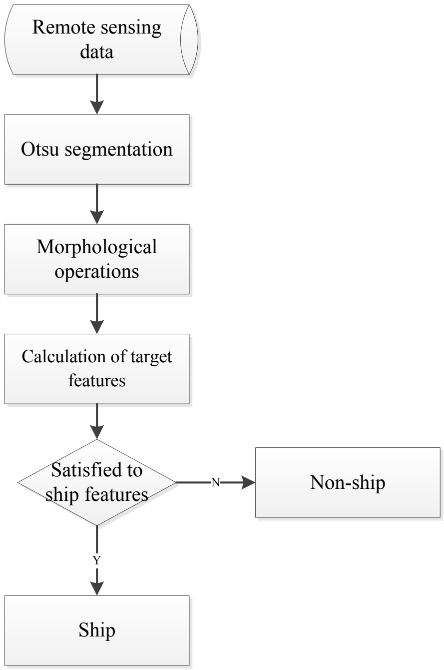


Fig.1 Ship target automatic detection flow

The high-resolution remote sensing image (Fig.2) is taken from the open remote sensing platform Google Earth, and its spatial resolution is about 1m.

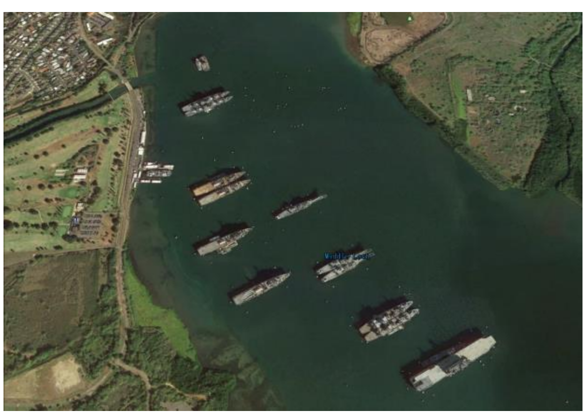


Fig. 2 The high-resolution remote sensing image used in this study

2.1. Otsu binary segmentation

Otsu binary segmentation algorithm is one of the most widely used method for threshold segmentation. It is realized based on the gray histogram of the image using the criterion of minimum intra-class variance of the targets and the backgrounds. This algorithm can make the targets and the backgrounds after segmentation have maximum difference, and it is considered as the optimal method of automatic threshold selection. It solves the problem of threshold selection in threshold segmentation, and performs better than the commonly used gray difference histogram method and differential histogram method [6].

Thus, the original remote sensing image is segmented with Otsu binary segmentation algorithm, and the result is shown as Fig. 3.

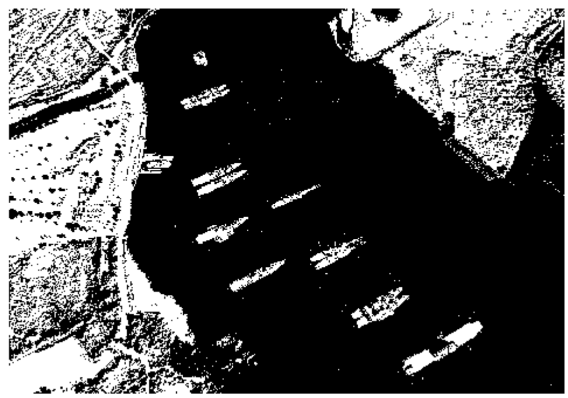


Fig.3 Result of Otsu binary segmentation

2.2. Morphological operations

After Otsu binary segmentation, the backgrounds are basically removed and the targets are highlighted as shown in Fig. 3, but some single targets are discrete without forming connected areas due to the high spatial resolution. This problem is solved using morphological operations, including bridge, removal of isolated points, filling, dilating, eroding, etc.

Each target object is then relatively complete after the above morphological operations, and the land regions are also connected to a whole area (Fig.4) which helps to decrease false alert.

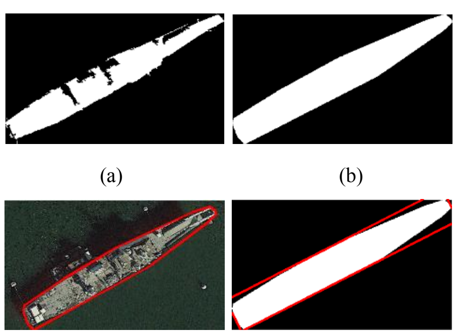
Fig.4 Result of Morphology process

2.3. Calculation of target features

Target features contains geometric features (area, length, width, ratio of length to width (RLW), etc.) and radiance features.

The ship mask should be firstly obtained by calculating the enclosing polygon of the morphological processed target (Fig.5a) to calculate other features as shown as Fig.5b, and the outline of the mask shown in Fig.5c indicates that the mask is obtained correctly using this method. Then the areas, average radiances of the targets can be calculated using the mask.

The min-area exterior rectangle of the mask is calculated as shown in Fig.5d, then the length and width of the min-area exterior rectangle present the length and width of the target. Thus, geometric feature parameters like the length, width, RLW can be calculated.



(a) (b)

(c) (d)

Fig.5 Processes of calculating target features

2.4. Ship target judgment

According to the ship features, some judgment rules are set to discriminate ship targets from non-ship targets. The rules adopt the parameters calculated in section 2.3, and they are set as follows:

(1) 80 < Length < 250;

(2) 10 < Width < 100;

(3) RLW > 2;

(4) Radiance > 90.

After the above judgment operation, the ship target detection result is shown as Fig. 6 and Fig.7.

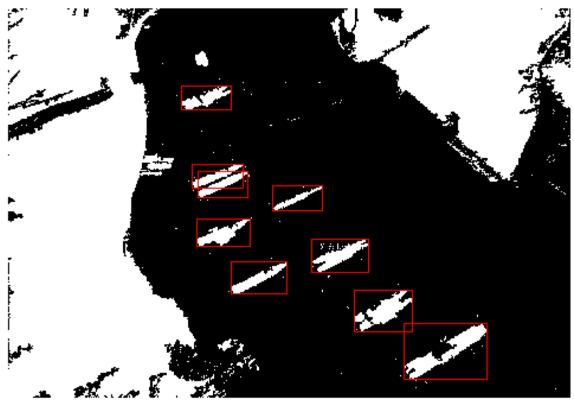


Fig.6 Ship detection result in binary image

Fig.7 Ship detection result in original image

3. RESULTS AND DISCUSSIONS

The ship target automatic detection results show that all of the large-scale ship targets are detected, no matter they are single or side by side. Only two small-scale ship targets are omitted, which are usually not interested targets. Once the small targets are also need to be detected, the judgment rules can be adjusted, and the result is shown in Fig.8.

Fig.8 Ship detection result including small targets

From Fig.8, we can see that the small ship can also be detected by this method, and the total detection rate is 94%. But another small ship which is anchored in the dock is still omitted. This is mainly caused by Otsu binary segmentation, which segment the ship together with the dock and the land. Therefore, this ship target automatic detection method is more suitable for detecting ship targets in water rather than anchored along the dock.

The ship target automatic detection method is applied to GF-1 data with 2m spatial resolution, and 21of the 23 ship targets are detected as shown in Fig.9. The total detection rate is 91%.

Besides, segmentation between the sea and the land is no longer a necessary step before ship detection in this study, which is usually a preprocessing step in classical ship detection method [7]. Using the automatic detection method proposed in this study, the land is treated as a target, and it is eliminated during the ship target judgment.

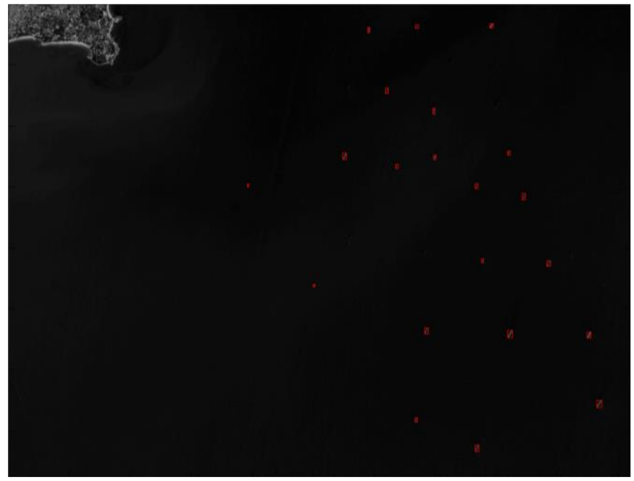


Fig.9 Ship detection result with GF-1 data

4. REFERENCES

[1] C. Corbane, L. Najman, E. Pecoul, et al. "A complete processing chain for ship detection using optical satellite imagery", *International Journal of Remote Sensing*, 2010, 31(22):5837-5854.

[2] J. Ai, X. Qi, W. Yu, et al. "A novel ship wake CFAR detection algorithm based on SCR enhancement and normalized Hough transform ", *IEEE Geoscience And Remote Sensing Letters*, 2011, 8(4): 681-685.

[3] J. Xu, K. Ji, L. Lei, et al. "Ship target detection from optical satellite remote sensing image based on GLRT," *Remote Sens. Technol. Appl*, 2012, 27(4): 616-622.

[4] Y. Liu, Z. Fu, F. Zheng. "Review on high resolution remote sensing image classification and recognition", *Journal of Geo-Information Science*, 2015, 17(9): 1080-1091.

[5] J. Xu, X. Sun, D. Zhang, et al. "Automatic Detection of Inshore Ships in High-Resolution Remote Sensing Images Using Robust Invariant Generalized Hough Transform". *IEEE Geoscience and Remote Sensing Letters*, 2014, 11(12): 2070-2074.

[6] N. Otsu. "A threshold selection method from gray-level histograms". *IEEE Transactions on Systems, Man and Cybernetics*, 1979, 9(1): 62-66.

[7] L. Gao, F. Bi, T. Long, et al. "Ship detection algorithm for optical remote sensing images", *J Tsinghua Univ (Sci & Tech),* 2011, 51(1): 105-110.