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AUTOMATIC SYSTEM FOR MEASUREMENT AND ALIGNMENT IN INDUSTRIAL VIDEO COLOR MONITOR MANUFACTURING PROCESS

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Abstract

A feasible solution to the problem of measuring and aligning automatically video color monitors in industrial manufacturing process is considered in this paper. The system is comprised of an integrated mechanical and software environment, and a digital video system is used as a feedback sensing for acquiring “in front of screen” image. Digital image processing techniques are used to pre-process the acquired image and digital image computational methods are employed to analyze screen geometric patterns, such as geometric distortion, rotation, vertical and horizontal centralization, and dimension (height and width). For monitors with total digital control the system can check and adjust automatically the circuits that determine screen geometry by using I^2C bus. The complete automatic measurement and alignment system can be used both on assembly line and quality control. Results show that the system can detect misalignment and geometric distortion, and avoid parallax effect in images of “front of screen”, as well as it can reduce time, improve precision, keep uniformity and increase productivity in video color monitor manufacturing line.

I. Introduction

In this paper we present an automatic measurement and alignment system developed for the adjustment of high precision video color monitors. This system was developed by the Integrating and Testing Laboratory (LIT) at the Brazilian National Space Research Institute (INPE) to meet the requirements established by an outstanding monitor manufacturer. The system is to be used both in assembly line and in quality control to improve the precision of video color monitors and increase the productivity of the manufacturing line.

The adjustment process of color display monitor is of great importance to fulfill the requirements for accomplishing high quality monitors [1][2]. The alignment measurement of images is one stage included in the adjustment process. The alignment process considers geometric patterns to achieve an appropriate performance of the color display tubes (CDT) to avoid geometric distortion on the images [3][4], such as barrel, pin-cushion, trapezoid, parallelogram, or seagull distortion. If an automatic system is used to measure and align screen geometry the productivity will be enhanced [1][2][5][6] and, the most important, will avoid parallax effect and then subjective interpretation when handmade adjustment is performed.

The developed automatic measurement and alignment system is based on geometric analysis considering actual images available in “front of screen”. The complete system is comprised of an integrated mechanical and software environment. A supervisor module, an operator module, a virtual pattern generator module (VTG) and an automatic measurement module interconnected by a human-machine Interface (HMI) compose the software environment.

II. Problem Description

One stage during the manufacturing of video monitors is the appropriate adjustment of geometric patterns to guarantee the quality of monitors. The measurement and alignment of those parameters is traditionally a manual process. This means that the quality of the whole process is determined by human operators who naturally present limited accuracy, low efficiency, and low reliability. Beyond being a critical and important adjustment activity, when human operators measure geometric distortions, rotation, vertical and horizontal centralization, and dimension (height and width) of front screen image of each monitor under test the time spent in limited by the human being abilities. In an industrial segment, the less time is spent in a manufacturing line the better it is. Therefore, an automatic system is required to enhance the productivity and improve the uniformity and quality of final products.

III. Overall System Configuration

The overall system is divided into software, mechanical, and vision subsystems (figure 1). The visual subsystem feedbacks front of screen images of monitors under test to the software environment. A camera acquires image sets by moving up and down, and forward and backward, by using precision ball screws, and angular ball bearing arrangement, respectively. The mechanical system allows continuous adjustment of those motions and the azimuth changing of the camera. The acquired images are pre-processed by using digital image processing techniques [7][8] and analyzed by different image computational methods [9][10]. These techniques and methods deal with segmentation operation (edge detection, edge polynomial approximation, and edge description), dimension computing, vertical and horizontal centralization, rotation, and screen geometry alignment.

Figure 1 – Actual Automatic Measurement and Alignment System

The methodology applied in the system identifies the deviation between measured images and test image patterns, and optimizes the adjustment of the monitors by indicating necessary offsets to reach the established requirements.

The camera acquires a front of screen image of a turned-off monitor in order to determine its framework. The image is pre-processed and morphologically transformed by using a smoothing filter to eliminate undesired high frequencies (noises), a color to gray-level transform algorithm, a “simple image statistic” (SIS) algorithm to transform the image in 24 binary standard (bitmap), a zero-crossing Laplacian filter algorithm to detect the inner border, and the “Zhang-Suen Skeletoning” algorithm to refine thick borders by finding thinning ones (unit thickness) and finally the “chain code” algorithm is used to storage the border in a final image [7][8][9][10].

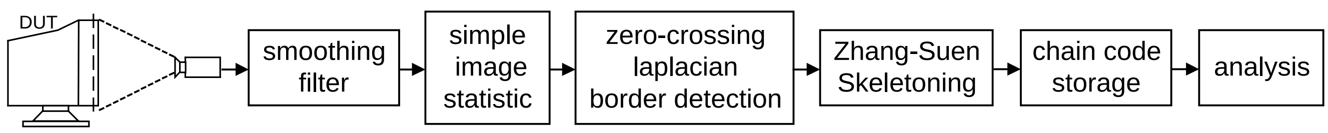

Figure 2 – Digital Image Processing & Morphological Transformation

The final result is a rectangle whose center is computed and compared with a center in the screen generated by the software environment in order to verify the centralization of the camera. If there is any misalignment the difference between both real screen and software presented centers determines how much the camera is far from the ideal position in order to guarantee accuracy during the alignment process. Carried out the centralizing proceeding, it is time to calibrate the system by establishing the relationship between number of vertical pixels and the opening vertical framework, and number of horizontal pixels and the opening horizontal framework. Afterwards, a 10x8 image pattern matrix to be used at the geometric alignment proceeding is generated in front of screen monitor by employing the software environment. The image obtained by the camera is now a set composed by the framework and the geometric pattern. This new image is also pre-processed and morphologically transformed as mentioned earlier and then analyzed to indicate specific geometric measurements concerned to the quality and precision of video color monitors.

All geometric analysis is done checking the pos-processed pattern matrix border against the framework rectangle border. Vertical centralization is computed by subtracting outer border of the pattern matrix from the inner framework border and then it is checked the equivalence at the top and bottom of the acquired image. Horizontal measurement is quite similar except by the equivalence is checked at the right and left side of the acquired image. Dimension is calculated by using the relationship between distance and pixels obtained at the calibration stage. Rotation is computed by finding the angle between the horizontal or vertical average line of the patterns matrix border and the inner framework border. And finally, geometric distortion is verified by comparing the pattern matrix template and the real image in front of screen.

The auto alignment system for geometry spent 6 seconds during the alignment process. The automatic sequence of measurement and alignment can be applied to all pre-established resolutions.

The inherent nonlinearities of the optical set composed by the camera (lens) and color display tube (screen) are canceled because the values used to compare the framework and the geometric pattern border measurement are relative values to each other.

This system can be employed both in the whole process of alignment or in the process of qualifying where the monitor is adjusted manually and the system is used to check adjustments done by the manufacturing line.

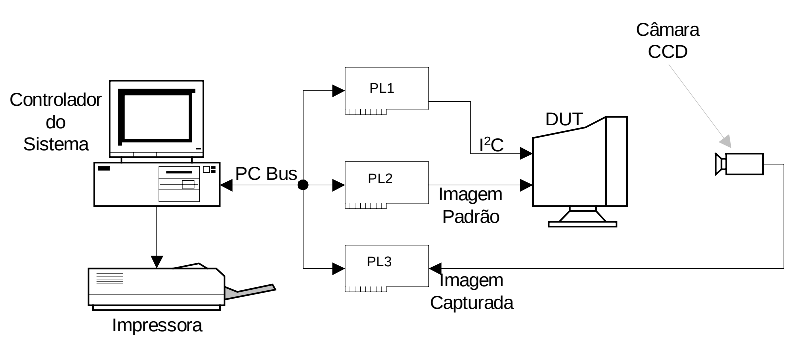

Figure 3 - Automatic Measurement and Alignment System

For monitors with total digital control the system checks and adjusts automatically the circuits which determine screen geometry. Otherwise, for monitors that are not totally controlled the system indicates how much analog devices must be modified by human operators and, afterwards, settles automatically the digital circuits. Adjustment commands are sent from the controller microcomputer to the CDT circuits by using I^2C bus. It's a private bus for simplifying circuits and maximizing hardware efficiency used in communication.

IV. Conclusion

An automatic measurement and alignment system for industrial video color monitor manufacturing process was presented in this paper. The developed system performs measurements faster than when handmade operation is carried out. The automatic measurement of the parameters concerned with the operation speed the productivity up and avoids parallax effect and visual misinterpretation. Besides, that industrial software development applied in a manufacturing line permitted the evaluation of digital image processing techniques to improve the quality of color display monitor. The system also allowed the elaboration of a human-man interface with an easy and flexible setup proceeding and operation. There is also an available database for searching and statistic analysis in order to improve quality and productivity. Finally, the automatic alignment system presents the advantage of working in natural lighting environment without interference of external lighting.

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