Bare Glass Inspection System using Line Scan Camera

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Abstract: Various defects are found in FPD (Flat Panel Display) manufacturing process. So detecting these defects early and reprocessing them is an important factor that reduces the cost of production. In this paper, the bare glass inspection system for the FPD which is the early process inspection system in the FPD manufacturing process is designed and implemented using the high performance and accuracy CCD line scan camera. For the preprocessing of the high speed line image data, the Image Processing Part (IPP) is designed and implemented using high performance DSP (Digital signal Processor), FIFO (First in First out), FPGA (Field Programmable Gate Array) and the Data Management and System Control part are implemented using ARM (Advanced RISC Machine) processor to control many IPP and cameras and to provide remote users with processed data. For evaluating implemented system, experiment environment which has an area camera for reviewing and moving shelf is made.

Keywords: FPD, Line Scan Camera, IPP, DMSCP

1. INTRODUCTION

Recently, the demand of a large size of LCD (Liquid Crystal Display) and PDP (Plasma Display Panels) which are substitute for CRT (Cathod Ray Tube) is increasing. FPD (Flat Panel Display) is used for today's desktop computers, digital phones, car navigation, video cameras and a variety of other devices.

These FPDs are susceptible to various defects during production. Therefore, many inspection systems are required in the FPD manufacturing process. Particularly, in the FPD manufacturing process, the detection of defects has to be done to reduce the cost before reaching the process that is difficult to fix.

Among the various inspection systems, the FPD's bare glass inspection system has an advantage of reducing the cost remarkably by detecting the defect early in the FPD manufacturing process. As the size of FPD is larger, the inspection system which can cope with large bare glass is also needed.

2. SYSTEM CONFIGURATION

In this paper, we designed the system architecture shown as the Fig. 1. Line image data from the cameras is acquired by the IPP. The image acquisition and defect detection are performed in real-time. Simultaneously, 1024x768 VGA output in IPP shows the image from the camera. Then defect data are transferred to the PC (Personal Computer) through DMSCP through Ethernet. User PC makes defect map with the acquired information and check the defect with the CCD camera for review.

3. IMAGE PROCESSING PART

Implemented IPP architecture is like the Fig. 2.

The IPP gathers digital image data from a line scan camera through the camera-link interface. Also IPP can process some kinds of preprocessing like background noise elimination or binarization . Preprocessing algorithm is designed to execute a real-time adaptive threshold algorithm [1] that eliminates background noise which is caused by the illumination and properties of camera. The algorithm is implemented on the FPGA (Field Programmable Gate Array) using VHDL (VHSIC Hardware Description Language).

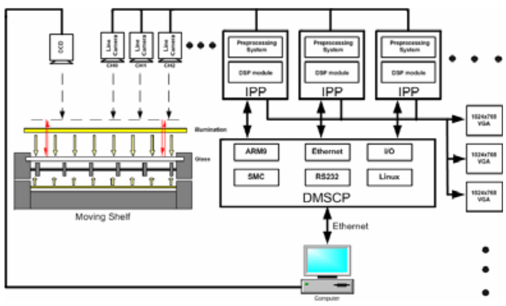

Fig. 1 The Whole System Architecture.

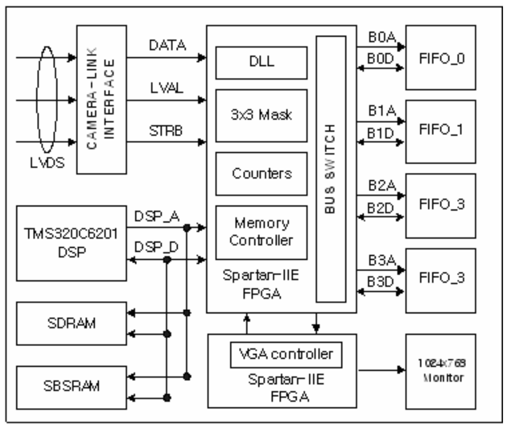

Fig. 2 IPP Block Diagram.

The memory for preprocessed image data is designed as a four-step pipeline architecture with the dual port memory for a real-time processing. And then, the high speed DSP (Digital Signal Processor), TMS320C6201 [2] of the Texas Instruments Incorporated, detects the position and the size of defects using the image data from the camera. These defect data are stored to a SBSRAM [3] (Synchronous Burst Static Random Access Memory) and are to be transferred to the DMSCP. Additionally, this part provides video output port converting 1024x768 frame image from 768 line images of 6048 pixels and displays the frame image on the VGA monitor in a real time. Whole this part is implemented on single PCB (Printed Circuit Board) as Fig. 3.

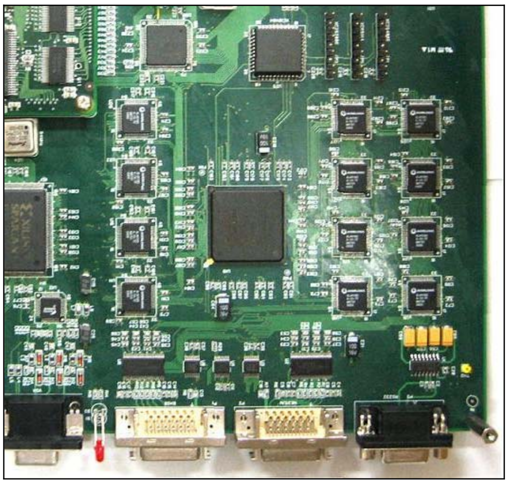

Fig. 3 Implemented IPP Circuit Board.

4. DATA MANAGEMENT AND SYSTEM CONTROL PART

Implemented DMSCP architecture is like the Fig. 4. DMSCP controls the IPP boards and cameras. This part can control up to eight IPP boards and cameras. And it also gathers defect data from the IPP boards at the end of the inspection process. ARM9 [4] core-based microcontroller is used and an embedded linux is adopted as the operating system. For interfacing to the ethernet, an embedded web server works on the operating system. Defect data from each IPP boards are prepared as a file and are ready to transfer to the SMDP through the ethernet with TCP/IP protocol. This part also is implemented on single PCB (Printed Circuit Board) as Fig. 5.

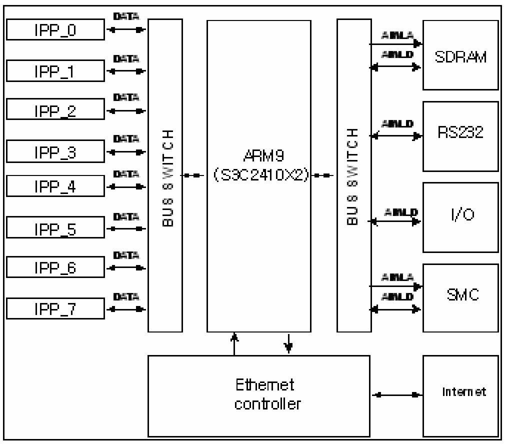

Fig. 4 DMSCP Block Diagram.

IPP which is designed as stand alone type and DMSCP board are added on the Subrack for VME bus to control many cameras simultaneously as in Fig. 6. In this way, many IPP boards can be added to extend cameras for higher horizontal resolution.

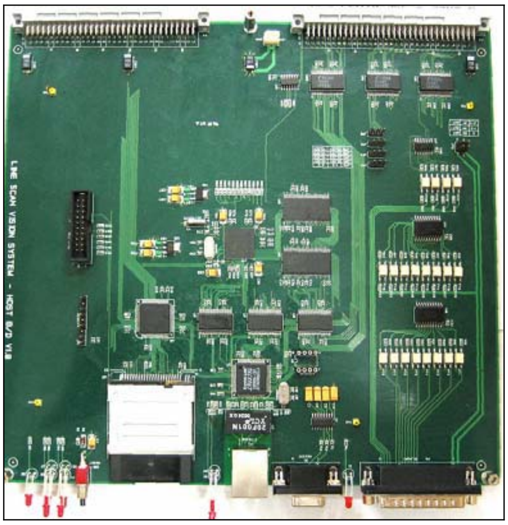

Fig. 5 Implemented DMSCP Circuit Board.

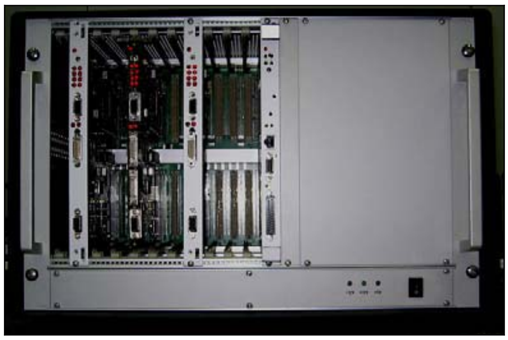

Fig. 6 IPP and DMSCP in Subrack.

5. MECHANICAL PART AND ILLUMINATION SOURCE

In this paper, for confirming the defect inspection, the defect information is acquired by running the line scan camera which accepts trigger signals from the motor of the transferring device while the bare glass which has defects is transferred on a moving shelf as in Fig.7.

For confirming the acquired defect information, the two-axis area camera system is used that the camera is moved to the point where the defect exists and magnifies highly.

Fig. 7 Mechanical Part and Illumination Source.

Also to suppress the image distortion from the line scan camera, linear illumination source are added on the mechanical part. And to check the real time line image from IPP, the frame image 1024x768 from the VGA output of IPP is shown through the monitor like Fig. 8. In this way, focus and brightness of the line camera are easily confirmed and then camera calibration is easy.

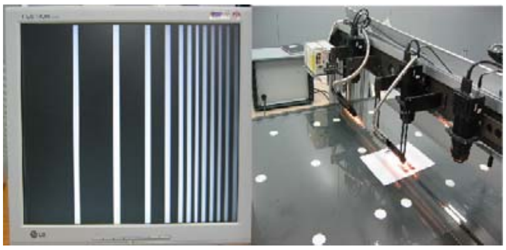

Fig. 8 1024x768 VGA Output.

6. USER INTERFACE

The user interface that makes defect map with the defect information from DMSCP through Ethernet and drives CCD camera for review is like Fig. 9. Through this user interface moving shelf and bare glass inspection system is controlled. The left bottom of Fig. 9 shows the defect map which is made by the defect data from the DMSCP. The left top of Fig. 9 shows the CCD camera image made from the defect map.

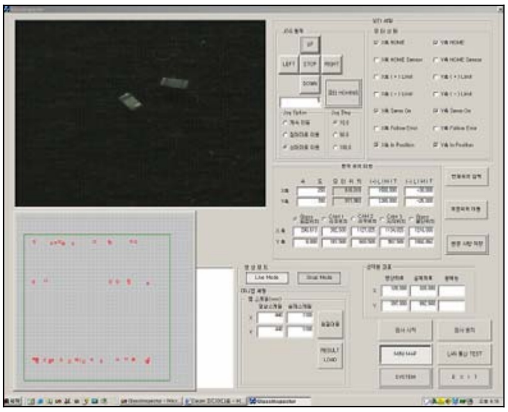

Fig. 9 User Interface.

7. CONCLUSIONS

Finally, the bare glass inspection system for the FPD which is the early process inspection system in the FPD manufacturing process is designed and implemented using the high performance and accuracy CCD line scan camera. The implemented system consists of the IPP, the DMSCP. And each part is composed of the many sub parts. The proposed system in this paper is expected to apply various FPD's bare glass inspection system.

In this system, horizontal resolution gets higher just by adding cameras. Implemented system is designed to process the high speed successive data which is one-dimensional. And it is a stand alone type which can save acquired image and processed results. Also, user PC can receive the processed results quickly through the Ethernet.

This system could be better if illumination equipment and mechanical part are improved. Because the detected defects are different according to the illumination [5]. It also needs database process of detected defects by implementing System Monitoring and Database Part (SMDP). And several basic filters for image processing by DSP module need to be invented and algorithms for application, too.

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