Improve target matching for FAST-SURF algorithm

Yuxiang Wang [1, a], Xinglong Wang [2, b]

[1]Chongqing University of Posts and Telecommunications, Academy of opto electronic engineering, Chongqing, 400065, China;

[2]Chongqing Ping Wei Industrial Group Limited by Share Ltd, Chongqing, 400065, China;

[a]837772330@qq.com, [b]62342769@qq.com,

Abstract

In order to solve the problem that the visual positioning speed is not enough in the industrial production of object transfer sorting, this paper presents an improved FAST-SURF algorithm for fast matching of target objects. The feature points were detected by FAST algorithm. The SURF feature descriptors were reduced from 64-dimensional to 16-dimension to narrow the range of feature points. The FLANN algorithm was used to search the feature points to be matched and the RANSAC algorithm was used to eliminate the mismatched pairs. The experimental results show that compared with the traditional SURF algorithm, the binocular FAST-SURF algorithm can shorten the matching time by about 0.8s, which proves the effect of this method on the target matching.

Keywords

Industry, cigarette package, binocular, matching.

1. Introduction

Industrial robots are widely used in object sorting palletizing, logistics and other industrial tasks. Obtaining and placing the target object is one of the important tasks of the industrial robot. Most industrial robots are still crawling in the level of repeat work after pre-plotting. This way of working has high requirements on the stability of the environment and can not cope with unexpected changes. With the continuous improvement of social productive forces, the requirements of various aspects of the robot system are also getting higher and higher. With vision system, industrial robots can identify and locate the target object, so as to enhance the robustness of the system and improve the real-time performance of the system to deal with unexpected situations. In recent years, more and more attention has been paid on the research of visual recognition and localization [1-9], and its application in industry is also more and more widespread.

Machine vision recognition still faces the problem of lack of timeliness in industrial robots' functions of grasping and placing. On this issue, many people have made their achievements. In 2015, Chang Xujian proposed the FAST-SIFT feature detection algorithm to speed up the detection of the algorithm [1], but the total time-consuming is still relatively long. In 2016, Han Feng adopted the SURF-RANSAC algorithm, The total matching time is reduced to a certain extent [2], but the timeliness is slightly lower. Moreover, monocular-to-dual-purpose method is cumbersome in industrial production and it is difficult to achieve timeliness. In 2017, Li X and others conducted the SURF algorithm Improved, faster matching, but lower correctness [3].

Based on the work of predecessors, this paper proposes an improved FAST-SURF algorithm to recognize industrial robots sorting targets with binocular stereo vision. Firstly, the possible feature points were detected by FAST, the SURF feature descriptor was reduced from 64-dimensional to 16-dimension to narrow the range of feature points. FLANN algorithm was used to search the feature points to be matched, and the RANSAC algorithm was used to eliminate the mismatched pairs. Compared with the traditional SURF algorithm, the proposed algorithm can better meet the real-time and matching accuracy.

2. Conventional SURF Feature Target Matching

SURF is mainly composed of Hessian matrix extraction feature points, Haar wavelet construction feature description points, nearest neighbor feature matching three processes.

2.1 Hessian matrix extraction feature points

The SURF algorithm performs Gaussian filtering on the image to obtain a filtered Hessian matrix. When the discriminant of the Hessian matrix obtains a local maximum point or a minimum point, it is a feature point.

2.2 Haar build feature description point

The eigenvectors are constructed to describe the extracted feature points. A square area is constructed by taking the feature points as the center, and a 64-dimensional eigenvector is generated by Haar wavelet response.

2.3 nearest neighbor feature matching

SURF algorithm uses the nearest neighbor matching method, first calculating the Euclidean distance of the feature points of all the feature points of the image to be matched to all the feature points of the reference image, obtaining the set of distances, and then comparing the set of distances to obtain the smallest Eu The distance d_1 and the next minimum Euclidean distance d_2. which is:

$$\frac{d_1}{d_2} < T \tag{1}$$

In formula (1): T is the set threshold, generally 0.6. If the ratio of d_1 to d_2 is less than the threshold, then the feature point and its corresponding smallest Euclidean distance feature point are matched with each other, otherwise, no point matches the feature point.

3. Matching algorithm in this paper

Based on the previous work, this paper studies the principle of FAST and SURF feature detection, detects possible feature points by FAST, reduces SURF feature descriptor descriptor from 64-dimensional to 16-dimension to narrow the range of feature point sub-domains, adopts FLANN algorithm Search for feature points to be matched, using RANSAC algorithm to eliminate false matching pairs.

Matching algorithm diagram shown in Figure 1:

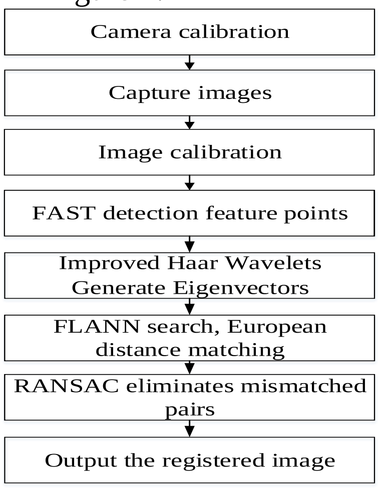

Figure 1 flow chart

3.1 FAST algorithm

The FAST feature detection algorithm is based on the definition of a corner point. FAST algorithm contains three main steps:

The gray value of a circle of pixels around the point to be detected is sufficiently different from the gray value of the candidate point that the candidate point is a feature point. Any point in the two-dimensional image can have the coordinates (x, y). Feature point description algorithm is as follows:

$$S_{p \to x} = \begin{cases} d & I_x \le I_p - t(darker) \\ s & I_p - t < I_x \le I_p + t(similiar) \\ b & I_p - t \le I_x(brighter) \end{cases} \qquad (2)$$

In formula(2): t is the threshold, (generally $t = 10$), which defines the gray point of any point on the circumference of the circle I_x, the center of the gray for the I_p. When the gray value of the central pixel is less than the pixel gray value $I_x + t$ at the surrounding point, then the gray pixel is considered to be darker, then $S_{p \to x} = d$; and so on similar s and brighter gray pixel b. In this way, three types of grayscale pixel points d, s and b are found at the edge of a circular region centered on the candidate feature point p. Statistics d or b times, if more than n (when the number of split test points is 12, that is, I_x the number of $3/4$), then that point is a candidate feature points.

Secondly, the candidate feature points are obtained by comparing the gray values of the pixels on the fixed radius circle. Using ID3 classifier, we can determine whether the candidate feature points are feature points based on the 16 features. The above steps to get d、s、b recorded as P_d、P_s、P_b, the calculated $S_{p \to x}$ must correspond to (2) some kind of situation. Let I_p be the feature point when $kp = true$, otherwise false. To determine whether a pixel is a feature point.

Finally, the feature points are trained by ID3 decision tree algorithm, and the corner response function V is calculated. Define a response function as follows:

$$V = \max\left(\sum_{x \in b} \left| I_{p \to x} - I_p \right| - t, \sum_{x \in d} \left| I_p - I_{p \to x} \right| - t \right) \qquad (3)$$

Non-feature points are eliminated using the conventional maximum suppression method.

3.2 The innovation and improvement of this article

The resulting FAST detector is selected in the main direction. Firstly, a circular neighborhood with radius of $6S$ (S is defined as the center of the feature points). Then the weighted Haar wavelet responses of pixels in the horizontal and vertical directions are calculated.

As shown in Fig. 3, the left side is the response of Haar wavelet in x direction and the right side is the response of Haar wavelet in y direction. The Gaussian weight coefficient is assigned to the response value so that the greater the weight of the Haar wavelet response that is closer to the feature point, the more traversing the entire circular region with a 60° fan template results in a cumulative vector of the Haar responses, The direction is the main point of the characteristic point.

Finally, calculate each feature point, get the main direction of all feature points.

Fig.2 Response of Haar wavelet

In the direction of the feature point, a square area with a feature point of $20s$ is constructed. As shown in figure (4), the area is then sampled at equal intervals (with a sampling interval of s) and converted into $2 \times 2 = 4$ sub-areas and 5×5 points in each sub-area. Calculate the Haar wavelet response for all sub-regions.

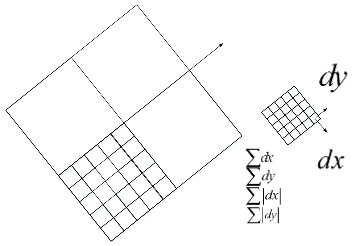

Fig.3 Feature descriptor generation process

Add dx、dy、$|dx|$、$|dy|$ to each sub-region, where dx、dy represents the corresponding Haar wavelet in the x and y directions, respectively. Get 4-dimensional feature description vector V :

$$V = [\sum dx, \sum dy, \sum |dx|, \sum |dy|] \tag{4}$$

The V sub-region of 4 together, to obtain $2 \times 2 \times 4 = 16$ -dimensional feature description vector, that is generated SURF descriptor.

It will be described that the FLANN algorithm is used to match and then the RANSAC algorithm is used to filter out the incorrect matching pairs to obtain the matching result.

4. Target matching experiment

4.1 binocular vision system

Before performing image matching experiments must first be calibrated. The experiment set up a binocular platform by a combination of two CCD cameras, CCD model MER-125-30GM / C *. The left CCD camera measured the system focal length of 23.349mm, the right CCD camera focal length of 23.249mm, the camera distance of about 150mm. Using Halcon13, opencv2.4.9 and other software as a development tool. Experimental computer parameters are as follows: I5-3210 processor, CPU frequency of 2.5GHz, RAM capacity of 4GB, 64-bit operating system. According to the experimental conditions and the actual scene, this experiment uses the standard calibration plate.

In the experiment, binocular vision system was calibrated using Halcon software. Experiments so that the left and right cameras at the same time the acquisition of 6 sets of space completely different calibration plate images collected image size are. Calibration of external and internal reference results shown in Table 1:

Table.1 Camera calibration results

Camera parameters	Left camera	Right camera
Reference matrix	$\begin{bmatrix} 826.998 & 1030.76 & 291.637 \\ 0 & 830 & 208.687 \\ 0 & 0 & 1 \end{bmatrix}$	$\begin{bmatrix} 827.131 & 1028.68 & 292.965 \\ 0 & 830 & 296.760 \\ 0 & 0 & 1 \end{bmatrix}$
Rotate the matrix	$\begin{bmatrix} 0.953 & -0.481 & -0.301 \\ 0.045 & 0.999 & -0.607 \\ 0.301 & 0.005 & 0.954 \end{bmatrix}$	
Panning vector(mm)	$[168.198 \quad 3.122 \quad 28.000]$	

In order to verify the matching effect of the algorithm in the target object, after the calibration and calibration of the camera are completed, the SURF algorithm and the SURF algorithm in reference 4 are used to match the calibrated images by using three different algorithms.

4.2 Target object matching

Acquisition of experimental images shown in Figure 6, left for the left camera (ie camera 1) acquisition, the right is the right camera (camera 2) acquisition:

Left Right

Figure 4 Original

The calibrated image is matched by three algorithms, and the matching result is shown in Figure 5, Figure 6 and Figure 7:

Figure 5 This algorithm

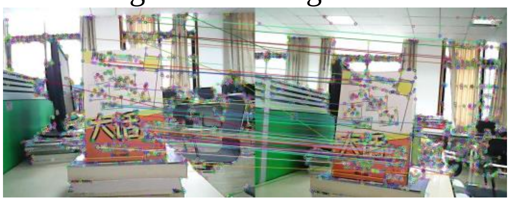

Figure 6 SURF algorithm

Figure 7 others algorithm

Through the matching experiments of three different algorithms, the matching experiment results of the three algorithms can be obtained.

The comparison experiment results of three different algorithms show that the proposed algorithm performs well, has high speed and high accuracy. The SURF algorithm has a slightly poorer matching effect, a slightly slower speed and a lower correct match rate. The other algorithms are well-matched but matched Speed and accuracy than the algorithm.

The experimental data shown in Table 3:

Table 3 Comparison of the results of three algorithms

algorithm	Extracting feature points takes time/s	Match total time-consuming/s	Correct match rate
This article	0.042	0.836	94.74
SURF	0.111	1.604	89.29
FAST-SURF[4]	0.057	1.182	92.73

5. Conclusion

In this article, a binocular vision system is used to capture the scene images of the target object, and the matching of the target object is achieved by adopting the improved FAST-SURF feature matching method. Firstly, the feature points are detected by FAST, the features of the target object are extracted by SURF, the feature points are searched by FLANN algorithm, and the false matching pairs are eliminated by RANSAC algorithm. The proposed method is better than SURF algorithm in matching speed and matching accuracy, which verifies the feasibility of this method and has certain practical value.

Acknowledgements

National Natural Science Foundation of China Youth Fund Project.

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