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An Innovative Method for Defect Detection in Digital Radiography Images

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Abstract*—The process of detecting the weld defect plays a vital role in the Non Destructive Testing (NDT) filed. An Innovative method for extraction of defects in digital radiographic welding images using mathematical morphology is proposed in the present paper. The proposed algorithm initially uses wiener filter for enhancing the input weld image. Then the Raleigh probability distribution function is used to highlight the defects and the boundaries of the weld region. Next mathematical morphological top-hat transformation is used to extract the defects existing in the input weld image. Then, the Otsu's global threshold method is used for binary conversion and the morphological opening followed by closing operations is used to smooth the detected defects. The experimental results clearly exhibit the efficacy of the proposed scheme.

Index Terms— **Closing, Opening, Otsu's Method, RPDF, Top-Hat, Wiener Filter.**

I. INTRODUCTION

Non Destructive Testing (NDT) is the technique of identifying the properties of material without making any damage. In the field of non destructive testing (NDT), the most important stage concerns the detection of welding defects. This could be very hazardous when dealing for example with rail roads, gas pipes, wheels, etc. Fortunately, radiography remains among the most adapted NDT processes for the control of welds of metallic pieces, because of its simplicity and its speed of implementation. In parallel, the development in the field of information technologies in particular in image processing, made it possible to invent new radiographic inspection methods able to detect and identify automatically welding defects by increasing the quality of information while decreasing diagnosis duration. Ioannis Valavanis et al.[1] presented a method for detecting and discriminating discontinuities in the weld images that may correspond to false alarms or defects such as worm holes, porosity, linear slag inclusion, gas pores, lack of fusion or crack. Juan Zapata et al. [2] described an adaptive-network-based fuzzy inference system to recognize welding defects in radiographic images by using image processing techniques, including noise reduction, contrast enhancement, thresholding and labeling, were implemented to help in the recognition of weld regions and the detection of weld defects. V. Vaithiyanathan et al. [3] presented a detailed survey on various segmentation methods used for detecting various types of weld defects. They concluded that specific type of segmentation algorithm is suitable for a particular type of weld defect. Region based technique is suited for porosity defect, Hough transform for lack of penetration defect and watershed for oxide inclusion defect which results in a good quality segmented image. Mythili Thiruganam et al. [4] focuses on automatic defect detection and counting in radiographic weldment images thus considering defects in weldment images as object of interest. To detect defects in radiographic weldment images, thresholding and segmentation algorithm is used. Rafael Vilar et al. [5] describe an automatic detection system to recognize welding defects in radiographic images. In a first stage, image processing techniques, including noise reduction, contrast enhancement, thresholding and labeling, were implemented to help in the recognition of weld regions and the detection of weld defects. Xin Wang et al. [6] developed an automatic computer-aided detection system based on Support Vector Machine (SVM) to detect welding defects in radiographic images. After extracting potential defects, two group features: texture features and morphological features are extracted. Afterwards SVM criteria and receiver operating characteristic curves are used to select features. Then Top 16 best features are used as inputs to a designed SVM classifier. Abdelhak Mahmoudi et al. [7] proposed a new method for segmenting digitized radiographic images which is based on histogram analysis, contrast enhancement and image thresholding. M.Ghazvini et al. [8] proposed an algorithm that calculates max and min medians as well as the standard deviation and average of detail images obtained from wavelet filters, then comes by feature vectors and attempts to classify the given tile using a Perceptron neural network with a single hidden layer. The optimal threshold method is used for the welding image segmentation by Wu Xiaomeng [9]. The quality of welds is judged by determining whether there has air bubble or not in the weld image. The present paper is organized as follows. Section II deals with the methodology and Section III describes results and discussions followed by conclusions at Section IV.

II. METHODOLOGY

The weld extraction is the first step in the development of defect detection and classification systems for weld radiographs. Much effort has been made to automate the process of defect segmentation and detection with the assistance of digital image processing techniques. Segmentation of weld defects is the most crucial part in defect detection to ensure defects do not 'escape' from the segmented image. In addition, radiographic images often

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contain noise. Inappropriate techniques may lead to the escape of defects. Image processing operations improve the qualities of an image. They can be used to improve an image's contrast and brightness characteristics, reduce its noise contents, or sharpen it details. The wiener filter can be defined as a Mean Squared Error optimal stationary linear filter for images degraded by additive noise and blurring. It not only performs the deconvolution by inverse filtering (high pass filtering) but also removes the noise with a compression operation (low pass filtering). So, the present paper first applies preprocessing technique by using an adaptive 7×7 Wiener filter. After preprocessing the input radiographic weld image, the next important step is to detect the weld region where this weld region consists of defects. To detect this region, the present paper used Raleigh Probability Density Function (RPDF). The RPDF of the input image is computed by the Equation (1).

$$RPDF(x,y,\mu) = \frac{I(x,y)}{\mu^2} e^{\left(\frac{-I(x,y)^2}{2\times\mu^2}\right)} \quad (1)$$

Where I(x,y) is the pixel value at location (x,y), μ is the mean of the input image. The RPDF is computed for each pixel value of the preprocessed weld image and the weld region is extracted. From the extracted weld region, the defects existing in the weld region are obtained by applying mathematical morphological operations. Mathematical morphology is well suited for handling geometrical structures of the input image. The present paper uses morphological Top-Hat transformation. Combining image subtraction with opening results is called top-hat transformation. An important use of top-hat transformations is in correcting the effects of non uniform illuminations. Next, the Otsu's global thresholding method is applied to detect the weld defect. On the binary thresholded image, the opening followed by closing operation is applied to smooth the detected weld defect.

III. Results and Discussions

The proposed algorithm is tested on various defective radiographic weld images. In this paper the results of three weld defective images are presented. The stepwise results of the proposed method for defect detection are shown in Fig. 1 to 3. The results clearly indicate that by applying wiener filter, noise is removed and the dark portions are enhanced in the input image. By the second step of applying RPDF operation, the weld defects and boundaries of the weld region are obtained. Then by using morphological top-hat transformation, the boundaries of the weld region are suppressed. Then the defects in the input weld image are given by the binary image computed by Otsdu's global threshold method. Finally with the opening followed by closing morphological operation, fine interior defective weld segments are identified.

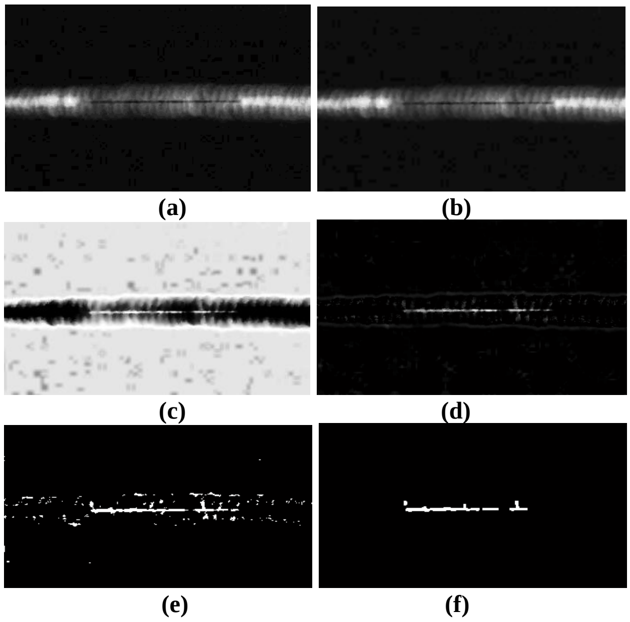


Fig. 1 Step By Step Results Of The Proposed Defect Detection Algorithm For Image 1 (A) Original Image (B) Wiener Filter (C) RPDF (D) Top-Hat (E) Binary (F) Opening-Closing.

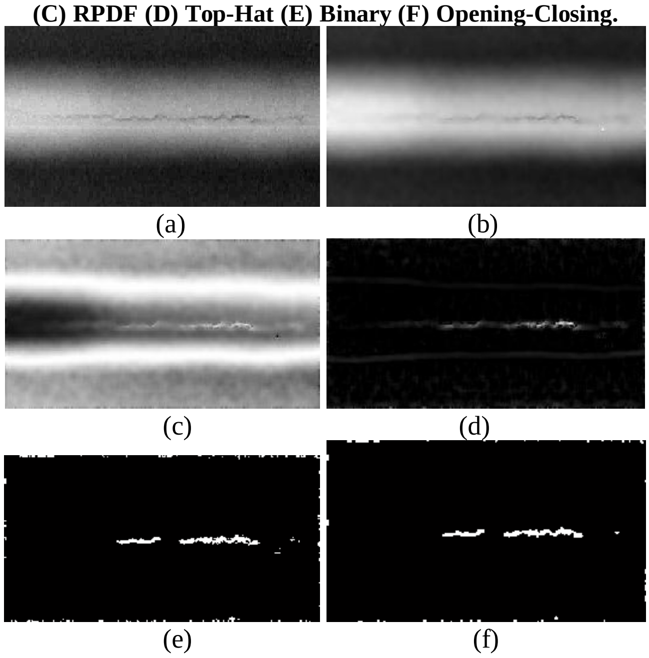
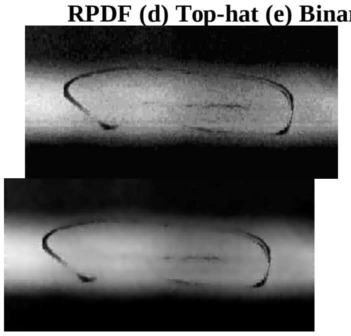


Fig. 2 Step by step results of the proposed defect detection algorithm for Image 2 (a) original image (b) Wiener Filter (c) RPDF (d) Top-hat (e) Binary (f) Opening-Closing.



(a) (b)

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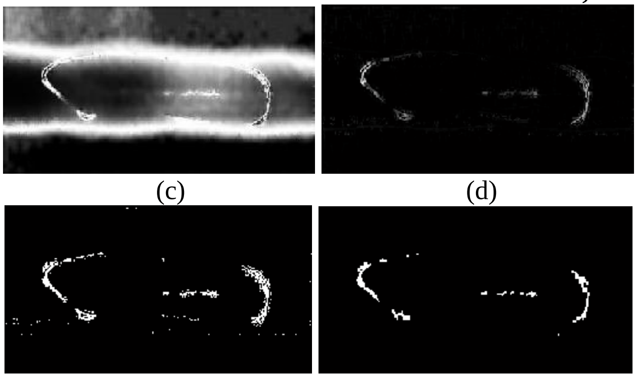

(c) (d)

(e) (f)

Fig. 3 Step by step results of the proposed defect detection algorithm for Image 3 (a) original image (b) Wiener Filter (c) RPDF (d) Top-hat (e) Binary (f) Opening-Closing.

IV. CONCLUSION

The present paper proposes an Innovative method for extraction of defects in digital radiographic welding images. The proposed method detects various types of defects and improves the computation complexity efficiency by using morphological operations. The future enhancement consists of quantifying the detected defect in the weld region with feature vector for classifying the defected weld images.

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