Video Monitoring System Application to Urban Traffic Intersection

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Abstract. Intelligent video surveillance technology can reduce the burden of workers and improve the efficiency of surveillance. A project of the video monitoring system with moving target detection function has been realized and applied to the urban traffic system. The background will have weak or obvious changes as time goes on, such as, the illumination change, the environmental effect, the movement of the background, and so on. If we always use the original background model, it will cause large error. Fixed threshold is not suitable for illumination change in the environment. An improved adaptive on-line Gauss mixture model is used to acquire the background model, and the background subtraction method is used to match the moving objects. Then, the motion detection function was realized in a specific region. If there are abnormal moving targets in a specific area, the linkage alarm function will be activated and handled by manual intervention. This algorithm can effectively reduce the error probability of target recognition caused by environmental changes, and provide strong technical support for real-time monitoring of traffic abnormalities.

Keywords: Video monitoring · Urban traffic · Gauss mixture model · Background subtraction method · Motion detection

1 Introduction

With the development and popularization of the computer and network, the urban traffic intersection monitoring system on the base of digital degree can be justified now. The modern solution project can make the roadway more high-speed, much safer and more efficient. ITS (Intelligent Transportation System) is a uniform information system. The design of the data information's net must be synchronous with the construct of the urban traffic system. With the construct of ITS's WLAN [1, 2], the data can be collected and the relative data of the accidental and road condition's can be statistical. The urban traffic intersection monitoring system [3, 4] is also a part of this integrated system. The basic principle is which called "Everything over IP". In the whole system, every device has been digital processed. When given the appointed address, the authorized user can visit all the data information freely [5]. All the data files, including the transmission of the vehicle's image files can be transmitted through the IP network. So, it can be concluded that the network is the basis of the whole system.

H. Song et al. (Eds.): SIMUtools 2019, LNICST 295, pp. 339–345, 2019.
https://doi.org/10.1007/978-3-030-32216-8_32

The paper develops a wireless video-monitoring project, which is based on the Web, and adopts the newest imbedded network camera. The video signals will be collected by the camera and then be coded, and the wireless network [6] will transmit the video data. First, the paper simply analyzes the virtue of multicast communication in a Local Area Network (LAN) [7]; expound the technical concept, the characteristic and the principle of the IP network multicast. Then, an improved adaptive on-line Gauss mixture model is used to acquire the background model, and the background subtraction method is used to match the moving objects. The motion detection function was realized in a specific region. Finally, experiments show that the target detection algorithm is effective. If there are abnormal moving targets in a specific area, the linkage alarm function will be activated and handled by manual intervention.

2 Realization of the System

We deploy one set of network camera at each roadway of the traffic intersection, using it to monitor the whole scale of the orientation of this roadway at the traffic intersection. We deploy one set of video server for each camera. The video server connects with the camera and the network. Its duty is to code and then to transmit the video signals collected by the camera through the network. In the monitoring center's client server of the urban traffic monitoring system, the job of monitoring and query can be done. We adopt the way of video recording when the vehicles arrive, and make it work 24 h a day to shoot all the vehicles that pass by, then give the digital video pictures to the computer to deal with directly.

After the set up of the hardware in the whole network, we also need a set of management system to make them work in phase. We can adopt a set of digital monitoring system to achieve these complicated works. The diagram of Fig. 1 can show the process.

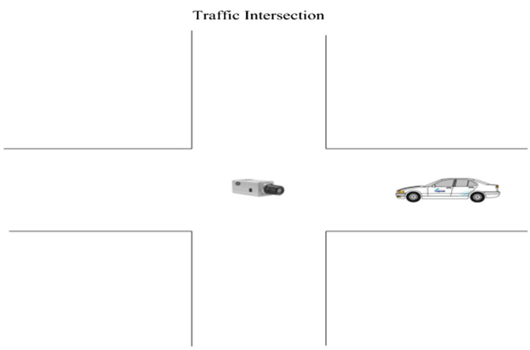


Fig. 1. Theory's diagram

The paper expounds the traffic intersection vehicles monitoring system's principles as follows:

2.1 System of the Traffic Intersection

Firstly we use a camera to video record all the vehicles passing by the toll station. Each one just records three to five seconds of these vehicles, so the quantity of the data will not be too large. Then we use the video server to connect the camera and the net to realize the digital code and transmission. Finally a main application server should be installed and a client server should be installed in the computer to check the pictures of the vehicles.

2.2 Function of the System

Firstly according to the need of the monitoring system, we can monitor any one, four, nine or sixteen pictures of these cameras installed and the main screen picture can be designed according to the need of the manager. Each application server should store all the vehicles' video files recorded by all these thirty-two cameras. The video record should be circular and all the video files should be stored of the latest one month. Different people should be given different permissions and doing their own business according to this. So using this technique, the system can be safe and reliable. All the servers can form an Intranet and communicate by "TCP/IP" and they can also link to the available network. The users can set their own names and passwords to monitor all sorts of information at anytime anywhere.

3 Realization of Alarm Linkage

3.1 Background Modeling

In actual environment, the background will have weak or obvious changes as time goes on, such as, the illumination change, the environmental effect, the movement of the background, and so on. If we always use the original background model, it will cause large error. So it needs update the background in time. Fixed threshold is not suitable for illumination change in the environment. The system uses an improved adaptive online Gauss mixture model to detect moving targets.

For a location point on the image plane, the historical data of I are recorded as $\{\mathrm{X}_1, \mathrm{X}_2, \cdots \mathrm{X}_{t-1}\}$. The characteristics of pixels are described by L Gauss distribution. The background gradient is represented by online updating. L = 8 is selected for modeling in the program. The estimated probability distribution of t time observations is as follows.

$$P(X_t) = \sum_{i=1}^{L} \omega_{i,t-1,l} \times \eta_l(\chi_{i,t}, \mu_{i,t-1,l}, \sum{}_{i,t,l}) \tag{1}$$

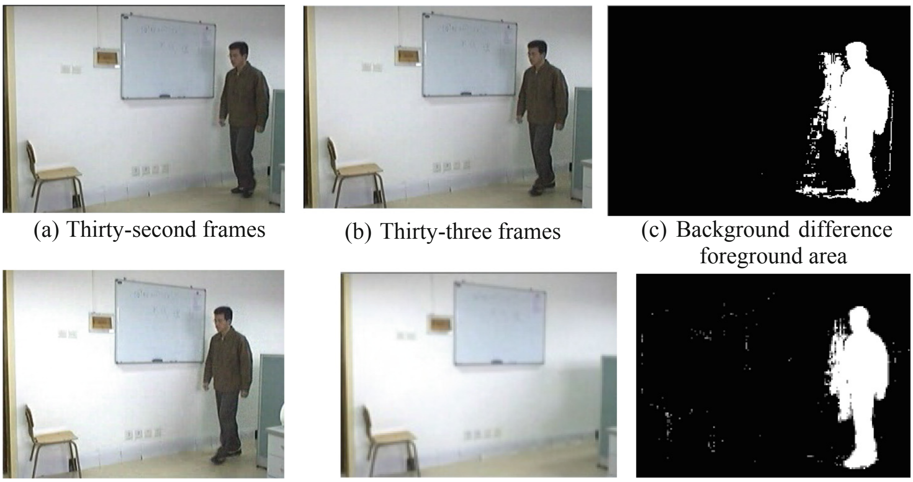
$\omega_{\mathrm{i,t-1,l}}$ is the weights of l Gauss distributions at T-1 time, $\mu_{\mathrm{i,t-1,l}}$ is the mean vector of Gauss distribution, η_l is the probability density function of l Gauss distributions and $\sum_{i,t,l}$ is a covariance matrix. The L models are queued according to the probability from large to small. The front of Gauss model represents the background and back of

Gauss model represents the foreground image. In the next frame, the brightness values of the pixels in this position are matched with L models respectively, so as to determine whether they belong to the foreground or background, and the updating model is based on the maximum matching degree.

3.2 Object Detection

In the system, video images which had been collected and compressed would be transmitted to the background server. The background server is responsible for distinguishing the moving regions, and extracts several moving regions from each image. Local region matching extracts the foreground motion region by adaptive Gauss background modeling, removes the unconcerned background region and reduces the matching range. In the same scene, there may be multiple moving targets, so matching requires matching between different targets. The two regions with the highest matching degree are matching targets. In this paper, background subtraction is used to match moving targets only.

Figure 2(a) and (b) are video thirty-second, thirty-third frame images. (c) is the foreground area detected, but it is extremely sensitive to external dynamic scene changes such as illumination and weather changes, with shadows appearing. (d) is an Illuminated image. (e) is the result of the background model based on Mixture Gauss Model. (f) is the result of foreground area detected after improvement. Through comparison, we can see that the algorithm has better target effect and smaller noise.



(a) Thirty-second frames (b) Thirty-three frames (c) Background difference foreground area

(d) Light image (e) Background model (f) Foreground area under Gauss model

Fig. 2. Target extraction in light changing environment

3.3 Motion Detection Parameters

Step 1: Set the resolution of motion detection, that is, according to the format of video (PAL, NTSC) and image resolution (CIF, 2CIF, etc.) as shown in Fig. 3.

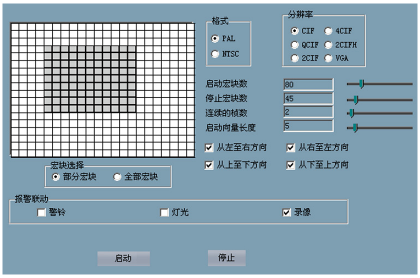


Fig. 3. Configuration of alarm linkage

Step 2: Set threshold values of start and stop motion detection. It is required that the threshold value of start is greater than or equal to the threshold value of stop.
Step 3: Set the number of continuous motion frames to start the alarm.
Step 4: Set the macro block size for motion detection.
Step 5: Set the direction of movement of macroblocks.
Step 6: Set the boot mask parameter and set the mask value.
Step 7: Start/Stop motion detection.
Step 8: Display the range of moving objects on the display screen.

3.4 Algorithmic Process

First, two consecutive frames are extracted from video. Then, an improved adaptive online Gauss mixture model is used to acquire the background model, and the background subtraction method is used to match the moving objects. Finally, the motion detection function is realized in a specific region. The algorithm process is shown in Table 1.

3.5 Operation Results

Figure 4 is the result of the video surveillance system when it starts motion detection. It shows that the yellow rectangular block is the moving part. Using the detection interval set in Fig. 3 and the improved background subtraction method, the moving regions in two or three adjacent inter-frame images are extracted. When the moving area is detected, the alarm program can be started, and the alarm information can be forwarded to each client by the server.

Table 1. Algorithmic process

Step	Algorithm
1	Import video
2	Extract two consecutive frames;
3	Record the historical data of I $\{X_1, X_2, \cdots X_{t-1}\}$
4	Estimate probability distribution of t time observations
5	Queue up the model
6	Get background model
7	Match the brightness values of the pixels in this position
8	Update model according to the maximum matching degree
9	Use background subtraction method to match the moving objects
10	Set motion detection parameters
11	Activate alarm linkage

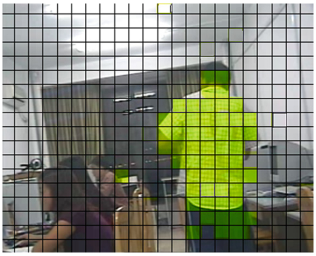


Fig. 4. Test of alarm linkage

4 Conclusion

The experimental results show that if the original background model is unchanged, the detected target will have errors. In this paper, motion detection technology based on improved adaptive online Gauss mixture model is applied in video surveillance system. This algorithm can effectively reduce the error probability of target recognition caused by environmental changes, and provide strong technical support for real-time monitoring of traffic abnormalities. The monitoring system has the advantages of wide monitoring range, adaptive moving target detection, good flexibility and high quality, so it is suited for using in the urban traffic system.

Acknowledgements. This work is partly supported by the Natural Science Foundation of Jiangsu Province of China (No. BK20161165), the Key Laboratory of Intelligent Industrial Control Technology of Jiangsu Province Research Project (JSKLIIC201705), Xuzhou Science and Technology Plan Projects (KC18011, KC16SH010, KC17072), Ministry of Housing and Urban-Rural Development Science and Technology Planning Project (2016-R2-060).

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