Study on the Theoretical Model Based on Image Processing Control System

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Abstract

With the development of information technology, requirements for image processing have been increasing as well. Only by resolving problems such as image acquisition, processing and storage in the vision measurement process effectively can it be possible to obtain high-standard image information. Based on NI FlexRIO technology, this paper uses a new graphical development platform with the combination of related graphics processing technology to produce a real-time acquisition and processing system, thus realizing the acquisition, processing and storage of image information effectively. Through relevant experiments, the working performance of the system under certain circumstances can be tested. Finally, depending on the superior performance, the result shows that image acquisition and processing is also applicable to other areas of expertise.

Keywords: Image processing technology, NI FlexRIO, acquisition, processing

1 Introduction

Measuring the motor process of a moving target is an important section of image processing and control, the important parameters of which include posture changes of the target and its motor trajectory[1-2]. Measurement and analysis of the two is a key basis for identifying the causes and results of accidents. Vision measurement is a widely used way to measure the motor process. However, the afterward off-line processing of the current technology cannot adapt to the development of the measurement technology[3-6]. Higher requirements are proposed for vision measurement system in many precision research industries and fields, for instance, the precision of image acquisition and processing is higher along with better performance of timeliness.

To meet the real-time requirements of image acquisition and processing, real-time image acquisition and storage shall be needed. Currently, technological methods that can meet the requirements include: realize it through the software on personal computers[7-9], through personal computers and dedicated accelerator cards, through the hardware program of unique microprocessor DSP, through SCM system, through DSP and the hardware programming of field programmable gate array FPGA. The microprocessor computing speed of the last method is very fast, while the programmable gate array FPGA has very high operational frequency and strong logical control over the system. By combining the two, better timeliness of image processing and control can be achieved.

2 Composition of the image processing control system

The NI FlexRIO device used in this study contains more field programmable gate array FPGA and DSP, which can meet the real-time requirements of the graphics processing control system. Its main composition includes: acquisition part of the image, processing part and storage part of the data information, among which, the image acquisition part is to control a special camera and conduct acquisition for the motor process of the moving target, thus realizing high-speed and high-resolution needs as well as caching the image data sent from the camera. The main work for the processing part is about image test, thresholding and extraction of the central coordinate on the basis of image acquisition[10-11].

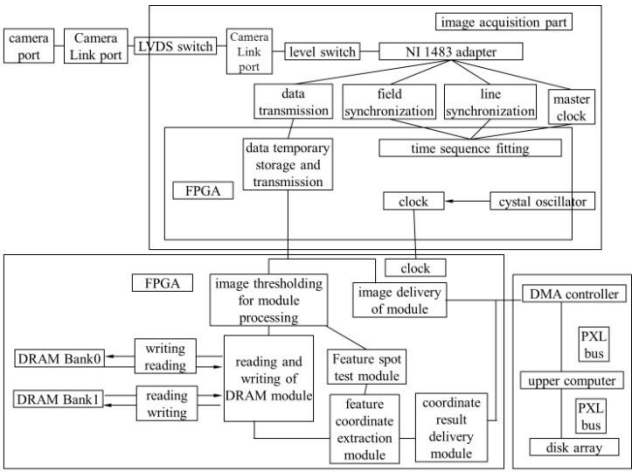

FIGURE 1 Framework of real-time image acquisition and processing

The work of the processing part is the core of the entire system, which can play a significant role in the realization of the real-time requirements for image processing and control. Finally, the anticipatory storage work is to store the processed image timely without damaging it, thus providing basis for further analysis and study. The work of the entire system is independent and combined organically.

Only by working effectively by all sections can it ensure the timeliness work of image acquisition. The following figure shows the real-time image acquisition and processing framework based on NI FlexRIO.

3 Realization of real-time image processing work

The equipment used in this study is relatively advanced, and there are not many relevant studies domestically at present. Therefore, it is to discuss the parameter performance of the equipment first, and then discuss the realization of timeliness of the image and data processing work along with the elaboration of the overall process.

3.1 HARDWARE EQUIPMENT USED IN THE IMAGE ACQUISITION AND STORAGE SYSTEM

The mainly applied hardware equipment includes: high-speed camera, FPGA processing device, data information transmission adapter, high-speed storage disk array, etc. By making use of FPGA processing device and data transmission adapter, it is to constitute the FlexRIO equipment:

The high-speed camera used in this study is a high-speed digital single- color one made in Germany, which has excellent performance and the highest resolution of 1696 × 1710. Even under the circumstance of highest resolution, the image acquisition speed is very high at about 280f / s. The data transmission speed is about 865MB / s with a variety of trigger approaches.

FPGA processor is the core processing part of the entire system, which can control the acquisition of the high-speed camera, the processing of the acquired image and the transmission of the data information. The FPGA processing module used in the study is FlexRIO series. There are 8210 pieces of programmable gate array FPGA and 188 DSP microprocessors in the entire module, which is with superior hardware data processing capability. In case of large resolution and fast collection speed, the occupancy of the system by resources can still maintain high-speed operation.

The data transmission adapter is produced by NI Company, which is specially allocated for FPGA processing wood. The high-speed camera is connected with the port of data transmission adapter. LVDA format is adopted for data transmission, which has very high speed and small noise. Therefore, it is an ideal choice in this study.

The high-speed storage disk array belongs to Model HDD-8265 produced by the same company, which is used for the storage of image information. The device is composed of a corresponding controller and hard disk. RAID is the controller, and the 12 3.5-inch SATA hard disks with the capacity of 1TB are selected as well. In RAID0 mode environment, the storage speed of high-speed storage disk array is at 7450MB / s or above. When it is in the RAID5 mode, the storage speed can still reach 710MB / s, which can well meet the real-time requirements. Further, high-speed disk array storage HDD-8265 can conduct a series of connection operations, which is very convenient.

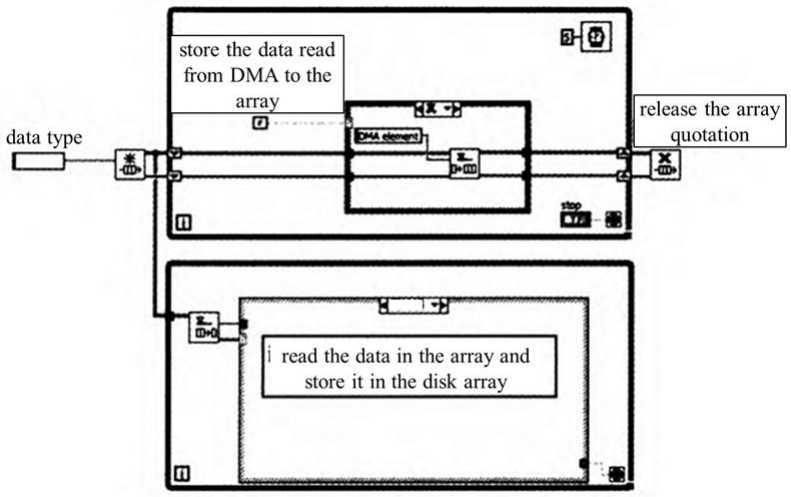

Figure 2 Real-time image storage program graph

3.2 REALIZATION OF REAL-TIME IMAGE DATA PROCESSING

While the image is transmitted to the upper computer for real-time storage after acquisition, FPGA can also realize the processing for the collected image information and store the obtained result in the upper computer. The phases of the processing mainly include: thresholding processing, data input, bright pixel detection, spot coordinate extraction, etc. Finally, the data transmitted out will be stored.

3.2.1 Shresholding processing

The original image captured by the high-speed camera cannot be with further treatment because its background and target zones are mixed together instead of being separated. So, it is needed to split the image zones first to extract the central coordinate of the spot. In general, the pixel grayscale is evenly distributed in the image area, and the grayscale difference at different areas may vary significantly. That's why it is needed for segmentation and ad-

justment by using the thresholding method. Make a comparison by making use of the threshold value T and the grayscale values in the original image, so as to determine which zone the pixel belongs to through the obtained grayscale value. Via thresholding processing, noises can be eliminated effectively as well.

It should be noted that, in the process of applying the threshold method, the trade-off shall be selected, which is a difficult point in this study. This paper selects the Otsu threshold method to choose T. The basic principle of this method is to use the best threshold and split the grayscale of the image into two parts, then calculate the interclass variance of the two parts as well as the maximum value. The specific flow is: First, assume the range of grayscale is {0, 1, 2, ••• l-1}. In this study, when the image grayscale is 8 bit, the range will be (0, 25), then the grayscale will be i and the pixel will be ni. So the total pixel will be

$$N = \sum_{i=0}^{255} n_i$$

.

The probability of the pixel appeared will be $P = \mathrm{n}_i / N$. Select the threshold t, the pixel will be divided into two types: C0 and C1, then the appearance probability of the two will be:

$$\mathrm{w}_0 = \sum_{i=0}^{t} \mathrm{n}_i / \mathrm{N} = \sum_{i=0}^{t} \mathrm{p}_i, \quad (1)$$

$$\mathrm{w}_1 = \frac{\sum_{i=t+1}^{255} n_i}{N} = \sum_{i=t+1}^{255} p_i = 1 - w_0 \quad (2)$$

Finally, we can know that the variance between the mean grayscale C0 and C1, and the threshold value can be determined:

$$d(t) = w_0 w_1 (\mu_0 - \mu_1)^2 \quad (3)$$

3.2.2 Parallel reading and writing of data

To achieve the extraction of the spot coordinate, it is needed to store the acquired data via FPGA, but if the image is directly stored in FPGA, massive image information will occupy a large amount of the memory space. Therefore, the study is to make use of the onboard of the module to write in the image data and read the spot zone pixel. In order to achieve the real-time image processing, the speed of FPGA must be improved, so it is necessary to use the ping-pong operation technology in the process, so as to realize the seamlessness among data images effectively. Ping-pong operation can conduct data analysis and processing constantly as a whole, which is with strong continuity and can greatly improve the speed of image processing.

In parallel reading and writing process, two dynamic RAMs shall be set, the specific processing steps of which include: input data and then choose the unit to allocate data to relevant dynamic RAMs; In the first buffer period, data shall flow into the first dynamic RAM named DRAM Bank0. In the second buffer period, data will flow into the second dynamic RAM named DRAM Bank1. Meanwhile, data cached in the first RAM named DRAM Bank 0 will be transmitted to a specific data processing module for analysis and processing. In the third buffer period, choose the unit for exchange as well, and transmit the data cached in the second period to the processing module for treatment. Do it in circles until the whole reading and writing process ends, in which process, the selected unit contains two sections including the output and input. According to the system operation, the two can cooperate orderly to produce extremely high working efficiency.

2.2.3 Spot detection

It is needed to test the spot and find the specific position of the spot in the image in order to find out its central coordinate. Then extract the target zone of the image containing the spot. Use the central coordinate extraction method to extract the spot. The test of spot is mainly by making use of the edge extraction algorithm. Although the method is feasible, it is time-consuming, which, apparently, cannot meet the real-time requirements of image processing. In this study, a new template is applied for spot test, the principle of which is to identify the pixel in thresholding processing to make it matched with the template and determine the spot position. This method is relatively with faster speed and higher feasibility.

3.2.4 Extraction of the central coordinate

The gravity method applied for spot extraction in this paper requires that all processing sections shall be completed within the period of FPGA operation. However, the programming way of traditional serial software is with low efficiency, which is no longer studied. In order to enhance the working sped of the system and program, the gravity method is realized inside the system by using the pipelining. Three steps are needed for one task. Serial operation of the tree steps is likely to result in lower working efficiency and more difficult accomplishment of the task within the operation cycle of the system. Therefore, the entire task is divided into several smaller ones. The result of the last operation can be retained through the shifting register, and task parallel can also ensure the completion of the work within the cycle.

The pipelining depth determines whether the final output result will fall behind the number of cycle. Assuming the depth of a pipeline is P, then the result will not be a final one and the operation will not be meaningful until cycle P. In this paper, the grayscale gravity is divided into various levels for operation by making use of the pipelining.

3 System performance evaluation

Finally, the system performance is tested along with high-speed shooting of the moving target in the process. As can be seen, the dispatch mode of the high-speed camera uses the internal trigger way whose image resolution is 1280 × 1024, pixel clock of the system is 70MHZ, speed is 645f / s and data transmission format is 12Tap / 8bit. Through the test, the maximum storage speed under RAIDO mode of the disk array can reach 700MB / s, and the system can

always maintain high working efficiency and stable operation via several times of experiments. As a result, high-resolution acquisition and high-speed transmission can be combined perfectly.

4 Conclusions

By analyzing the composition of the image processing system, this paper aims to discuss the realization of real-time image processing work in detail. Through the NI FlexRIO system, pipelining technology and virtual instrument technology, it is to develop a set of prominent acquisition and processing system with high timeliness, so as to achieve high-speed image acquisition, processing and storage. It is with the significant advantages of high working efficiency, large storage capacity and fast speed. It has been verified by relevant tests that the system can maintain satisfactory stability in case of long-term working state, and the image processing precision can reach the sub-pixel level. In addition, it is of great value in other relevant fields as well.

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