Research on multi vehicle tracking based on TLD optimization algorithm

Chao Wang*, Lei Huang, Zhiyuan Li
Zhengzhou Institute of mechanical and electrical engineering, China
wlzx@csic713.com.cn
854909839@qq.com

Abstract. With the increasing complexity of traffic conditions, the research on multi tracking technology of vehicle targets has become a hot topic. In this paper, a multi vehicle tracking algorithm based on TLD optimization algorithm is proposed, including TLD optimization algorithm of detection module and KCF algorithm of tracking module. The experimental results show that the proposed algorithm has small time delay in multi vehicle target tracking, and it can track multiple targets stably and meet the performance requirements.

1. Introduction

With the increasing number of urban vehicles, China's urban traffic system is facing many problems. Therefore, we need to timely monitor and supervise the road system and vehicle flow. As an important branch of intelligent transportation system, traffic information acquisition system plays an extremely important role in tracking and detecting targets. Especially, the moving object detection technology is the key to help it quickly and effectively collect video information. Therefore, at home and abroad began to strengthen the research of moving target detection technology, and constantly optimize its tracking technology, in order to detect and analyze the target faster and better.

Among them, most of the foreign researches are based on the combination of theory and practice. For example, the advanced research projects agency of Defense (DARPA) developed the (VSAM) system jointly with Carnegie Mellon University and salno company in the United States [1]. Instead of using a single camera for monitoring, it uses multiple cameras and adopts multi-directional and multi angle monitoring mode to realize complex scenes. Although this system is mainly used in the construction of campus information system, it also plays an important role in many fields such as traffic monitoring and community monitoring. Taking TLD algorithm as the basic framework, Su Jia et al. Used the frame difference method in the detection module to detect the foreground, reducing the detection area and improving the detection speed; in the tracking module, the kernel correlation filtering algorithm was used, and a new update strategy was adopted. The filter model in the tracker was updated by the tracking results of the detection module. The single target tracking robustness and accuracy in the OTB test are very good. However, in the case of multiple targets, the accuracy can not meet the requirements [2]; Wang Jun [3] applied the algorithm based on foreground image and gradient image to vehicle detection, which improved the detection efficiency, but the adaptability of the algorithm was poor, and the tracking stability was not good in the case of occlusion; Guo Xiaoguang [4] proposed the improved vibe detection algorithm and multi-target tracking based on region matching Association, which had good application Scene, the next step is to improve the real-
time performance; the TLD algorithm based on hog-svm detection proposed by Tian Changsheng [5] has significant effect on pedestrian tracking, but it is not applied in multi vehicle scenarios.

2. TLD optimization algorithm for dynamic detection

Compared with other online detection methods, the detection effect of TLD algorithm is slightly better than that of other online detection methods. However, in the tracking process, there may be multiple targets or many similar targets, so its detector needs to compare and analyze every suspected target in the video. At the same time, in the whole video monitoring system, there are many sub windows, each sub window The target vehicles displayed are not the same, which not only reduces the efficiency and real-time performance of target tracking, but also requires us to spend a lot of time to check and detect them. Therefore, in order to improve the accuracy of tracking results and ensure the tracking speed, we began to optimize and upgrade the TLD detection algorithm, and extended the dd-tld algorithm. Firstly, using the dd-tld algorithm, the detection range of the detector can be shortened as much as possible, so as to improve the tracking efficiency and save time. At the same time, this method can also be effective according to some characteristics of the target. Identifying similar targets helps us to quickly find the final target we need.

2.1. Double Kalman filter for acceleration correction

There are many algorithms to predict the target position. Because the ultimate purpose of the target location prediction is to reduce the detection range and speed up the detection time, we should choose an efficient and fast prediction method. Kalman filter can track the target in time and effectively, and greatly improve the accuracy of detection. The principle of Kalman filter is to analyze and predict the posterior distribution of tracking state in detail combining with its recursive equation, so that the target to be tracked can be accurately found. However, in the case of some background changes or moving targets that are difficult to master, it is far from enough to rely on the recursive equation of Kalman filter to analyze and calculate, not only the detection time is long, but also the detection time is long. Therefore, the velocity dimension is introduced into the recursive equation to construct a detection region optimization algorithm based on Double Kalman filter [6] acceleration correction prediction.

2.1.1 principle of DKF algorithm

DKF[7] algorithm needs to make two Kalman filter predictions in the process of one prediction, and use the prediction results of the first iteration to correct the control vector of the second prediction. The model of dkf algorithm is shown in Figure 1. In the figure, the circle represents the system vector, the square represents the matrix, the regular hexagon represents the Gauss noise, and the corresponding covariance matrix is marked at the bottom right. As can be seen from the figure, we use K0 for the first prediction and K for the second prediction. Firstly, in the first prediction process, we transfer the system vector x in the state of k-1 to the matrix f to obtain the system vector x at the state of K0. At the same time, we can also obtain the time vector X through the Gaussian noise w of the covariance matrix Q. Then, in the state of K0, the system vector x obtains the time system vector Z through the matrix H. But vector Z is affected by Gaussian noise V of covariance matrix R. Then the system is updated to enter the second prediction. The second prediction is transferred from the first prediction. First, we calculate the state vector X of the production time k by the system variable x at K0 of the transfer matrix F, and then the control vector U of the K time passing through the transfer matrix G and the Gaussian noise w whose covariance is Q at k time. At the same time, the produced state vector x at time k can obtain the observation vector Z at time k through the observation matrix H, and Z is also affected by the Gaussian noise V whose covariance at time k is r. Finally, the observation vector Z at time k is used to change the whole system to generate the optimal prediction vector. So far, the two Kalman predictions are completed. Through the two compensation predictions, the convergence speed of the original Kalman filter can be accelerated and the target position can be predicted more accurately.
2.1.2DKF Implementation process
In the operation of dkf filter system, after each prediction, the predicted acceleration is taken as external error to accelerate the predicted position of the target, and then a smart measurement operation is performed. This can accelerate the convergence speed of the original Kalman filter and predict the target position more accurately. The structure of Kalman filtering system includes two-way prediction[8]. The state equation of the first prediction is as follows:

\[ x_{k0} = Fx_{k-1} + w_{k0} \]  

The observation equation of the first prediction is as follows:

\[ z_{k0} = Hx_{k0} + v_{k0} \]  

The equation of state for the second prediction is as follows:

\[ x_k = Fx_{k0} + Gu_k + w_k \]  

The observation equation of the second prediction is as follows:

\[ z_k = Hx_k + v_k \]  

2.2. flow of dynamic detection optimization algorithm
In order to optimize the traditional TLD algorithm, we add the detection region optimization algorithm based on double Kalman filter acceleration correction prediction to the TLD detector of the algorithm, in order to track the target more quickly and improve its detection efficiency. When detecting in advance, we should first determine the approximate position and moving speed of the tracking target in the previous picture, and then use the dkf algorithm to calculate the moving speed of the tracked target in the current picture by using the sum of the horizontal and vertical displacement vectors of the target position from one frame to the next frame, in pixel / frame. Determine its location. Then, we determine the length and width of the detection range according to the moving speed of the moving target, and then roughly estimate the center position of the detection area according to the predicted position of the target. Finally, all the sub windows which roughly coincide with the prediction region are submitted to the detector, and then the detector compares them one by one to find the final target we want. However, if the detector fails to detect the target we are looking for due to other objective factors, we need to analyze the sub window outside the detection area again to ensure that it is safe.

3. Improved TLD tracking algorithm
The tracking module of this algorithm uses KCF[9] algorithm to track, and on this basis, the tracker update strategy is added. The detection results are used to modify the tracking results of the previous
frame, and then the filter model of the current frame is updated with the modified results of the previous frame with a certain learning rate, so as to further enhance the robustness and accuracy of the tracking module. The tracking module process and update strategy framework are shown in Figure 2.

4. Experimental results and analysis
The experimental platform to verify the performance of the algorithm is visual studio 2010, opencv2.4.4 image processing library, running on Windows 7 ultimate operating system, hardware environment is Intel Xeon X5650 @ 2.67GHz processor, memory 8GB.

In order to fully demonstrate the effectiveness of the algorithm, this paper selects 100 sets of test videos from OTB [10], the authoritative test data set platform in the field of target tracking, to complete the experiment.

The dkf detection algorithm and KCF tracking algorithm are used to track multiple vehicles in the test video. 85 and 115 frames of the video are intercepted, as shown in Fig. 3(a) and Fig. 3(b). It can be clearly seen that the vehicles appearing in the field of view are marked according to the time sequence and can be tracked in real time. In order to verify the anti-interference performance, three can be marked at a time, and if more than three vehicles are not marked for tracking. It is found that when other vehicles appear in 115 frames, the gate can also track stably, and the performance meets the experimental requirements.
5. Conclusion
In this paper, the dynamic detection algorithm is used to design the detector. The core of the algorithm is to design a two time Kalman filter with acceleration correction, which can speed up the detection speed and improve the efficiency of target recognition. In the tracking algorithm, KCF algorithm is used to modify the tracking result of the previous frame, and then the modified result of the previous frame is used to improve the learning rate. The new current frame filter model further enhances the robustness and accuracy of the tracking module. In this paper, we only study the multi-target tracking in normal weather, and the multi-target tracking in bad weather such as snow and rain has not been verified, which is the direction of the next work.

References
[1] Trademarks; Trademark Application for "VSAM I/O PLUS" Filed by EMC Corp.[J]. Computers, Networks & Communications,2016.
[2] Su Jia, Gao Lihui. Improved TLD tracking algorithm using frame difference method and correlation filtering [J]. Computer engineering and design, 2020,41 (06): 1694-1700(in Chinese).
[3] Wang Jun. implementation and optimization of vehicle detection and tracking image processing algorithm based on bwdspl042 [D]. Anhui University, 2016(in Chinese).
[4] Guo Xiaoguang. Research on vehicle multi-target tracking and feature extraction in traffic video [D]. Tianjin University of technology, 2017(in Chinese).
[5] Tian Changsheng. Research on pedestrian tracking with PTZ camera based on improved TLD algorithm [D]. Harbin Engineering University, 2017(in Chinese).
[6] Qu Haicheng, Shan Xiaochen, Meng Yu, et al. TLD target tracking algorithm with dynamic adjustment of detection region [J]. Computer applications, 2015 (10): 277-281(in Chinese).
[7] Chang Kai. Research on short-term power prediction of micro grid group based on dkf algorithm [D],2016.
[8] Liu da. Research on video coding based on dual reference frame motion compensation [D],Harbin Institute of technology.
[9] Huang Nan, Lu Feng, Wang Qinzha. Parameter configuration of KCF algorithm in vehicle target tracking [J]. Software engineering, 2019 (9): 12-16(in Chinese).
[10] Xu Zheng. Research on target tracking method based on deep learning [D]. 2020(in Chinese).