A Pedestrian Tracking Algorithm Based on Camshift and Kalman Filtering

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Abstract: ***The traditional MeanShift algorithm , for video target tracking, is prone to color interference, loss of target occlusion, and the speed and degree of convergence of the algorithm. The Camshift algorithm is used to improve the Camshift algorithm by Kalman filter, which can predict the position of the target in the next frame image and determine the Camshift algorithm in the pedestrian tracking search area to overcome the target block and noise interference. Experiments show that the method has well pedestrian tracking effect and application prospect.***

Keywords: Camshift, Kalman filter, pedestrian tracking

1. Introduction

In the field of computer vision technology, pedestrian tracking in video sequence is an important research direction. In the video security monitoring, target tracking and other fields have great application prospects. MeanShift algorithm has no parameters, the advantages of fast matching are widely applied to the target tracking field. However, the MeanShift algorithm does not have the function of an adaptive window, and the histogram feature lacks spatial information in the target color feature description. To solve this problem, Bradski[1] proposed a color histogram as the target tracking algorithm, continuously adaptive mean shift (Camshift) algorithm. The algorithm, which can automatically adjust the size of the window, is esay to calculate and more accurately and stability to track the target with real-time. It can be a good solution to the general situation of the target block. However, the Camshift algorithm only traces the target based on the color information to establish the target histogram and the algorithm can not be tracked correctly if there is a large area similar to the color interference and occlusion in the background. If there is high-speed walking pedestrians, it can not effectively track pedestrians .So the effect of the algorithm is not good.

In this paper, a pedestrian tracking algorithm based on Camshift algorithm and Kalman filter is proposed for shortcomings of Camshift algorithm. Based on the Camshift algorithm, the Kalman filter method is introduced into pedestrian motion position prediction. The experiment shows that the algorithm can effectively solve the problem of color interference and occlusion, and can track the pedestrian correctly, and has good real - time performance.

2. MeanShift algorithm for pedestrian tracking

The n sample points $x_i, i=1,2,...,n,$ in the d-dimensional space R^d can be defined as the basic form of the MeanShift vector at the x-point:

$$M_h(x) = \frac{1}{k}\sum_{x_i \in S_h}(x_i - x) \qquad (1)$$

Where S_h is a high-bit sphere region with a radius h and a set of y points that satisfy the following relationship, which can be defined as:

$$S_h(x) \equiv \left\{ y : (y-x)^T (y-x) \le h^2 \right\} \qquad (2)$$

It can be known that $(x_i - x)$ is the position offset of the sample point x_i for the selected reference point x, and the MeanShift vector $M_h(x)$ defined by the equation (1) is the offset vector of the k sample points in the falling region S_h with respect to the point x. The process of first and reanalysis. Thus, the MeanShift vector points to the direction of the probability density gradient. The MeanShift algorithm can be used to determine the moving direction of the tracking object step by step. The convergence of the MeanShift algorithm will be iteratively calculated and eventually converge to the specific position of the tracking object to achieve the purpose of tracking.

The current frame starts at $y0$ and calculates the feature $\{P_u(y0)\}u=1,2......m$ of the candidate target. And then calculate the candidate target and the target similarity, the calculation of the right $\{w_i\}i=1,2......m$. Then MeanShift algorithm is used to calculate the need to detect the target of the new location of the human body. The formula is as follows:

$$y_1 = \frac{\sum_{i=1}^{n} x_i w_i g\left(\left\|\frac{y_0 - x_i}{h}\right\|^2\right)}{\sum_{i=1}^{n} w_i g\left(\left\|\frac{y_0 - x_i}{h}\right\|^2\right)} \qquad (3)$$

If $\|y_1 - y_0\| < \varepsilon$, then it will stop. Otherwise $y0 \leftarrow y1$ will be converted to recalculate the similarity between the candidate target and the target and add a restriction in the center of the new target which must be located near the original target center.

Experiments show that with the Nao robot recording video, the resolution is 320×240 and each frame is 15FPS. The algorithm will output the target histogram shown in Figure 1 and output candidate histogram as shown in Figure 2. It can finish tracking well. But the experiment environment is not blocked in the case. If there is block, it will not be able to track the pedestrian.

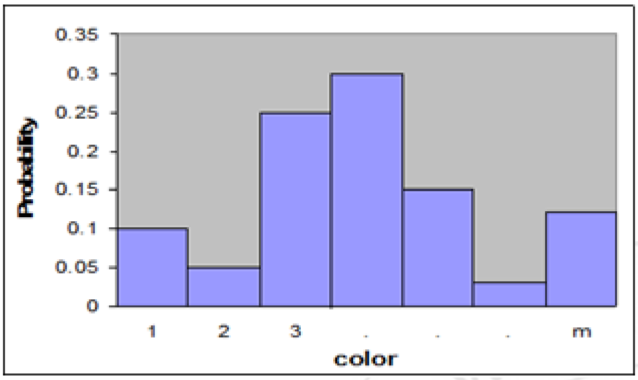

Figure1: Target histogram

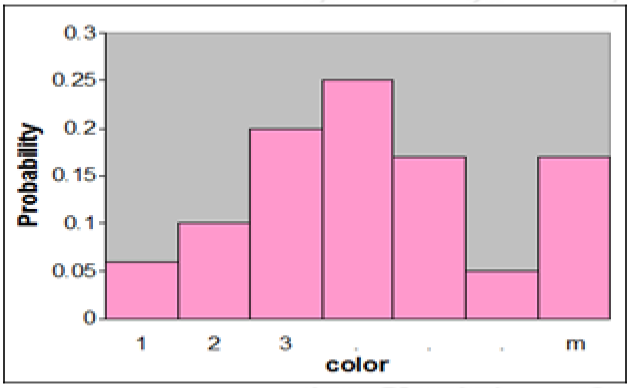

Figure 2: Candidate histogram

3. Camshift and Kalman Filtering Algorithm for Pedestrian Tracking

We can see that the RGB color space is sensitive to the brightness change of the illumination. In order to reduce the influence of the brightness change on the pedestrian tracking, the Camshift algorithm transforms the RGB color space into the HSV color space, which uses the H component to establish the histogram and the feature match. Setting the search center is the key to the Camshift algorithm. If (x, y) is the pixel position in the search window, $I(x, y)$ is the pixel value at the projection (x, y). Therefore, its search window centroid position is defined as the zero moment in the calculation window:

$$M_{00} = \sum_x \sum_y I(x, y) \tag{4}$$

Define the first order of x and y as:

$$M_{10} = \sum_x \sum_y xI(x, y) \tag{5}$$

$$M_{01} = \sum_x \sum_y yI(x, y) \tag{6}$$

This allows you to get the location of the search window centroid, defined as:

$$(x_c, y_c) = \left(\frac{M_{10}}{M_{00}}, \frac{M_{01}}{M_{00}}\right) \tag{7}$$

And then adjust the size of the search window according to center of mass M_{00}. The process of the algorithm is:

Step1: Initialize the search window
Step2: Calculate the color probability distribution of the search window (reverse projection)
Step3: Run the MeanShift algorithm to get the new size and position of the search window
Step4: In the next frame video image, the value in Step3 re-initializes the search window size and location. Then jump to Step2 to continue.

Kalman filter algorithm, a fast and efficient recursive estimation algorithm, can accurately predict the target speed and location. Kalman filtering uses state equations to describe the state of the transfer process. The state of the system and the observational equation are defined as:

$$X_k = A_{k,k-1} X_{k-1} + V_{k-1} \tag{8}$$

$$Y_k = H_k X_k + W_k \tag{9}$$

Where X_k and X_{k-1} are the state variables at time k and $k-1$, $A_{k,k-1}$ is the corresponding state change matrix. H_k is the observation matrix at time k, V and W represent the state noise and observation noise matrix. The corresponding variance matrices are Q and R. Let the respective values of the state vector $X_k = [x_{sk}, y_{sk}, x_{vk}, y_{vk}]$ represent the position and velocity in the x and y directions, respectively. The observation vector $Y_k = [x_{tk}, k, y_{tk}]$ represents the observation position of the target. The process of the algorithm is:

Step1: Calculate the position Y of the target by the Camshift algorithm.
Step2: Calculate the target $X_{k,k-1}$ using the Kalman filter algorithm.
Step3: Calculate the final position of the target.

4. Experimental Verification

In this paper, the Camshift and Kalman filtering algorithms are combined for track pedestrians. The experiment platform is Visual Studio 2010 and OpenCV2.4. The video sequence with 320×240 resolution is selected experimentally. Figure 3 shows the pedestrian is not subject to the beginning of the tracking effect. Figure 4 shows pedestrians are blocked when the preparation can be prepared to predict the effect of tracking. The experiment shows that the method has well property of real-time and robustness, especially in the case of complex background and occlusion. It also has well tracking effect.

Figure 3: Start tracking effect

Figure 4: Block after tracking effect

5. Conclusion

In this paper, a pedestrian tracking algorithm based on Camshift and Kalman filtering is proposed. The Camshift algorithm is used to iterately calculate the best matching window and spatial information. Kalman filter is used to predict the state of the moving object. Experiment shows that the method has the advantages of relatively and easily tracking the effect and application prospects.

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