CLASSIFICATION OF WELD BEAD DEFECTS BASED ON IMAGE SEGMENTATION METHOD

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ABSTRACT: Defect is an imperfection that could impair the worth and utility of a finished good. The defects show some disorder of the product and it is opposite the standard or criteria that have been stated. In defining and detecting the defects occur, many ways have been discussed and observed. However, the techniques or ways are not appropriate or not suitable for some condition and situation. In addition, welding process is one of the critical processes in detecting and defining defect to ensure the quality of the weld bead. To overcome the problem in detecting and defining defects, image processing is one of the methods in improving the process of detecting defects. The defects are classified based on automatic thresholding method that automates detecting and defining the defects. This study proposes a Decision Tree-based classification of weld bead defects through segmentation of image. The result obtained shows that the classification is effective in identifying the weld bead defects with 89% accuracy. For future work, the focus will be made to improve the detection accuracy by integrating suitable filters.

KEYWORDS: *Welding Defect; Weld Bead Defect; Image Processing; Otsu Method*

1.0 INTRODUCTION

Image processing is a growing research area covering a full range of techniques for the manipulation of digital images. Traditionally, many image processing tasks require high computational amount. One reason for this is the vast amount of information that involves processing, more than seven million pixels per second for typical image sources [1]. However, as computing technology advances, common modern servers are now capable of executing image processing tasks in a real-time manner. Image processing has been utilized in wide range of applications. These include medical [2], manufacturing [3-5], biometrics and security [6-7], power and chemical [8], aerospace applications [9] and others.

In welding inspection, inspectors typically use non-destructive test to obtained defects that occur in welding bead or welding parts. The process of the inspection takes a long time to get the result [10]. Thus, by applying vision system in the inspection of welding part, it provides an alternative inspection approach in the field of welding process. However, there are still some questions are need to be answered. For example, will different welding gas cause different type of defect? Will the shape and the characteristics for each defect differ from each other based on the welding parameters applied? This research is meant to find the answers. Additionally, the welding defects are taken using camera which synonym with vision system. The images of welding defects are captured in order to determine the type of defects through the features of the images. The process of capturing the images is part of image processing process. In image processing itself, it divided into some sub image processes which are image enhancement and image acquisition and image segmentation. The sub processes also can be called as image pre-processing, image processing and image post-processing.

However, there are specific problems that are restricting the ability of automated vision inspection for welding process. To our best knowledge, there is very limited information in classifying types of surface defects of a welded product for image processing purpose. This is critical as the defect features that are required for image processing are not yet established. As discussed earlier, only certain types of defects may be analyzed using vision inspection. As such, it is important to identify and classify the types of welding defects that are going to be studied. Consequently, appropriate image filter and segmentation methods to process the image must be identified. This requires the use of methods that are capable to yield good result with low computational requirement so that it may provide result in a timely manner. This research would like to achieve the following objectives in order to establish defects inspection system based on vision system that able to accurately detect and classify surface defects based on the appearance features. The objectives are:

i. To classify types of surface defects through features identification.
ii. To assess and validate welding inspection system using vision system.

2.0 DEFECTS INSPECTION FOR WELDING PROCESS

The welding process is a process combination of two similar parts or different parts to form a finished product. In welding process itself, there are many types of welding process which are MIG Welding, TIG Welding, Arc Welding and Gas Welding [11].

The term of visual inspection defines human visual perception. The visual system is a part of central nervous system. It consists of the eye as a light – sensitive organ used to differentiate between brightness and darkness, which can differentiate complex characteristics such as variation of shape, color, brightness and distance. Visual system can detect and interpret information from visible light to build a representation of the surrounding environment.

Iyshwerya et al. [12] proposed an algorithm suitable for real time system that is capable to detect defects for Mild Steel (MS) welding chip. The system developed is focused on high-speed inspection operation. Meanwhile, Senthil Kumar et al. [13] proposed an identification algorithm for surface defects of butt joint. CCD camera was used to capture the image of welding surface. The process selected is metal inert gas (MIG) welding.

Besides that, laser-based vision inspection system has been proposed to measure detect defects of weld bead profile. A sensor was used and is easily calibrated. The extraction algorithms and image processing profiles and features are shown. The defects of multilayer welding processes are detected by and the dimension parameters of weld bead are measured [14].

Additionally, vision inspection system also was developed to inspect welded nuts that use support hinge for support the trunk lid of car. Previously, the inspection process of welded nuts is using manual eye inspection. The process of manual inspection caused poorly quality of the welded nuts. In order to improve the inspection, 3D mechanical design tool and pro-engineer were used to manage the exact tolerance. The tools are used in simulation vision based automatic inspection. This leads to the cost saving in manufacturing besides increasing the quality of welded nut [15].

Furthermore, Nguyen and Lee [16] proposed laser vision based weld quality inspection system for non-destructive weld measurement and defect detection. It was designed based on the principle of laser triangulation. The system summarizes the respective extractions of weld joint profile and feature points, weld bead size measurement and defect detection. Sliding vector machine is used for detecting feature points on the laser stripe profile. Upon testing for real time inspection, the system proves to have high accuracy and satisfactory performance.

A control system structure is used for an x-ray based welding inspection and image recording, and also new method to synchronous movement between the inner and outer robots. The purpose to have a new design is to relative movement of robots and utilizes to synchronize the movement of dual robots. From the simulation results, it shows that the outer robot tracks also track the movement of inner robot. Implementation of welding inspection and image recording system cases are based on the experiments of the visual servo control algorithms [17].

Automated visual inspection has been developed to solve the matter of time and labor intensive. The use of various process characteristics is critical in extracting certain features that are most relevant to the inspection and evaluation of the particular process. The result is expressed as a relative quality evaluation system has potential for use as a post weld quality evaluation system or due to the high update rate of the overall vision system as of real time control system [18-19].

3.0 METHODOLOGY

In order to conduct this analysis, the following sequence of activities had been designed: identification of process flowchart; designing the programming structure; conducting the proposed classification; followed by testing the programming and end with measurement of defect classification.

Segmentation process took part in the image processing procedure, the first step of image processing must be conducted. It is a process whereby to get the image of the welding product. The first step of image processing process is image enhancement that involves with image acquisition process and image filtering process. Image acquisition process is a process of capturing the product welding image by using controller which is in this case, camera is the controller or device in fulfilling the first step of image processing process.

Then, it followed by image filtering process that involves with three methods of image filtering. To ensure the result of the image filtering, PSNR evaluation is been calculated. According to the PSNR result, an improve filter for image filtering is been proposed. The improved filter is improving by adding a method that makes the image sharp and is combined with the best method filter based on situation. Consequences, the result of the image filter will undergo the next step of image processing process which is image segmentation.

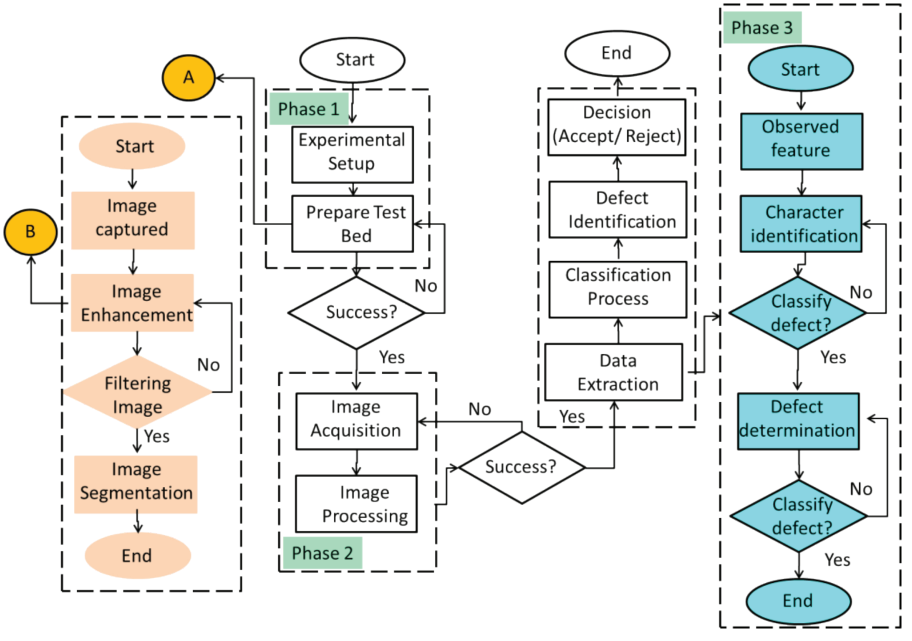


Figure 1: A flow chart for the feature selection and classification algorithm

In image segmentation, the image of weld bead will be specified and segment to get a clearer picture of the weld bead. From the segmented, the defect image of the weld bead will be recognized as stated in international standard organization. Moreover, based on some parameter, the defect obtained will be classified. The defects have been grouped. The defects classified have been name according to the group defect. If there are defects in the weld bead image, the product will be rejected or rework. Likewise, if there is no defect detected, the product will be accepted. The flowchart of the research is summarized in Figure 1 where the defects classification is mainly used in Phase 3.

This research proposes a classification of welding defect based on Decision Tree approach. The welding surface defects depend on four parameters which are: i) number of close loop (NCL), ii) number of end point (NEP), iii) the thickness or width and short in height of the weld bead (Thickness) and iv) Thin. The proposed classification for image defect welding is depicted in Figure 2.

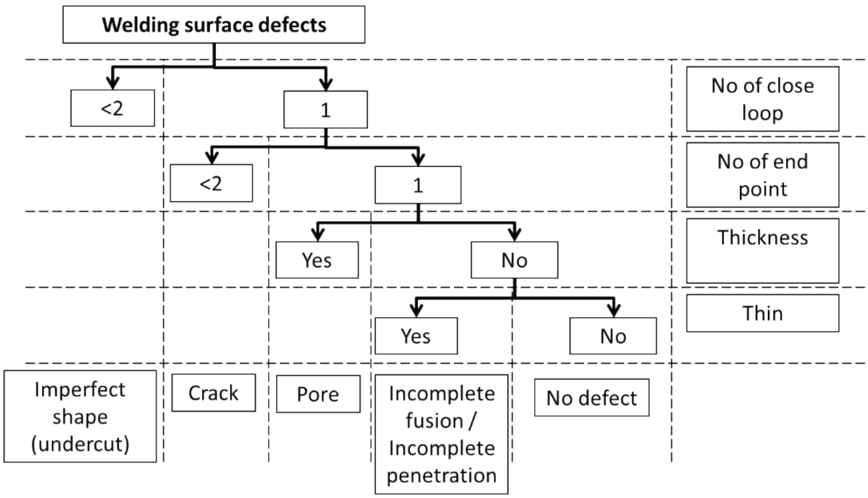


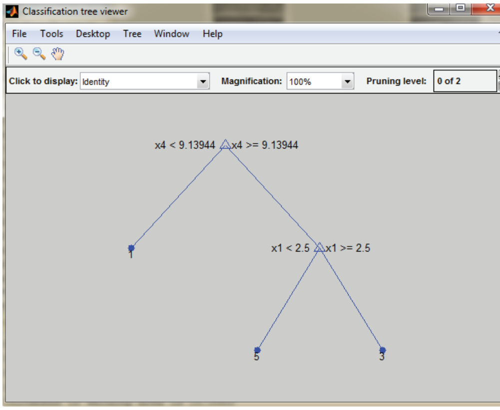
Figure 2: Proposed classification of welding defects

4.0 RESULTS AND DISCUSSION

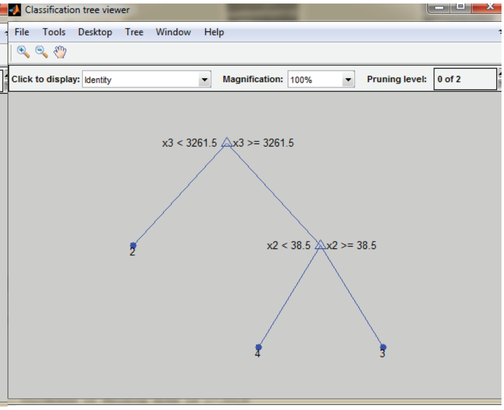
By using MATLAB programming, graph decision tree for classification is generated. The result shows the classification of the defects that obtain in the image welding. The defects are classified through class defect that declared in the MATLAB programming.

Figure 3 shows examples of decision tree results that were generated by the program based on the features for defect detection. Figure 3 (a) shows result classification for Carbon Dioxide (CO_2) gas. The result shows that the image welding consists of defect; which is imperfect shape that was obtained in Class 3. In addition, Figure 3 (b) shows graph decision tree for gas Argon (Ar). The defect obtained for the image welding is porosity which belongs to Class 5. Meanwhile, for result (c) it shows graph decision tree for gas Mixture (combination gas between CO_2 and Ar). The defects occur is overlap defect that placed in Class 1.

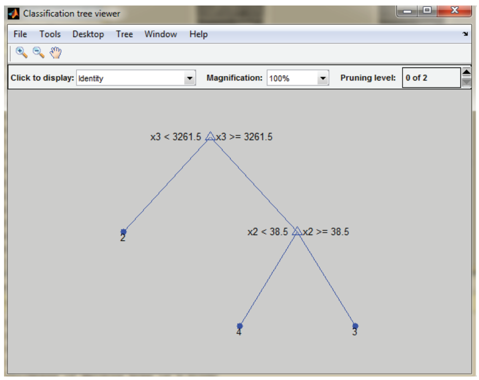
Partial results of the weld bead defects detection (gas type: CO_2) based on the proposed classification are listed in Table 1. The results show that consistent outcomes could be expected for the proposed classification with 89% accuracy. Due to page constraint, only the result for CO2gas type is included in this article.



(a)



(b)



(c)

Figure 3: Decision tree program for feature-based defect detection for: (a) Defect identification for Carbon Dioxide (CO2) gas (Porosity defect), (b) Defect identification for Argon (Ar) gas (Imperfect shape defect) and (c) Defect identification for Mixture of CO2 and Argon (Ar) gases (Incomplete fusion defect)

Table 1: Weld bead defects detection based on the proposed classification (Gas type: CO_2)

Image Defect	Defect detected	Defect class
1a	Imperfect shape	Class 3
1b	Imperfect shape	Class 3
1c	Imperfect shape	Class 3
2a	Imperfect shape	Class 3
2b	Imperfect shape	Class 3
2c	Imperfect shape	Class 3
3a	Porosity	Class 5
3b	Imperfect shape	Class 3
3c	Overlap	Class 1

4a	Imperfect shape	Class 3
4b	Imperfect shape	Class 3
4c	Overlap	Class 1
5a	Imperfect shape	Class 3
5b	Imperfect shape	Class 3
5c	Porosity	Class 5
6a	Overlap	Class 1
6b	Imperfect shape	Class 3
6c	Imperfect shape	Class 3

Based on the experiments, it is found that segmentation method using Otsu Method is capable to provide reasonable result. This is consistent with the finding stated earlier [18-20].

5.0 CONCLUSION

The objective of this research has been successfully achieved. Based on the segmented image, the features and characteristics of the weld bead images have been extracted. Consequently, the features have been identified and classified based on decision tree approach. The proposed classification has been programmed by using Matlab and validated through manual comparison. With regards to the classification, the most suitable methods could be utilized to process the images based on the respective defect features. Therefore, the system is capable to produce better defect detection. The tested program has successfully detects and classifies the weld bead defects based on the image provided. For future work, the focus will be made to improve the detection accuracy by integrating suitable filters. Several performance measurements such as (Peak Signal-to-Noise Ratio) PSNR and histogram techniques could be useful to determine the accuracy level.

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