Research on Urban Intelligent Traffic Monitoring System Based on Video Image Processing

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Abstract

With the continuous development of computer technology and intelligent technology, more and more traditional industries complete transformation relying on the new intelligent industry. In urban traffic monitoring, traditional methods use video image acquisition equipment to collect all the data and then rely on the manpower to complete the monitoring process, not only waste a lot of artificial resources, but also the efficiency is low, the error rate is high. On the basis of computer and intelligent technology, the video image processing technology is adopted in this paper, the prototype of a city intelligent traffic monitoring system is constructed, this paper focuses on the analysis of the functional design of intelligent traffic system, video image processing and database analysis module based on summary. The system can bring intelligent analysis to the traditional traffic control industry with the current increasing data quantity and increasing data analysis's difficulty, not only can save a lot of manual monitoring and control processing, but also the efficiency is high, the real-time analysis results can be achieved.

Keyword: video image processing; intelligent technology; monitoring system; vehicle analysis; license plate analysis

1. Introduction

With the rapid development of internet of things sensor technology, network transmission technology, computer technology, artificial intelligence technology, Europe and the United States began to try to use these new technologies in all walks of life to improve the intelligence and wisdom level. Especially in the field of traffic, research which was applied by high and new technology to enhance the management level, ease traffic pressure, enhance traffic safety is increasing, and then a new field of research, intelligent traffic is produced [1].

At present, the application of Internet of things technology in the field of intelligent transportation has been mature. Video surveillance technology based on image processing is an important part of the Internet of things technology, it is the most important and direct way to realize multi information perception [2]. How to optimize and transform it with new technology, so that it can better adapt to the development trend of intelligent video surveillance in the era of Internet of things, providing more powerful support for the work of public security traffic management department is imminent. The main research in this paper is based on the Internet of things video sensor technology, computer technology and other high-tech, intelligent traffic monitoring system which is based on video image processing of the public security traffic management department's actual business needs as the starting point [3].

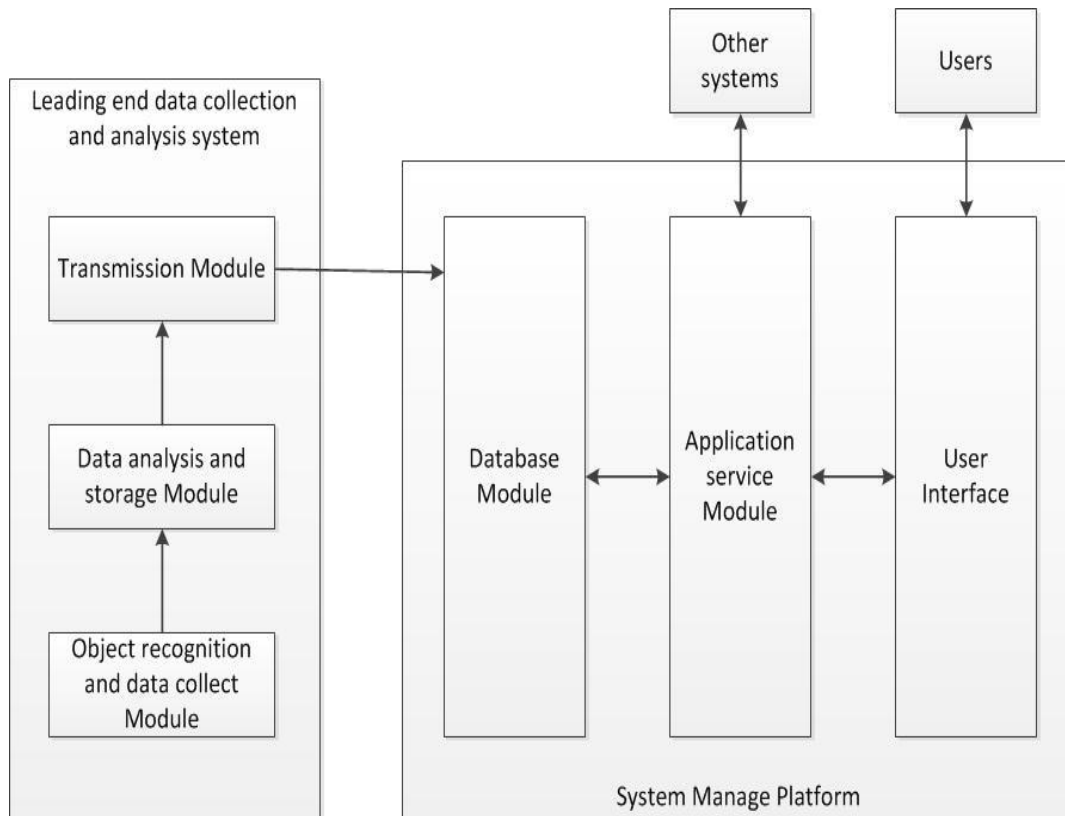## 2. Design of Intelligent Traffic Monitoring System

2.1. Overall System Design

To achieve the goal of intelligent transportation system (ITS): Using video monitoring system to collect the information of road vehicles, using the algorithm to deal with the vehicle information returned by the analysis and compared with the rules set by the system, If there is any illegal behavior (trailing, decks, vehicle crime), the system realizes the real-time alarm, and automatically capture the image, save normal travel vehicle image information, routine data statistics query and other operations[4]. The hardware system architecture of intelligent traffic monitoring system is shown in Figure 1:
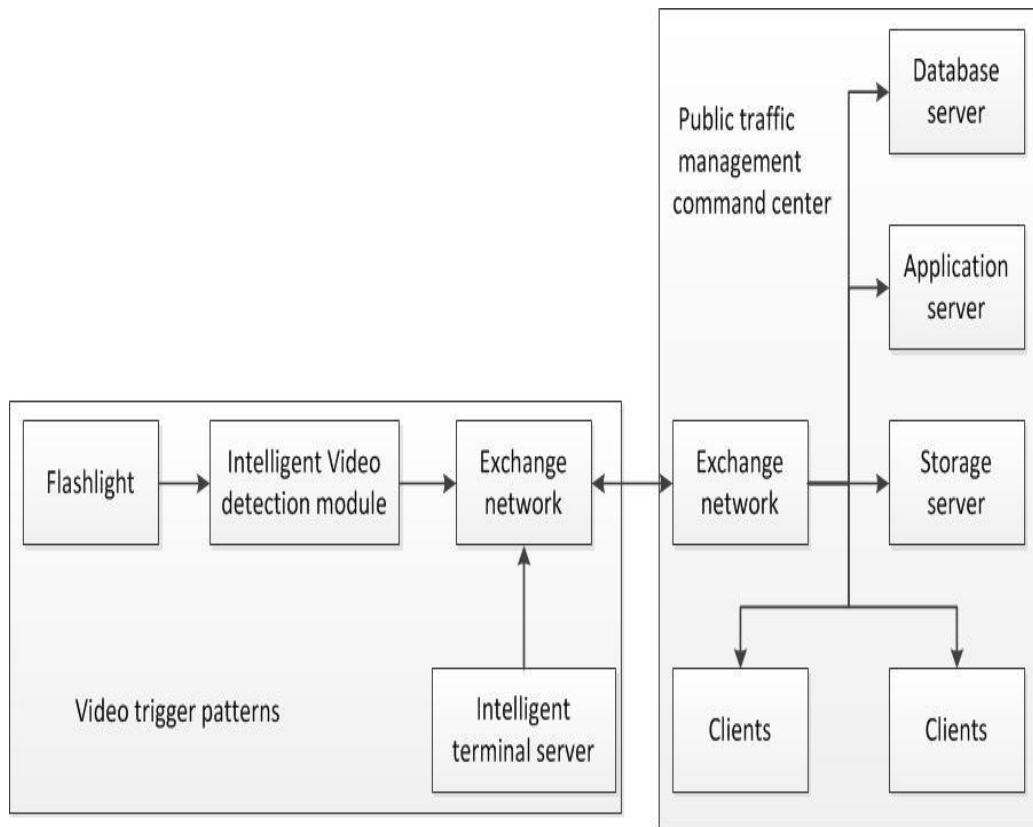
Figure 1. Hardware Structure of Urban Intelligent Traffic Monitoring System

According to the overall system hardware structure, we divide the system into two subsystems [5]. The system structure is shown in Figure 2. Two subsystems are front-end data acquisition and analysis subsystem, system management platform.
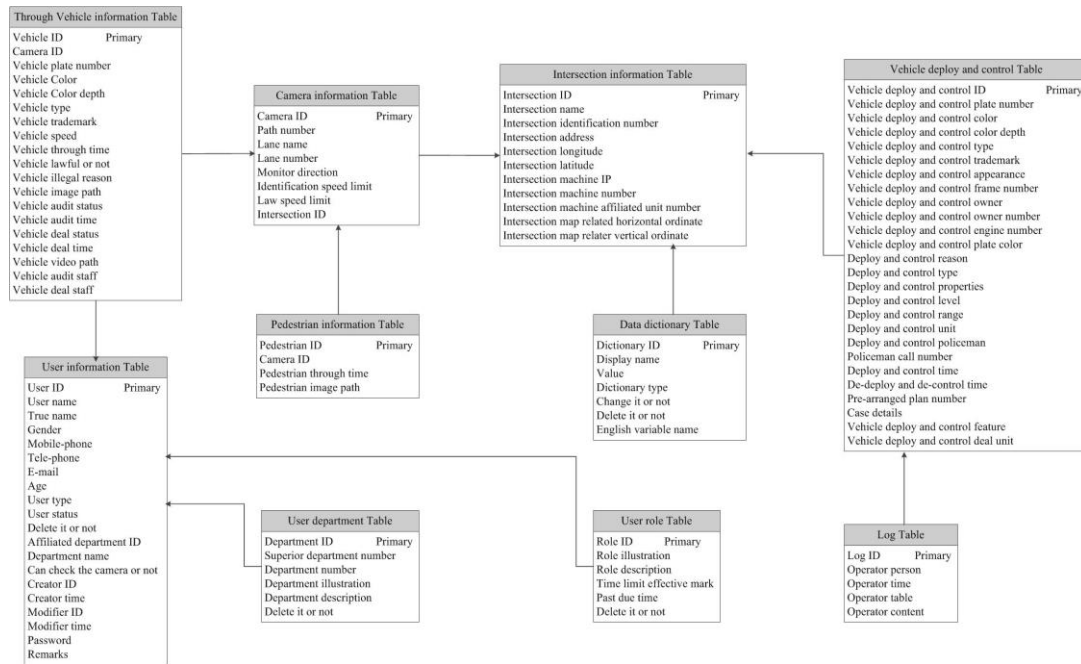
Figure 2. Software Structure of Urban Intelligent Traffic Monitoring System

As shown in the picture above, two systems constitute the overall system, according to preset parameters, the front-end data acquisition and analysis subsystem will process and analyze the vehicle image in real time images which are captured, get the license plate number, license plate color, vehicle type, *etc.*, and the analysis results and the picture files stored locally are sent to the system management platform data management module after local storage, the management platform application service module is responsible for monitoring and analyzing the data state of the data management module, providing users with functional services, and providing a service interface to other systems for calling and docking.

2.2. Database Design

Data management module is responsible for the management of stored data, and provides data support for human-computer interaction module [6]. Aiming at the system data structure, database design is as follows:

According to requirement analysis and system function design, database system contains "by vehicle information table", "camera information table", "crossing information table", "dispatched vehicles table", "pedestrian information table", "data dictionary table", "user information table", "role context menu table", "user departments table", "user role table, the log table" and so on. The following is a detailed description of the database logical structure and management platform system table name list and each table field. The logical structure of the database is shown in Figure 3 below:

Through Vehicle information Table

Vehicle ID   Primary
Camera ID
Vehicle plate number
Vehicle Color
Vehicle Color depth
Vehicle type
Vehicle trademark
Vehicle speed
Vehicle through time
Vehicle lawful or not
Vehicle illegal reason
Vehicle image path
Vehicle audit status
Vehicle audit time
Vehicle deal status
Vehicle deal time
Vehicle video path
Vehicle audit staff
Vehicle deal staff

Camera information Table

Camera ID   Primary
Path number
Lane name
Lane number
Monitor direction
Identification speed limit
Law speed limit
Intersection ID

Intersection information Table

Intersection ID   Primary
Intersection name
Intersection identification number
Intersection address
Intersection longitude
Intersection latitude
Intersection machine IP
Intersection machine number
Intersection machine affiliated unit number
Intersection map related horizontal ordinate
Intersection map relater vertical ordinate

Vehicle deploy and control Table

Vehicle deploy and control ID   Primary
Vehicle deploy and control plate number
Vehicle deploy and control color
Vehicle deploy and control color depth
Vehicle deploy and control type
Vehicle deploy and control trademark
Vehicle deploy and control appearance
Vehicle deploy and control frame number
Vehicle deploy and control owner
Vehicle deploy and control owner number
Vehicle deploy and control engine number
Vehicle deploy and control plate color
Deploy and control reason
Deploy and control type
Deploy and control properties
Deploy and control level
Deploy and control range
Deploy and control unit
Deploy and control policeman
Policeman call number
Deploy and control time
De-deploy and de-control time
Pre-arranged plan number
Case details
Vehicle deploy and control feature
Vehicle deploy and control deal unit

Pedestrian information Table

Pedestrian ID   Primary
Camera ID
Pedestrian through time
Pedestrian image path

Data dictionary Table

Dictionary ID   Primary
Display name
Value
Dictionary type
Change it or not
Delete it or not
English variable name

User information Table

User ID   Primary
User name
True name
Gender
Mobile-phone
Tele-phone
E-mail
Age
User type
User status
Delete it or not
Affiliated department ID
Department name
Can check the camera or not
Creator ID
Creator time
Modifier ID
Modifier time
Password
Remarks

User department Table

Department ID   Primary
Superior department number
Department number
Department illustration
Department description
Delete it or not

User role Table

Role ID   Primary
Role illustration
Role description
Time limit effective mark
Past due time
Delete it or not

Log Table

Log ID   Primary
Operator person
Operator time
Operator table
Operator content

Figure 3. Database Logic Structure of Urban Intelligent traffic Monitoring System

The design contents of the database table are shown in Table1

Table1. Database Tables

Table Name	Description
VEH	Through vehicle information table
DEPCONVEH	Deploy and control vehicle table
WALKER	Pedestrian information table
MONITOR	Camera information table
INTERSECTION	Intersection information table
XD_USER	User information table
DEPT	User department table
ROLE	User role table
ROLE_MENU	Role menu correlation table
DATA_DICTIONARY	Data dictionary table
LOG	Log table

2.3. System Platform Design

Intelligent traffic integrated management platform is a software system of intelligent traffic video surveillance system, is also the core of the whole system. It can query, control, and data mining vehicle data [7]. Provide some important information effectively but usually cannot be found for public security and traffic management. The intelligent transportation integrated management platform using C/S network structure, forming surveillance, alarm, data mining system independently. In the whole network structure, different functions can be used according to each user's rights.

According to the application of functional types, the platform can be divided into three functional modules, respectively is: basic function module, intelligent research and judgment module and system management module, function structure as shown in figure 4:
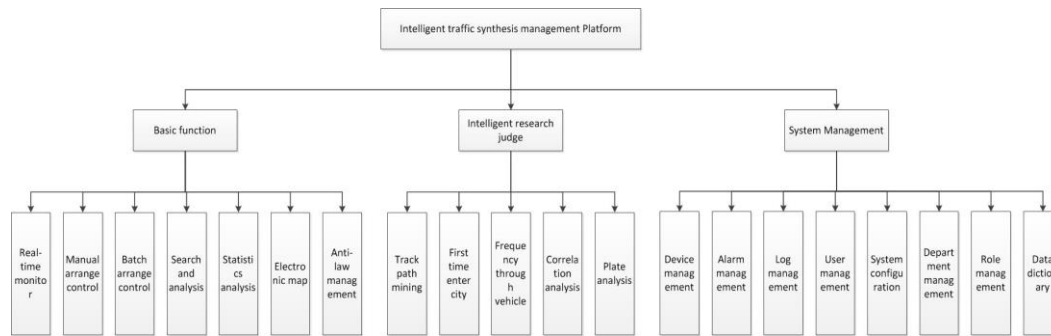
**Figure 4.Functional Structure of Urban Intelligent Traffic Monitoring System**

In addition to the real-time video monitoring function, basic function module also includes dispatch, query, statistics, maps and illegal management. Compared with the basic function, the function of intelligent research and judgment module has a certain degree of complexity. Through intelligent analysis of vehicle detection, information collection and vehicle tracking, intelligent mining research and judgment on the travel path of the vehicle, for the first time into the statistics and mining frequent analysis, correlation analysis, through the deck or other abnormal conditions are realized. The system management module mainly aims at some basic system, the basic information of the system hardware, the system user and then carries on the maintenance and the management.

2.4. Key Technology Analysis

2.4.1. Intelligent Vehicle Detection Technology Based on Adaboost: The vehicle identification method based on vision can be divided into four kinds; they are feature, optical flow field, model and machine learning [8]. Feature based vehicle detection method is mainly based on the vehicle symmetry, shadow and edge features. In order to get the exact result, it is usually combined with the shadow, symmetry and edge features. The optical flow method is mainly realized by the camera motion, the front obstacle movement or the instantaneous velocity field of the two relative motion, but the method is sensitive to noise and light, and the computation is large. The method based on model firstly established two-dimensional or three-dimensional, and then matched with the image to be detected, but the method is excessively dependent on the vehicle model. Machine learning transforms the data into information which is mainly used extract rules or patterns from the data, then the data is classified and identified. The algorithm of machine learning based on SVM or neural network has a large amount of computation, and the recognition performance needs to be further improved [9].

Based on this, the system uses a recognition algorithm based on Haar features combined with AdaBoost classifier. Training the classifier for vehicle detection by a large number of image at the car tail, so as to achieve the rapid and effective identification of the front vehicle in the high grade highway environment.

The whole recognition process is divided into two steps: off-line training and on-line identification. The off-line training process uses the class Haar feature to extract the image of a large number of vehicle samples. Then, the Adaboost algorithm is used to select the effective class Haar feature to form a strong classifier; First, the process of online identification extract key Haar features, then input characteristics to off-line training, take vehicle identification in the classifier. Flow chart of the algorithm is shown in Figure 5.
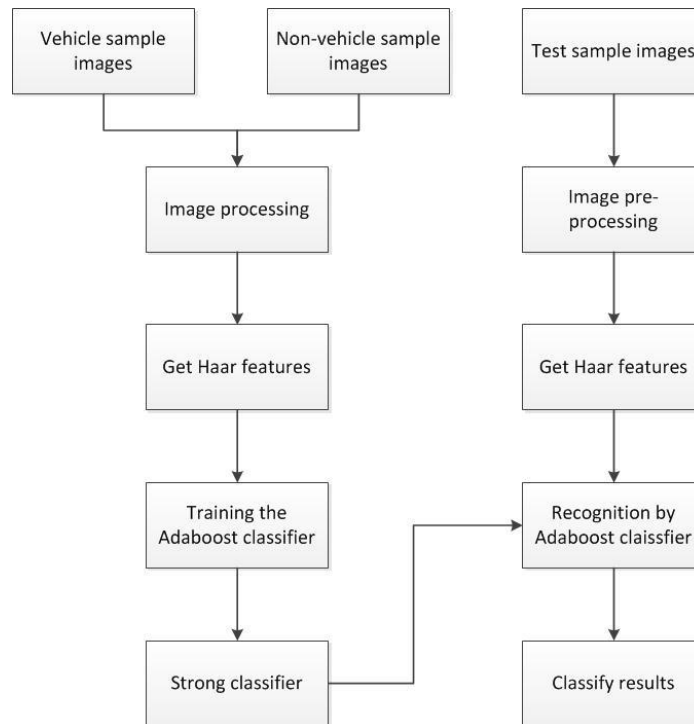
**Figure 5. Vehicle Detection Process**

The training samples are divided into positive and negative samples, the positive sample is the picture of the vehicle samples, and the negative samples are the other random samples. Positive sample selects the vehicle rear image of different models, angles and distance; negative samples choose any non-vehicle image. In this paper, we choose 1000 positive samples and 3000 negative samples. The training sample grayscale image is shown in Figure 6 (a).

(a) Positive Samples   (b) Negative Samples
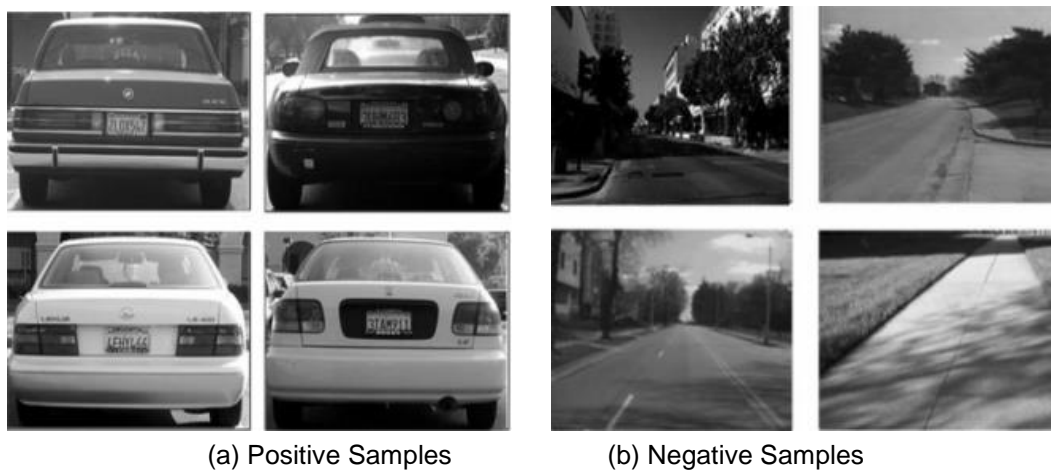
Figure 6. Positive and Negative Samples for Training

Class Haar features describe the gray level difference between the two adjacent rectangular regions, and use black and white to represent the two types of regional [10]. These rectangular areas are of the same size, shape, and vertical or horizontal. Five basic rectangular features window are shown in Figure 7. The definition is as follows:

(1) Two rectangular regions (horizontal and vertical): calculating the difference between the two regional pixels.

(2) Three rectangular regions (horizontal and vertical): calculate the difference of total pixels between both sides of the rectangle and the middle rectangle region.

(3) Four rectangular regions: calculating the difference of the pixels in each pair of the diagonal.

(a)Haar Rectangle Feature   (b) Vehicle Rectangle Feature
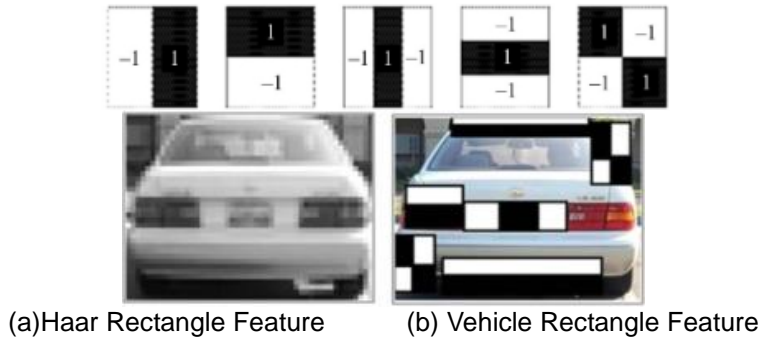
Figure 7. Haar Rectangle Feature Window

It is similar to the characteristics of human face. In normal light illumination conditions, the vehicle has the obvious characteristic of shadow and density differences with respect to the surrounding traffic environment, such as vehicle shadow at the bottom, the clear density differences between vehicle top and sky which will form the main characteristics of rectangular, just shown in Figure 7 (b).

Adaboost algorithm is used in the classification process of vehicle detection [11]. AdaBoost algorithm training with a basic classifier (weak classifiers) for different training sets, and then set the classifier together in different training sets obtained, that constitute a stronger final classifier (strong classifier). Theoretical proved that, as long as the classification ability of each weak classifier is better than random guess, when the number tends to infinity, the error rate of the classifier will tend to zero. The different training set in AdaBoost algorithm is realized by adjusting the weight of each sample. At the beginning, the weights of each sample are the same, and a basic classifier is trained by h1(x). For error-classifying samples in the h1(x), we can increase the corresponding sample weight; and for the correct classification of the sample, we can reduce the weight. This can highlight error-classifying samples, and a new sample distribution is obtained. At the same time, we give H1 (x) a weight according to the situation which can indicate the importance of the basic classifier. The less the error-classifying is, the greater the weight is. In the new sample distribution, the basic classifier is trained once again to get the basic classifier h2(x) and its weight. Followed by analogy, after T times of this cycle, we got T basic classifier, as well as the corresponding weights of T. In the end, the T basic classifier is accumulated in a certain weight, and the final classifier is obtained.

The specific description of the AdaBoost algorithm is as follows:

Assuming that X represents the sample space, the Y represents a collection of the sample class identity, assuming binary classification problem, which limits the $Y= \{-1, +1\}$. Order $S= \{(X_i, y_i) |i=1,2,…,m\}$, as the training set, including $X_i \in X$, $Y_i \in Y$.

① Initialize the weights of the M sample, and the distribution of Dt is assumed to uniform distribution: $D_t(i)=1/m$, $D_t(i)$ is expressed in the t round of iteration to give samples(x_i,y_i) of the weight.

② T represents the number of iterations.

③ For t=1 to T do

According to the sample distribution of Dt, generated training set St through the training set S sampling (there are playback).

Training classifier ht on the training set St.

Classifying all samples in the original training set S by using the classifier ht.

Get the classifier ht：X →Y, and the error epsilon εt=Pri-Di[ht(xi) ≠yi].

The αt＝（1/2）ln[(1-εt)/ εt].

Update the weights of each sample

$$D_{t+1}(i) = \frac{D_t(i)}{Z_t} \times \begin{cases} e^{-\alpha_i}, & if & h_t(x_i) = y_i \\ e^{\alpha_i}, & if & h_t(x_i) \neq y_i \end{cases},$$ …. (1)

Among them, Zt is a normal factor, to ensure that ΣiDt+1(i)=1

end for

④ The final output forecast:

$$H(x) = sign\left(\sum_{t=1}^{T} \alpha_t h_t(x)\right)$$ …. (2)

Through the extraction of features, training and testing, the system of the vehicle detection results as shown in Figure 8, the vehicle detection results can meet the requirements of the current stage of vehicle monitoring.

Figure 8. Results of Vehicle Detection

2.4.2. Intelligent License Plate Recognition Technology based on OCR: License plate recognition based on image processing save the complex equipment placement and money, so as to improve the economic benefit. The city intelligent traffic monitoring system can quickly and effectively determine the vehicle identity; secondly, because of the use of advanced computer technology, it can improve the recognition speed, solve the real-time requirements. In addition, it can identify according to the image, so it can be involved in the system to solve the identification error, and other methods are difficult to interact with others. At present, most of the license plate recognition system is based on the direct method, which generally includes several parts [12].
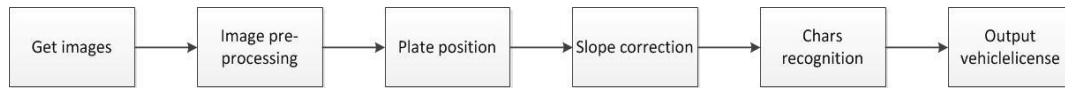
Figure 9.The Process of License Plate Recognition

(1) Image acquisition section. When the system detects a vehicle (by buried induction coil or beam detection), trigger image acquisition system, plate front view or rear view by the CCD camera intake license, control the scene illumination by light detection device, control the camera shooting angle by position detection device.

(2) Image preprocessing part. It requires the collection of images to enhance the image, smooth filtering and other operation, the purpose is to highlight the main features of the license plate, in order to extract the license plate better.

(3) The license plate location. Starting from the visual angle, according to the character of the target plate, corresponding feature extraction based on gray level image. License plate location is the key and difficult point in the license plate recognition system, the actual noise images in complex background interference will make positioning difficult. License plate extraction is a process to find the most suitable for the characteristics of the license plate area. Essentially, it is a problem to find the optimal location parameter in the parameter space.

(4) Tilt correction. When CCD camera get the license plate image, the license plate area sometimes is tilted in the license plate image. Tilt of the license is not conducive to the subsequent character segmentation and recognition, may also cause the loss of license content which result in the failure of the character recognition. Therefore, it is necessary to tilt correction before the character segmentation and recognition.
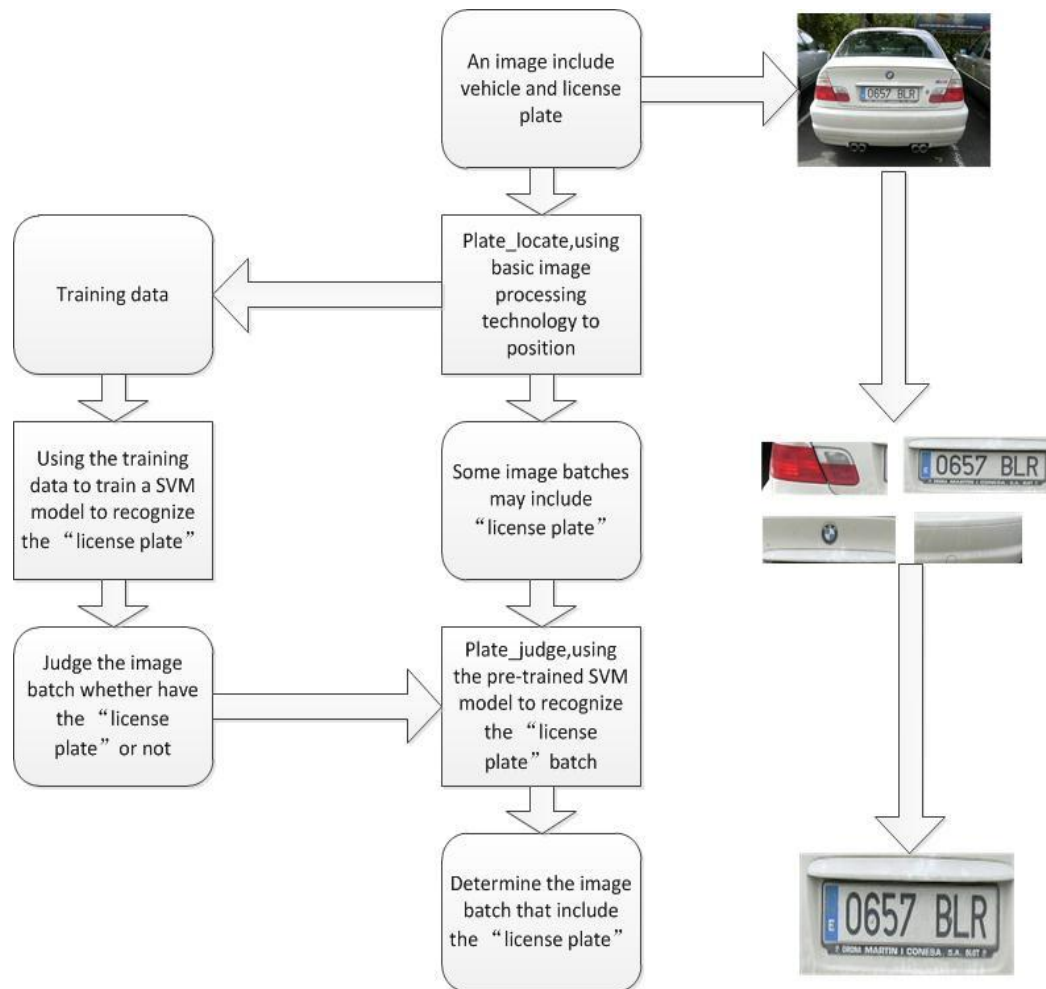
(5) Character segmentation. That is to separate the single character in obtained license (including Chinese characters, letters and numbers, *etc..*) in order to facilitate character recognition.

(6) Character recognition. It is the normalized processing of the segmentation of the characters. It carries on the character recognition, converts to the text to deposit the database or to display directly.

Among them, the most important two parts are the license plate location and character recognition.

From the point of view of human vision, and according to the characteristics of the character of the target area of the license plate, the corresponding features are extracted on the basis of the gray image. License plate location is the key and difficult points in the license plate recognition system. The noise and complex background of the actual image can make the positioning very difficult. License plate extraction is a process to find the most suitable for the characteristics of the license plate area. Essentially, it is a problem to find the optimal location parameter in the parameter space.

In the natural environment, the automobile image background is complicated, the illumination is not uniform, and how to accurately determine the license plate area is the key of the whole recognition process. First, the video images collected were large scope search, finding several regions accord with license plate features of the as the candidate region, doing further analysis and evaluation of these candidate regions; finally, selecting an optimal area as the license plate area, and dividing it from the image [13]. Figure 10 shows the process of license plate location.
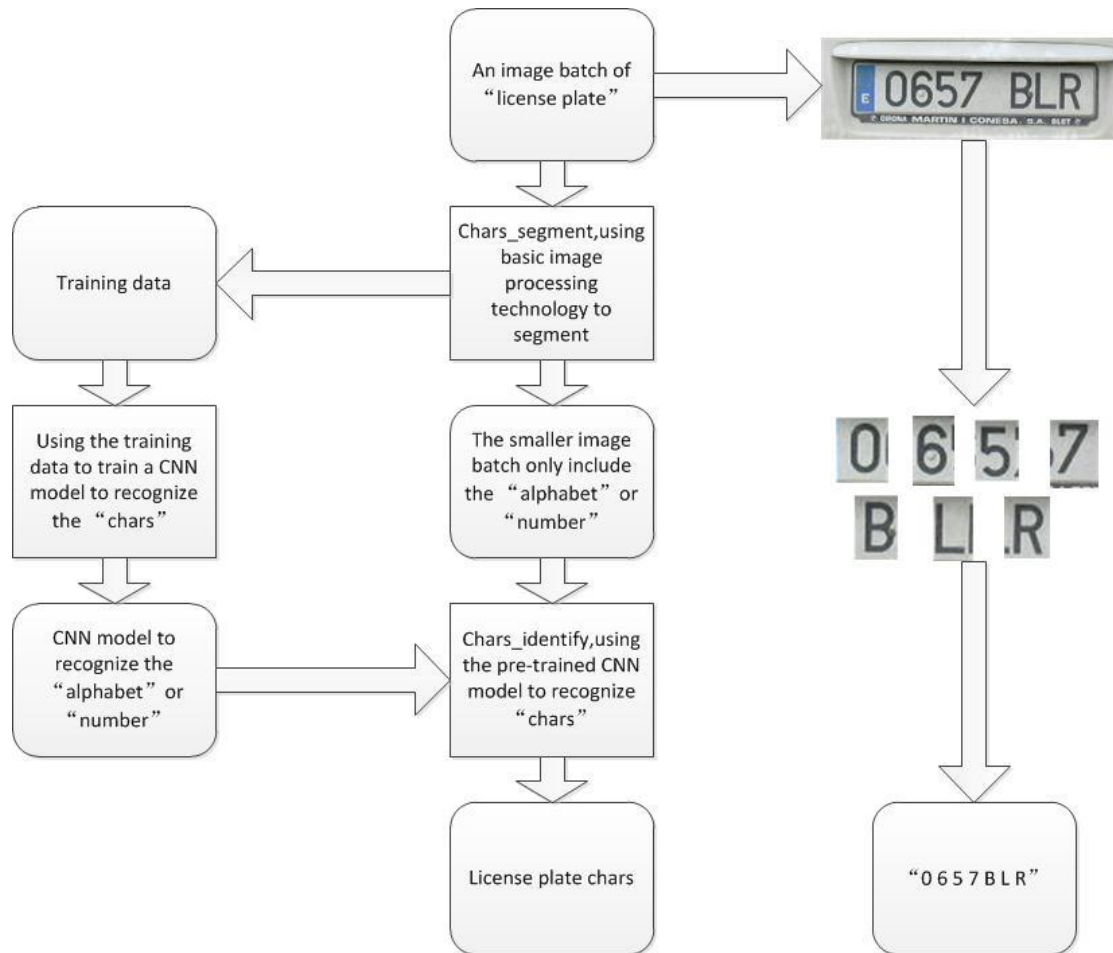
Figure 10. License Plate Locating Process

In order to facilitate character recognition, character segmentation is to isolate the individual character of the license (including Chinese characters, letters and numbers *etc.*.) [14]. In order to achieve better segmentation, the general knowledge and a priori information are very useful, according to the information contained in the image, the corresponding judgment criterion and control strategy can be formulated to complete the automatic segmentation.

The traditional character segmentation algorithm can be divided into three categories: direct segmentation method, Segmentation method based on recognition and adaptive segmentation line clustering method. The direct segmentation method is simple, but its limitation is that the determination of the segmentation point needs high accuracy; the segmentation based on the recognition results is the combination of the recognition results and the segmentation, but it requires high accurate recognition results. According to the coupling degree of segmentation and recognition results, it has different division. Adaptive segmentation line clustering is a classifier, we use it to determine whether each column of the image is a line segment, it is an adaptive neural network according to the training samples, but for adhesion of characters are difficult to train.

Because the object of this paper is relatively small, the number of the license plate is relatively small, so the direct segmentation method is adopted. Specifically, the projection method is used to segment the characters roughly, then we classify the objects according to the width of a single character. Finally, we split adhesion character and combine fracture character.

After completing the location of license plate area, license plate area is divided into individual characters, and then carries on the recognition. Due to the projection of the character in the vertical direction, the projection character in the vertical direction has a local minimum in character or characters within, and this position should satisfy the character writing format, character, size limitation and some other conditions of license plate. Using the projection method to the complex environment of the car image segmentation has a good effect. Figure 11 shows the character segmentation process.

Figure 11. Character Recognition Process

Through the process of license plate recognition, the key license plate location technology and character recognition is established in the urban intelligent traffic monitoring system, and carries on the license plate recognition, Figure 12 shows the results of the license plate recognition, the recognition rate is higher, it can complete the function of urban intelligent traffic monitoring system.

**Figure 12. Results of License Plate Recognition**

3.Conclusion

With the continuous development of computer technology and intelligent technology, more and more traditional industries complete the transformation rely on the transformation of the industry. In the traditional urban traffic control system, it is needed to analyze and judge the traffic, which waste the great manpower and material resources. In addition, the error rate is high, and the traffic monitoring cannot be completed in time. In this paper, a city intelligent traffic monitoring system based on video image processing is constructed from the view of video image processing technology. The system that bases on license plate and vehicle analysis completed the function of the vehicle detection, vehicle feature high-definition camera, driving speed detection, automatic license plate recognition, body color recognition scope, vehicle identification, capture photos, identification record storage and remote auto update. Based on these features, the author summarizes the database design and key technology. People can quickly and timely complete the function of vehicle, vehicle license plate monitoring by the city intelligent traffic monitoring system. It replaces the traditional method of artificial analysis and judgment which has a strong practical significance.

References

[1]   D. Ngoduy, "Analytical studies on the instabilities of heterogeneous intelligent traffic flow", [J]. Communications in Nonlinear Science and Numerical Simulation, vol. 18, no. 10, (2013), pp. 2699-2706.

[2]   J. Gubbi, R. Buyya and S. Marusic, "Internet of Things (IoT): A vision, architectural elements, and future directions[J]. Future Generation Computer Systems, vol. 29, no. 7, (2013), pp. 1645-1660.

[3]   H. O. Al-Sakran, "Intelligent Traffic Information System Based on Integration of Internet of Things and Agent Technology", [J]. International Journal of Advanced Computer Science and Applications (IJACSA), vol. 6, no. 2, (2015), pp. 37-43.

[4]   A. Garg, "A novel approach to improve intelligent traffic management system (ITMS)", [C]//Green Computing and Internet of Things (ICGCIoT), 2015 International Conference on. IEEE, (2015), pp. 679-682.

[5]   X. P. Xu Y. Y. Yin and J. H. Yan, "Research Report on Mass Rule Parallel Processing Technology in Intelligent Traffic System", [J]. Parallel and Cloud Computing Research, vol. 3, (2015), pp. 8-11.

[6]   C. Pan, Z. Yan and X Xu, "Vehicle logo recognition based on deep learning architecture in video surveillance for intelligent traffic system", [C]//Smart and Sustainable City 2013 (ICSSC 2013), IET International Conference on. IET, (2013), pp. 123-126.

[7]   H O. Al-Sakran, "Intelligent Traffic Information System Based on Integration of Internet of Things and Agent Technology", [J]. International Journal of Advanced Computer Science and Applications (IJACSA), vol. 6, no. 2, (2015), pp. 37-43.

[8]   X. Wen, L. Shao and W. Fang, "Efficient feature selection and classification for vehicle detection", [J]. Circuits and Systems for Video Technology, IEEE Transactions on, vol. 25, no. 3, (2015), pp. 508-517.

[9]   S. H. Lee, M. S. Bang and K. H. Jung, "An efficient selection of HOG feature for SVM classification of vehicle", [C]//Consumer Electronics (ISCE), 2015 IEEE International Symposium on. IEEE, (2015), pp. 1-2.

[10]   X. Wen, L. Shao and W. Fang, "Efficient feature selection and classification for vehicle detection", [J]. Circuits and Systems for Video Technology, IEEE Transactions on, vol. 25, no. 3, (2015), pp. 508-517.

[11]   D. Dooley, B. McGinley and C. Hughes, "A Blind-Zone Detection Method Using a Rear-Mounted Fisheye Camera with Combination of Vehicle Detection Methods", [J], (2016).

[12]   N. Z. Dina and M.Dailey, "EMPIRICAL STUDY OF CAR LICENSE PLATES RECOGNITION", [J]. JUTI: Jurnal Ilmiah Teknologi Informasi, vol. 13, no. 1, (2015), pp. 1-11.

[13]   A. Dev, "A Novel Approach for Car License Plate Detection Based on Vertical Edges", [C]//2015 Fifth International Conference on Advances in Computing and Communications (ICACC). IEEE, (2015), pp. 391-394.

[14]   M. Xu, J. Ni and M. Xie, "A Dynamic Template Combination of Pixels for License Plate Recognition", [C]//The Proceedings of the Third International Conference on Communications, Signal Processing, and Systems. Springer International Publishing, (2015), pp. 687-693.

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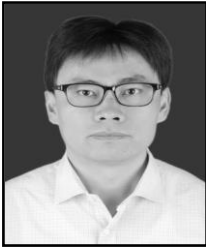
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