A Ship Detection Algorithm for SAR Image Based on Box-plot

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1 INTRODUCTION

The surface ship plays a key role for various countries to monitor and protect national seas. In order to accurately grasp the maritime information, target (ship) detection is crucial. At present, the ship detection is mainly based on Synthetic Aperture Radar (SAR) image and one of the main ship detection algorithms is Constant False Alarm Rate (CFAR) algorithm. However, this algorithm needs to estimate data distribution in advance and then to detect the target. Therefore, the detection results mostly depend on the accuracy of the background model we selected.

In SAR images, the ship target is characterized as high bright pixels while the sea background is characterized as dark pixels. The ship target occupies a small part of the image and the sea background occupies most of the image. Thus, the pixel of the ship target can be regarded as outlier.

Box-plot is a statistical method to show the distribution and properties of data according to five statistics, namely maximum, upper quartile, median, lower quartile and minimum. And the method is widely used in outlier detection.

In this study, box-plot is applied to ship detection and a new ship detection algorithm is proposed. The detection results is compared with the two-parameter CFAR algorithm which assumes that the sea background obeys the Gaussian distribution.

2 METHOD

When using box-plot for ship detection, a threshold is calculated first by quartiles and abnormal point factor k. Then, by comparing the data with the threshold, we can judge whether it is an outlier, that is, the ship target.

In order to reduce the influence of uneven distribution of sea surface, sliding window(see figure 1) is used. When detecting, the sliding window traverses the whole SAR image according to a certain step size (same as the size of the target window), and detects one by one. The criterion in which the detected point in the target window is judged as the target is

$$\mu_T > Q_3 + k(Q_3 - Q_1) \tag{1}$$

where μ_T is the mean of the target window, Q_1Q_3 respectively correspond to the lower quartile and the upper quartile of the background window. k is the abnormal point factor. Besides, pre-screening is adopted to reduce the amount of calculation. The pre-screening method is still box-plot, and the calculation method of pre-screening threshold is

$$T_0 = Q_3^G + k^G(Q_3^G - Q_1^G) \tag{2}$$

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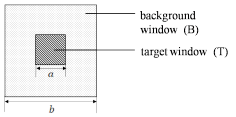

Figure 1: The detection window of ship detection algorithm based on box-plot(B:background window T: target window)

where $Q_1^GQ_3^G$ respectively correspond to the lower and upper quartile of the whole SAR image. k^G is global abnormal point factor.Finally, the morphological analysis, including the ship spacing and the ship area, is used to further screen and obtain the final detection results.

Compared with two-parameter CFAR algorithm, the threshold in this algorithm is only related to the quartiles and abnormal point factor k. Thus, it is unnecessary to estimate the distribution before detection. Therefore, the new algorithm has no requirement of pre-estimation processing on the data, which can detects more truly and intuitively.

3 RESULTS

Series satellite-borne SAR images of the Strait of Malacca and its nearby sea areas are used for experiments. And the proposed algorithm is compared with two-parameter CFAR algorithm at two aspects: detection time and detection effect.

For detection time, with the calculation time of pre-screening, I/O and morphological screening, the total detection time of this algorithm is slightly slower than the two-parameter CFAR algorithm. But in terms of detection effect, the proposed algorithm has the same or even better detection effect, especially when the distribution of the sea background is quite different from the Gaussian distribution. We will show the detail of the numerical result in the poster.

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