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A Method Using Auxiliary Direction to Improve SURF Recall

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Abstract. Classic SURF algorithm may lead to matching failure, low recall because of incorrect main direction when constructing feature points describing operator. To solve it, A Method using auxiliary direction to improve SURF recall is put forward. The improved algorithm first select out auxiliary direction which is similar to main direction in characteristics, then generate new operator for describing the auxiliary direction characteristic. When matching, the improved algorithm adopts stricter nearest neighbor proportion inhibition. Experimental results show that feature point recall increase about 6% compared with the classical SURF while maintaining the precision.

Keywords: SURF, Auxiliary direction, Recall, Precision, nearest neighbor

1 Introduction

Matching point pairs of one identity object in two pictures that are not completely the same is the basic task in the application of computer vision. There are some common algorithms for detecting feature points, such as Harris[1], Hessian-Laplace[2,3], Sift, SURF, etc., of which Harris algorithm detects feature points by finding points which change greatly in gray level of both X direction and Y direction[4], but it doesn't have scale invariability. Sift algorithm was formulated in 1999, which attempts to find critical points in spaces of different scales[5], and obtains corresponding scale, position, rotation angle and so on, which have scale invariability and be used widely[6]. The main flaw of Sift is slow. SURF algorithm is the improvement of Sift algorithm [7]. It chiefly accelerates the calculating process by integral image. Its speed is approximately three times of Sift algorithm and the performance of intensity roughness and fuzzy is also better than Sift.

2 Detecting and matching feature points in SURF

The procedure of classical SURF algorithm consists of constructing scale space, determining feature points, distributing principal direction and generating descriptor.

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Feature point pairs can be matched after we get the set of descriptors of feature points of two images [13- 15].

2.1 Constructing scale space

To reach the goal of scale invariability, we need to find feature points in different scale spaces. Specifically, we would convolute the image I(x,y) with the Gaussian kernel, which is shown in equation(1).

$$L(x, y, \sigma) = I(x, y) * G(x, y, \sigma) \quad (1)$$

G(x,y,σ) is Gaussian function in different scales. To smooth the image in multi-level, we need to use different Gaussian kernels to convolute with the image. Every level can also be decomposed to multi-scale. Then, constructing DoG scale space by subtracting the continuous image of Gaussian scale space successively.

In this process, we use box filter with integral image to approximately calculate the value of Hessian determinant. The speed of calculating is improved in a great degree because we only need addition and subtraction.

2.2 Determining feature points

One point can be determined as a feature point if it satisfies one of the following:

(1)The value of Hessian determinant is greater than a threshold;

(2)In this scale and adjacent two scales, selecting 3*3 area centered by current point in each scale, there would be 27 pixels. The gray value of current point is the maximum or minimum of these 27 pixels.

Because the marked feature points are in different scale spaces, we need to apply 3-D linear interpolation to map them into the original image, thus the feature points we obtained are in sub-pixel level.

2.3 Distributing principal direction

In order to make the algorithm be directional invariable, we need to distribute a principal direction for every feature point, and then rotate the descriptor according to the principal direction.

In the scale of the feature point, calculating the vertical and horizontal feature of the Harr wavelet of all points in the area of the sector that has the radian of 1/3 and the radius of 6 times of current scale, rotating this sector in some interval, using its horizontal wavelet feature and vertical wavelet feature, we would generate the local direction vector. Rotated it 360 degree, we would find the longest one of those wavelet feature vectors, which the direction is exactly the principal direction of this feature point.

2.4 Generating descriptor

Selecting a rectangular area centered by the feature point that the length of side is 20 times of current scale, rotate the rectangle and its content according to the principal direction, and divides this area into 16 blocks. In each sub-block, calculate the sum of the feature of Harr wavelet and the sum of absolute value of the feature of Harr wavelet in horizontal and vertical direction for those 25 pixels. There are 4 description data in each sub-block. Hence, the descriptor of every feature points includes 64 description data in all.

2.5 Matching feature points

In SURF algorithm, there are many ways to match feature points. One simple and common way is following:

(1)Detect all feature points in two images A and B that are waiting for matching, and save their feature descriptors.

(2)Traversal all feature points in image A. For each descriptor, calculate the Euclidean distance of all feature descriptors of image B. Mark the minimal distance as Dis1, the second smallest distance as Dis2. If (Dis1/Dis2) < proportional threshold, then preliminary matching succeeds. This step is called nearest neighbor proportion inhibition. Generally, the value of this threshold would be 0.7. It should be mentioned that the smaller threshold, the larger proportion of correct matching, i.e., the higher precision, but the correct matching point pairs would be smaller, i.e., the smaller recall.

(3) Bidirectional matching. Transpose the image A and B in step 2 with the same matching standard. If the matching pairs of image B and A is the same as the result of image A and B, keep it as a matching result, else ignore it.

3 Conclusions

In this paper, through introducing the auxiliary direction generated feature point descriptor involved in feature matching, setting appropriate parameters for the conditions of introducing auxiliary direction, and using stricter nearest neighbor inhibition strategy for matching involving auxiliary direction descriptor. Experimental results show that the improved algorithm discussed in this paper can guarantee precision in basically the same premise, or better, to improve the algorithm's recall rate of about 6 percent with respect to the classical SURF, increasing the number of correct matching pairs, providing more effective information of location for image post-processing, while improving the robustness of the algorithm. From another perspective, though there is no detailed experimental data, it can be inferred that, if properly decrease the proportion inhibition threshold of principal direction feature descriptor, then the recall will be flat with the original algorithm, the precision rate will be improved.

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