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Detection of Weld Defects by Computer-Aided X-Ray Radiography Image Processing

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ABSTRACT

The X-ray radiographic testing method is often used for detecting weld defects as a nondestructive testing method (NDT). Due to the difficulties in identifying small defects from the X-ray film, skilled labourers should be trained. However, recently it has been difficult to employ skilled labourers. Moreover, for the identification process, not only the labourers' skill influences the testing result, but also it is difficult for skilled labourers to assess small flaws within a short time. In comparison, computer visual image processing systems have some good characteristics, allowing objective assessment, high-speed judgment, nonhuman error, etc. Therefore, an image processing system allows weld defects to be detected using X-ray radiography in the presence of background noise. This paper deals with an image processing method for detecting defects, such as pores, slag inclusions and cracks, and discusses a system of displaying defects by computer graphics.

INTRODUCTION

Because defects in weld metal affect the strength of the welded joint, many nondestructive inspection methods, such as ultrasonic testing, magnetic particle examination, liquid penetrant testing, etc., have been proposed and are used. The X-ray radiographic testing method is especially superior as regards testing data and the ease of the testing method. However, when the defect is small, it is difficult to identify the existence of defects, defect type, defect shape, etc. using an X-ray film. On the other hand, it is difficult to employ skilled labourers and moreover, efficiency of identifying operation of X-ray film becomes important (for example, Daum et al., 1987). Therefore, in order to identify weld defects automatically from X-ray films, an image processing system was constructed. That is to say, the images in an X-ray film are taken by a CCD camera, and then the image data are processed using a personal computer. Thus, images of weld defects are displayed clearly on a CRT. In this paper, the optimum image processing method to eliminate noise and to abstract defects is discussed. Moreover, the displaying method of a clear defect image, by which a nonskilled labourer can identify defects, is discussed.

EXPERIMENTAL EQUIPMENT

Fig. 1 shows the arrangement of equipment. The system is constructed by a CCD camera, an image memory board (256×240×6 bit), a monitor, a personal computer, etc. Defect images in an X-ray film situated on a lighting box are taken by a CCD camera and the image data are transmitted to the personal computer through the image memory board as digital data. The image data are analyzed and processed in the computer, and the resultant defect image is displayed on a CRT.

The X-ray films used in this study were obtained by X-ray inspection of welded joints of steel pipes welded by the submerged-arc welding process. In the films several defects, such as blowholes, slag inclusions and cracks, are included. In Fig. 2a~c, X-ray inspection results are shown by photographs. Because the image of the defects in the X-ray film is not clear, sketches of defects are shown on the right side of the figure.

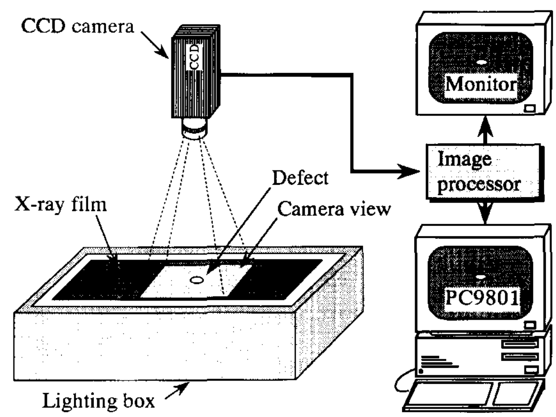

Fig. 1 Arrangement of equipment

TAKING OF HIGH-CONTRAST IMAGES

Generally, X-ray film has a lower contrast, and accordingly it is difficult to detect weld defects. Therefore it is very important to take the image in the X-ray film at as high a contrast image as possible. A method to obtain a high-contrast image was proposed. In the process the image taken by the CCD camera is transmitted to the personal computer, and the analogue data of brightness distribution in the image are converted to digital data of 64 steps. Accordingly, an improved method to convert the analogue data to digital data in the process was discussed. Generally, the brightness of each pixel in the image taken by a camera is converted to a voltage between zero to V_{max} (in this equipment, normally V_{max} = 5V). Then the voltage datum is converted to a digital datum in 64 steps. In this case, brightness distribution of a general image may use only a part of the voltage area ΔV_{img} as shown in Fig. 3a. If the ΔV_{img} is small, it is impossible to take a higher-contrast

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