Detection Method of Ship Target Infrared Polarization Image

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Abstract. In the face of complex background and severe weather environment, infrared polarization detection has obvious advantages. In this paper, the ship target detection method based on infrared polarization image is studied and the ship target infrared polarization image detection method based on local contrast is proposed. The ship target detection accuracy of the proposed algorithm is 0.956, and the false alarm rate of the ship detection is low, which verifies the effectiveness of the detection algorithm in detecting the ship target, which has great application value in military applications.

Keywords: The ship target, the polarization, local contrast, accuracy, false alarm rate.

1. Local contrast of single scale

Different from visible light images, it can characterize the detailed information of the target to detect the target, especially when the ship target is relatively small, infrared image and infrared polarization image have less detailed texture features. The contrast between infrared and infrared polarization image targets and background is relatively large, which can be used to detect ship targets. Nie Jin Yan [1] proposed the research on the infrared small target detection algorithm based on local contrast enhancement, namely the infrared small target detection algorithm based on fusion and local contrast enhancement and the infrared small target detection algorithm based on multi-scale local consistency measurement. Pan Shengda et al. [2] proposed a target detection method based on double-layer local contrast, aiming at the problem that the traditional detection method based on human vision system is easy to cause false alarm detection under complex background, which has better detection performance under different complex scenes [3-6].
Figure 1 is the local contrast detection algorithm. U represents the target area, V represents the local background area, and W represents the whole image. On the image W, take the sliding window V, which slides from left to right from top to bottom in the image W. Each sliding window is divided into 9 blocks, and the number of each region is shown in Figure 1(b), in which the 0 region is the central region.

Then calculate the average value of each window, expressed as 

$$m_i = \frac{1}{N} \sum_{j=1}^{N} I_{ij}$$  \hspace{1cm} (1)$$

Calculate the local contrast value of the sliding window, define the area around the central area and the contrast value:

$$c_i^* = \frac{L_0}{m_i}$$ \hspace{1cm} (2)$$

Where, $L_0$ is the maximum value of 0 in the intermediate region, and $C_n$ is defined as:

$$C_n = \min L_n \times c_i^* = \min L_n \times \frac{L_0}{m_i} = \min \frac{L_0^2}{m_i}$$ \hspace{1cm} (3)$$

Among them, $\min \frac{L_0^2}{m_i} = \frac{L_0^2}{\max m_i}$.

It can be seen from the formula that the value $C_n$ is related to the local extremum $L_n$ and $\max m_i$, so the algorithm is easily affected by the gray value of a single pixel.

Because the pixel size of the target will change, window u will be the same size as the target. Therefore, it is necessary to calculate local contrast values at different scales to calculate the final contrast figure $\hat{C}_{p,q}$. $l_{\text{max}}$ is the maximum size of the target. Calculate the contrast graph for each scale from 1 to $l_{\text{max}}$. For the image, the contrast value of each point is $\hat{C}_{p,q}$:

$$\hat{C}_{p,q} = \max_{l_p,l_q} C_{p,q}^l$$  \hspace{1cm} (4)$$
2. Adaptive scale local contrast

In this paper, an adaptive local contrast method is designed to overcome the difficulty of scale selection in images with large size differences.

In the long distance and ultra-long distance ship target detection, the target generally occupies a small area, even in the form of dots, and there is no obvious contour information and detail information, while the short distance and medium distance usually have obvious detail characteristics and contour information.

The size of the ship target is assumed to be greater than $3 \times 3$, and the local contrast template size is $9 \times 9$. The image is transformed as follows:

$$r_n = \begin{bmatrix} 1 & 1 \\ \frac{1}{2} & \frac{1}{2} \end{bmatrix}, n = 1, 2, 3, \ldots$$

(5)

Where, $p$ represents the row transformation coefficient, $p = \left\lfloor \frac{n-1}{3} \right\rfloor$, $q$ represents the column transformation coefficient, $q = n - 1 - \left\lfloor \frac{n-1}{3} \right\rfloor$, $\left\lfloor \cdot \right\rfloor$ means round down.

According to the single-scale contrast algorithm, the local contrast image under scale $r_n$ is segmented by Formula (6) to obtain the segmentation image $T_{r_n}$, and the number of target areas in the segmentation image $T_{r_n}$ is counted.

$$T_{r_n} = I_{r_n} + k \times \sigma_{r_n}$$

(6)

Where, $I_{r_n}$ and $\sigma_{r_n}$ respectively represent the mean value and standard deviation of the local comparison graph under scale $r_n$, and $k$ represents the segmentation coefficient.

When the local contrast area is smaller than the target in scale, the local contrast error is caused. When the local contrast area is the same as the target in scale $n$, the local contrast response is the largest. Finally, the maximum local contrast at each scale is calculated as the final contrast figure:

$$\hat{C}_{M,N} = \max_{r_n \leq \gamma \leq 1} C_{M,N}$$

(7)

Where, $\hat{C}_{M,N}$ is the final local contrast image.

3. Experimental results and analysis

In this paper, a total of 312 ships targets of 160 groups of sea-sky background collected by the laboratory infrared polarization camera are tested. Some test results are shown in FIG. 2. The detection algorithm suppresses most sea clutter and background noise, and the ship target is significant. The outline information is obvious.
Figure 2. Renderings of ship target detection.
In Figure 2, (a), (c), (e) and (g) are infrared polarization images of ship targets; (b), (d), (f), and (h) are local contrast detection images to further verify the detection performance of the algorithm. The definitions of accuracy rate and false alarm rate of commonly used evaluation indexes are adopted, and the formula is as follows:

$$\text{Far} = \frac{f_p}{(tp + fp)}$$
$$\text{Cr} = \frac{tp}{nops}$$

(8)

Where, Far represents the false alarm rate, Cr represents the accuracy of detection, the number of real ship targets in the image is nops, the number of correctly detected ship targets is tp, and fp represents the number of detected false alarms.

Statistical results of the algorithm detection in this paper are shown in Table 1.

| Actual number of ships | Number of detected ships | accuracy | Mistakenly identified number | False alarm rate |
|------------------------|--------------------------|----------|------------------------------|------------------|
| 312                    | 298                      | 0.956    | 13                           | 0.043            |

According to Table 1, the detection accuracy of the proposed algorithm for ship targets is 0.956, and the false alarm rate of ship detection is low, which verifies the effectiveness of the detection algorithm in detecting ship targets.

4. Conclusions
In this paper, an infrared polarization image detection method of ship target is proposed. The final scale is determined according to local alignment response of different scales, and the ship target is detected according to the maximum response of each scale. The algorithm in this paper effectively solves the problem of detecting ships in the scene of sea and sky.

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