Digital Video Image Preprocessing Algorithm Based on Embedded System

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Abstract. To solve the massive noise contained in the images acquired under low illumination, we designed a digital video image Preprocessing device with the denoising function. Based on the embedded CPU and operating system, video images are acquired by the camera. The noise contained in the video images is filtered by the improved median filtering algorithm and wavelet image denoising. Subsequently, the images are transmitted through USB and network interface, and the storage function of image files is implemented. The device can remove the noise contained in videos effectively, which is conducive to performing more advanced processing on the images.

Keywords: Digital Video Image, Image Denoising, Embedded System, Median Filtering

1. Introduction
With the rapid development of social economy, people have paid increasing attention to public social security [1–2]. As a new sector, the security industry develops very fast. Video surveillance is one of the essential means of social security system, which is extensively used in squares, stations, wharves, parking lots, communities, banks and other places[3-4]. Traditional video acquisition system does not process video signal, In this chapter, we designed a digital video image Preprocessing device based on the embedded system to collect video images via the camera, remove the noise contained in the images, and transmit the image file by USB and network interface [5].

2. Overall structure
The functions of the digital video image Preprocessing device are as follows:

1) Camera interface. The interface circuit is provided for the camera so that the system can connect the camera equipment with the pal and NTSC system, and collect the video image through the camera.

2) File storage system. The system has a large capacity linear non-volatile memory to store image files. The memory is supplemented by the file system, and users can read and write file images through standard file operation.

3) Master USB interface. The system is configured with USB master interface, which can process the image file through USB flash disk or mobile hard disk.
4) Network interface. The system includes standard Ethernet interface, through RJ45 interface and TCP/IP protocol for data communication.
5) Human-computer interaction equipment. It has the function of human-computer interaction. It can interact with users through keyboard and LCD.

3. System hardware design

3.1. CPU selection and hardware resource allocation
ART company is the world's leading intellectual property design supplier of 16/32-bit RISC microprocessor. ART company transfers high-performance, low-cost and low-power RISC microprocessor, peripheral and system chip design technology to its partners so that they can use these technologies to produce chips with different characteristics. ARM processor has the characteristics of small size, low power consumption, low cost and high performance.

Samsung's S3C44B0X chip is a 16/32-bit RISC processor. Its integrated on-chip functions include 8kbcache, internal SRAM, 71 general-purpose I/O ports, external memory controller (chip selection logic, FP/Edo/SDRAM controller), 8 external interrupt sources, LCD controller, etc. the hardware resources provided by S3C44B0X are enough to complete the more complicated work. In this design, S3C44B0X is selected as the central processing unit.

3.2. Video signal acquisition interface
Video signal includes not only image signal, but also line synchronization signal, line blanking signal, field synchronization signal, field blanking signal, slot pulse signal, pre-equalization pulse, post equalization pulse, etc. Hence, the circuit for A/D conversion of video signals is highly complicated. To collect the video signal, we have to grasp the logic relationship between various signals accurately. Saa7111 is a programmable video input processing chip developed by philips company. It uses the characteristics of composite TV signal spectrum interleaving and uses a digital comb filter to implement the high-precision separation of the bright color signal. Saa7111 contains two analog processing channels, which can select the video source and anti-aliasing filter. Meanwhile, it can also perform the analog-to-digital conversion, automatic embedding, automatic gain control, clock generation, multi-mode decoding, and other operations. The field synchronous signal VREF, synchronous line signal HREF, clock reference output LC2, and pixel clock signal CREF in SAA7111 chip are all directly led out by the chip pin, thus eliminating the design of clock synchronization circuit and significantly reducing the design complexity.

The proper peripheral circuit is required for the regular operation of the main control chip. Hence, the design of the peripheral circuit is crucial for the normal operation of the main control chip. The peripheral circuit is designed based on the SAA7111 chip, including power circuit design. The operation of the control system needs a power supply with high stability and reliability. In this paper, 24V DC voltage and +3.3V DC voltage are selected. Among them, 24VDC mainly supplies power for stepping motor circuit and heating module. Without adding independent design, it can directly use the 24V DC power supply for power supply.

![Figure 1. +3.3V DC power supply circuit](image-url)
3.3. Storage system
The other primary function of the device is the storage of image files. It is essential to choose a suitable non-volatile storage medium. NAND flash memory is superior to NOR flash memory in writing speed, capacity per unit volume, and service life. It adopts I/O parallel interface mode and is suitable for the data storage medium. K9F2808 is 8bit16mb NAND flash memory, and nGCS4, its interface circuit to S3C44B0X, is one of the chip selection signals of CPU, which is used as the address strobe signal of K9F2808. Ngecs4 is connected to the read-write control terminal of K9F2808 after the logic operation with the read-write signal of CPU and the nWE signal of write pin. The GPC0 ~ GPC4 pins of CPU C port are connected to the timing pins R/B, CE, CLE, and ALE of K9F2808, and the read-write timing is generated by software, data line IO0 ~ IO7 of K9F2808 are connected to data bus DATA0 ~ DATA7of CPU.

4. System software design
4.1. Migration of embedded uClinux system
The uClinux is the main product of Lineo company. It is also the model of open-source embedded Linux. The uClinux is mainly designed for the embedded system without MMU (memory management unit) of the target processor. It has been successfully transplanted to many platforms[7]. The uClinux is an excellent version of embedded Linux, abbreviated as micro-Conrol-Linux. It has carried forward the outstanding characteristics of standard Linux and forms a highly optimized and compact embedded Linux after miniaturization in various aspects. Although its volume is very small, it still retains most of the advantages of Linux: high real-time; multi-task and multi-user; stable and good portability; excellent network function; It has complete support for various file systems and abundant API standards. It has accomplished miniaturization for embedded systems and supports multiple CPUs at present. Its compiled target file can be controlled in the order of hundreds of KB, and has been successfully transplanted to many platforms. S3C44B0X is a CPU without MMU. Because many chips and peripherals have been added in the design, including flash, SDRAM, LCD, video processing chips, etc. The drivers of these chips and peripherals should be written under the operating system of uClinux. Meanwhile, the file system code, USB storage code, and SCSI code are transplanted to the uClinux operating system. This paper completes the driver design and code migration of these devices.

When wavelet high-order statistical design is performed row by row for the continuous tone image, the error of the previous design is transmitted to the pixel point of the current design $x^{(i,j)}$ represents the currently designed pixel, $x^{(i,j)}$ represents the sum of the errors delivered by the designed pixels for the neighborhood, $b^{(i,j)}$ is a pixel $(i,j)$ the binary quantization result of, $u^{(i,j)}$ represents the pixel gray value after adding the diffusion error.

$$u^{(i,j)} = x^{(i,j)} + \sum_{i',j'} e^{(i',j')} \times k_{i',j'}$$

$$x^{(i,j)} = \sum_{i',j'} e^{(i',j')} \times k_{i',j'}$$

$$b^{(i,j)} = \begin{cases} 0, & \text{if } u^{(i,j)} < t \\ 1, & \text{if } u^{(i,j)} \geq t \end{cases}$$

4.2. Digital video image programming
Digital video images can be stored in memory by writing the interrupt service program of field synchronization interrupt, row synchronization interrupt, and pixel synchronization interrupt of the video signal. To exchange information among three interrupt service subprograms, we have defined
the following global variables. Among them, Bufer1 and Bufer2 are used for video data buffer, and the pointer SamplePoint points to one of the buffers. As the buffer for collecting data; the donepoint pointer is another buffer for collecting data of a field. The vertical interrupt service subroutine is set to bVerFlag variable, and the horizontal interrupt service subroutine is set to bHorFlag. Both flag bits are used to determine whether the current pixel is the starting position of row and field in the pixel interrupt service subroutine. The main video data acquisition is completed by the pixel interrupt service subroutine, and the pixel interrupt service subroutine process

Different error diffusion filters can generate different quality wavelet high-order statistical images. As shown in Figure 2, figure 2 (b) is the wavelet high-order statistical image after Lena continuous tone image (as shown in Figure 2 (a)) is designed by wavelet high-order statistical quantization.

![Figure 2. Image](image)

After the design of the grid image designer, the wavelet high-order statistical binary image has the following characteristics:

1. It retains the essential content features of the original image, such as edge information, texture features;
2. The wavelet high-order statistical image after the binary quantization dramatically reduces the image's order information, which is convenient for data design;
3. The point density feature of the image is easy to be extracted from the generated wavelet high-order statistical image, which belongs to the statistical feature quantity and has certain robustness to the post design operation of the forensics area;
4. The binary quantization design of the image has reduced the complexity of the subsequent calculation and design of images.

5. Conclusion
Based on the embedded processor S3C44B0X and operating system uClinux, a digital video image Preprocessing device with the image denoising function is designed in this paper. The device can complete the acquisition of video images and the storage of image files through the camera, filter the noise contained in the images based on the denoising algorithm, and transmit image files through the USB interface and network interface. The digital video image device designed in this paper has a resolution of 320 × 240 pixels and a field frequency of 50 Hz. It has been applied to the track image acquisition of tracking intelligent vehicles and obtained excellent effects.

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