Sea Antenna Detection Based on Gray Threshold Analysis

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Abstract: Based on the important role of sea-antenna detection in ship target detection and tracking in sea-sky background, this paper proposes a sea-antenna detection method based on edge gray gradient threshold analysis and least squares fitting method. By analyzing the image and adjusting the step size of the linear filter to expand the gray gradient difference near the sea antenna, the edge coordinates are extracted by threshold analysis, and the sea antenna is extracted by the least squares straight line fitting method. The simulation is performed by MATLAB, and the results show that the proposed algorithm can accurately extract sea-antennas under complex backgrounds, and has good adaptability and practicability.

1. Introduction

At long distances (greater than 6km), the sea-sky background image can be divided into three parts: sky, sea and sea antenna. The sea antenna is a connecting line between the sky and the sea background. It is often visually formed by an outline of the sky and the gray scale of the sea and sky background. Due to the interference of clouds and sea clutter in the sky, the ship target in the whole sea and sky background is not easy to track stably, but the ship target generally appears in the sea antenna area. Therefore, the sea antenna area range is first determined, and the ship standard can be delineated. Search range, suppress unnecessary noise and other objects outside the sea antenna area, reduce the false alarm rate, and reduce the amount of calculation. It is an important step in the tracking of ships under the complex sea and sky background. Considering that the sea antenna is extracted to locate the sea antenna area, the sea antenna extraction algorithm only needs to give the area range, and considering the influence of the natural environment and the shooting conditions, sea-sky regional test results need to be adaptable to various situations [1].

In the color image of sea and sky background, if the sea antenna is used as the dividing line, the whole image can be roughly divided into two areas: the sky area and the sea area, and in the geometric structure, the two areas are in a stacked relationship. Among them, the sky area is located at the upper part of the image, and the sea area is located at the lower part of the image. On the other hand, compared with the sky area, the color of the sea area is more vivid, so its saturation is larger, and the saturation of the sky area is smaller. In addition, due to the strong reflection in the sky area, the brightness is large, while the reflection in the sea area is weak, the brightness is small, and the brightness between the sky and the sea water changes significantly [2]. The sea antenna area is between the sky and the ocean, and the brightness is relatively sharp compared to the other two parts. The gray scale changes sharply in the vertical direction, and the change in the horizontal direction is relatively flat [3]. Based on this characteristic, this paper proposes a new sea antenna positioning algorithm by expanding the gradient in the vertical direction.

2. Traditional sea antenna detection algorithm

The sea antenna exhibits a long straight-line characteristic, and the sea antenna is generally extracted according to the idea of detecting a straight line. Regarding the extraction method of sea antennas, many scholars at home and abroad have conducted a lot of research in recent years. The wavelet transform method has a large amount of calculation and it is difficult to meet the real-time requirements. The methods suitable for real-time application mainly include line scan method, straight line fitting method, Otsu segmentation method and Hough transform method.

2.1 Line scanning method

Since the sea horizon is an approximately horizontal straight line, the line scan method first finds a vertical gradient image, and then accumulates the gray value of the gradient image line by line. In general, it is assumed that the gradient value at the sea antenna is large, so that the gradient accumulated value at the row of the sea antenna is also relatively large. By finding the row with the largest accumulated value, it is considered to be a sea antenna, which can be used as a sea antenna extraction result. Output. For images with low signal-to-noise ratio and high sea wave interference, the value of the line at the non-sea antenna is often equal to that of the sea-earth antenna, and even exceeds the accumulated value at the sea-earth antenna. At this time, the sea-antenna extraction is caused. The result is wrong, which seriously affects the detection rate of the algorithm.

2.2 Hough transform method

The sea-antenna extraction method based on Hough transform: Firstly, the canny operator is used to perform edge detection on the pre-processed image to obtain the binarized edge image [4]. Then the Hough transform is performed on the edge image to detect the straight line in the edge image [5]; finally, the straight line represented by the peak point with the largest response of the Hough transform is output as the extraction result of the sea antenna. However, in the edge image, the cloud layer and the ocean wave will also form obvious linear features. After Hough transform, the response value is sometimes larger than the response value of the real sea antenna, which easily interferes with the extraction of the sea antenna.

2.3 Otsu division method

The method of extracting the sea antenna by Otsu segmentation is to use the Otsu method for segmentation after image preprocessing. In general, due to the infrared image of the sea and sky background, between the sea and the sky the gray scales of the sea and the sky are relatively uniform. The difference in gray scale is large, so the Otsu method is used to segment the sea and the sky. The boundary between the two parts is extracted by the edge line and can be regarded as a sea antenna. In some scenarios, it is difficult to adapt to the complex and varied Haitian background infrared image with Otsu segmentation threshold [6].

2.4 Straight line fitting

The straight-line fitting method first calculates a vertical gradient for the preprocessed image. Usually, the vertical gradient value of the position of the sea antenna is relatively large, so the position with the largest gradient of each column is selected as the data point set for straight line fitting. Using these points for straight line fitting, the fitted line can be used as a sea antenna extraction result. For images with low sea-antenna signal-to-noise ratio and large amount of sea wave interference, the position of the sea-antenna extracted by column is usually incorrect, and the result of the fitting is not the position of the real sea-antenna.

3. Specific steps for grayscale gradient threshold threshold analysis

Through the image analysis of the sea-sky background, the sea-antenna is approximated by a straight line, in order to solve the problem of inaccurate judgment in the row-accumulation value of the non-sea antenna in the line scanning method and the accumulated value of the sea-antenna. The method improves the vertical gray gradient by adjusting the filter step size, and the sea antenna should be at the maximum of the vertical gradient. If the coordinate position of the sea antenna can be accurately found, the problem of inaccurate position of the sea antenna in the straight-line fitting method can also be solved. The specific steps of the method are shown in Figure 1:

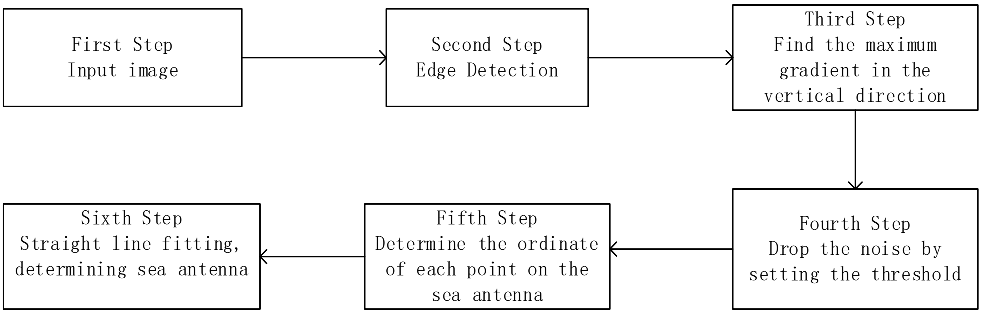

Figure 1. Specific steps of the experimental analysis

3.1 Edge detection

The sea antenna area is between the sky and the ocean, and the brightness is relatively sharp compared to the other two parts. The gray scale changes sharply in the vertical direction, and the change in the horizontal direction is relatively flat. A sea-antenna that approximates a straight line can expand the gray-scale gradient difference by selecting a suitable edge detection template for line detection. Because the gray levels of the pixels on both sides of the edge are significantly different, they form a stepped edge. The function of the edge detection template is to subtract the gray value of the lower neighbor point from the gray value of the lower neighbor point as the gray value of the point. In the region where the gray scale is similar, the result of this is that the gray value of the point is close to 0; and in the vicinity of the edge, the gray value has a significant jump, and as a result, the gray value of the point is large. This template is an edge detector. Its mathematical meaning is a gradient-based filter, which is also known as an edge operator. The sea antenna is generally close to the horizontal direction, so the edge is exactly vertical, so we use a gradient template whose gradient is vertical to detect its edge.

-1	-1	-1
2	2	2
-1	-1	-1

Small step size

-15	-15	-15
30	30	30
-15	-15	-15

Horizontal step

Figure 2. Horizontal line detection template

The template shown in Figure 2 moves across the image and is more strongly correlated to the horizontal line (one pixel wide). For a constant background, a larger response may be produced when the line passes through the middle row of the template, as shown in Figure 2 for the two templates to be used for horizontal detection. The priority direction of the template is weighted by a larger coefficient than the other possible directions, and the sum of the coefficients of each template is 0, which indicates that the response of the template is 0 in the constant luminance region. Compared with the second picture and the third picture in Figure 3, the step size of the template is adjusted to significantly increase the gray level gradient, which is more convenient for subsequent detection.

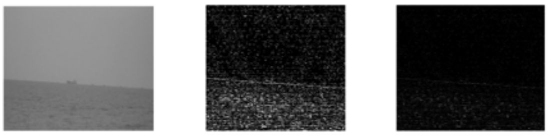

Figure 3. Different horizontal line detection

3.2 Sea antenna parameter determination

As shown in the second figure of Figure. 3, the gray image of 576*720 is selected, and the position of the sea antenna can be made more obvious by increasing the gradient of the horizontal line detection template. If the size of the ordinate of each pixel of the sea antenna position can be determined, and the abscissa is the number of pixel columns of the image, the coordinates of the point on the sea antenna can be expressed. As can be seen from each column, the position of the sea antenna is basically the first maximum value of each column of pixels. Since the sea antenna is above the water surface, it is not necessary to consider the influence of the surface noise on the sea antenna point.

As can be seen from the second graph, the gradient of the sky point may be the maximum value of a column of pixel gradients, which will cause a large error in the determination of the left side of the point on the sea antenna. However, most of the points will be concentrated on the sea antenna, and the vertical coordinate of the first largest point in the vertical direction will be plotted in the figure. It is obvious that most of the points can still be in the vicinity of one line, if the distribution of some points is compared Dispersion, this will lead to a larger variance of these points, so you can set the threshold to round off the scattered points.

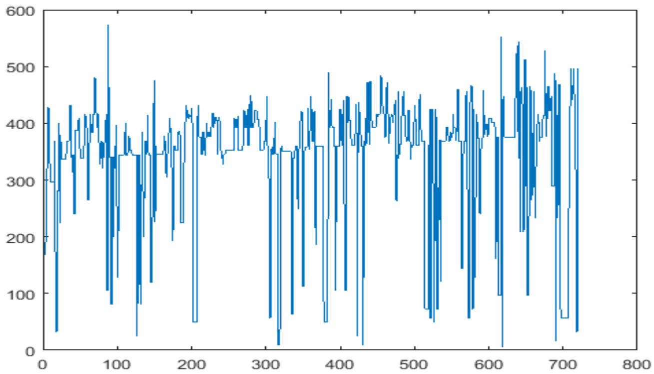

Figure 4. Maximum Vertical Point Coordinates

First, ask for the average number of rows of sea antennas in all areas. $\overline{y} = \frac{1}{k}\sum_{i=1}^{k} y_i$. Set a threshold T, when y_i satisfies $\overline{y} - T_1 < y_i < \overline{y} + T_2$, so think of this point as the point of the sea antenna. As can be seen from Figure 4, the threshold is set up and down standard deviation indicates the degree of partial mean of these points. As shown in Figure 4, if the appropriate threshold is selected, the deviation point is deleted and the mean is retained, so that the sea antenna can be approximated to the maximum extent. According to Figure 4, the points are different in position above and below the mean. So, we set $E_p - k_1\sigma_p < y_i < E_p + k_2\sigma_p$, and y_i Will be the point of the selected sea antenna.

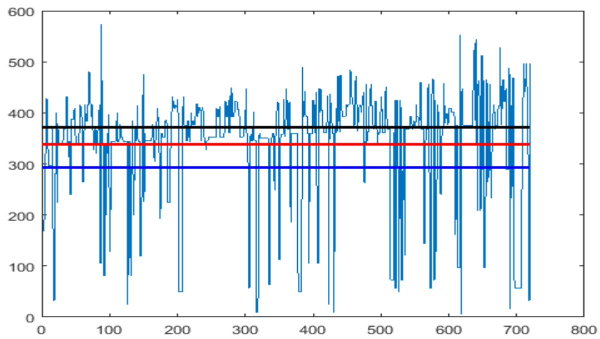

Figure 5. Threshold range determination

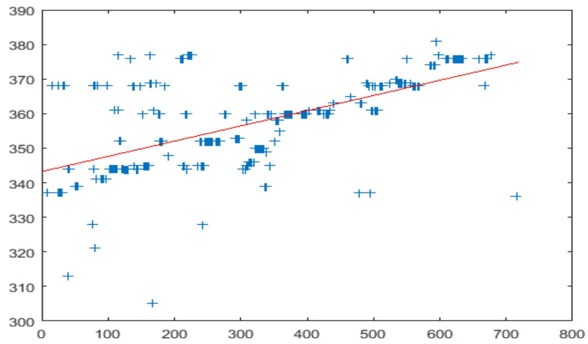

Figure 6. Selected points

As shown in Figure 5, the red line represents the mean, and the position of the black and blue lines is the point selected by the threshold, which contains the most accurate point around the sea antenna. To choose different depending on the image. We set different thresholds. As shown in Figure 6, the point between the thresholds will be around a straight line, so the correctness of the threshold selection can be proved.

3.3 Least squares straight line fitting

According to the results of 3.2, the ordinate and abscissa of the point around the sea antenna can be found and processed as a straight line. The equation for setting the sea antenna is:

$$y = kx + b \tag{1}$$

Let the coordinates of the point of each sea antenna be:

$$k = \frac{N\sum_{i=1}^{N} x_i y_i - \sum_{i=1}^{N} x_i \sum_{i=1}^{N} y_i}{D} \tag{2}$$

$$b = \frac{\sum_{i=1}^{N} x_i^2 \sum_{i=1}^{N} y_i - \sum_{i=1}^{N} x_i \sum_{i=1}^{N} x_i y_i}{D} \tag{3}$$

$$D = N\sum_{i=1}^{N} x_i^2 - (\sum_{i=1}^{N} x_i)^2 \tag{4}$$

4. MATLAB simulation and analysis

Figure 7. Simulation results

According to the content of the previous chapter, determine the parameter points of the sea antenna, fit the sea antenna according to the straight-line fitting method, and simulate on the software platform MATLAB2010, as shown in Figure 7, the red line is the fitted straight line, and the sea. The matching of the antenna is very high, which proves that this method is feasible.

5. Conclusion

In this paper, an effective method for sea-antenna extraction in sea-sky background is proposed, which first uses the first detection template to increase the gradient difference near the sea-antenna, and then detects the coordinates of the first maximum value of each gradient in the vertical direction, and then sets The adaptive threshold is selected according to different graphics, and the interference points of the sky part are rounded off, so as to select the coordinates of the point close to the sea antenna position as much as possible, thereby extracting the sea antenna by straight line fitting. Since the step size of the line detection is increased, the interference of the sky background and the sea surface background is effectively suppressed, and the target information is enhanced, which is very advantageous for the subsequent sea antenna extraction operation. The simulation results show that the proposed method can solve some problems of the traditional sea-net antenna detection algorithm. It does not need to filter and remove the image before, which can simplify the operation and effectively suppress the interference and certain environmental changes. It has high robustness, accuracy and real-time

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