Chapter 2

Related Works

2.0 INTRODUCTION

In today’s scenario, for performing NDT process, image processing plays a vital role. Notably, in the field of manufacturing to detect the process defects, image processing based techniques are followed for assessing the quality. Several attempts had been made in past to improve the quality of the defect detection and classification process through various possible approaches. This chapter highlights the significant contribution of various researchers from the perspective of NDT process and the associated methodologies.

In general, the objective of using the NDT processes is to improve the productivity and quality of the process. Specifically, in the field of manufacturing, the NDT process helps to examine the internal characteristics of an object or material without destroying them. The major activities involved with the NDT are detecting internal and external defects. One of the most widely used approach for this defect detection is the radiographic based image processing. The method involves mostly a semi-automated system to detect a pattern of defects followed by categorization of them. Some of the significant research happened in this decade towards this industrial radiographic image processing and its methods are outlined in the following sections.

2.1 SURVEY OF DEFECT DETECTION METHODS

Some of the pioneers who have contributed significantly in the past few years include Shafeek et al. (2004), Gang Wang et al. (2002), Yi Sun et al. (2005), Nacereddine et al. (2005), and Mansouri et al. (2006). The focus of these systems was towards welding
defect detection. According to Anouncia et al. (2006) one of the widely used approaches on welding defect detection is artificial intelligence based approach which caters its spectrum mostly around neural, fuzzy and genetic based methods. Keeping these methods as basis, in the past few years, several attempts had been made by various researchers towards improving the accuracy on defect detection.

Likewise, Dobrzanski et al. (2006) proposed a system to detect defects in casting process. A multilayer perceptron neural network method was applied for the classification of defects in only Al-Si alloy casting, EN AC-AlSi7Cu3Mg. In 2007, Lim et al., proposed a new automatic radiographic image analysis system using genetic algorithm for the pattern detection, especially defect detection in weldment. On the other hand, Amin (2008) used Radial Basis (RB) and Learning Vector Quantization (LVQ) methods to classify the weldment defects. But the samples which were used for training is twenty only. Hence, the performance of the system appears to be inadequate. Guo et al. (2009) carried out the work on inspection and condition assessment of sewer pipeline. The developed system detected more than one particular class of sewer defect. Similarly, an automatic estimation of the contours of weld defect in radiographic image was introduced by Goumeidane et al. (2009). The statistical formulation used for contour estimation, failed to differentiate the defects from the background. Ioannis Valavanis et al. (2010) discussed a method for the detection and classification of defects in weld radiographic images. The results were cross validated with support vector machine, neural network and K-nearest neighbor. But the accuracy of the classification rate is left out with no clue. Jebarani Sargunar b et al. (2010) developed a system to interpret the type of defects in industrial radiography. The developed system mainly focused on few
types of defects such as porosity, lack of penetration, shrinkage and fracture. The back propagation method is used for training phase and Gaussian Mixture Model (GMM) classifier is applied to classify the defects. This method did not address about the other defects such as tungsten inclusion, crack and group porosity. Another attempt by Jebarani Sargunar et al. (2010) introduced a system to detect defects such as porosity and slang inclusion. Fuzzy logic was applied for automatic region recognition of weld defects. The results obtained from fuzzy based approach are moderately better. Ultimately, Juan Zapata et al. (2011) developed an automatic system to detect, recognize and classify weld defects in radiographic images. An artificial neural network (ANN) and an adaptive network based fuzzy inference system (ANFIS) were used to evaluate the performance of results. The result obtained from ANFIS is comparatively better than ANN approach.

Hassan et al. (2012) implemented a system for weld defect detection from geometric features, the focus of the work is more on feature extraction and neural based classification for defect detection. Srikanth et al. (2012) discussed a novel approach for automatic defect detection in weld radiographic images. The approach consisted of the following steps: preprocessing, morphological opening operation and statistical operation. The proposed approach supported detection of defects: Cluster Porosity (CP), Slag Inclusion (SI), Lack of Penetration (LoP), Inadequate Weld Reinforces (IWR) and Oxide Inclusion (OI).

According to the review by Suhaila et al. (2012) it is observed that most of the researchers have used threshold based segmentation followed by support vector machine, K-nearest neighborhood and artificial neural network techniques for classification of defects. Wenming Guo et al. (2013) discussed an effective edge detection method for
detection in radiographic images for welds. A study of three different edge detection techniques on weld radiographic image is carried out to identify a suitable method.

Another milestone on the research of defect detection reached out with the contribution of G.M Atiquur and Mobarak Hossain (2009). They described a method to detect the defects automatically and to control the quality of ceramic tiles. Defects such as pin hole defects, blob defects, crack defects, spot defects, edge defects and corner defects are discussed and the defect detection rate is observed to be better than the existing method for ceramic tiles.

In a similar way, an effective weld defect classification algorithm developed by Rafel et al. (2009) showed 25 shape descriptors for the classification. The developed system contained a multi-layer perceptron (MLP) neural network for training the shape parameters from the simulated images of weld defects and achieved maximum classification accuracy. Apart from the contribution in the field of object detection, the investigation also widened in applying artificial intelligence techniques at different stages of processing prior to detection and classification. In particular, most of the method suggested the use of these artificial intelligence techniques for image segmentation process as this process plays vital role in the detection and categorization.

2.2 SURVEY OF SEGMENTATION TECHNIQUES

In General, segmentation techniques involve edge detection, thresholding and clustering for segmenting the region/boundary or detect the edges from an image. The purpose of edge detection is to identify areas of an image where a large change in intensity occurs. Edge detection is usually done using local linear gradient operators such as Sobel, Canny, Zero cross edge detection and Roberts cross edge detection methods.
Thresholding is another approach used for segmentation in various images processing application. An object having homogenous intensity and a background with a different intensity level could easily be differentiated with this approach. Different types of existing thresholding techniques are global thresholding, adaptive thresholding, histogram equalization and Otsu thresholding. The segmented image out of these methods contains more useful information for subsequent key processes. Clustering is yet another technique that attempts to access the relationships among patterns of the data set by organizing the patterns into groups or clusters. K-means clustering and fuzzy C-means clustering are the widely used clustering techniques.

Similarly, region based segmentation is carried out to segregate a group of connected pixels with similar properties are called region. In region based segmentation an image is partitioned into regions that correspond to objects or parts of an object. Watershed segmentation, salient region detection and single seeded region growing are the most applied region based segmentation techniques.

Some of the work carried out in past towards segmentation of images are outlined in the subsequent paragraphs.

2.2.1 HIGHLIGHTS ON EDGE BASED SEGMENTATION

Zhang Yan et al. (2013) presented the analysis of image segmentation in radiographic images. The edge based segmentation techniques such as, Sobel, Canny, Log operators are used to detect the defects. Eight - neighborhood bilinear interpolation non maximum suppression methods is employed to improve the detection performance.
Om Prakash et al. (2011) presented a method for color image segmentation using simple single seeded region growing algorithm and adaptive thresholding. The method applied only for Berkley segmentation database images. The results were analyzed based on Liu’s F-factor. Though the results obtained were satisfactory, it failed to segment the images present in the other image databases. Manisha et al. (2010) used adaptive thresholding approach on grayscale images to extract true edges and tried to reduce the false edges. On the other hand, Kekre et al. (2010) discussed an approach for enhancing the tumor area in mammography images. The approach used extended sobel operator to perform 2-dimensional spatial gradient measurement on a mammography image. The technique was able to find the approximate absolute edges at each point in an input grayscale image. Further to add, Padmavathi et al. (2010) demonstrated segmentation of underwater images by applying Fuzzy C-means clustering using nonlinear assessment. The system achieved desirable results. Mengmeng et al. (2010) aimed to explore the zero-crossing edge detection method based on the scale-space theory. By applying this operator the edges were obtained with one pixel width image border. The results were compared with other edge detection method and the results showed more precise edges than other methods.

Kekre et al. (2010) introduced a novel image retrieval method based on shape features extraction using gradient operators. The shape features were extracted using slope magnitude method by using Roberts, Sobel, Prewitt and Canny gradient operators. Based on the performance ranking it was concluded that the Robert mask shape block truncation coding method was able to retrieve relevant information.
Yafeng et al. (2009) applied salient region detection technique for both color and grayscale image. The accuracy of extracting the region of interest from color image was highly considerable. But accuracy of extracting the region of interest from a grayscale image was not so good when compared to color images. Xin Wang et al. (2006) had proposed an improved histogram equalization technique to enhance the aircraft digital radiographic images. The classification of enhanced images results was desirable. Zeljko et al. (2006) developed a system to detect defects in ceramic tiles. Canny edge detection technique was used to detect the edges. This technique was able to detect the edges with higher rate of accuracy.

2.2.2 HIGHLIGHTS ON CLUSTERING BASED SEGMENTATION

Suman Tatiraju et al. (2008) discussed an approach for image segmentation using K-means clustering, expectation maximization (EM) and normalized cuts on grayscale images. The proposed K-means clustering algorithm was applicable only to the images which had smaller values of k. When images had larger values of k, the clusters were formed in discrete places. This was observed to be the drawback of proposed approach.

Nassir Salman et al. (2006) introduced two different segmentation approaches for grayscale images. In the first approach, K-means clustering was used for initial stage and next stage watershed technique was applied. The accuracy of the segmented regions was highly acceptable. In the initial stage image has segmented as region by applying K-means and for the next stage edge strength was applied. In the validation process, the first approach was able to give better result when compare with the second approach.

Funck et al. (2003) analyzed the results obtained from using a variety of algorithms for wood surface feature detection and defined several measures for
examining algorithm performance. Performance analysis of segmentation algorithms on images of Douglas-fir veneer showed that region-based algorithms had the greatest performance. For image enhancement, Otsu thresholding method provided better results.

Qussay et al. (2003) discussed about the image segmentation methods for edge based and region based segmentation. Experiments of segmentations resulting from edge based methods and region growing methods were not same. From the results it was concluded that the region growing techniques were generally better in noisy images where edges were extremely difficult to detect.

2.2.3 HIGHLIGHTS ON THRESHOLD BASED SEGMENTATION

Ping-sung liao et al. (2001) proposed a multilevel thresholding technique which takes lesser execution time compared to other thresholding techniques.

Ningbo et al. (2009) applied Otsu thresholding technique for shape based image segmentation in grayscale images and images were segmented with higher rate of accuracy. As per the literature survey, it is clear that, the significance of segmentation process is more when compared to other early image processing key stages.

Jehad et al. (2008) proposed an efficient approach for object recognition. Mathematical morphological technique was applied to correlate and retrieve the objects. The Laplacian of Gaussian technique was applied for detecting the edges.

Bing-Fei Wu et al. (2005) had proposed a new region based segmentation method for resolving issues associated with the complexity of backgrounds of complex document images. The proposed method processes the document image regionally and adaptively according to local features using two stages. An automatic localized multilevel thresholding method was utilized to recursively segment a specified block region into
several layered image sub blocks. Followed by a multilayer region based clustering was a performed to aggregate layered image sub block with homogeneous features into associated object layers. Experiment results on text extraction from complex document images demonstrated the effectiveness of the proposed method.

From the survey performed, it is clear that image segmentation has major role to play in the process of object detection and identification. Also, it is noted that the performance of the various segmentation techniques can vary from image to image depending on the shape and the modality of images.

Though, these works showed significant results for object segmentation and detection, the inclusion of shape and size remained limited for the classification. Especially, in the field of industrial radiographic image processing, it remained very much limited as rest of the approaches provided acceptable results by compromising the accuracy. In order to improve the accuracy rate of classification, several approaches had been adopted. One of the promising approaches found through literature is the fractals that described the shape and pattern for any object.

2.3 SURVEY ON FRACTAL BASED IMAGE ANALYSIS

Among very few such researches, Dimitrios et al. (1998) explained texture classification on image using fractal dimension method. The classification results are comparatively higher than other classification methods.

Maria Vesela et al. (2001) proposed fractal dimension method to count the yeast cells in a digital image. A fractal is a mathematical tool, which consists of various kinds of fractal dimension methods for analyzing an object to find its self similarity and scaling
properties. Most of the researchers have used a box counting method for classification of an object.

Andre Balan (2005) proposed a new image features extractor built on the fractal analysis of medical images segmented by a texture-based algorithm. The results obtained showed that it efficiently represented medical images content, allowing effective and efficient indexing and retrieval of images.

Fuyuan peng et al. (2005) proposed a texture analysis approach based on fractal theory to decompose directionally and scaling texture information of different undersea objects. The undersea image classification was done using fuzzy pattern recognition approach. According to them, the classifications of undersea image results were reliable.

V. Hotar et al. (2006) discussed the box dimension method used for analyzing surface defects especially deep crack defects. The method of evaluation of defects was better than neural network algorithm.

Tuan (2007) used a fuzzy fractal dimension method for extracting novel feature of mass spectrometry. The result obtained from this method was superior to other feature extraction methods.

Tuan (2008) through the article fuzzy fractal analysis of molecular imaging data, addressed the issue of interaction and behaviors of complex biological networks using fractal computation tool. A fractal tool used to analyze molecular imaging data and the extracted molecular imaging data appears to be very useful sources of information. A contextual framework of fuzzy mixture fractal dimensions and fuzzy distortion measurement was proposed for classification of biological data. The method proved worthy classification algorithm than other algorithms.
Ivanonic et al. (2009) proposed a fractal analysis method to reveal the relative complexity of color images of skin lesions. A method used lacunarity as a complementary tool to differentiate two lesion with the same fractal dimension. Thus the literature show cased the ultimate use of fractal analysis in imaging to get improved results.

From the study made, it is seen that most of the approaches concentrated on any one of the process such as image segmentation or classification or semi-automated process of same. In most of the cases, shape has not been considered for classification. And it is observed that all the efforts were on to the stored or stimulated images only.

Keeping these issues as motivation, it is decided to design an automated framework for image analysis and classification in industrial radiographic images. The framework focused in finding appropriate segmentation process to develop a complete automation through automated region of extraction followed by all the other traditional image processing tasks. The system included fractal based image analysis and soft computing based classification strategies to support the automation in every stage of classification.