Design of intelligent traffic light control system based on traffic flow

Wu Hejun
Academy of Information & Communications Engineering
Tianjin Polytechnic University
Tianjin Municipality, China
whj1517@126.com

Miao Changyun
Academy of Information & Communications Engineering
Tianjin Polytechnic University
Tianjin Municipality, China
miaochangyun@tjpu.edu.cn

Abstract -The article puts forward a design of intelligent traffic control system based on traffic flow, and proposes the intersection video image processing and traffic flow detection algorithm. Application of DSP technology, design the system hardware, write the corresponding software, and realize the intelligent control of traffic light at the intersection according to traffic flow, improving the intersection vehicle capacity of passage.

Index Terms - DSP; image processing; traffic flow detection; intelligent control

I. INTRODUCTION

With the rapid economic development, urban traffic congestion increasingly causes people's concern. For most of the city's traffic signal light control, transport sector survey on traffic flow in advance, apply statistical methods to get time of traffic light. Then, they set the time into Single-chip Microcomputer. The SCM controls the change of traffic light by the time. And the fact that traffic flow is uncertain, often occurring such phenomena: the direction of the green light has few vehicles, but the direction of the red light has a long line waiting through the intersection. As the randomness of traffic flow change, statistical method has not been able to adapt to the rapid development of the transport situation. We will need real-time control of intelligent traffic lights according to traffic flow, which improves traffic junction situation.

The current intelligent traffic light control system based on traffic flow have infrared sensors in traffic flow, but the test results is not accurate, and easily lead to errors; there is a sense coil to detect traffic flow, but prone to electromagnetic interference, resulting in inaccurate test results; Some photoelectric detector for the core design test circuit, but it is difficult to cope with weather changes, test results is less reliable. This design is a video capture traffic flow as the core of the intelligent traffic light control system, a better realization of the intelligent control of traffic lights intersection.

II. SYSTEM DESIGN

Intelligent traffic light control system based on traffic flow is formed of a camera, video capture module, DSP module, traffic light driver module and traffic light group. The block diagram is shown in Figure 1. The camera real-time captures video image of intersection, processing by the video capture module, and digital video signal will be sent to the DSP module, processed to calculate traffic flow. The DSP module instantaneously control traffic light through traffic light driver module according to traffic flow, thereby enhancing the capacity of vehicles crossing. The system installation and use are not necessary to contact highway entity, easy to maintain. Accurate detection of traffic flow and instantaneously controlling traffic light can improve the intersection vehicle crossing capacity, so that we could save a lot of wait time and energy[1].

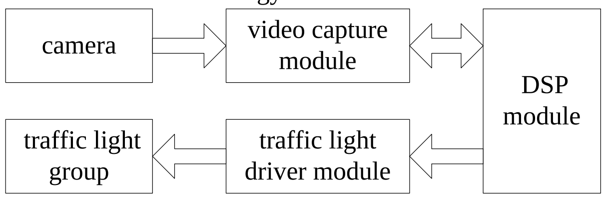

Fig. 1 Diagram of the system

III. HARDWARE DESIGN

A. The Selection And Installation Of The Camera

The quality of the video image directly affects the precision, which intelligent traffic system controls traffic light. The key factor determined video quality lies in the selection and installation of CCD camera. The main factors we considered when selecting the camera is sensitivity, resolution, waterproof, anti-fog, anti-corrosion, anti-sunshine, the price and so a series of indicators, to ensure that the camera can work in the harsh environment outdoor all-weather work. Camera installation method is of particular importance[2], assuming the camera installation height is h, camera angle is α, the level of the camera angle looking down is β, then the actual distance of the camera view is

$$h\Big/\tan(\beta-\frac{1}{2}\alpha)-h\Big/\tan(\beta+\frac{1}{2}\alpha)\,. \qquad (1)$$

Therefore, in order to ensure adequate distance of view, the basic principle installed the camera is: The camera must be mounted on the monitor road just above, and as high as possible; Vertical projection of the camera should be paralleled to the direction of road as much as possible; The Relations of the camera level angle looking down β and camera angle α have to satisfy $\beta=\frac{1}{2}\alpha+(0^\circ\sim 5^\circ)$.(2)

Camera installation is shown in Figure 2.

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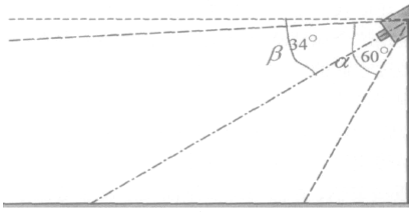

Fig. 2 Diagram of camera installation

B. Video Capture Module Design

The core chip of video capture module is TVP5146, which is high quality decoding chip. It can change all common baseband analog video format into digital video format. It supports A / D conversion of RGB and YPbPr signals, supports for NTSC, PAL and SECAM composite video decoding and A / D conversion, supports that the S terminal signal is converted to YPbPr signals. When sampling width of the A / D converter achieve 10bit, A / D converter sampling rate can be up to 30MSPS. The chip has 10 video input pins, so it supports many image formats separate and composite input. Video data is converted to 10bit YUV4: 2: 2 format by TVP5146, and is sent to the video front-end. Then, it is sent to the DSP module for further processing[3].

Considering the huge amount of image processing, to reduce computation and achieve real-time processing, we can set virtual coil in the video images collected(refers to a rectangular detection area in an image, called virtual coil). The width of the virtual coil is equal to a lane width. Several virtual coils divide up the junction image side-by-side. Image processing and traffic flow testing are carried out within the virtual coil. Due to poor visibility at night, we can add a secondary light in junction to improve traffic flow calculation accuracy.

C. DSP Module Design

The core of the DSP[4] module is DM6437, and the design block diagram shown in Figure 3. DDR2 SDRAM is used to store programs and data. NAND Flash is used to curing program and data. I^2C expansion provides configuration to some chips that are supported by I^2C. CCDC can provide interfaces to image sensor and video data, and accept image data, which the video decoder chip TVP5146 accomplishes format conversion. Chip DM6437 is used to control various peripheral chips and achieve algorithm. TI's DM6437 is a digital video design application of digital media processors in the framework of DaVinci technology, which uses C64x+ core. Compared to C64x core, on the one hand it increases stream media processing instructions, which improve DSP processing power in streaming media, on the other hand it improves the stability of the operating system. Basic frequency of the chip comes up to 600MHz, with enhanced VLIW architecture which enables that a single clock cycle can handle multiple instructions. The chip contains eight functional units and 64 general registers. On-chip memory 32KB L1P , 80KB L1D and 128KB L2 could flexibly configure to CACHE and RAM. 32bit of DDR2 storage controller enable maximum addressable 256MB of storage space, the highest support 333MHz bus rate[5].

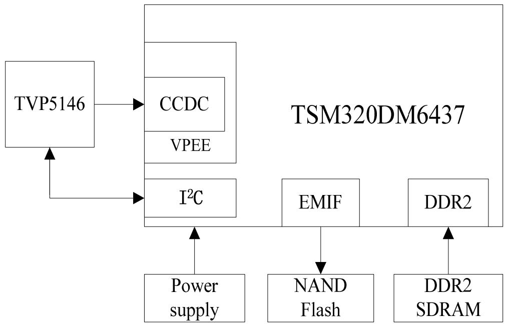

Fig. 3 Diagram of DSP module

D. Traffic Light Driver Module Design

The core of traffic light driver module design applies LM3407 chip. It is a type of pulse-width modulated floating-type step-down converter which integrated N-channel power MOS FET , which is designed to provide precise constant current output to drive light emitting diode (LED). The driver circuit is shown in Figure 4. LM3407 input voltage range is 4.5V-30V, output voltage range is 0.1V-0.9V, and does not require external control circuit compensation. So, it is a ideal device for LED drive device[6].

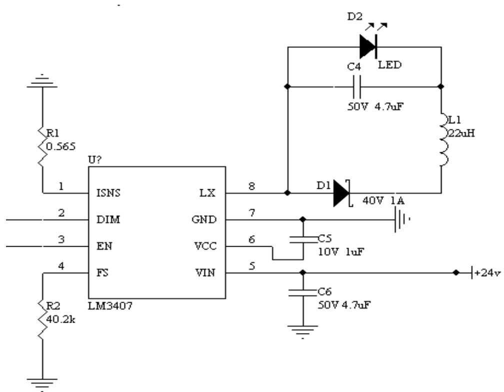

Fig. 4 Traffic light driver circuit

IV. VIDEO IMAGE PROCESSING AND TRAFFIC FLOW DETECTION ALGORITHM

A. Intersection Video Image Processing Algorithm

First of all the images of virtual coil inside are made gray, processed filtering and removed noise and so on. The system extracts moving object by the background difference method, then, processing image threshold segmentation[7]. Original image is set $f(x, y)$. Using the appropriate methods select threshold, the image is divided into two parts. Segmented images

$$g(x, y) = \begin{cases} 1, f(x, y) > T \\ 0, f(x, y) \le T \end{cases} \tag{3}$$

Similarly, in the case of multi-threshold segmentation can be expressed as

$$g(x, y) = K \quad T_{k-1} < f(x, y) \le T_k$$
$$k = 0,1,\Lambda ,K \tag{4}$$

T_0, $T_1 \Lambda$, T_k is a set threshold. Then, segmented images are processed edge detection by applying Canny operator.

Known $f(x, y)$ in the θ direction along the r gradient are defined .As follows,

$\frac{\partial f}{\partial r} = \frac{\partial f}{\partial x} \cdot \frac{\partial x}{\partial y} + \frac{\partial f}{\partial y} \cdot \frac{\partial y}{\partial r} = f_x \cos\theta + f_y \sin\theta$, $\frac{\partial f}{\partial r}$ of maximum condition is $\frac{\partial(\partial f / \partial r)}{\partial \theta} = 0$ .Now,

$f_x \cos\theta_g + f_y \sin\theta_g = 0$, so $\theta_g = \tan^{-1} f_y / f_x$. (5)

Maximum gradient

$g = [\frac{\partial f}{\partial r}]_{\max} = \sqrt{f_x^2 + f_y^2}$, commonly known as the gradient model. It can be obtained by $\theta_g = \tan^{-1} f_y / f_x$.

Compared with other differential operators, the most complete edge detection is obtained by Canny operator.

B. Traffic Flow Detection Algorithm

After edge detection, image is processed and analyzed by applying morphology methods[8]. Common morphology operations are erosion and dilation. Given binary image $I(x, y)$ and as the binary template of structural elements $T(I_j, j)$, The typical corrosion and expansion of operations can be expressed as

Corrosion: $E(x,y) = (I \otimes T)(x,y) = \mathop{AND}_{i,j=0}^{m} [I(x+i, y+1) \& T(i,j)]$ (6)

Expansion: $D(x,y) = (I \oplus T)(x,y) = \mathop{OR}_{i,j=0}^{m} [I(x+i, y+1) \& T(i,j)]$ (7)

After several filtering, filling binary images of the vehicle and extracting feature, the processed the contours of images have some changes than original images. However, under certain degree of accuracy that can be tolerated. It enables the vehicle to change a complete object, functions migrating to DSP mark images and accurately calculate traffic flow.

VI. SOFTWARE DESIGN

A. The Main Program Design

According to intersection video image processing and traffic flow detection algorithm, to compile the main program of intelligent traffic light control system, the main program flow chart is shown in Figure 5. The camera intakes video images from intersection, through TVP5146 decoder chip change analog video signals into digital video signals, then sent them into the DSP module, which calculates the traffic flow, and instantaneously controls the traffic lights according to the size of traffic flow.

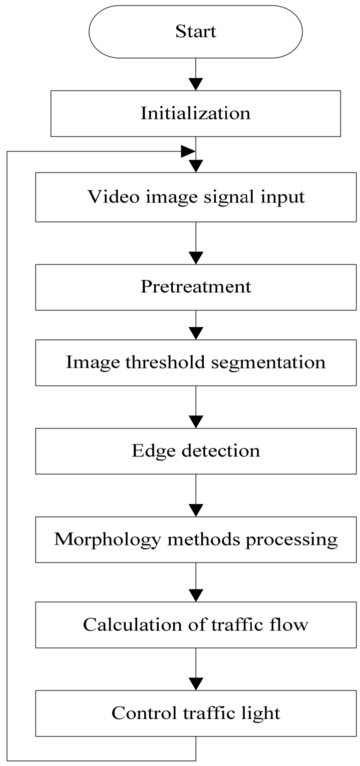

Fig. 5 The main program flow chart

B. Intelligent Traffic Light Control Subprogram Design

When system is working, DSP module processes video image and calculates the traffic flow, calculate the green time of each phase, implement intelligent control of traffic lights. Traffic light control flow chart is shown in Figure 6. The green light duration in the Figure a, b, c, d is calculated based on the traffic flow.

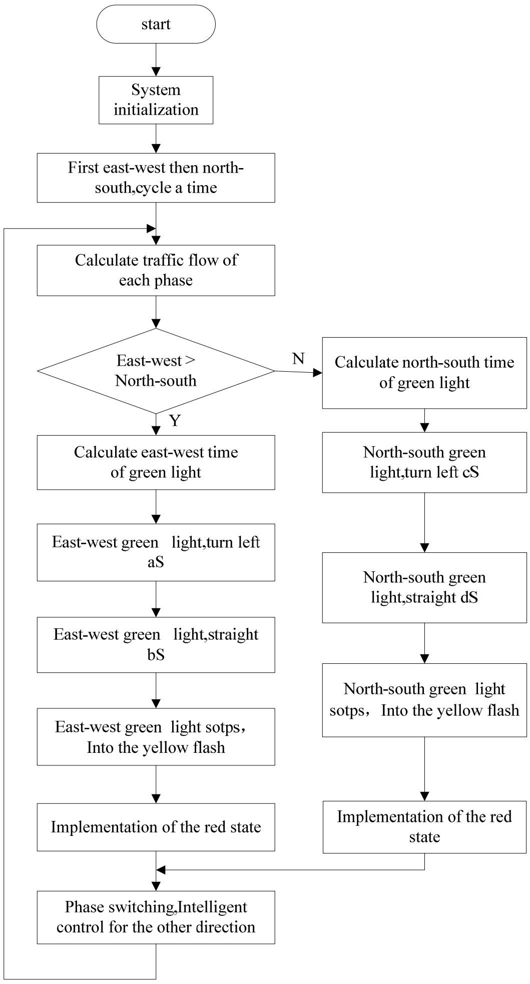

Fig. 6 Flow chart of intelligent traffic light control

VI. CONCLUSION

In this paper, DSP technology is applied, intersection video image processing and traffic flow detection algorithm is proposed. Calculating the intersection traffic flow exactly, this changes the traditional traffic light timing control, avoids the vehicles stranded of crossing as much as possible, mitigates the traffic congestion effectively, realizes the intelligent control of traffic lights. Intelligent transport system is the next generation transportation system, as an important part of ITS, Intelligent traffic light control system has important significance and potential applications.

VII. REFERENCES

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