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Vehicle Detection and Tracking Based on GSM and Enhanced Camshaft Algorithm

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***Abstract*—Vehicle detection & tracking is an important part of the intelligent transportation system with the rapid development of computer vision, video based vehicle detection and tracking technology has become a hot topic .In this paper, on the foundation of the present work, an enhanced detection tracking algorithm is proposed based on the popular gauss mixture model (GMM) and camshaft first, GMM is used to extract the foreground, and them the morphological operations is carried out to enhance the image, so that to remove the random noises. Finally, enhanced camshaft is designed to track the vehicle which is discussed in detail below. The experimental results demonstrate that the tracking accuracy can be improved.**

***Index Terms*—Vehicle Detection, Vehicle Tracking, GMM, Number detector.**

I. Introduction

Nowadays, with the sharply increasing of city transportation burden, it is urgent to build a real-time and efficient ITS (Intelligent transportation system) [1] which is applied to traffic control and road traffic information collection. As the primary level of ITS, the detection and tracking of on-road vehicles timely and effectively become an important task, because it determines the performance of the following upper-level task-vehicle behavior analysis .The integrated information of the vehicle features gathered in the lower level are imported into the highest level to model and predict the typical on-road behavior and goals of other vehicles on the road .Based on this, many researchers devote to the researchers devote to the researchers devote to this hot topic. For decades of years, many algorithms and frameworks are proposed Due to the development of computer vision-based based detection and tracking have become the camera, the vision-based detection and the popular research branch. Regard to the detection, there are two technical frameworks; appearance –feature and motion-based. For the former, the appearance, such as the size, shape and color etc. is extracted by some typical descriptors including HOG, SURF, gobor, Harris and optical flow etc. considering the dynamic of vehicle, motion- based algorithms are given in .During the tracking stage, the verified vehicles are tracked in subsequent images by various tracking filters, such as the typical kalman filter. Particle filters, and mean-shift .In recent years, deep learning is also applied to vehicle detection. But the process of training the model takes too long and has high requirement, for hardware. For balancing the performance and cost, it comes to number detector. A Based on mean-shift filter, number detector proposed to deal with the target deformation and occlusion. For better tracking accuracy in the complex environment, the enhanced number detector method is proposed because of its good performance in solving the adhesion vehicle tracking. The rest of the paper is organized as follows: Section 2 describes the vehicle detection and tracking methods in detail. Section 3 shows the experimental results of the proposed method and conclusion of the word is given in section 4.

II. Proposed method

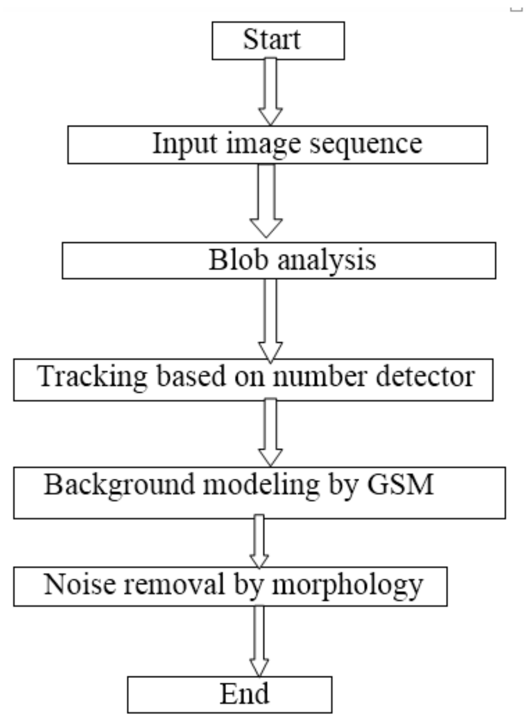

Fig. 1. Block diagram

Concentrated on designing valid vehicle detection and tracking algorithm, in the paper, the extra noise removed by morphology operator after are background suppression. Additional, the GMM and enhanced number detector method

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are discussed 40 enhance the accuracy and efficiency of vehicle tracking. The flowchart of the proposed method is given in Fig. 1. According to the flowchart, the work is carried out by five steps which is inputting image sequence, background modelling by GMM, noise removal by morphology, blob analysis and tracking based on number detector one by one. In this section, a detailed description of the algorithm is given in the following. Figure1. The flowchart of proposed method

A. Step-1: Input Image Sequences

The image sequences are collected by the camera setting up on the over bridge and decomposed into frames.

The frames can vary from 1 to n so they can be accepted by the System one by one. The above step can be accepted by the system one by one. The about step can be expressed as follows.

$$V = \{F1\}, I = 1, n$$

Where, V is the frames collected and represents the total number of frames in the sequence.

B. Step-2: Background Modeling By GMM

GMM is a density model composed of several components of gauss function. It models each pixel as a mixture of two or more Gaussians temporally with online updated. These distributions are estimated as either a stable background process or short-term foreground process by evaluating its stability. If the pixel distribution is stable above threshold, then it is classified as background pixel. This method is suitable for background extraction process because of its good performance in multiple target detection and changes of light. Gauss mixture model is widely used in background modeling. In the proposed method, 40 frames of the video without cars are selected to model the gauss background.

C. Step-3: Noise Removal by Morphology

After step 2, the background is achieved by GMM and them the foreground is segmented by subtracting the background from the original image. However, there still exist some noise which is caused by changing light and other disturbances. In order to remove the unwanted noise as much as possible the morphological opening and closing operators are elimination the noise with sharp edges caused by traffic lights, sign posts etc. Further it can fill the holes due to the subtraction operation and forming multiple single-connected components. As shown in Fig. 2, it is clear that after the morphological operator the foreground is composed of several connected regions without holes.

D. Step-4: Blob Analysis

After the noise removal, the foreground objects a is achieved by extracting the connected component. In this section, the Blob analysis method. Is used to detect cars. Blob analysis is used to analysis the connected region of the same pixel in the image. In the experiment. Every connected component is treated as a vehicle marked by a bounding box.

The camera is fixed on the bridge so the area of vehicles have a certain range in the image. To extract the candidate vehicle the connected component whose size doesn't meet with the range limitation will be removed. Large amounts of data are collection for the Gauss distribution fitting to get the satisfied threshold of vehicles' area in the image. Finally 400 is chosen as the minimum area of the connected component are assigned a bounding box tag. The Fig. 3, shows the result of blob analysis.

Fig. 2. Original frame

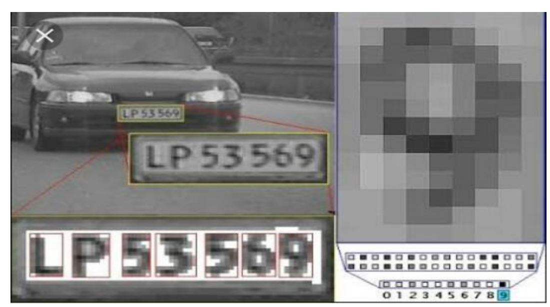

Fig. 3. Blob analysis

Fig. 4. KLT tracking

The algorithm uses cost matrix to record the position of cars and predicted cars. For cost matrix, the number of column is equal to the number of row is equal to the number of cars in the previous frames. The cost matrix records the distance between the centroid of each car predicted by last frame and the one in the current frame. It can be expressed as formula.

E. Step-5: Tracking Based on Number Detector

1) Number Detector Algorithm

Number detector is an improved version of the mean shift algorithm for video object in one dimensional histogram which is applied to find the peak of the probability density histogram back projection. Its basic idea is that all frames of the video image are performed. Mean shift operation, and the operation result of the previous frames (the center and size of the search window) is taken as the initial value of the search window in the next frame with the mean shift algorithm. Number detector has been widely used in face recognition. Due to its excellent performance in the face recognition area, it is creatively applied to road vehicle detection in this paper. The principal of number detector can be summed up as the following Steps.

Step-1: Select the ROI which contains the vehicle object.
Step-2: Convert the frame to HSV model.
Step-3: Generate the object model using the ROI image.
Step-4: Use histogram back projection to create probability density image.
Step-5: Use Mean-shift to find the centroid of the object.
Step-5: The new position is treated as the new ROI for the next frame.

F. Enhanced Number Detector Method

The original number detector could not be applied to vehicle tracking directly because it’s too sensitive to noise and adhesion of the vehicles. So in this section, some constraints on the original number detector method are introduced to enhance the tracking performance. From the start frame of one video, each detected vehicle target is identified by an identity by an identity (ID) which could uniquely identify a car as shown in Figure 4. The number of column. J is equal to the number of row.

cost(I,j)=[(track(i).centroidx-detection
(j).centroid.x)^2+(track(i).centroid,y)^2]^1/2

After generation the cost matrix, it comes to the enhanced part .If the distance in the cost matrix is less than 20, it’s considered that the car appears again in the next frame. The location information of this car is updated with the new location. The car in the current frame is called to be matched. If the target in the current frame is called to be match, then its location would be stored and it would be treated as a new car which just appears. If the car in the last frame doesn’t have a target to match, without considering it having disappeared at once, the system watches for 20 frames and uses the predicted location to update its location .If still no car could match it in 20 frames. It’s finally considered that the car disappeared. But if a car can’t have a match when it appears within the time of 8 frames, it’s just considered that the object was noise and just let it disappear. All of the parameters are obtained by doing a lot of experiments and comparing their performance. The performance of the enhanced number detector method will be discussed in detail in the following section.

III. EXPERIMENTAL RESULT

The performance of the proposed method is compared with the number detector algorithm without the enhanced details above. The experiments have been performed in MATLAB version 2018a an Intel(R) Core(TM) machine with 4GB RAM. A digital camera is set up on the bridge whose height is same with the traffic light in china. The video which were used to test can be broadly categorized into three types. (I) Video of road with only cars, (II) video of road with different kinds of road with different kinds of vehicles like bicycle and bus which is not the detection kinds of vehicles like bicycle and bus which is not the detection target. (III) Video of road with vehicle adhesion. The performance of the proposed method is discussed in the three scenes in detail.

IV. CONCLUSION

In this article, an enhanced vehicle detection and tracking method is proposed. The GMM and enhanced Camshaft provide a better solution in solving the problem of vehicle detection and tracking in complex road environment. The proposed method have addressed the complex situations in the experiment and generated better quality of results. The experimental result shows that the proposed method has certain advantages in the city road environment for vehicle Kaiyang Zhong et al.: Vehicle Detection and Tracking Based on GMM and Enhanced Camshaft Algorithm detection and good robustness in the complex road environment. The experimental result contributes to intelligent transportation system. In the future, we will continue to optimize the algorithm to realize the detection and tracking of vehicles in more complex road environment.

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