International Journal of Applied Engineering Research
ISSN 0973-4562 Volume 10, Number 3 (2015) pp. 7485-7493

http://www.ripublication.com

Defect Classification in Weld Radiographs Using Discrete Stockwell Transform

K.Sudheera

Assistant Professor
Department of Electronics & Control Engineering
Sathyabama University
sudhirasatya@gmail.com

Abstract

To obtain the quality of weld material, industrial radiography is one of the most widely used NDT technique. As radiography is indirect technique, radiographs are analyzed for defect detection. Conventional classification techniques involve ANN, thresholding, fourier and wavelet transforms. In this paper, an algorithm is described for the classification of weld defects like slag, porosity which are obtained from real time weld radiographs. To improve the defect detection stockwell transform is used. The classification is done by obtaining the change of pattern for the given flaw in both defect and non defect regions and this pattern classification is justified by the statistical parameters like mean and variance for both defect and non defect region.

Introduction

Weld defect detection is of major concern in industries. Non Destructive Testing (NDT) is the process of testing the material for identification and evaluation of all types of defects in it without actually damaging the material and ensure safety. Such methods are magnetic particle inspection, ultrasonic testing, eddy current, acoustic emission, thermal inspection and many more [2]. These techniques only visualize the discontinuity in the test signal due to weld defect and recognize only specific defects. Radiography has the capability to identify different types of defects in the images. The method of obtaining these images is based on the fact that more energy is absorbed by the defect area and appear darker in image (Hayes, 1997). Some of the most common weld defects that can be identified in the radiographic images are the worm holes, slag inclusion, linear porosity, gas pores, lack of fusion or crack . Generally in industries the defect analysis is human dependent which is subjective in nature. However the task challenging is contrast between the defect region and the non-defect region is not clearly visible to the naked eye, the intensity levels are different due to radiation absorption and undesirable edges are also present. Fourier transform does not position time and frequency at the same time. Wavelet transform gives only the scale information with limited range. Hence in this paper S-transform [3] first proposed by R. G. Stockwell in 1996 is used for feature extraction. It is unique, in that it provides frequency-dependent resolution while maintaining a direct relationship with the Fourier spectrum. It is stable in noisy condition[12].

Related work

Considerable research has been done in classifying the weld defects. Ioannis Valavanis et.al 2010[1] proposed a method for defect detection for 24 radiograph images based on sauvola local thresholding and graph based segmentation. Defect classification was done based on the geometric features and texture features for identifying different defects like worm holes, lack of fusion, cracks, then these feature vectors are given as input and classified using Support Vector Machines (SVM) and the Artificial Neural Networks (ANN). T. Warren Liao et.al 2003[4] has given an algorithm for defect detection by case based reasoning with MLP NN based attribute weighting, they justified their method with 750 sample and conclude a successive rate of 25 sample. D.Mery et.al [5] has detected defects using texture features based on co-occurrence matrix for 3 distances, and 64 texture features based on Gabor functions. Then the feature were analyzed independently using a threshold classifier as no defect or defect region based on set threshold value . E. S. Amin et.al.[13], detected defect in three steps, initially by removing noise in image with filters, secondly enhanced the image with canny filter. Then classification was performed, initially training with 20 samples and then giving 5 inputs to the radial basis (RB) and learning vector quantization (LVQ) neural network. T Y Lim et.al., [9] proposed defect detection using back ground subtraction method and automatic thresholding and classified the defects using neural network. Yan Hanbing et al., [14] proposed method for identifying and classifying defects using K-fold cross validation and SVM based binary decision tree. Zheng Sun et. al.,[15] proposed algorithm for crack defects that to line crack detection by enhancing the defect features by removing noise using wavelet transform and morphological method and the extraction is done using fuzzy support vector machine (FSVM) and Beamlet transform. Vaithiyanathan et.al., [7] classified the defects by first segmenting the defect region Through watershed segmentation. Feature extraction is done using Projection Profile and Geometric invariant moment and classified using Learning Vector Quantization (LVQ). Ge Liling et, al.,[16] had detected defects based on the hierarchical approach by selecting different thresholds for different defects. N. Nacereddine et. al.,[17] extracted features based on the geometric characteristics and the classification was performed using Principle Component Analysis. Zhang xiao-guang et. al.,[18] presented a algorithm for automatic recognition of weld defects using fuzzy neural network **(FNN).** However from the related work all the proposed techniques use artificial neural network in which they have to be trained with prior inputs. Some have classifiesd using the simulated output. In this proposed method real time radiographs have been used.

Proposed Method

Table 1. lists the dimensions of the weld pieces where defects are introduced. Initially the image is converted into gray scale image. The weld pool area is separated based on the fact that the intensity of the weld area is higher than the intensity of the whole image. Secondly, the pattern is obtained for the defect and non-defect region using Stockwell transform. The output of the Stockwell transform is an N x N matrix in which the row elements determine the frequency and the column elements determine time. The Stockwell transform co-efficients for the defect and the non-defect regions are obtained. The steps involved in determining Stockwell co-efficients [3] are as follows: Initially Fourier transform of N point time series is calculated. Then spectrum is shifted so that the voice frequency becomes zero. Next the Spectrum is multiplied with the n point voice Gaussian function to select the frequency range. Next the N-point Inverse Fourier transform is applied to this product and the voice is popularized by determining Inverse Fast Fourier Transform. This Procedure is repeated until all the voices are populated. In order to perform classification, frequency patterns are obtained based on the stockwell co-efficient of the defect and non-defect region.

Table 1: Dimensions of the weld pieces

Material/ Dimension in mm	Defect Type	Defect Length in mm	Distance from 0 mm
Carbon Steel 17403 / 12THK x 300 LONG	Slag	20	140
Carbon Steel17404 / 12THK x 300 LONG	Porosity	25	207
Stainless Steel 17406 / 12THK x 300 LONG	Slag	18	51
Stainless Steel 17408 / 12THK x 300 LONG	Porosity	22	68

Fig1: input image for Slag CS#1

Fig2: input image for Porosity CS#1

Fig3: input image for Slag SS#1

Fig4: input image for Porosity SS#1

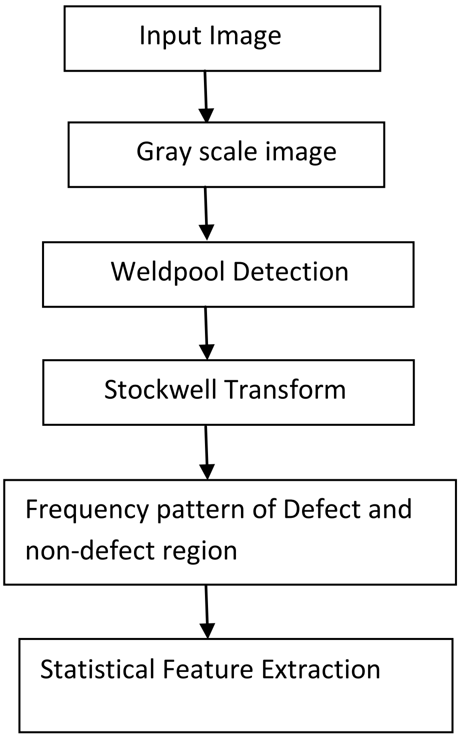

Fig 5.Proposed Methodology

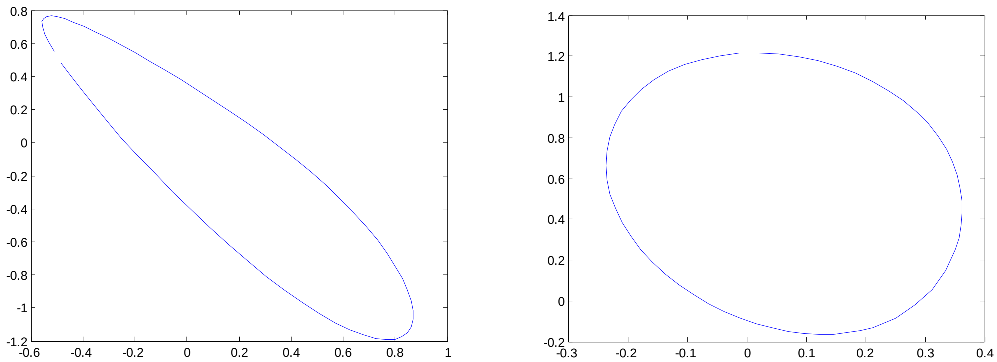

Fig6 a,b : Frequency Pattern of Defect / Non – Defect Region of Slag(Carbon Steel #1)

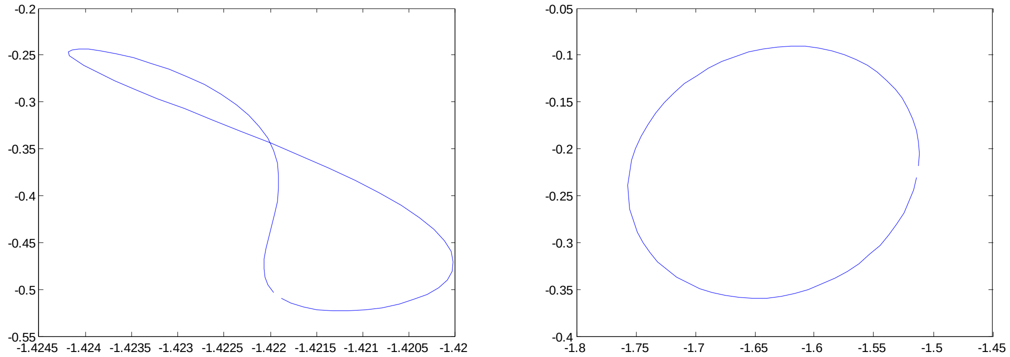

Fig7c,d : Frequency Pattern of Defect / Non – Defect Region Porosity (Carbon Steel #1)

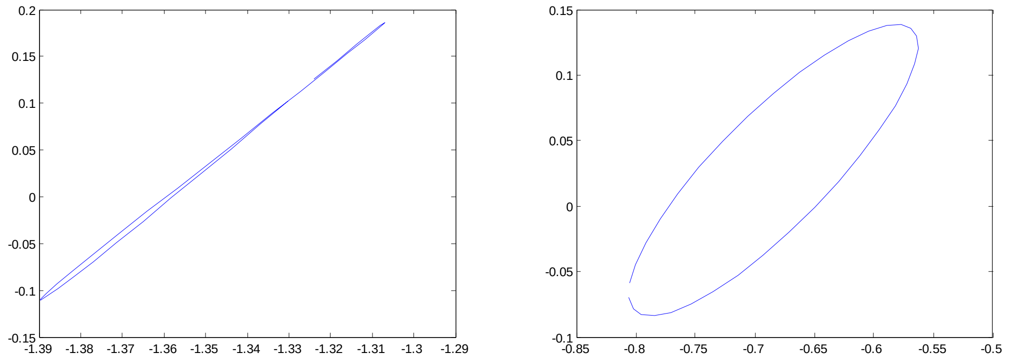

Fig8 e,f : Frequency Pattern of Defect / Non – Defect Region Slag(Stainless Steel #1)

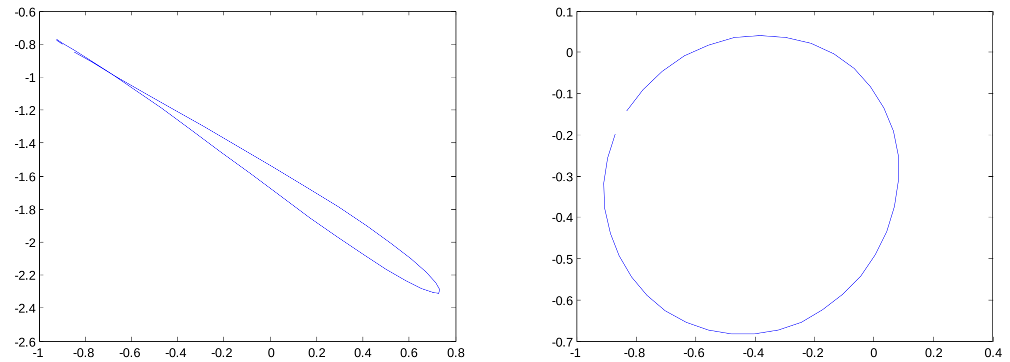

Fig9 g ,h : Frequency Pattern of Defect / Non – Defect Region Porosity (Stainless Steel #1)

Table 2: Statistical Output for the Defects

NATURE OF THE MATERIAL	DEFECT	MEAN		VARIANCE	
		Defect	**No-Defect**	**Defect**	**No-Defect**
Carbon Steel	Slag	2.2394	2.2612	0.0273	0.0406
	Porosity	4.1881	3.9888	1.2132	0.0715
Stainless Steel	Slag	1.5710	1.6304	0.3919	0.5544
	Porosity	5.0214	5.1864	3.7815	6.9840

Results and Discussion

Figure a,c,e,g depicts the pattern for the defect region. Figure b, d, f, h represents the pattern for the non-defect region. From the subjective analysis it is seen that there is a pattern change in the frequency representation for the obtained Stockwell co-efficients of defect/ non-defect region. From table it is found that porosity in stainless steel has the highest mean for the defect region. Slag in carbon steel has the lowest variance value for defect region. porosity in stainless steel has the highest mean for the non-defect region. Slag in carbon steel has the lowest variance value for non-defect region.

CONCLUSION

In this paper an efficient technique for classifying the defect has been proposed using stockwell transform. Weldpool is extracted from weld radiograph and stockwell transform is applied on the defect and non-defect region. It is found that there is a distinct frequency pattern for the defective region when compared to the non-defective region. It is found that the pattern is different for the volumetric and planar defect not only from the subjective analysis but also from the statistical parameters. The low frequency component (slag) has the lowest mean in Stainless Steel defect region and lowest variance in Carbon Steel defective region. Low frequency component (slag) has the lowest mean in non-defective region for Stainless steel and lowest variance in low frequency component (slag) in carbon steel. This proposed technique has successfully given intra class variance. Inter class variance has to be found and it has to be validated with large database.

Reference

1. Expert Systems with Applications, Multiclass defect detection and classification in weld radiographic images using geometric and texture features, Ioannis Valavanis a, Dimitrios Kosmopoulos b, doi:10.1016/j.eswa.2010.04.082. p.no 1-9
2. Anouncia, S. M., & Saravanan, R. (2006). Non destructive testing using radiographic images – A survey. Insight: Non-Destructive Testing and Condition Monitoring, 48(10), 592–597.

3. R. G. Stockwell, L. Mansinha and R. P. Lowe, “Localization of the complex spectrum: The S transform”, IEEE Trans. on Signal Processing, vol. 44, no. 4, (1996), pp. 998-1001.
4. T. Warren Liao, E. Triantaphyllou and P.C. Chang, Detection of Welding Flaws with MLP Neural Network and Case Based Reasoning. International Journal of Intelligent Automation and Soft Computing, 2003. P.no.1-23.
5. D Mery and M A Berti, Automatic detection of welding defects using texture features, International Symposium on Computerized Tomography and Image Processing for Industrial Applications in Radiology (CTIP-2003), June 23-25, 2003, Berlin. Insight Vol 45 No 10 October 2003. P.no.676-681.
6. Tosapolporn Pornpibunsompop World Academy of Science, Engineering and Technology Vol:6 2012-08-21 “Non-Destructive Evaluation of Launch Tube Welds with Radiography”. P.no 1464-1467
7. Dr.V. Vaithyanathan, Dr.B. Venkatraman, Anish raj M.M ,Journal of Theoretical and Applied Information Technology 31st December 2011. Vol. 34 No.2 “Weld Defect Detection in Radiography Based on Projection Profile and RST Invariant by using LVQ” ISSN: 1992-8645, p.no 167- 172
8. Sangita Dubey, Kamal Shah. “Analysis of Various Flaws Detection Using Segmentation Techniques in Weld Images” International Journal of Advances in Engineering & Technology, May 2012
9. T Y Lim, M M Ratnam and M A Khalid “Automatic classification of weld defects using simulated data and an MLP neural network” NDT Insight Vol 49 No 3 March 2007, p.no.154 – 159.
10. Romeu R. da Silva, Luiz P. Calôba, Marcio H. S. Siqueira. , and João M. A. Rebello1 “Patterns Nonlinear Classifiers of Weld Defects in Industrial Radiographies” proceedings of Pan American Conference for Non Destructive Testing, brazil, 2003
11. Ying Yin Gui Y. Tian “Feature Extraction and Optimisation for X-ray Weld Image Classification”17th World Conference on Nondestructive Testing, 25-28 Oct 2008, Shanghai, China
12. R.G. Stockwell, Why use the S-Transform?, Fields Institute Communications Volume 00, 0000
13. E. S. Amin, “Application of Artificial Neural Networks to Evaluate Weld Defects of Nuclear Components”, Journal of Nuclear and Radiation Physics, Vol. 3, No. 2, 2008, pp. 83-92
14. Yan Hanbing Zhao Lina Ju Hui, “Research on SVM Based Classification for Welding Defects in Radiographic Testing” 978-1-4244-4131, 2009 IEEE.
15. Zheng Sun, Dianxu Ruan, Yun Ma1, Xiaolei Hu, Xiao-guang Zhang, “Crack Defects Detection in Radiographic Weldment Images using FSVM and Beamlet Transform” 2009 Sixth International Conference on Fuzzy Systems and Knowledge Discovery. 978-0-7695-3735-1 2009 IEEE DOI 10.1109.
16. Ge Liling, Zhang Yingjie “Hierarchical Segmentation Approach to Detection of Defects on Welding Radiographic Images” 978-1-4244-2800-7/09. IEEE ICIEA 2009.

17. N. Nacereddine, M. Tridi "Computer-aided shape analysis and classification of weld defects in industrial radiography based invariant attributes and neural networks" Proceedings of the 4th International Symposium on Image and Signal Processing and Analysis (2005).
18. ZHANG xiao-guang, XU jian-Jan', LI yu "The Research of Defect Recognition for Radiographic Weld Image Based on Fuzzy Neural Network" Proceedings of the 5n World Congress on Intelligent Control and Automation, June 15-19, 2004, Hangzhou, P.R. China. 0-7~03-8273-0/04 2004 IEEE.