Design of Video Monitoring System Based on ARM+DSP Dual Core and Improved Motion Detection Algorithm

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Abstract. This paper designs a video surveillance system that uses TMS320DM6467 dual-core processor as the control core, and puts forward an improved motion detection algorithm named background frame differential method to realize the video image of moving target detection, which uses mathematical morphology filtering method to fill a void in the motion area and remove isolated noise, using high real-time line segment labeled area growth method for detecting the target connected domain so as to realize the identification of moving vehicle. The system has stable performance and good real-time detection effect.

1. Introduction
With the rapid development of computer technology and communication technology, human society has gone into the era of intelligence, and the number of vehicles is increasing, therefore the world situation is more and more serious in traffic congestion and traffic accident. In order to ease traffic pressure and ensure traffic safety, video monitoring technology is widely used, the multimedia network video monitoring system based on embedded become the development direction in the field of video surveillance research today. The most critical part of video monitoring technology is the moving target detection technology, which lays a foundation for the tracking and analysis of moving targets in the later stage. It has been widely used in medical image processing, video monitoring, remote sensing data analysis, indoor monitoring, traffic security, military detection and other fields. Therefore, this paper designs an intelligent traffic monitoring system based on TI's Davinci series DM6467, ARM+DSP dual-core embedded platform and video intelligent monitoring algorithm for detecting moving targets.

2. System hardware design
The system consists of three parts: video acquisition module, video processing and output module, and video receiving and monitoring module. The specific design architecture is shown in figure 1. In the video acquisition module, the network digital camera is selected to complete the image acquisition task, and the image is transmitted to the video processing and output module through Ethernet. This module adopts the Da Vinci processor TMS320DM6467 launched by Texas instruments at the end of 2008, which is based on DSP and ARM dual-core architecture, and integrates the high-performance TMS320C64x+DSP core and ARM926EJS processor. The embedded system run by ARM core can...
receive the image data transmitted by the acquisition module at any time, which is processed and judged by the algorithm in the DSP core module, and finally outputs the detection and recognition results to the video receiving and monitoring module.

There are rich peripherals in TMS320DM6467 and it is an ideal choice for digital multimedia processing. ATA hard disk storage module is connected to the chip through the DM6467 peripheral interface. The DDR module stores image data and ensures the operation efficiency of the embedded system. The Ethernet network interface realizes the physical transmission function of the underlying Ethernet. Moving target detection algorithm module is the core of intelligent monitoring. It supports the core of C64X+DSP to process image data. JTAG debugging interface and RTC clock are convenient for online programming, debugging and system maintenance. PC monitoring platform provides system operation and monitoring information for monitoring personnel.

3. System software development

3.1. Development of the underlying driver module

This system adopts the development environment construction scheme combining the virtual machine of Windows+Linux operating system and the target system. The device driver is the bottom layer of software development and the core of the hardware platform to work normally. In this paper, DM6467 system driver development is according to the preparation rules of Linux kernel module for programming. The code structure of Linux device driver is roughly divided into several parts: driver registration and cancellation, opening and releasing of equipment, read/write operation of equipment, control operation of equipment, interruption of equipment and polling processing. The specific structure is shown in figure 2. The ARM kernel and C64x+ kernel architectures are different, Therefore, it is necessary to develop a kernel module that specifically converts physical addresses for Linux applications to call. The application of DM6467 platform kernel module is shown in figure 3.
3.2. Application architecture design

How to interac and synchronize the data between ARM and DSP is the key problem of this system. The communication process between ARM and DSP is shown in figure 4. After loading the DSP module, the DSP algorithm module also starts to run and waits for the writing of new image data in an infinite loop. On the ARM side, Linux applications will create communication interactive threads. After receiving the image data sent by the video collection thread, the kernel signal of interrupt DSP will be sent out after the writing is completed, and the DSP end will be suspended and wait for it to send an interrupt signal to wake up.

![Flow chart of mutual communication between ARM and DSP.](image)

The ARM kernel runs other threads to ensure multitasking. DSP kernel will receive the interrupt signal and go into the DSP interrupt service routine, and set the logo that image is ready, and DSP end algorithm program will begin to deal with image data, after the processing results will be written back to the shared memory region, and the interrupt signal of ARM will be sent, and sets the shared memory region to available, waiting for the update of the next image data. The suspended communication interaction thread on the ARM side will be awakened again, and the results in memory will be fetched for proper processing and sent to the video monitoring side. The architecture of multithreaded communication is shown in figure 5.

The Ipcamera thread is responsible for receiving image data frames from the webcam and storing them in the shared memory area. The Image Calc thread is responsible for taking data frames from the shared memory area, decoding the data by controlling the DSP, storing the decoded results in the shared memory area, and determining whether there is an event. The Upload thread is responsible for fetching data frames from the shared memory area to package and Upload, and if there are events, upload them first. The PC thread is responsible for receiving and analyzing the parameters sent by the PC console and sending messages to the Ipcamera and Calc threads.

4. System algorithm design

4.1. Detection process of moving vehicles

The detection process of moving vehicles mainly includes five steps: video image acquisition, image preprocessing, moving image region differentiation, regional target feature detection and vehicle target recognition. In order to reduce the interference caused by slight edge jitter or edge error in image acquisition, this paper uses mean filtering method for image preprocessing. The image is processed by mathematical morphology method to obtain a relatively intact area, which is convenient to extract some features of the moving area for analysis, so as to distinguish the difference between moving vehicles and pedestrians, branches, etc., and finally complete the video image moving vehicles detection by using the motion detection nuclear target recognition algorithm. Due to the limited space, this paper mainly describes the detection and recognition algorithm of moving targets.
4.2. Improved moving target detection algorithm

4.2.1. Frame difference background detection method. The idea of the inter-frame difference method is that the difference value of the characteristic value (such as grayscale and brightness) of the corresponding pixel in the continuous frame of video image, when the difference value is greater than the defined threshold value, it is identified as the pixel point that is in motion; otherwise, it is classified as the background point. This method can quickly detect the moving area, calculate quickly and use less image data, which only needs adjacent two frames of images, and the time interval between frames is short, and the impact of external light, weather and other is small, but the accuracy is not high, and it is easy to appear void or even ghost. Background subtraction method is to compare the current frame image with the calculated background image. If the difference value is greater than the given threshold value, it will be judged as a moving target; otherwise, it will be regarded as a background target, so as to separate the moving region from the stationary region. This method can detect vehicles well under complex background with high real-time capability but poor adaptability. Based on the shortcomings of the two detection algorithms and their advantages, this paper proposes an improved detection algorithm for moving targets, namely frame difference background detection method, in order to achieve better real-time detection effect. The algorithm flow is shown in figure 6. Firstly, three frame difference method is adopted to do adjacent difference for N frames, and the obtained results are used to find the intersection, so as to obtain a relatively intact background image in the static state. Secondly, by updating the background image, the pixel values of each frame are blended into the background image at a relatively gentle coefficient to adapt to the changes of the background image environment. Newly, the background subtraction method is used to extract the moving region from the image. Finally, binarization and other processing methods are used to complete the motion detection.

4.2.2. Establishment of background model. Due to the motion state of pixel gray value changes quickly, the image acquisition of the first N frame respectively between adjacent three frame difference is shown in formula 1 to 3. Assuming that it sets within a period of time (0~t) gained by the image of a pixel value is \( f_0(x,y) - f_1(x,y) \), and the hypothesis three adjacent frame image pixel value is \( f_{k-1}(x,y), f_k(x,y) \) and \( f_{k+1}(x,y) \) (0<k<t), while the pixel values used to make the difference can be the grayscale, brightness value and chroma value of a pixel value, this paper select for the grey value, as shown in the test formula 4.

\[
M_1(x, y) = \begin{cases} 
1 & \left| f(x, y) - f_{i-1}(x, y) \right| > T_i \\
0 & \text{else} 
\end{cases} \quad (1) \\
M_2(x, y) = \begin{cases} 
1 & \left| f(x, y) - f_{i+1}(x, y) \right| > T_i \\
0 & \text{else} 
\end{cases} \quad (2)
\]

\[
M_i(x, y) = \begin{cases} 
1 & M_1(x, y) \cap M_2(x, y) = 1 \\
0 & \text{else} 
\end{cases} \quad (3)
\]

\[
b_{i+1}(x, y) = \begin{cases} 
f_{i+1}(x, y) & \left| f_{i+1}(x, y) - f_i(x, y) \right| < T_{i+1} \\
0 & \text{else} 
\end{cases} \quad (4)
\]

After all values are processed, average all values stored in the array to obtain the image background value within this period of time t, as shown in the formula 5.

\[
B(x, y) = \frac{\sum h_i(x, y)}{k} \quad (k > 0) \quad (5)
\]

Where, the value \( k \) is the total number stored in the array. If time \( t \) is large enough, the number of detected background values greater than zero will be greater than zero, so as to obtain the initial background image. After establishment of the initial background image, the moving target can be detected for the subsequent frame image.

4.2.3. Background model update. Because in a busy intersection, the state of pedestrians and vehicles is always changing, when in the state of green light, it will be detected as a background image, and when in the state of traffic, it will be detected as a moving image. Therefore, the background image is not invariable in motion detection and is always changing. Therefore, it is necessary to update
the background image at any time to adapt to the changes of traffic environment and prevent misdetection or omission. The update process is shown in figure 7. The update of the background image is not entirely dependent on the current pixel value, but also associated with previous frames. Good response of the current frame is integrated into the background at the rate of small frame in formula 6, but the current frame image is integrated into at the same time, and noise and fast moving object is integrated into the background image in the formula, with the increase of time, these factors will bring the background image of real gray distortion, and bring a large error for the later movement deciding.

This article is selected $\rho=0.02$.

$$B_t(x, y) = \rho f_t(x, y) + (1 - \rho)B_{t-1}(x, y) \quad \rho \in (0, 1)$$  \tag{6}

Figure 6. Flow chart of frame difference background.  Figure 7. Background update figure.

4.3. Moving target recognition algorithm

The commonly used detection method for vehicle target area is connected area marking algorithm, which generally includes area growing method and pixel marking method. The region growth method can detect the connected region of any shape, and the detection effect is good, but the marked pixel will be scanned for many times, and the computational load is large and the memory is large, so it is not suitable for the embedded system. Pixel labeling method is fast in the case of connected region comparison rules, but in the case of irregular, it needs to spend a lot of time to process equivalent conflict markers, so the algorithm is inefficient. Therefore, this paper adopts the line segment marker region growth method to detect the connected region. First of all, the whole image is scanned step by step, and the set of all continuous moving point areas, namely the target segment is scanned, and the line number, left endpoint, right endpoint and initialization mark of the target segment are recorded, and these target segments are stored in a set array. After all target segments are scanned, the first target segment is found in the set, which is marked and pushed onto the stack, and the neighborhood search is conducted with this segment as the center to detect whether there is an unmarked target segment connected with this segment in the upper and lower rows. If there is a new target segment, mark it as pushed and push it on the stack, and start searching up and down again with the new target segment as the center. If there is no the current period of pop up the stack, and will pop up target marker for the detection area, repeat the above operation, in each round of operation will determine at the end whether the stack is empty, if it is empty, then this round of the movement of all target segments have all of the target area was detected, you can start the next round of moving region detection, until all target segment is marked, and algorithm is the end.

This method not only makes full use of regional neighborhood information, but also a scan can mark image all movement target area, there will be no equivalent label phenomenon, and in the process of the tag to search the record external rectangular required parameters, then the difference between vehicle of sports line drawing, final movement markers of vehicle detection, speed is quick and easy. Figure 8 shows the captured frame 51 image, and Figure 9 is the final rendering of moving
vehicle detection. It can be seen from figure 9 that all objects close to the shooting lens are drawn in the form of external rectangles, which has a good effect.

Figure 8. Image taken at frame 51.  
Figure 9. The final detection and recognition map of the moving vehicle.

5. Conclusion
In this paper, the intelligent video monitoring system based on ARM+DSP dual-core and motion detection is studied. The embedded technology is combined with the moving target detection algorithm to realize the system's function of detecting and recognizing moving vehicles and lay a certain foundation for the subsequent high-level algorithm. However, there are still some deficiencies. When the shooting is far away and the traffic flow is large, a moving flow area will be detected, which is not convenient for vehicle identification. Therefore, the detection algorithm can be further improved and optimized, so as to have better adaptability. At the same time, the function can be further expanded.

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Reference
[1] Texas Instruments. (2008) TMS320C64x C64x+DSP CPU and Instruction Set ReferenceGuide.  
[2] Peng Q.Q., Guan Q.. (2004) Principle and application of DSP integrated development environment CCS and DSP/BIOS. Electronic industry press,Beijing.  
[3] Li Y., Hou H.L.. (2019) Study on adaptive three-frame difference algorithm based on improved mean value modeling[J].Electronic measurement technology,42:21-24.  
[4] Zhang K., Yang C.K., Zhou C.P., Li X.. (2019) Overview of uav video image moving target detection algorithm [J]. Liquid crystal display,34:98-109.  
[5] Dai L.L., Du R.. (2018) Moving target detection method applied to embedded video monitoring system [J]. Electronic technology and software engineering,15:178-179.  
[6] Chen R.. (2018) Research and implementation of moving target detection algorithm in intelligent monitoring system. Xiangtan university.