TELKOMNIKA, Vol. 11, No. 5, May 2013, pp. 2475 ~ 2484
ISSN: 2302-4046

3G Intelligent Video Analysis System of Vehicle on DM6446

Lin Mei, Longhu Chen*, Zhiwei Tang
The Third Research Institute of Ministry of Pubic Security, Shanghai, P.R. China
*Corresponding author, e-mail: [a] ahutea@163.com

Abstract

Traditional vehicle video monitoring system enjoys not only large data but also dispersion, so it is difficult to retrieve and network. Wireless intelligent video analysis system of vehicle on DM6446 is designed to solve the problem. In which ARM side of DM6446 completes the main control of the system, then it calls intelligent video analysis algorithm in DSP side of DM6446 through the Codec Engine, which greatly improves the efficiency of the system, and the TCP/IP protocol controls data transmission in the WCDMA network. The monitoring display terminal gets video information by accessing the corresponding IP address. The experiment shows that the system designed realizes intelligent recognition of license plate and vehicle body color safely and reliably, and the wireless network is coherent.

Keywords*: DM6446, intelligent video analysis, color recognition, license plate recognition*

1. Introduction

With the rapid development of multimedia technology and information technology, the digital video monitoring system has been widely used in monitoring of traffic. The network has also become a trend of the digital video monitoring system, but the cable network has been unable to meet the needs because of its highly dispersed distribution, also it is difficult for traditional video monitoring system to retrieve because of its large data, and it can only be recognized by your eye. Also, The paper designs a intelligent video analysis system of vehicle based on the third generation mobile communication technology and TI DaVinci video technology.

The system uses TMS320DM6446 as the control chip, which is a new platform for digital image video and audio processing system supported by TI company. It includes an ARM926EJS as the ARM core and a C64+ as the DSP core. The ARM system completes the video acquisition and peripheral control, also the DSP system realizes the algorithm and encode [1]. Because of the data stream of video monitoring system is large, the ordinary wireless communication cannot achieve high performance, which is limited by the bandwidth. However, 3G technology has broken the restriction of bandwidth and the wide coverage of the 3G network provides the possible for wireless video monitoring. Here, the designed system on DM6446 accesses into WCDMA networks through PPP dial-up on the ARM side in order to transmit the data.

2. The Design Principle of System

2.1. The Design of Structure

3G vehicle intelligent analysis system is mainly composed of three parts: the video acquisition and analysis system, 3G wireless transmission, display terminal. The principle diagram is shown in Figure 1. The analog video data acquisited by camera with PAL standard is encoded by TVP5150 chip, and then it is converted to be digital video signals with YUV format, which will be read into the system by V4L2 driver in LINUX operating system in ARM side of the DM6446. The stream of video data will be compressed, encoded and calculated on DSP side, and then the processed results will be accessed into 3G networks, and transmitted by the Internet in order to view on display terminal.

Received January 19, 2013; Revised March 10, 2013; Accepted March 19, 2013

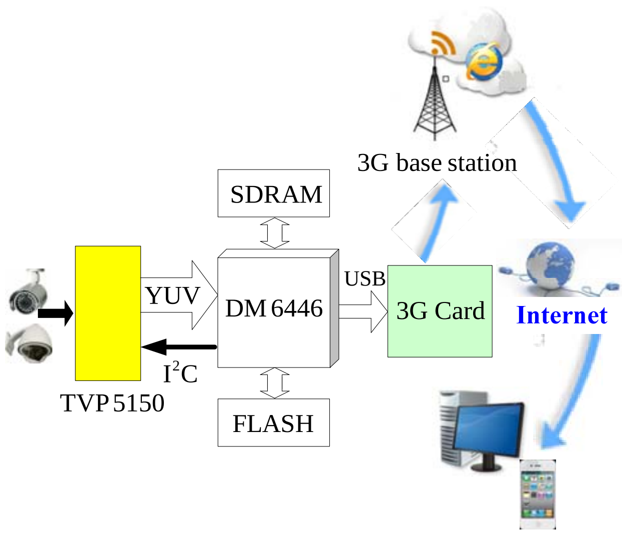

Figure 1. The structure and principle diagram of the system

Among them, the video acquisition and analysis system is realized by the DM6446, ARM core controls the video acquisition and display and transmission, DSP core runs vehicle intelligent analysis algorithm.

2.2. The Structure And Development of Double CPU

DM6446 is a double CPU system, including ARM subsystem and DSP subsystem. The double CPU structure is shown in Figure 2 [2].

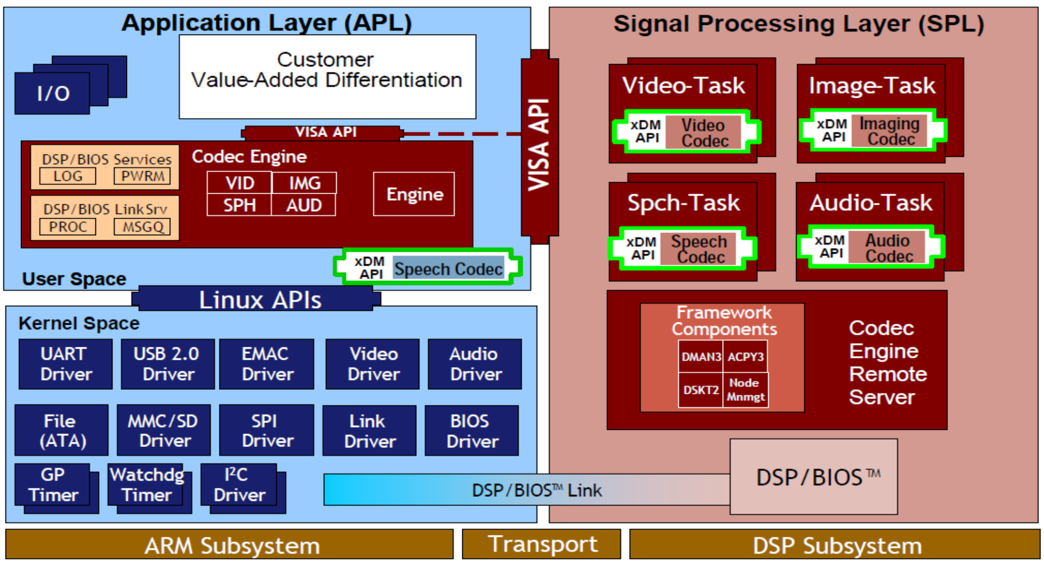

Figure 2. The double CPU framework of DM6446

The ARM subsystem contains user space and kernel space. User space adopts codec_engine framework, which is a bridge connected ARM with DSP. codec_engine framework calls and runs XDM standard algorithm in DSP side by calling VISA API, so the algorithm running in DSP side must meet the request of XDM standard interface. The XDM standard is based on the xdais standard, but simplifies xdais standard interface according to the characteristics of audio and video processing [3].

The Dsp subsystem contains XDM standard algorithm and framework components and DSP/BIOS LINK. The software module of framework components manages memory and DMA resources in DSP side. DSP/BIOS LINK is a underlying software system for communicating between DSP core and ARM core, and codec_engine also establishes on this software.

The steps of double CPU development is follows:

(1) develop the audio and video codec algorithm meeting with XDM standard by CCS, and generate a codec algorithm Library document *.lib (or *.a64P in Linux OS).
(2) compile the program in the DSP Server to generate a executable file *.x64P which will run on DSP core.
(3) create a Codec Engine configuration file *.cfg according to the DSP Server name and the specific audio and video codec algorithms.
(4) write your own application codes according to the different codec, DSP Server and configuration file *.cfg. After compile and linke, executable file in ARM side will be generated.

2.3. The Principle of Codec Engine

Codec_engine achieves mainly through VISA API, VISA API is divided into four parts:VISA create/control/process/delete.

Before calling VISA API, it should load executable code into memory of DSP by calling Engine_open() in your application and starts the program in DSP side, then DSP runs initialization program in DSP Server. It will create a lowest priority task RMS (Remote Management Server) in DSP side. RMS is responsible for the management and maintenance of corresponding instances of particular codec algorithm.

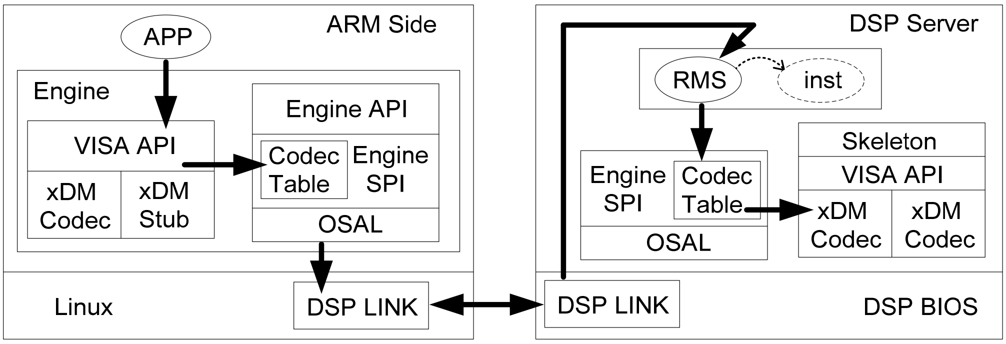

Figure 3. The flow chart of VISA create/delete

When application calls VISA create to create a algorithm codec, VISA create function will find the corresponding codec in codec table of Engine SPI and run it on DSP side. Then Engine SPI pushes the VISA create command to RMS running in DSP side by OSAL (Operating System Abstraction Layer) and DSP/BIOS Link. RMS finds out the right codec algorithm in codec table of Engine SPI, then a corresponding instance or task will be created in the RMS and VISA create returns an instance handle in order to operate subsequent VISA control/process/delete, which is shown in Figure 3. VISA delete is similar to VISA create, but it only deletes the corresponding instance of the codec algorithm.

VISA control can dynamically modify the codec instance properties and VISA process can call codec algorithm in DSP side, which is shown in Figure 4. The xDM Stub will collect the passed parameters when application calls the VISA process/control, and convert them to physical addresses which can be identified by DSP. Stub passes them to DSP instance through Engine SPI, OSAL and DSP Link [4]. The parameters and commands will be parsed out in DSP instance by Skeleton, and the VISA control/process in DSP side can control or process the codec algorithm.

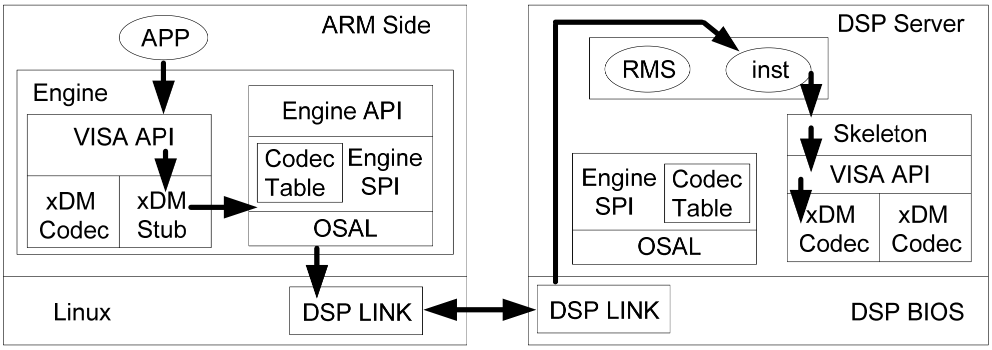

Figure 4. The flow chart of VISA process/control

3. The Design of Acquisition Terminal

3G is mainly composed of three parts: the video acquisition, 3G

The wireless vehicle intelligent analysis system is mainly composed of the video acquisition and analysis system, wireless transmission part, display terminal. The principle diagram is shown in Figure1. The analog video data is acquisited by camera with PAL standard.

The acquisition terminal is mainly composed of a camera, video processing circuit and software system, and the camera collects the external video signal using Pioneer Times PNT-628. The analog video signal acquisited will be converted to YUV format by TVP5150 decoder chip, then captured by the VPFE on the DM6446, also encoded and displayed by the VPBE [5]. The software system adopts TI codec library to simplify the algorithm design. Software development mainly focus on application program of ARM side, including the main thread, video capture thread, video processing thread, camera driver. The architecture of software system is shown in Figure 5.

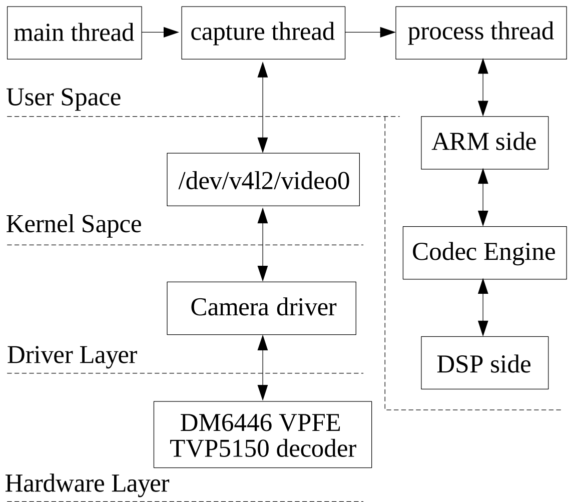

Figure 5. The software development framework of DM6446

The main thread completes the system parameter initialization, and opens video capture thread and video processing thread. The video capture thread calls the V4L2 driver in kernel space to operate TVP5150 encoder to realize video signal acquisition in the hardware layer by I2C bus control. The video processing threads calls the XDAIS standard algorithm on the DSP side by codec Engine on the ARM side to realize intelligent analysis algorithm.

3.1. Video Acquisition Thread

Figure 6 is the flow chart of video acquisition thread. The video acquisition thread opens video equipment with file format in the Linux system, also needs to select the video input channel. Initializing acquisition parameters is mainly for setting the video input format and the width and height of the image. The resolution of this system is Dl format (720x576) in PAL standard. It needs to allocate a buffer for acquisition equipment in order to store the data, and uses mmap () function to map device memory address in kernel space to the user space address, so that the user space can get the data from the kernel space. The user space reads video data in frame by calling the Framecopy_copy () function. it calls the close () function to close the video equipment after finishing reading the video data, at the same time, it calls unmmap () to terminate memory mapping and memory releasing.

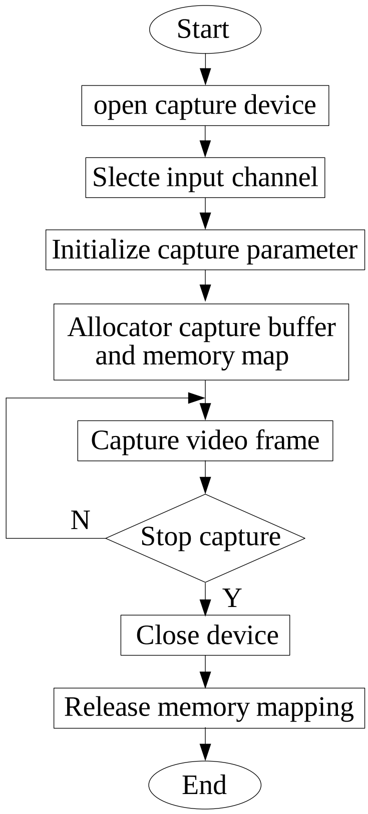

Figure 6. The flow chart of video acquisition thread

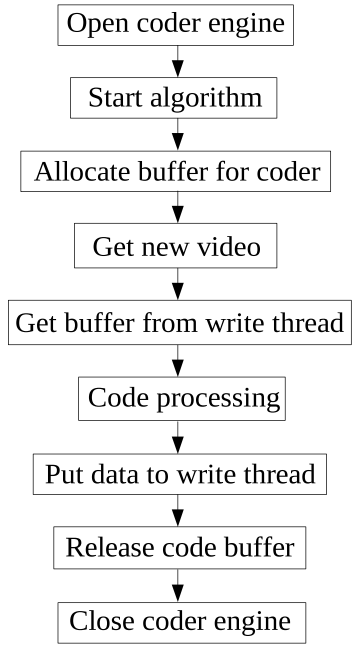

Figure 7. The flow chart of video processing thread

3.2. Video Processing Thread

The video processing thread mainly analyses video content. The result will be sent to the client through the network. The program on the ARM side will call the algorithm on the DSP side to analyses video content, so it needs to open Codec Engine and algorithm examples, then a buffer needs to be got from the acquisition thread with video data. Before the analysing, it needs to apply a buffer in write thread to store the result data. After the analysing, the result data will be written into the buffer of write thread, and the buffer got from the acquisition thread will be released at the same time, so that it can capture video data again [6].

4. The Design of Intelligent Analysis Algorithm
4.1. License Plate Recognition Algorithm

The license plate recognition system can be sequentially divided into vehicle image acquisition, image preprocessing, license plate location, character segmentation and recognition. As is shown in the Figure 8.

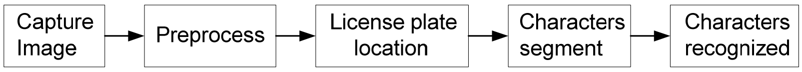

Figure 8. The component of license plate recognition system

CCD camera captures the video frame in real-time, and gets the image containing vehicles from the video stream. In order to eliminate of interference, it conducts a image preprocessing, then follows license plate location to look for the target area of calculation. After that, the characters in license plate should be segmented, and they will be recognized one by one.

The specific recognition algorithm is shown in Figure 9.

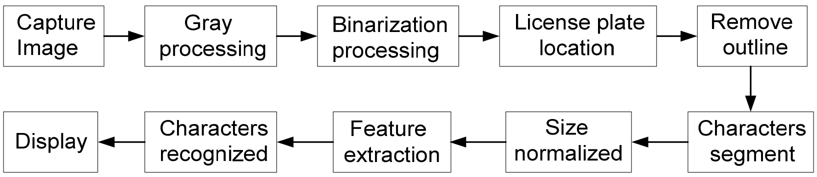

Figure 9. The flow chart of license plate recognition system

Because of its color palette is more complicated, it is necessary to turn the acquisition color image into gray. In order to carry out the follow-up image processing operations, the gray-scale image needs image binarization processing. Because of the significant difference between the license plate color and background color, the system adopts the threshold method. License plate outline also can interfere the recognition result, so it needs to be removed. We can use the line by line scanning method, which determines the location of outline according to the distribution of black and white pixels. However, the recent recognition algorithm only can judge feature for each character, so characters need to be segmented, also we can adopt the line by line scanning method. In each captured image, the character size is different, so the extracted feature values are also different in each time, and it can not use ready-made mold to identify the character, therefore, we must make the character size uniform to improve recognition accuracy. You can get the original character height, and compare it with the required height of the system, so that the height transform coefficient for each character will be got, then the original image can be mapped into the new images with interpolation method. In order to identify the license plate characters, it must be extracted the feature from each character. There are many feature extraction methods, but the mesh feature extraction method can reduce the character inclination offset impact. The character image area will be divided into 9 grids with equal size. Then counts the number of white pixels in each as feature vector. In character recognition, we adopt the minimum distance matching method to compare the current character feature vector with that in characters library, which is shown in Formula (1). The current character can be seen as the character in library, when its feature vector is the minimum distance with that of character in library [7].

4.2. The Body Color Recognition Algorithm of Vehicle

Color recognition principle is based on the color matching for the color feature parameters containing in image histogram. It is the first to capture YUV format image data, then converts YUV format data into RGB format data, and calculates the color feature values, finally, matches them with the color feature parameters in each one of sample, and the matching principle is based on the minimum distance of color histogram. The histogram distance of color space is defined as Formula (1):

$$D(b)=\sqrt{\sum_{i=0}^{n}(a_i-b_i)^2} \quad (1)$$

In which:

a_i is the appeared number of the i gray level in current image

b_i is the appeared number of the i gray level in color b sample.

If the D(b) is smaller, the distance between the current color and color b is more close, and the current color will be more similar with color b.

Using gray histogram as color feature parameters, we should match feature parameters for each color component, because the image has three color components of R G B. In order to improve the system accuracy and the anti-jamming ability, we propose an algorithm with 6 components of YUVRGB in feature parameters at the same time, and use a 48 dimensional array Histo [48] to record the values of these features, in which RGB color space occupied by the array of low 24 bits and YUV color space occupied by the array of high 24 bits. So the color feature values in the sample can be saved in Histo [color] [48], and the variable color in Histo[color] [48] represents the various colors. Recognition program will calculate the feature value Histo [48] according to the current color, then calculate the distance with Histo [color] [48] by formula (1). There will have one corresponding color in Histo [color] [48] to make the distance minimum, then the corresponding color is the current color of vehicle.

The diagram of color recognition based on DM6446 is shown in Figure 10. After the initialization of all registers and VPFE configuration in ARM side, ARM side can capture video image, and the data should be stored in shared memory configured in VPFE [8].

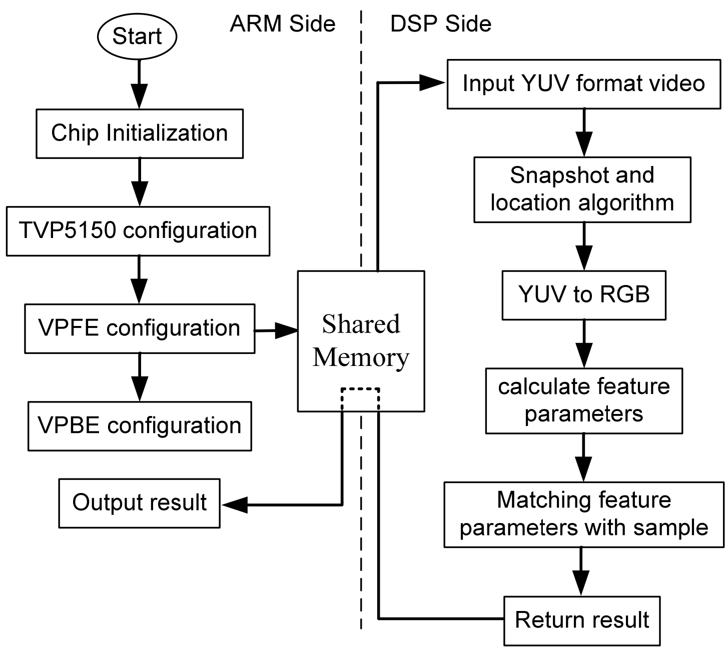

Figure 10. The flow diagram of vehicle body color recognition based on DM6446

In recognition algorithm, it firstly reads YUV format video signal, and captures target image through the snapshot algorithm, then gets the concern point in image with the location algorithm to reduce the interference caused by the other part in image, and turns YUV format into RGB format, and records the number of pixels of RGBYUV color components, which will be deposited into the array of Histo [48], and that is the color feature value. Finally, it will match with color feature value Histo [color] [48] by different color value to find the closest color, and returns to the ARM side for display.

5. The Design of 3G Video Transmission System

It uses the MC703 CDMA EV-DO wireless module made by Huawei company as the hardware platform, which connects with the system of DM6446 by the USB bus. The 3G network connect each other with peer-to-peer (PPP) protocols, which has completely realized in the Linux operation system, so the support of PPP protocol should be added into Linux kernel before WCDMA network connecting, and it needs to transplant corresponding dial-up software to connect with internet. The dial-up software of pppd is widely used in embedded wireless device, because its executable program is only a few hundred KB after transplantation. Finally, the dial script realizes WCDMA network connection by pppd call commands.

For the real-time applications of H.264 video transmission, the delay and jitter result from TCP retransmission mechanism is intolerable, therefore it needs to use the UDP transport protocol, but in this paper we only transmit the usefull information in video [9]. In order to ensure the transmission reliability, we adopt the TCP/IP. Figure 11 is presented information transmission framework based on the TCP/IP. Firstly, TCP header will be firstly packaged into the result of intelligent video analysis system in transport layer. then IP header will be packaged into TCP packet to create IP packet in network layer. The IP packet is transmitted to the 3G module with USB bus, and it will be sent to the internet by the wireless.

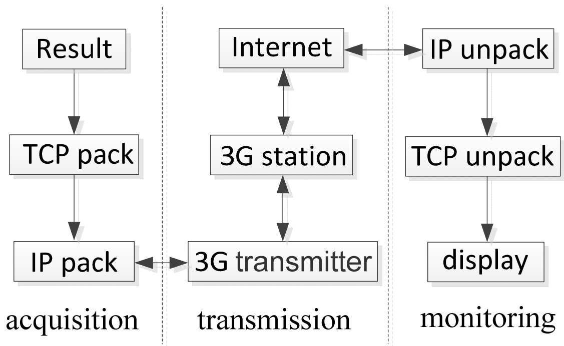

Figure 11. The 3G wireless video transmission framework based on RTP/UDP/IP

6. The Software Design of Monitoring

Monitoring software runs on the display terminal of the video monitoring system. Whether it is PC or PDA device, it enjoys the same design method. A set of monitoring software has been developed with Microsoft Visual C++6.0 based on PC to display the content of video, which includes TCP/IP communication, data receiving and information display [10]. The software mainly listens to destination IP address, and receives the data from the IP address continuously. The information can be got in the application layer after removing IP header and TCP header, then the monitoring software displays them on the screen.

7. System Experiment

In order to verify the feasibility of the design and the reliability of the system, a series of experiments were conducted. The experiment mainly analysed vehicles in a certain road of Shanghai.

The display interface of monitoring system is shown in Figure 12, including recognition results of license plate and vehicle body color. It outputs the result in the form of characters and save them in text in the host computer. System gets the current frame data with the snapshot, which will be transmitted through the 3G network to the host computer. It is a frame data which is shown in the photograph. The intelligent analysis results will be transmitted to the monitoring system in PC also through 3G network.

During the experiment, the recognition algorithm of vehicle body color is faster, approximately 90ms per one calculation, and the accuracy rate of recognition is about 80%. But recognition algorithm of the license plate is slower, approximately 510ms per one calculation, and the accurate rate of the recognition is about 70%. The whole system can operate reliably without abnormal fault. 3G wireless system enjoys a short delay when transmitting, changed with different time and weather environment. People can not feel the time delay and the system basically achieves the expected goals.

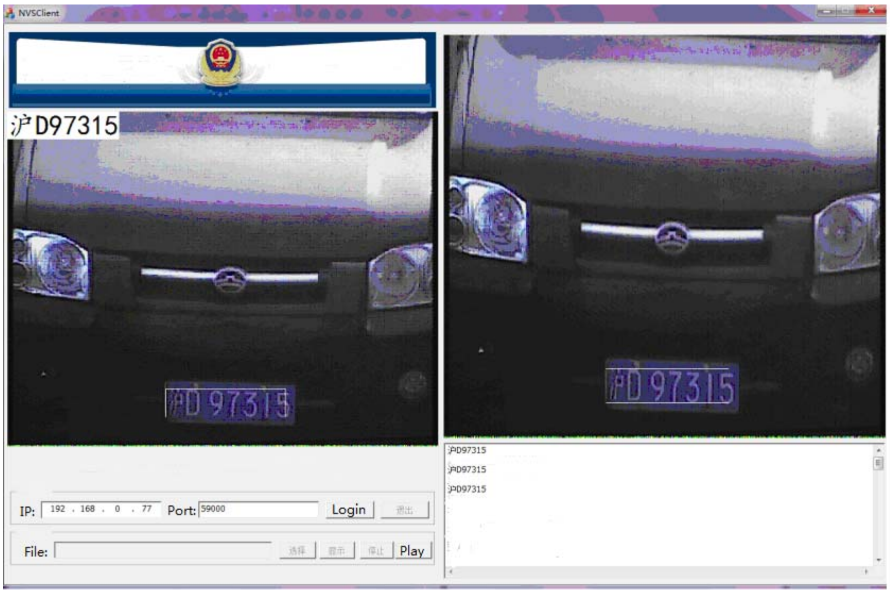

Figure 12. Interface of monitoring system

8. Conclusion

In this paper, wireless vehicle intelligent analysis system based on DM6446 has been designed with 3G technology and TI Davinci video technology, which enjoys simple design, small volume and other characteristics. Not only does it solve the problem of video searching, but also it enhances the networking capability of distributed video system, which can be widely used in information appliances, intelligent community and traffic, remote reading meter. It expands the network video monitoring system, and enjoys a good economic and society benefit.

Acknowledgements

This work was financially supported by the Projects in the National Science & Technology Pillar Program (2012BAH07B01).

References

[1] TEXAS INSTRUMENTS. TMS320DM6446 Digital Media System-on-chip. *Texas Instruments*. 2007: 11-23.
[2] TEXAS INSTRUMENTS. TMS320dm6446 DVEVM V2.0 Getting Started Guide. *Texas Instruments.* 2009: 4-4.
[3] TEXAS INSTRUMENTS. xDAIS-DM User's Guide. *Texas Instruments*. 2007: 2-3.
[4] TEXAS INSTRUMENTS. Codec Engine Algorithm Creator User's Guide. *Texas Instruments.* 2007: 3-3.

[5] TMS320DM644x DMSoC video processing back end (VPBE) user s guide. *Texas Instruments.* 2007: 17-19.
[6] Chai Ying. The Research and Design of Embedded Video Surveillance Server Based on DM6446. Guangzhou: Jinan University. 2010: 52-63.
[7] Shyang-Lih Chang, Li-Shien Chen, Yun-Chung Chung, Sei-Wan Chen. *IEEE TRANSACTIONS ON INTELLIGENT TRANSPORTATION SYSTEMS*. 2004; 5(1): 42-53.
[8] Longhu Chen, The design of universal visual color recognition system based on sample learning. *Microcomputer Information.* 2012; 28(12): 142-143
[9] Meng Fanxin, An Implementation of RTP-BASED Network Transmission in Video Data. *Computer Engineering and Applications.* 2004; (11): 143-145.
[10] Zhang Zhaowei, Zhou Bing. Design and implement of an H.264-base and Embedded-base video surveillance system. *Microcomputer Information*. 2006; 25(3-2): 40-42.