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Target Local Matching Recognition Algorithm based on Improved Harris Key Point Detection Operator

Hui Tian, Gang Liu

Henan University of Science and Technology, No. 203, Kaiyuan Avenue, Luolong District, Luoyang, Henan 471023, China

Abstract: In the process of attacking fighters, helicopters and other targets, infrared imaging guided air-to-air missiles once they find themselves intercepted, they will release interference to induce the missile to deviate from the trajectory, which brings great difficulties to the missile to successfully destroy the target. When infrared interference occludes aircraft targets, a target local matching recognition algorithm based on the improved Harris key point detection operator is proposed. The algorithm first uses the Gaussian smoothing window to count the gradients in the x direction and y direction of each pixel, forms an autocorrelation feature matrix and calculates its feature values. Because smaller eigenvalues can be used to characterize the prominence of the curve, the minimum eigenvalue is used as the corner response function value, and the point when greater than the given threshold is marked as the key point of the aircraft target. In the process of interference occlusion of aircraft targets, the local matching recognition of targets is achieved by calculating the Euclidean distance of the feature descriptors between key points. Experimental results show that the proposed improved algorithm can achieve local matching recognition of infrared aircraft targets when infrared interference occludes aircraft targets.

Keywords: Object Detection; IR Target; Harris.

1. Introduction

Infrared imaging guidance is a guidance technology that uses image information to control the aircraft to accurately fly to the target, and Automatic Target Recognition (ATR) is the process of computer automatic target capture and classification, which is one of the core technologies of infrared imaging guidance. In order to achieve the task of completely destroying the target, the missile needs to confirm the aiming point, which is generally the key part such as the engine or cockpit of the aircraft target, and the premise of the aiming point confirmation is that the aircraft target needs to be identified under interference conditions. Therefore, it is necessary to realize anti-interference recognition of infrared aircraft targets under the condition of interference masking targets.

When interference occludes the target, the overall characteristics of the infrared aircraft target fail, and local features need to be used to describe the exposed part of the target, and the key point features can be applied to this detection task. When some overall shape features of the target, such as aspect ratio, circumference concave-convex ratio, etc., change, it can be considered that interference occludes the target, at this time, the local matching recognition of the aircraft target is realized by calculating the Euclidean distance of the feature descriptor between key points.

2. Model Image Segmentation based on Mixed Gaussian Background

Corner points are a very important feature of images and play an important role in image recognition. The corner point retains the important features in the image, while eliminating the redundant amount of data, and the information of the corner point is high, so the algorithm based on the corner point is generally more efficient.

The Harris corner point detection algorithm [1] is an improvement on the Moravec algorithm [2], which not only detects grayscale in four directions, but calculates the sum of grayscale change values after the rectangular window moves in any direction. The Harris detection algorithm determines corner points based on an autocorrelation matrix that describes the neighborhood change information of pixels. The Harris operator has translation and rotation invariance, fast calculation speed, and by quadratic approximation of the corner point response function in the neighborhood of extreme points, the Harris operator can achieve subpixel positioning accuracy [3].

The specific method is: first move the processed image window *w* (generally a rectangular area) in any direction by a small displacement (x,y), then the amount of gray change can be defined as:

$$\begin{aligned} E_{x,y} &= \sum w_{u,v}[I_{x+u,y+v} - I_{u,v}] = \sum w_{u,v}[xX + yY + O(x^2, y^2)]^2 \\ &= Ax^2 + 2Cxy + By^2 = (x,y)M(x,y)^T \end{aligned} \quad (1)$$

where $w_{u,v}$ represents the sliding window function, $I_{u,v}$ represents the image grayscale, $I_{x+u,y+v}$ represents the image grayscale after translation, and X and Y are first-order grayscale gradients. Use the Gaussian window $w_{u,v}$ to count the gradients in the x and y directions of each pixel.

Also, definitions:

$$A = X^2 \otimes w, B = Y^2 \otimes w, C = (XY) \otimes w \quad (2)$$

Where $\otimes$ represents convolution. Autocorrelation matrix M of pixels (u,v):

$$M = \begin{bmatrix} A & C \\ C & B \end{bmatrix} \quad (3)$$

Find the eigenvalues λ_1 and λ_2 of the matrix $M(x,y)$, and then judge whether it is a corner point according to the corner point response:

$$R = \det M - k(traceM)^2 \quad (4)$$

where $detM$ represents the determinant of the matrix M; $traceM$ represents the trace of matrix M; k is a constant. The formula is expressed as:

$$\det M = \lambda_1 \lambda_2 = AB - C^2$$
$$traceM = \lambda_1 + \lambda_2 = A + B \qquad (5)$$

When the calculated corner response function value R is greater than the given threshold and is a local maximum, it indicates that the pixel is a corner point.

Harris calculation is simple, the extraction of corner points is reasonable and uniform, and the stability is related to the k value, but k is an empirical value, and it is difficult to set the optimal value. The stability of the corner points is actually related to the small eigenvalues of the matrix.

When the shape is a segment, the eigenvalues in the segment domain are close to 0, regardless of the length and direction of the segment. When the shape is an ellipse, the two eigenvalues of the autocorrelation matrix are λ_L, λ_S, $\lambda_L > \lambda_S$, $\sqrt{\lambda_S}$ and $\sqrt{\lambda_L}$ are assumed to be the major and minor axes of the ellipse. If the shape is a circle, the two values are equal. Therefore, a small eigenvalue λ_S can be used to measure the prominence of each boundary point p_i on the curve segment. If the value λ_S of a point p_i exceeds a predetermined threshold, the point can be considered an angular point. A point on a straight line will cause a smaller eigenvalue λ_S close to 0, while a point on a sharp corner will produce a larger λ_S value.

Therefore, on the basis of Harris corner point detection, the corner point detector is constructed by calculating the minimum eigenvalue of the autocorrelation matrix as the corner point response function, so that there is no need to adjust the k value:

$$R = \min(\lambda_1, \lambda_2) \qquad (6)$$

3. Key Feature Matching

After the key point extraction is completed, the features need to be described, the specific process is: first construct a coordinate system for the main direction of any key point, so that the generated descriptor has rotational invariance, and then divide the spatial neighborhood of the scale where the key point is located into 16×16 space, and then evenly divide into areas of size 4×4, and then calculate a gradient histogram in 8 directions for each region, sort it according to the position, and obtain a feature vector of 4×4×8=128 dimensions, that is, the description vector of key points.

After the features are described, the similarity is measured according to the description vectors, and the Euclidean distance of the two feature vectors is generally used as the discriminant criterion for feature similarity. Euclidean distance is the distance of each feature point on the target image, and its distance from all the remaining feature points is calculated one by one. The calculation formula is:

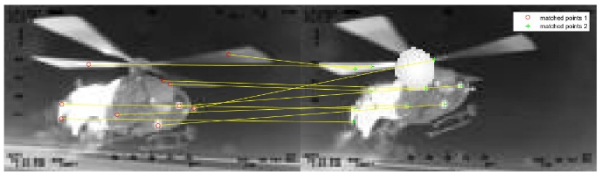
$$d\,(x, y) = \sqrt{\sum_{i=1}^{128} (x_i - x_i^{'})^2} \qquad (7)$$

Where x_i, x_i' are the eigencomponents of the two key points to be matched.

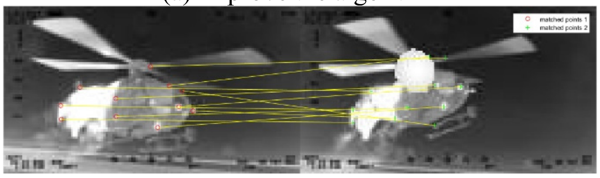
If the ratio of these two-feature points $R = d_1 / d_2$ from d_1 and d_2 is less than a certain threshold, it can be considered as a pair of matching points.

4. Experiment and Analysis

The dataset used in the experiment is the LSOTB-TIR dataset [4], in which three helicopter sequences are generated and added to the helicopter image for the movement, radiation, and delivery mode of real interference. The image when the interference occlusion target is selected for the algorithm test in this section, and the results are shown in Fig.1~Fig. 2.



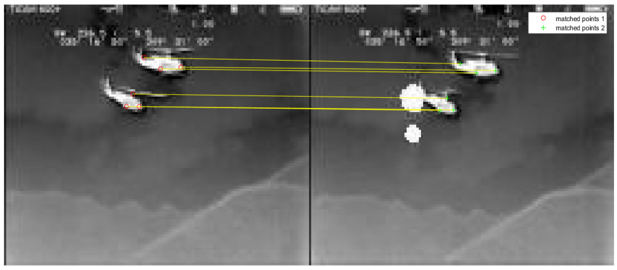
(a) Improve the algorithm



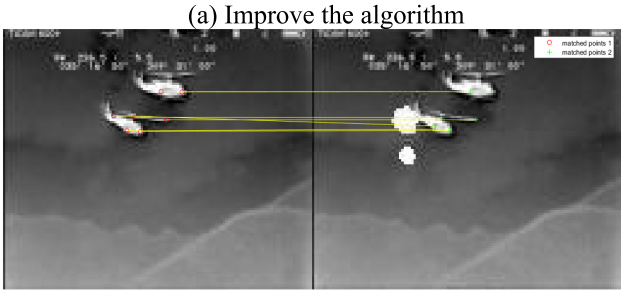
(b)Harris

Fig 1. Matching results 1

From the detection results of Figure1, it can be seen that there are six pairs of matching errors in the feature points extracted by the original Harris algorithm, among which the points on the template fuselage are incorrectly matched to two pairs on the nose of the image to be measured, the points on the fuselage are incorrectly matched to three pairs on the fuselage, and the points on the fuselage are incorrectly matched to one pair on the wing. The improved Harris algorithm has only three pairs of matching errors, where the dots on the nose are incorrectly matched to the wing pair, the dots on the fuselage are matched to the fuselage pair, and the point positions on the wing are incorrectly matched by a pair.



(a) Improve the algorithm



(b)Harris

Fig 2. Matching results 2

From the detection results of Figure2, it can be seen that the feature points extracted by the original Harris algorithm have a pair of matching errors, and the points on the wing are matched to the fuselage; The improved Harris algorithm extracts feature point pairs that match correctly, and for unblocked aircraft, the improved algorithm extracts feature points on the nose, tail, and wing, while the original algorithm does not extract feature points on the wing. The matching point pairs extracted by the FAST algorithm have the same effect as the improved Harris algorithm, the wrong matching point pairs extracted by the SIFT algorithm are all on the background, and only three pairs of matching pairs are correctly matched on the target, and the matching point pairs extracted by the BRISK algorithm are correct, but the number is small, only two pairs.

5. Summary

When interfering with occlusion targets, an improved Harris key feature extraction method based on minimum eigenvalue is proposed, and then the local matching recognition of aircraft targets is realized by calculating the Euclidean distance of the feature descriptors between key points. Experiments demonstrate the effectiveness of the proposed method in this chapter.

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