Development of Test Facility Remote Control System by Using Vision Technology

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1. Introduction

A lot of cables are currently used in nuclear plant. Those cables should be satisfied with EQ program compliance with 10CFR50.49. Particularly, the cables should be verified to perform required function under harsh environmental service conditions that can be exist during LOCA (Loss of Coolant Accident). For this reason, we established LOCA test system for ensuring that the cables can perform their function in LOCA conditions. In this system, to execute LOCA test of cables, we must monitor the system for 24 hours a day for abnormal accident or failure during test. This situation is so ineffective, and loss of human resource. Therefore, it is so important to establish network remote control system to monitor the LOCA test system in office or even home.

2. Systems for Network Remote Control

2.1 Configuration of the systems

In order to control remotely, we must check the current conditions of LOCA test system. So we need to install the CCD camera. The current state of LOCA test system is checked by grabbed image from the CCD camera. And the camera should be able to grab a variety of region because the region which should be monitored is very wide. Therefore, installed camera should have more than two degrees of freedom and have motorized zoom lens for detail monitoring of specific region. EVI-D70, which is purchased for remote control system, evolves pan/tilt stage, which can rotate 360 degrees for pan, 180 degrees for tilt, and motorized zoom lens, which has focal length from 4.1mm (wide) to 73.8mm (tele) and F number from 1.4 to 3. We used Matrox Morphius as an image grabber board, and the image grabbed from EVI-D70 can be painted in PC monitor using Mil-Library. The grabbed and digitalized image can be used to be transferred to client PC, and also used to acquire the condition data of LOCA test system. We decided to choose TCP communication method which is relatively safe and lossless as a method for transferring image data through the network.

By the way, because digitalized image data from camera is raw data, the data has relatively big size. If the image

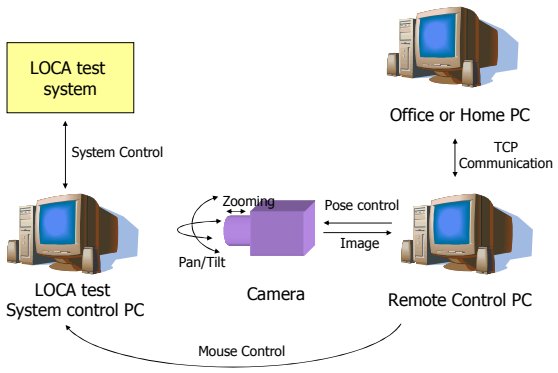

Figure 1. The schematic diagram of the system

have RGB color and VGA(640*480) resolution, the size of the mage data is 900kbyte. In this situation, it is difficult to transfer the image data as a speed of more than 4 frames per second. However, if the image data is compressed to JPEG image with a few losses, the size of image data decreases definitely. The more the size of image data is decreased, the more the number of frame per second is increased. This method also has disadvantages of processing load. In this situation, compression and decompression of JPEG image is repeated frequently, so the PC has heavy processing load. Actually, the number of frame per second depends on the CPU clock and performance.

Then, client PC which receives the image of LOCA test system should control the LOCA test system. Because the computer connected to the LOCA test system is so sensitive, it is so dangerous to execute another program when LOCA test program is executed. Therefore, we proposed the method to control mouse which is connected to system. We approached to this problem by controlling the hardware not software. Parallel port is used to generate control signals.

It is ineffective to transfer the all image of the system as a real time, because we can check the current conditions of LOCA test system through the data shown in PC monitor. At normal times, if the data shown in PC monitor is only transferred, the size of data and processing load is extremely decreased. In order to transfer only condition data, not image data of the system, we should read automatically the system data shown in PC monitor. Using

the method of image processing, we can get the condition data of the LOCA test system. The algorithm of image processing will be described in Section 4. The schematic diagram of system is shown in figure 1.

2.2 Control of the mouse

In order to control the LOCA test system in client PC, we use the method to control the mouse of LOCA test system controller PC. The ball and USB type mouse is selected because of simple structure and freely accessible interface.

The ball type mouse works as follow. According as the ball is moved, the roller with rectangular hole between infra-red LED and photo detection sensors is rotated. If the roller rotates one direction, the signal of photo detection sensors is changed frequently. The direction and frequency of changed signal decide the direction and speed of mouse in PC. We need four control signals for controlling mouse movement, two signals for up and down, and others for right and left. In case of click of mouse button, it is consisted of simple switch. Therefore, we designed simple circuit with transistors. We need two control signals for controlling the click of mouse button. Because six signals are needed to control mouse, the parallel port which is able to transfer eight signals at once is utilized. The Schematic circuit is shown in figure 2.

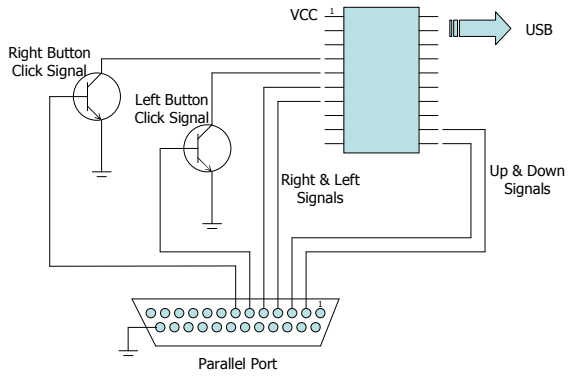

Figure 2. The schematic circuit of mouse controller

2.3 Image processing algorithm for numeral recognition

When transferring the condition information of LOCA test system, we can transfer the only system data, not real time images. So, automatic recognition of LOCA test system is needed, and the method of image processing of camera image is proposed. All the condition data of LOCA test system is numeral data, and only numeral recognition using image processing is needed. Image processing algorithm is as follow.

First of all, the camera is moved toward the monitor, and the image of monitor is captured. Then, background and numeral data is distinguished by binarizing captured image. That image should be removed the noise by using median filter which removes the noise, but leaves the edges. And then, segmentation which separates each number should be executed by region growing method as shown in figure 3. The each segmented number image is recognized to real number as a method of numeral recognition algorithm. The algorithm is to extract unique feature of each number.

Figure 3. Segmented numeral regions

3. Conclusion

We established the remote control system which can control and monitor the LOCA test system in everywhere to access to internet. For this system, we used TCP communication for image transformation, remotely controllable mouse for controlling the system PC, and image processing method for numeral recognition of condition data of LOCA test system. As a result of usage of this system, we can perform the LOCA test of cables effectively without loss of human resource.

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