A DETECTION OF WELDING TRACE USING X-RAY IMAGES 
BASED ON 2-D WAVELET TRANSFORM

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ABSTRACT

Welding inspection is highly essential presently owing to task monitoring creates of credibility and safety to the company and all users. Welding inspector is required to use much more ability and experiences including complicated technology as complemented assistance to inspect/check the welding trace in both during welding and after that. Therefore, this paper presents a detection of welding trace using films of X-ray images and 2-D wavelet transform for analyzing any defects after complete welding. The defects would be found within the welding trace in equipment or construction materials such as air bubble, incomplete weld etc. It ensures/guarantees that the equipment or construction are whether durable or safety. From the experimental results, we shall take photograph of the welding trace which might have some defects within the linkage using the X-ray films. There are 25 images of the welding trace for testing and verifying. All images can be checked for the errors in the linkage.

1. INTRODUCTION

In industrial field, the security or safety is another one which is very important apart from quality and reliability. To maximize efficiency, the part required to be checked carefully before the actual deployment. Quality examination of the linkage after welding is another issue that cannot be overlooked. Better welding quality is not only to build confidence in security but also to create reliability for the manufacturers. It has affected the accuracy in various kinds of assembly tasks in industry e.g. automobile manufacturers, docks, gas pipelines and etc. Moreover, the construction industry whether buildings or construction is used in transportation such as electric trains (subway/sky train) etc. It is required to be validated the quality of the linkage while welding, after joining and while working in order to ensure that the construction contains such strength and safety sufficiently for opening as services.

Quality control of the material is really essential. There are 2 crucial controlling methods such as examining by using inspection method with destructive testing and another method by using nondestructive testing-NDT. Inspection method with destructive testing is an examination of mechanical property of material to find out tension, bending, collision, hardness testing etc. The specimen which has already passed the test will be damaged and cannot be used again. Whilst the nondestructive testing-NDT is an inspection process used to find deficiency of the joints or any abnormality within the parts e.g. crack or air bubble etc. without resulting in fragment and causing damages to the tested parts. The tested parts already passed the test are undamaged and can be brought to reuse and to ensure that the parts have quality and safety when used.

In the past, the testing method for inspecting the joint/linkage had several formats to be done, and the most popular process is nondestructive testing-NDT by viewing image from X-ray film. This method will be tested by human being, actually, the inspector, due to its most simplicity and convenience. However, it is not the most accuracy and fastest because it is an incapability to identify details within the linkage most accurately. Several factors may cause such errors e.g. working environment, inspector’s health or feeling sort of dizzy caused from glaring the light for such a long period.

The related research papers of the past could be divided into 2 major groups as follows. The first group is an inspection of the deficiencies using ultrasonic technology and the second group is the use of images. For testing process to find any detects, each group has used the different methods. There are 4 papers proposing the use of ultrasonic technology. For analysis approach [1], the test was done by using ultrasonic and the wavelet is used to detect any defects. Whilst the paper [2] also was done by using ultrasonic and taking the wavelet and neural network to work out together in order to detect the size of the defects. In addition, the ultrasonic machine must be imported from abroad when employing this method. The practitioners need to be specially trained for such skills. The major problem when operating with the ultrasonic machine, is the evaluation to find out any size, shape and type of the
defects which depends on the operator’s capability, working manually, with high rate of errors and time-consuming. From the past, there were some inventors created a testing process using probe from ultrasonic machine [3] based on wavelet and neural network. Whilst the paper [4] would be tested by using the probe as well, but it can test only the welding trace of the conjunction joints which are displayed in terms of the waveform.

For the second group inspecting the deficiencies based on images, the X-ray film of the welding trace was taken through the process of wavelet and neural network. For example, this paper [5] has presented the use of images and neural network for testing arc trace but it can test only the welding trace of conjunction joints. Another paper has presented the use of wavelet [6] to detect the deficiency of the work by reducing the noise in the images using the wavelet denoising using log-gabor with phase preserved in order to make the defects of the work-piece being noticeable evident. However, the images from such method are different from the research to be offered because they are taken in the case of the welding trace just newly finished using thermal camera. This may cause such mistakes easily due to testing via images which should wait until the work-piece getting cold to maintain complete welding.

In this paper, the detection of welding trace has presented through the use of the X-ray film and the 2-D wavelet transform. This method is to take the images of X-ray film which had already been passed through the denoise process before getting into the 2-D wavelet transform. Then, RGB image is converted to gray image. Finally, dilation and thresholding are applied for verifying the defect of welding trace. However, the former paper [6] had done only the denoise process in the images for improving the image defects. It is not to inspect the results of welding defects.

2. PROPOSED METHODS

Figure 1 shows the flowchart of the process for detecting the defect of the X-ray image using the 2-D wavelet transform. The procedures can be described as follows.

2.1 De-noise

De-noise is a method used to reduce annoying noise form surroundings/environment to increase efficiency of inspecting the welding by using images from X-ray film. Since the images of X-ray film of the welding joint still has such noise which causes problem when checking. This will probably result in the image analysis process error. Therefore, noise reduction is a major step of this process. In order to yield the most accuracy, actually most data images have interferences mixed within them which will be more or less depend on sources of the data images. Before inspection, make sure whether getting data more accuracy by using improving process to compress by compressing and segregating all data images. Noise removal in the data images will be used frequency filtering to eliminate the interference from the images.

![Figure 1 Flowchart.](image1)

2.2 2-D Wavelet Transform

The 2-D wavelet will transform the x-ray images using Haar window [7] for separating the high and low frequencies as the following equation [8]. The 2-D discrete wavelet transform (DWT) represents and image in terms of a set of shifted and dilated wavelet functions \{\(\psi_{\text{LH}}, \psi_{\text{HL}}, \psi_{\text{HH}}\)\} and scaling functions \(\phi_{\text{L}}\) that form orthonomal basis for \(L^2(\mathbb{R}^2)\). Given a \(J\)-scale DWT, an image \(X(s,t)\) of \(N \times N\) is decomposed as

\[
X(s,t) = \sum_{k=0}^{N-1} \sum_{l=0}^{N-1} a_{k,l} \psi_{k,l}(s,t) + \sum_{j=0}^{J-2} \sum_{k=0}^{N^2} b_{j,k} \phi_{j,k}(s,t)
\]  

(1)
with $\psi_{s,k,t} = 2^{-j/2} \Omega(2^{-j} s - k, 2^{-j/2} t - i), \psi_{j,k,t} = 2^{-j/2} \psi_{j+1,k,t} (2^{-j} s - k, 2^{-j/2} t - i), B = \{ LH, HL, HH \}$ and $N_j = 2^j$. In this work, LH, HL, and HH are called wavelet or DWT subbands where $a_j$ is a scaling coefficient and $\psi_j$ denotes the $(k, t)$-th wavelet coefficient in scale $j$ and subband $A$ (Approximation Area).

### 2.3 Decomposition Multiresolution (Selecting Vertical Subband)

The 2-D wavelet transform separates the components from the diamond images. Figure 3 shows wavelet decomposition tree using level one where $f(x,y)$ is input image whilst $f_{LL}(x,y), f_{LH}(x,y), f_{HL}(x,y)$ and $f_{HH}(x,y)$ are coefficients of wavelet. $h_0(n)$ is a low-pass filter and $h_1(n)$ is a high-pass filter where $2 \downarrow 1$ is a decreased data of $\frac{1}{2}$ row and $1 \downarrow 2$ is a decreased data of $\frac{1}{2}$ column [9].

![Figure 3 Wavelet decomposition tree.](image)

The welding images using 2-D wavelet transform can separate the components from the welding images as shown in Fig. 4. Figure 4 shows subbands of the welding images where $H_1, V_1$ and $D_1$ are horizontal, vertical diagonal details in level 1, respectively. $H_2, V_2$ and $D_2$ are horizontal, vertical diagonal details in level 2, respectively. $A$ is approximation in level 3. Finally, we select only the vertical subband because it is clear to check the defect of welding trace.

![Figure 4 The divided steps for subbands of the image using the 2D-wavelet transform.](image)

### 2.4 RGB To Gray Image

This step is a conversion for RGB to gray image after finishing the step 2.3. The objective in this step is to prepare the selected image of the vertical subband being the RGB image which is converted to the gray image for a suitable format to use further the next step 2.5.

### 2.5 Dilation & Thresholding

The dilation will add pixels to the boundaries of the objects in an image which is equivalently resulted in gradually enlarging the boundaries of the objects. Therefore, the gray image of the vertical subband from the step 2.4 is dilated for extended defect of the film image. Finally, this resulting image is changed to a binary image using the thresholding method for remaining the image defect (vertical subbands).

### 3. EXPERIMENTAL RESULTS

Development of approach is capable to apply the knowledge of images processing to solve problem occurred in defect detection in the welding trace. The problem solving of this defect detection is the process of taking image file from X-ray film for taking pictures of the weld with defects in various styles. Then the process is to find any defect of piecework using the wavelet transform for checking to see clearly and quickly. From the experimental results, there are 25 images of the welding trace for testing and verifying. All images can be checked for the errors in the linkage.

These are example results of welding X-ray images for checking the defect in case of the air bubble. They will be seen as follows. Figure 5 shows de-noise X-ray image before taking into the 2-D wavelet transform. Figure 6 shows the resulting images of decomposition using the 2D wavelet transform. Figure 7 shows the selected image of the vertical subband in level 3. It can be seen from Fig. 7 that the defect is air bubbles because they normally will appear the wavelet decomposition of level 3. Figure 8 shows the resulting image of the vertical subband in level 3 after converting RGB to gray image. Figures 9 and 10 show the resulting images of dilation and thresholding, respectively, for the subband V in level 3.

![Figure 5 De-noise X-ray image.](image)
4. CONCLUSION

This paper has presented the detection of welding trace through the use of the X-ray film and the 2-D wavelet transform. This method is to take the images of X-ray film which had already been passed through the denoise process before getting into the 2-D wavelet transform. Then, RGB image is converted to gray image. Finally, dilation and thresholding are applied for verifying the defect of welding trace. From the experimental results, there are 25 images of the welding trace for testing and verifying. All images can be checked for the errors in the linkage.

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7. REFERENCES


