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Design and implementation of moving object detection based on Zynq

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Abstract: In recent years, video image processing technology has made rapid progress. Some algorithms related to moving target detection and tracking, relying on the rich resources of computers, make the implementation of these algorithms based on the PC platform has been relatively mature, but there are problems such as poor real-time performance, high power consumption, resource consumption. The Zynq hardware platform has both FPGA, which is good at parallel operation, and ARM core, which is good at control, which can effectively implement the algorithm transplantation of moving target detection and effectively improve the above shortcomings. The system takes Zynq hardware platform as the core unit, which is composed of video image acquisition module, image processing module, information transmission module, DDR cache module and display module. The PL side of Zynq implements video image acquisition, gray conversion, frame difference algorithm, expansion corrosion algorithm. The PS terminal mainly completes the configuration of IIC camera and VDMA. The output module finally realizes the output of HDMI through protocol conversion. This system has wide application value in moving target detection.

Keywords: Zynq; Frame difference algorithm; Image processing; Moving object detection.

1. Introduction

Moving target detection refers to constantly segment and extract the changing part caused by the constant movement of the object from the background in the video, while suppressing noise as much as possible, including foreground noise and background noise, so as to accurately judge the region where the moving target is located. According to the motion state between the image background and the target, it can be divided into two types of image: the first type is that the background remains stationary while the moving target is in motion, that is, the moving target detection and tracking in the static scene; The second is that the background image keeps moving, while the moving target to be captured in the image is also in relative motion, that is, the moving target detection and tracking in the moving scene. Among them, the first target detection in the static background is relatively simple and easy to achieve, because the background image is stationary, so we only need to make the difference between the moving target region and the background region to separate the moving target.

There are many methods to realize moving target detection under static background. The focus of these algorithms is to filter out small background interference changes that are not completely and absolutely unchanged in the background image. The main methods include background difference method, frame difference method, optical flow method and mixed Gaussian model method. For scenes in which the background image and moving target are both in motion and the background is in static state, the processing method is different. In this state, we mainly detect the target through matching algorithm. When the detected target and background are both in motion, it is impossible to detect the target only by image difference method. This requires algorithm estimation and compensation for the whole image. In this case, block matching and optical flow estimation are used to detect moving objects in moving background images.

Based on the Zynq fully programmable platform, the design adopts the method of hardware and software co-design to realize the motion detection system from IP core design, hardware system integration, embedded application program control. Reasonable use of Zynq's parallel computing capability on the PL side to accelerate the image processing algorithm and the efficient and concise control capability on the PS side.

2. Methodology

2.1. Overall system design

The system is designed by Zynq-7020 development board, and the moving target detection system is realized by the co-design method of hardware and software. PL part to complete the algorithm logic design, PS part to complete the VDMA and IIC driver writing. The PL section allows for hardware acceleration.

The architecture of the system is shown in Figure 1. The image data collected by the camera is input to the image processing module for a series of calculation and processing. After converting the RGB data format into AXI Stream through Video in video input IP, video data communication is carried out with VDMA IP. The video data is written into the DDR3 of Zynq chips through VDMA. Each time an image data is written into the DDR3, the video data will be three caches, and then sent out through the established VDMA. The VDMA sender is connected to the IP core of Video out. Video data will form video stream information after entering Video out, and then form image signal output in accordance with VGA timing together with VTCC IP. A protocol conversion IP of HDMI converts Video out of VGA video signals into HDMI video signals for display. The PL part of the whole system is mainly responsible for image acquisition, image processing and image display, while the PS part is mainly responsible for camera register writing and DDR read and write control.

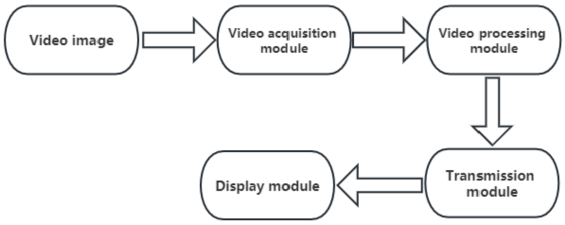

Figure. 1 Block diagram of moving target detection system based on FPGA

2.2. Image acquisition module

This design uses the OV5642 camera module, support two signals independent or simultaneous display function. Register configuration of OV5640 is configured through the IIC interface of FPGA, and its appearance is shown in Figure 2[6-7].

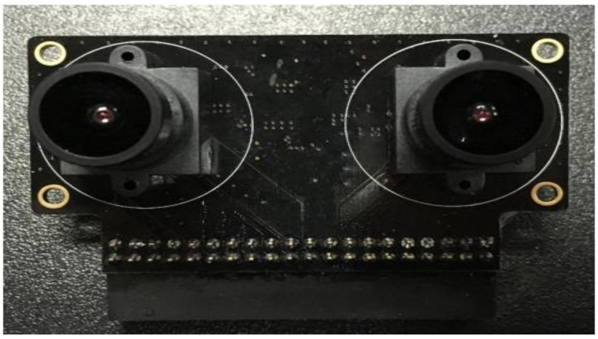

Figure.2 OV5642 camera module

The logic block diagram of software design of image acquisition module is shown in Figure 3. Firstly, FPGA implements register configuration of binocular camera through I2C bus, and then the video enters the camera data acquisition module. First a write signal is generated, data is put into the FIFO register, and then data is written to the dynamic random-access memory when the FIFO data store overflows. When the line display is required, the display module needs to read data from the dynamic memory into the FIFO register, and then after processing through the HDMI interface to the display screen [8-10].

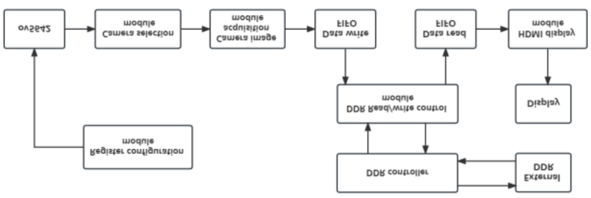

Figure.3 Image acquisition module software design logic block diagram

2.3. Image processing module

The logical block diagram of the image processing module is shown in Figure 4 below. Firstly, the video image data is collected through the image acquisition module, and the data is taken out from the image cache module for processing. Firstly, the gray-scale processing is carried out. And to ensure that the amount of computation as small as possible, processing data as simple as possible, so as to occupy less hardware resources, processing speed and accuracy will come up. Therefore, before the algorithm operation, the color image is first converted into the corresponding gray image, and then the image after graying is processed is processed by median filtering, which uses the median gray value of the neighboring gray value of each pixel as the gray value of the processed pixel, so as to eliminate some isolated noise. This is the open operation mentioned above. You do a corrosion and then you do an expansion. Then, the image after filtering is processed by the interframe difference algorithm, and finally morphological filtering is carried out to remove the noise to obtain a perfect difference absolute value matrix. Then, the image is scanned to find the area larger than the threshold value. With Xmax, Xmin, Ymax, and Ymin for this area, you can attach the bounding box to the image for output display.

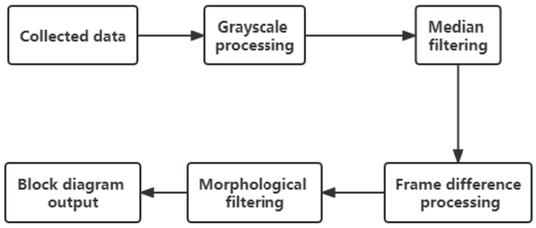

Figure.4 Image processing module logic block diagram

2.4. Display module

After being processed by the image processing module, the position information of the moving target can be detected, and then the information needs to be displayed by the image and position information display module. The logical block diagram is shown in Figure 5. Firstly, the image information is transmitted to the display screen by using the HDMI interface. Therefore, it is necessary to set up a display system in the PL side, the implementation of a variety of schemes, but because of the huge data, so cannot be separated from the DMA system, DMA system can quickly carry out the data from the DDR and send to the display module, which can reduce the CPU overhead in the system. VDMA is a DMA developed by Xilinx for video input and output. The cached image read from the PS DDR via VDMA requires a series of operations to output the HDMI display, because the data read from the DDR is AXI stream data, which is a data stream that needs to be converted into a video stream. Therefore, after data conversion through Video on Screen Display module, VTC module will generate a clock for video image output, and then VGA image can be produced and displayed on VGA display. However, in order to use HDMI display, VGA image needs to be converted into HDMI image again. After HDMI_FPGA IP can complete this series of operations, done these can be the moving target detection after the video image output on the display.

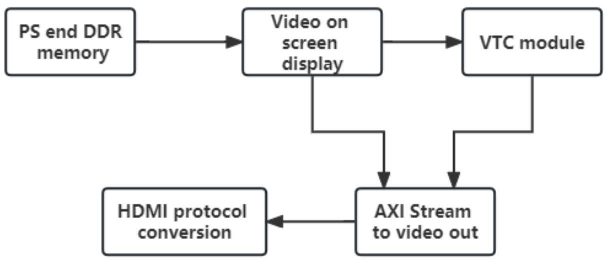

Figure.5 Image information display module logic block diagram

2.5. Block Designer project drawing

The system adopts modular design inside, and its internal module design is shown in Figure 6. The first is the image acquisition module. OV5640 binocular camera is used to collect two channels of image information, and then it is fused into the image processing module.

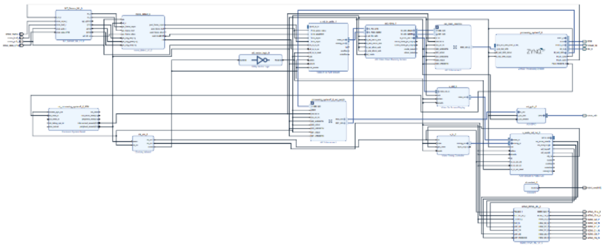

Figure.6 BD engineering drawing

3. Results and discussion

The system uses 5V power supply for power supply, and adopts JTAG interface and Xilinx special emulator for download simulation. Meanwhile, serial port and HDMI interface are integrated on Zynq7020 system board, and the camera is connected with 40-pin interface. It mainly completes the development platform of Zynq7020 platform and image acquisition module, as shown in Figure 7. In the initial trial phase of system power-on, the initial configuration tasks of image acquisition module, image processing module and image and position information acquisition module are firstly completed. After the initialization is completed, the system begins to collect image information through the OV5640 camera. The system will process the collected video image information frame by frame, and then enter the moving target detection processing unit after gray processing and median filtering processing. At the same time, it will be displayed by HDMI interface display.

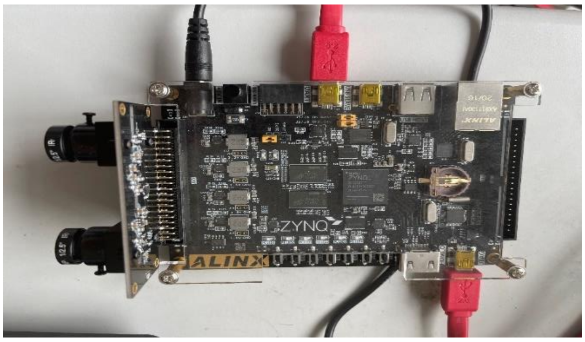

Figure.7 Physical system diagram

The processed image displayed through the HDMI interface display is shown in Figure 8. The image acquisition module was tested using the display with HDMI interface, Zynq platform and OV5642 camera, which was transmitted to the LCD display through the HDMI transmission channel, and the stability and integrity of the image were observed.

Figure.8 Complete the renderings

After testing, if the target to be detected is far away from the system, it will not be captured. Here, the algorithm needs to be refined, and detailed research in this direction can be carried out in the future, hoping to solve this problem in the future learning road. Currently, objects far away from the test can be detected, which can be seen in the image. At this time, the portrait has become relatively small, the level in the hand is particularly small, the number of pixels is very small, so the detected object is not perfect detection, after all, this involves the hardware and algorithm problems, to be further investigated.

4. Conclusion

This design mainly introduces the design and implementation of the moving target detection and tracking system based on Zynq. This paper first from the recent years of low-end hardware platform to do the moving target detection problem of low power consumption high efficiency, leads to the research direction of this design, and then this paper first on the FPGA development technology and the use of Zynq processing platform to do a detailed introduction, then analyze and compare a variety of moving target detection algorithms, At the same time, it also introduces the advantages of interframe difference algorithm, and the advantages of moving target detection and tracking system based on Zynq. Then the overall design of the system is introduced, and the design of each component module of the system is analyzed and introduced, and finally the detection system is tested and analyzed.

Acknowledgments

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