An Efficient Moving Target Tracking Strategy Based on OpenCV and CAMShift Theory

Dongyu Li[1]

Abstract Image movement involved background movement and target movement. The complexities of movement increased the difficulty of target tracking. This study was implemented in the Window platform and the Microsoft visual C compiler environment, and used camera as a video capture device. The system of moving target detection and tracking was realized based on continuously adaptive mean shift and open computer vision theory, achieved moving target tracking by improving the algorithm. The experimental results showed that the proposed moving target detection algorithm was superior to the traditional mean shift tracking. It could track target efficiently, and further real-time drew motion trajectory.

Keywords: Object tracking, Moving detection, Color histogram

1 Introduction

Target tracking is an important research topic and key technology in visual surveillance, the theory is determined each frame in the motion state of research target in the sequence images, and realize the real-time tracking of the targets. At present, one of the key technologies in intelligent video applications were separating moving object from the video, detecting and extracting the research objects[1]. Moving object detection technology could be used to detect, classify and track objects in the scope of the camera monitoring the scene, and could be applied to all kinds of monitoring purposes. Such as illegally parked vehicles detection, perimeter security and intrusion detection[2]. On account of its broad application prospects and significant advantages, the research on moving object detection and tracking system has important significance for intelligent video monitoring system development[3]. In this paper, moving object tracking system was designed using OpenVC which is Intel open-source function database, it could invoke the video streaming of camera directly, and track moving object using the common Visual

[1] D. Y. Li (✉)
Department of physics and Electronic Engineering , Qujing Normal College, 655011 Qujing, China
e-mail: sym8295@163.com

c++ development platform. The advantages of this technology were short system development cycle, simple system framework and so on. At present，the arithmetic of background subtraction, optical flow estimation and digital image difference were used to study moving target detection commonly[4]. Due to the error at the process of image acquisition, the change of beam on the background and other factors, the effect of the arithmetic of background subtraction had been affected. The advantages of different method were simple algorithm framework and good real time, but the shortcomings were existed ghost image and discontinuous contour of tracking image.

Analyzed and compared the arithmetic of background subtraction, optical flow estimation and digital image difference，the improved algorithm of three frame difference was used to study the object tracking. The improved algorithm update the motion history image to eliminate ghost image，and expansion operation to dispel the discontinuous contour of tracking image. This method performs the real time tracking target under complex background[5]. The improved algorithm procedures are as follow：

- Detected moving object by three frame difference algorithm.

At first, the algorithm calculates the absolute difference $d_{(k-1,k)}$ and $d_{(k,k+1)}$ of adjacent two frames image. Secondly, binary process was used to threshold values, and obtained the binary image $b_{(k-1,k)}$ and $b_{(k,k+1)}$. At last, the position of ever pixel in the image $b_{(k-1,k)}$ and $b_{(k,k+1)}$ by using the Boolean and operator, and got the binary image D_k of three difference algorithm，that is moving object.

- Updated motion history image to eliminate ghost image.

In the MHI（Motion History Image），the move occur pixel was set to current time, the moving last long time pixel was eliminated. The function of update motion history image was showed below.

$$\mathrm{mhi}(x,y)=\begin{cases}\text{timestamp}, & \text{if } \ \text{silhouette}(x,y)\neq 0\\ 0 & \text{if silhouette}(x,y)=0,\\ & \quad \text{and mhi}(x,y)<\text{timestamp - duration}\\ \mathrm{mhi}(x,y), & \text{else}\end{cases}$$

In the function, “timestamp” is current time, “duration” is maximum duration time of moving tracking, “silhouette” is image mask code, there are nonzero pixel consist in moving frame.

- Expansion operation by 3×3 square-shaped structure elements to dispel the discontinuous contour of tracking image.

Based on the characteristic of image, circular-shaped or square-shaped structure elements could be used to dispel the discontinuous contour of tracking image. Because the results of difference algorithm include the square-shape inanition, so square-shape structure elements method was used to dispose the image. The 3×3 square-shaped structure elements method is optimal selection.

2 Moving Object Tracking Algorithm

OpenCV was provided by Intel Company, which is open computer Vision. It is consist of a serial of C functions and C++ functions, and include three hundreds of API. The application developers could familiarize the design possess of image, video disposal and computer vision rapidly. The well transplantable character and unified the framework of OpenCV could shorten the development cycle of system design, and the system is more stable. Base on the result of this algorithm, if the detecting the moving object which tally with requirement, the system will track the moving object automatically. The works that follow will ameliorate the algorithm using CAMshift program, and achieve tracking the moving object.

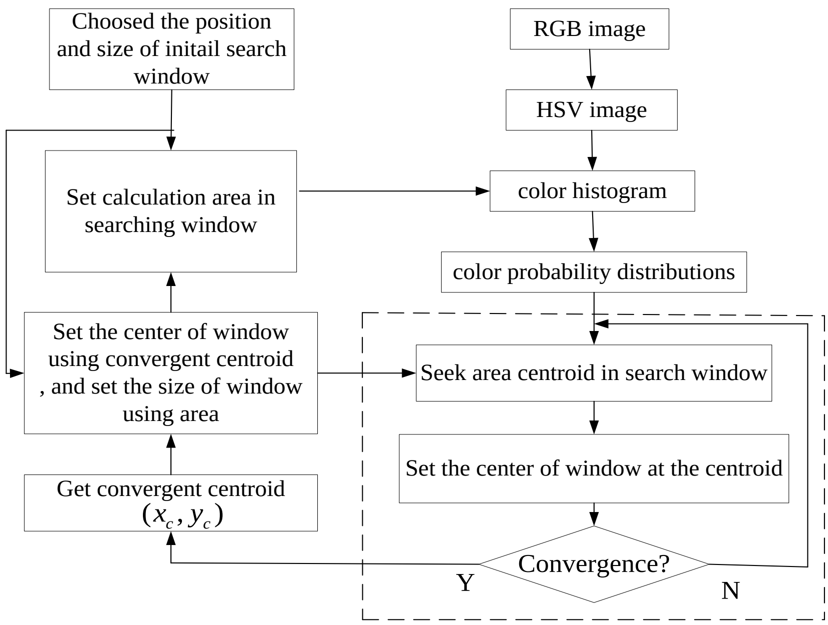


Fig. 1 The flow chart of CAMShift tracking algorithm

CAMShift (Continuously Adaptive MeanShift) algorithm track the object by detected the color information of moving object in the video. Figure 1 showed the flowchart of this algorithm. At first, every frame picture was translated into the form of HSV color space. The centroid and size was obtained by CAMShift algorithm to calculate the color probability distributions[6]. The dashed rectangle is hardcore of MeanShift program. The main algorithm was composed of three parts:

- Obtain the moving object area by the moving target detection part, and made the area as choose ROI, that is choose the initial search window .
- Back Project is calculate the color histogram of tracked target. In the every color space, only the HSV space had the H weight to denote color information. So in the calculation process, other color space must be transform to HSV space, and get H weight to compute 1D histogram of an image[7]. According to color histogram, the original image was transformed to color probability distributions image, this process was defined as Back Projection.
- Seek the centroid at currently frame by MeanShift algorithm. Choose the ROI area, and get the information of position and size. At first, calculated the centroid of window, and set the center of window at the centroid. Repeat the steps until the center of window is convergence. When seek the centroid at currently frame, the zero order moment must be obtained, it indicate the size of the area. the zero order moment was defined as follow：

$$M_{0,0} = \sum_{x,y} [I(x, y)] \tag{1}$$

Calculated the first order moment of X and Y:

$$\begin{cases} M_{1,0} = \sum_{x,y} [I(x, y)x] \\ M_{0,1} = \sum_{x,y} [I(x, y)y] \end{cases} \tag{2}$$

In this function, I(x, y) is the pixel of coordinate(x, y)， the range of variants x and y was the search scope. Calculate the centroid of window was (x_c, y_c) :

$$x_c = M_{1,0} / M_{0,0} \qquad y_c = M_{0,1} / M_{0,0} \tag{3}$$

Get the direction angel, minor axis and major axis of tracking object by calculate second order moment. The second order moment expressions as follow:

$$\begin{cases} M_{2,0} = \sum_{x,y} [I(x, y)x^2] \\ M_{0,2} = \sum_{x,y} [I(x, y)y^2] \\ M_{1,1} = \sum_{x,y} [I(x, y)xy] \end{cases} \tag{4}$$

The direction angel of object major axis expressions as follow:

$$\theta = \frac{1}{2}\arctan\left[\frac{2(M_{1,1}/M_{0,0} - x_c y_c)}{(M_{2,0}/M_{0,0} - x_c^2) - (M_{0,2}/M_{0,0} - y_c^2)}\right] \tag{5}$$

In the expressions (6), a, b and c was defined：

$$\begin{cases} a = M_{2,0}/M_{0,0} - x_c^2 \\ b = M_{1,1}/M_{0,0} - x_c y_c \\ c = M_{0,2}/M_{0,0} - y_c^2 \end{cases} \tag{6}$$

In the image, the length of object major axis and minor axis was calculated according to the follow function:

$$\begin{cases} I = \sqrt{\dfrac{(a+c) + \sqrt{b^2 + (a-c)^2}}{2}} \\ W = \sqrt{\dfrac{(a+c) - \sqrt{b^2 + (a-c)^2}}{2}} \end{cases} \tag{7}$$

- Using the CAMShift algorithm to achieve the target tracking. MeanShift algorithm was implemented to all frames of order images, and the calculation result of last frame was set as initial value of CAMShift algorithm search window of next frame. This iterative process may be continued until some criterion for convergence is met, and final realized the tracking to the targets with high precision.
- Programming：According to the algorithm，VC++ based on Windows was chosen as compiled platform. The function of OpenCV database was used to realize moving target detecting and tracking algorithm. As following, centroid projection algorithm was used to located center of calculation target. At last, improved CAMShift algorithm calculate the centroid information which obtained from centroid projection algorithm, and realize the real-time tracking of the targets. Figure 2 showed the neat flow chart of improved algorithm program.

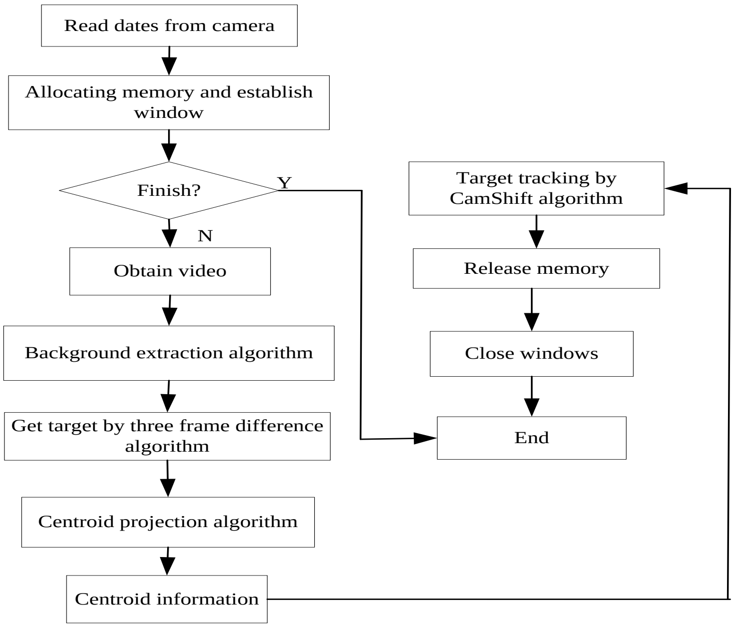
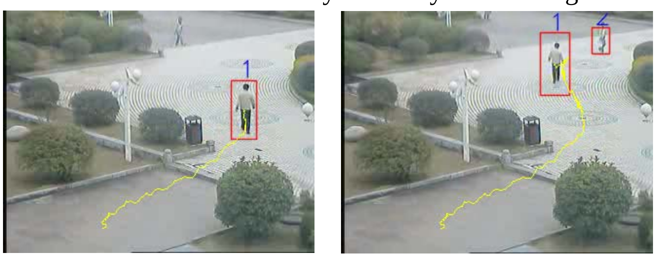


Fig. 2 The neat flow chart of improved algorithm program.

3 Results and Discussion

The target tracking system platform was composed of computer, display and camera. The realization algorithm is accomplished by VC++ platform. The video was obtained by a USB camera at campus, image size is 320×240 pixel, the frame rate varies is 10 frame per second. Compared the performance of the improved algorithm with the mean-shift algorithm, it was observed that both the improved and mean-shift algorithm were able to track the objects at mostly frames. Figure 3 showed the efficient tracking result of proposed system with improved CAMShift algorithm. Analyzed the experiment video, Figure 3(a) showed that two objects occur at 214th frame, the one is object 1 and the another is object 2. The object 2 was not be detected due to the color was very similarity in the background.

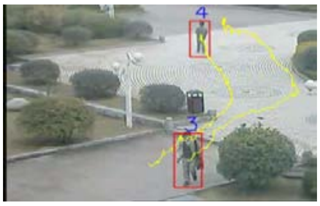


(a) 214th frame (b) 269th frame

(c) 286th frame

(d) 443th frame

(e) 555th frame



(f) 582th frame

(g) 691th frame

(h) 728th frame

(i) 744th frame

(j) 817th frame

(k) 862th frame

(l) 975th frame

Fig. 3 Selected frames of the tracking results from the video

4 Conclusion

In this study, an efficient detecting and tracking moving target system was proposed based on OpenCV function database platform. The known disadvantage of this system is that it had simple implementation platform and shorten periods. The improved algorithm showed its adaptation when the background was complex or there are object/background appearance variations. It had nice adaptations of different occasion by ordinary mend. In addition, we also showed that an optimistic tracking design still provides acceptable tracking accuracy and time consuming. The results showed that the improved algorithm was superior to the traditional MeanShift tracking algorithm. The objects could be detected efficiently, and further drew motion trajectory, its calculation complexity is much less than traditional MeanShift tracking.

Acknowledgment This study is funded by the science foundation of Qujing Normal College (Grant No. 2010QN026)

References

1. Babu R. V., Sures S. and Makur A.(2010) Online adaptive radial basis function network for robust object tracking. *Computer Vision and Image Understanding*, 114(3):297–310
2. Liu Z., Shen H., Feng G. Y. and Hu D.W. (2012) Tracking objects using shape conext matching. *Neurocomputing*, 83(4):47–55
3. Belaroussi R. and Milgram M.(2012) A comparative study on face detecting and tracking algorithm. *Expert systems with Applications*, 39(8):7158–7164
4. Mazinan A. H. and Latifi A.(2012) Applying mean shift information and Kalmanac filtering approaches to object tracking. *ISA Transactions*, 51(3):485–497
5. Yao A. B., Lin X. G., Wang G. J. and Yu S. (2012) A compact association of particle filtering and kernel based object tracking. *Pattern Recognition*, 45(7): 2584–2597
6. Vu T. D., Burlet J. and Aycard O. (2011) Grid-based localization and local mapping with moving object detection and tracking. *Information Fusion*, 12(1):58–69
7. Karasulu B. and Korukoglu S.(2012) Moving object detection and tracking by using annealed background subtraction method in videos: Performance optimization. *Expert Systems with Applications*, 39(1):33–43