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Development of a Pin Hall Remote Inspection System based on Auto-Recognition of the Hall Center

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1. Introduction

Many of the safety instruments are related to the NPP coolant systems. The first coolant system includes radioactive contaminated water and the secondary coolant system includes clean water. If there are some defects in the coolant systems, these conditions may cause serious accidents such as the loss of national electric power and of human lives. So the diagnosis of the coolant systems has become an important issue in the nuclear power plant.

The environments of diagnoses in the nuclear power plant are very dangerous to the human. So the auto inspection and monitoring methods have been adapted to NPP's diagnoses.

We have developed a pin inspection system that includes an inspection robot, an image processing system, a web-server and various control systems.

2. Pin Hall Inspection System

This system was developed to inspect the guide tube support pin. This system consists of a UT inspection robot, a robot control server, an image processing server, an inspection application server, a web server and a web camera server.

The robot has two cameras to monitor the operation and find the center position of the target pin. The monitoring image is sent to the remote user web browser through the web camera server. The position of the image is sent to the image processing server. It calculates the moving path of the robot and the position of the target pin automatically. It sends the information to the robot control server.

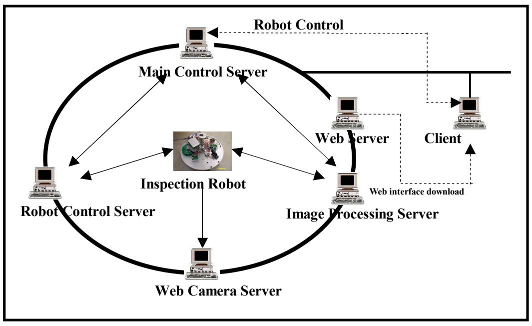

Fig. 1. Guide tube support pin inspection system

The acceptable position error range of the inspection robot must be within 2mm for the guide tube support pin(diameter 25mm) UT inspection. The dead reckoning method is not compatible to finding the accurate center position of the pin and the guide tube hole because of the growth of the accumulated error. We use the compensation of the accumulated error to decrease this problem.

The captured image size is 160x120. We apply zero padding to the original image for the effective two-dimensional FFT and changed it to 256x128 size. This size is appropriate for the real time calculation(10 frames/sec) in the image processing system. It is built on a Pentium-4 2GHz computer. We apply the Fourier Transform to the image that includes the tube hole and pin image. The transformed image is used as a matched filter. Figure 2 shows the matched filters. The left one is for guide tubes and the right one is for support pins.

Fig. 2. Images of matched filter

The image processing system takes the image of the guide tube form, the built-in camera and makes it as a binary image. Figure 3 shows the real image and the binary image.

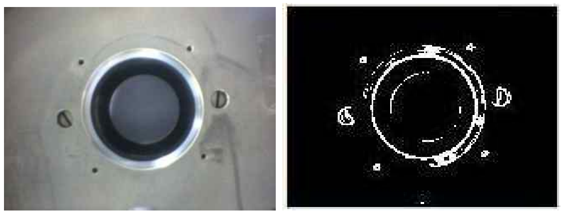

Fig. 3. Real and binary image

When the binary image passes through the matched filter, we can get the center position of the guide tube hole. The bright pixel of figure 4 is the center position.

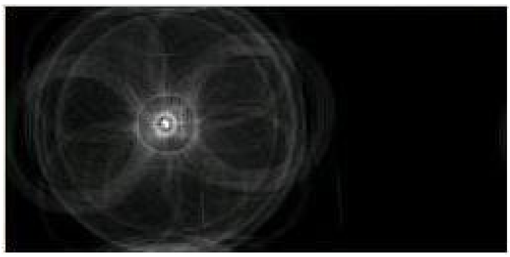

Fig. 4. Filtered image

We remove the guide tube image from the filtered image to get the positions of the support pins. Figure 5 shows the binary image without the guide tube image.

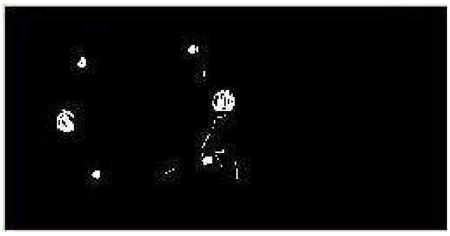

Fig. 5. Binary image without tube image

When we pass the figure 5 through the matched filter for support pins, we can get the center positions of two support pins. They are the bright pixels in the figure 6.

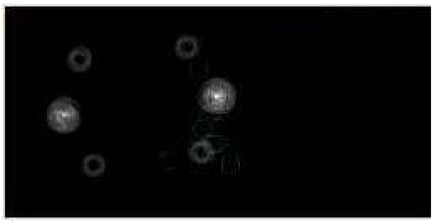

Fig. 6. Binary image without tube image

Then we must calculate the robot position. We can find out the robot position from the two center positions and the angles of them.

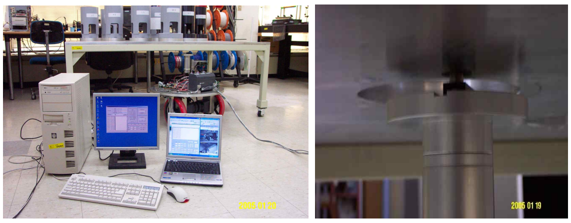

Fig. 7. Auto-inspection for a pin

When the remote user presses the target pin button and the auto-inspection button on his web browser, the robot starts an inspection for the target pin automatically.

3. Remote and Auto-Inspection Model

It has a remote application server and a web server. The remote user interface is operated in the web-java environment. It is clear that the web-java environment offers excellent compatibility to this application.

We suggest a remote application server as a middle server that has some applications for controls and communications. The applications are programmed in the respective native language and they reduce the overhead of the remote user interface. The remote user interface receives preprocessed data. When some errors occur in the inspection system, the main control programs of the inspection control system and the remote server applications work together to solve the problems. Then the application server sends the results to the remote user interface. The inspection system and the application server must include service error recovery procedures.

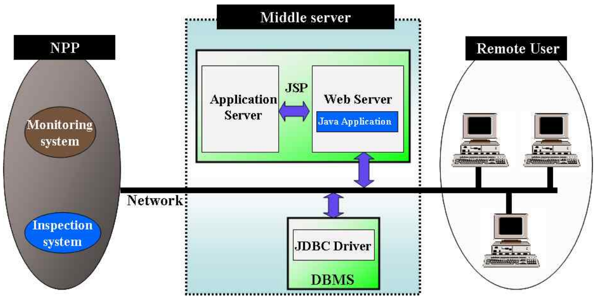

Fig. 8. Remote Inspection Structure

4. Conclusion

A nuclear power plant has a large amount of safety instruments and 20 reactors are operating in Korea. Each nuclear power plant has its own unilateral diagnosis operation systems for the safety instruments. And the execution of the diagnosis is performed in radioactive areas. It causes the redundancy of monitoring systems, the difficulty of data sharing and dangerous working environment. The remote diagnostic technologies to cover these problems are essential for the nuclear power plants safety.

It requires many technologies to develop a remote diagnostic system for a nuclear power plant. Knowledge of physics, electronics, mechanical engineering, nuclear engineering and computer engineering are used to develop it. There are many ways to construct it. We described our three diagnostic systems and suggested a common structure.

Remote data acquisition and processing are unsolved factors in our research and development, but we have some solutions to improve them.

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