Faculty of Manufacturing Engineering

IMPLEMENTATION OF VISION SYSTEM FOR DEFECTS CLASSIFICATION METHOD USING INTERNATIONAL STANDARD WELDING IMPERFECTION

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IMPLEMENTATION OF VISION SYSTEM FOR DEFECTS CLASSIFICATION METHOD USING INTERNATIONAL STANDARD WELDING IMPERFECTION

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DECLARATION

I declared that this thesis entitled "Implementation Of Vision System For Defects Classification Method Using International Standard Welding Imperfection" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : …….

Name : …….

Date : …….

APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Master of Science in Manufacturing Engineering

Signature : …….

Supervisor Name : …….

Date : …….

DEDICATION

To my beloved mother,

my beloved family,

who gave me the greatest gift anyone could give to another person:

They believed in me.

ABSTRACT

Defects are ones of the problems that should be minimized by any manufacturing company. Defects occurrence will decrease the performance of a production system. Defects typically occur in many kinds of product especially in manufacturing field. This research proposes an automated inspection of welding defects particularly the surface defects that are normally inspected manually. In order to inspect the welding product, Metal Inert Gas (MIG) welding has been chosen to be tested using three types of gases which are Carbon Dioxide (CO_2), Argon (Ar) and gas mixture (combination of CO_2 and Ar). The selection of the three types of gases is because the three types are the most widely used gases in the industry. Currently, many of the companies in Malaysia are implementing manual visual inspection conducted by operators. As welding is a highly repetitive process, the operators will have high hazard exposure. In order to improve the working condition, vision system is proposed. This research proposes a classification of the defects method that involves with image enhancement, image filtering and image segmentation. The classification method is involve with decision tree . A proposed of decision tree is lead to the image determination. In image filtering method, an improved method is applied to get a better picture of the image. The peak signal to noise ratio (PSNR) and mean square error (MSE) is calculated. The result obtained shows that the system is capable to detect welding defects successfully. According to the result, percentage error rate for both situation of the noise shows that the result is less than 30%. In addition, it shows that the most of the result is same with the expertise. Thus, the system is success for the classification of welding defect.

ABSTRAK

Ketidaksempurnaan dalam sesuatu produk atau kecacatan merupakan masalah yang perlu diminimumkan oleh syarikat-syarikat pembuatan. Kecacatan produk akan menyebabkan penurunan kepada tahap sistem pengeluaran. Kecacatan berlaku dalam pelbagai jenis produk, terutama dalam bidang pembuatan. Kajian ini mencadangkan pemeriksaan secara automatik terhadap kecacatan kimpalan terutama kecacatan permukaan produk kimpalan. Dalam usaha untuk memeriksa produk kimpalan, kimpalan logam gas lengai (MIG) dipilih untuk dikaji dengan menggunakan tiga jenis gas iaitu karbon dioksida (CO_2), argon (Ar) dan campuran (gabungan CO_2 dan Ar). Pemilihan tiga jenis gas adalah ketiga-tiga gas tersebut adalah yang paling banyak digunakan di industri. Kebanyakan industri di Malaysia masih mengamalkan pemeriksaan kecacatan secara manual yang dijalankan oleh buruh. Disebabkan proses kimpalan mempunyai cirian proses berulang yang tinggi, buruh akan terdedah dengan risiko kesihatan. Bagi menambahbaik keadaan kerja, sistem pemeriksaan secara automatik dicadangkan. Kajian ini mencadangkan kaedah pengelasan kecacatan yang melibatkan penapisan gambar dan segmentasi gambar. Bagi proses mengklasifikasi kecacatan yang terdapat pada imej kimpalan, carta pokok telah digunakan. Carta pokok akan membantu dalam mengklasifikasikan kecacatan. Dalam kaedah penapisan gambar, satu kaedah yang lebih baik digunakan untuk mendapatkan gambaran yang lebih baik. Puncak isyarat kepada nisbah bunyi (PSNR) dan min ralat kuasa (MSE) dikira. Keputusan kajian yang diperolehi menunjukkan sistem dapat mengenalpasti kecacatan dengan baik. Berdasarkan keputusan itu, peratusan ketidak samaan adalah kurang dari 30% dan ini menunjukkan kebanyakan jenis kecacatan yang diperolehi dari sistem adalah sama dengan keputusan yang diberikan oleh kepakaran. Oleh yang demikian, sebagai kesimpulannya, sistem ini adalah berjaya bagi mengklasifikasikan kecacatan pada kimpalan proses.

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LIST OF SYMBOLS, ABBREVIATIONS AND NOMENCLATURE

MIG	-	Metal Inert gas
GMAW	-	Gas metal arc welding
CO_2	-	Carbon Dioxide gas
Ar	-	Argon gas
PSNR	-	Peak Signal to Noise Ratio
MSE	-	Mean Square Error
ISO	-	International Standard Organization
GPS	-	Geometrical Product Specification
QC	-	Quality Control
NDT	-	Non-destructive testing
0D	-	Zero-dimension
1D	-	One-dimension
2D	-	Two-dimension
3D	-	Three-dimension
MRI	-	Magnetic resources imaging
CT	-	Computer topography
RBF	-	Radial basis function
A	-	Ampere
V	-	Voltan
cm/m	-	Centimeter per meter
db	-	Decibel
s	-	Second
PCNN	-	Pulse Coupled Neural Network
PDE	-	Polynomial Differential Equation
SOM	-	Self Organizing Map
FDT	-	Fuzzy Decision Tree
SVM	-	Support Vector Machine

kNN	-	Nearest Neighbour Classifier
LDA	-	Linear Discriminat Analysis
DLDA	-	Diagonal Linear Discriminant Analysis
QDA	-	Quadratic Discriminant Analysis
DQDA	-	Diagonal Quadratic Discriminant Analysis
NB	-	Naïve Bayes
FFNN	-	Feed Forward Neural Network
CART	-	Classification and Regression Tree
LSDA	-	Locality Sensitive Discriminant Analysis
FS	-	Fuzzy Sugeno
PNN	-	Probabilistic Neural Network
ANN	-	Artificial Neural Network
HOG	-	Histogram of Oriented Gradient
RF	-	Random Forest

LIST OF PUBLICATIONS

Nurfadzylah Awang, Muhammad Hafidz Fazli Md Fauadi, Syahril Anuar Idris and N. Syakirin Rosli, 2016. An Improve of Image Filtering Method in Welding Inspection Using PSNR Evaluation. In Journal of Advanced Manufacturing Technology (JAMT)-accepted.

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CHAPTER 1

INTRODUCTION

1.1 Overview

An inspection is most generally, an organized examination or formal evaluation exercise. In engineering, inspection activity involves the measurements, tests and gauges, that applied to certain characteristics in regard to an object or activity. Inspection may be a visual inspection or involve sensing technologies such as ultrasonic testing, accomplished with a direct physical presence or remotely such as a remote visual inspection and manually or automatically such as an automated optical inspection. Non-contact optical measurement and photogrammetry have become common Non-destructive test (NDT) methods for inspection of manufactured components and design optimization.

Quality control or QC is a process by which entities review the quality of all factors especially involved in the production. Controls include product inspection where every product is examined visually and often using a stereo microscope for fine detail before the product is sold into the external market. Usually, inspectors will be provided with lists and descriptions of unacceptable product defects such as cracks or surface blemishes (Evans, 2014).

Defects are ones of the parameters in quality control. It can be divided into four categories which depend on their dimension. The dimension can be calculated into 0D, 1D, 2D and also 3D. In 0D, defects that usually occur are point defects. The defects occur because of the atom missing or in irregular places in the lattice (vacancies, interstitials, and

impurities). However, in 1D dimension, defects that occur is linear defects. It occurs when a group of atoms in an irregular position, for examples in screw and edge dislocations. Meanwhile, planar defects occur in 2D. It occurs at the interfaces between homogenous region of the material such as grain boundaries and the external surface. Besides that, 3D defects refer to volume defects which means extended defects occurs as pores and cracks in a solid state.

With a specific end goal to eliminate the quality problems, the high-level management may combine the utilization of manual inspection and image processing or vision system. Image processing or vision system is a developing field covering a full technique for preparing of computerized pictures. Be that as it may, in our ventures, vision framework is less utilized in light of restricted innovation and aptitude. This kind of mode still has its shortcoming which is exactness of the distinguishing surrenders in the product. The surface imperfections are the principle deserts that will be resolved in this research. Other than that, the deformities likewise are originating from assembling division which is welding process.

Welding process is widely used in the heavy sector industries (Gibson et al., 2014). In welding process, there are many types of welding. However, Metal Inert Gas (MIG) welding is famously and commonly used by the industries in welding process. MIG welding could work with most metals either ferrous and nonferrous metals. The MIG welding needs a low skill level in order to handle it and can be used in any kind of the welding position. It can work in semiautomatic and automatically. Direct current (DC) need to be used in MIG welding. Compare with other types of welding processes, MIG welding is more flexible in any kind of condition. Even though the typical cost for MIG welding is higher compare with Shielded Metal Arc, but MIG welding is more applicable and easy to handle because it requires low skill and it can be used in most kind of metals with many types of field. Besides

that, the cost is still affordable because it's in a medium price, not in a high price Table 1.1 shows comparison between welding processes (Kalpakjian, 2006).

Table 1.1: Comparison between welding processes (Kalpakjian,2006)

Welding Process	Operation	Advantage	Skill level required	Typical cost of equipment ($)
Shielded metal arc (SMAW)	Manual	Portable and flexible	High	Low (1500+)
Gas metal arc (GMAW/MIG)	Semiautomatic or automatic	Works with most metals	Low to high	Medium (3000+)
Gas tungsten arc (TIG)	Manual or automatic	Works with most metals	Low to high	Medium (5000+)
Flux-cored arc	Semiautomatic or automatic	High deposition	Low to high	Medium (2000+)

1.2 Research Motivation

In welding inspection, non-destructive tests are typically used to detect defects that occur in welding bead or welding parts. The process of the inspection takes a long time before the result could be obtained (Rosado, 2010). Thus, by applying vision system in the inspection of the welding part, it provides an alternative inspection approach in the field of the welding process. However, there are still some questions are need to be answered. Will the different welding gas cause different defects to occur? The study will also analyze the type of defects that occur when different type of welding gases are used. Furthermore, the shape and the characteristics for each defect might differ from other based on the welding parameters applied. 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 will be followed by image processing process. The image processing itself is divided into some important sub-

processes which include 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.

After image enhancement and image acquisition were executed, image filtering method will be used to remove or to clear all the flaws that will become a constraint in defining the defects occur in the image. Will image filtering method is capable to improve the image quality? Many types of image filtering method in vision system in order to remove the disturbance in the image. However, different types of noise will result to different types of image filtering method. After that, image segmentation will be focusing on segmented the weld area to define the defects occur. The time process of defining the defects occur will be reduced and the process will be more effective. Therefore, there are needs to identify the methods and tools used in order to establish a consistent vision inspection system.

1.3 Problem Statement

The inspection usually refers to the assessment of the quality of some characteristics in relation to a standard or a specification. There are many types of inspection, normally being used by industries or company in order to make sure the product or the work had been done properly or accurately according to the requirement or law that stated. Nowadays, in heavy industries such as industries that involved with welding process usually using manual inspection to check the defect occurrences in welding product. Manual inspection refers to the inspection that is conducted by an operator using naked eye inspection. The ability of eye inspection is limited and easily influenced by the environmental factors. Furthermore, eye inspection can only determine the status of the product externally and will go for accept and reject without knowing the type of problem occured. The defects that occur are typically

in various types and the shape of the defects must be different. Sometimes, the problem that occurs can still be rework product.

In order to improve the ability in inspection welding product, vision inspection system can be one of the systems to improve the effectiveness of inspecting welding product. However, in inspection, the vision system is not widely used in our industries. Nevertheless, vision inspection system had been used widely in many kind of sectors in developed countries. Moreover, vision system is easy to handle and save energy and time. There are many functions and method that can be used in vision system. In order to improve the application of vision system in inspection, image filtering method and image segmentation can be used. Image filtering method is a method that good in removing noise in an image. By using the method, the image will be clear from the noise disturbance.

Welding inspection is widely conducted by using the Non-Destructive Test (NDT). Some examples of NDT techniques are radiography, ultrasonic, eddy current, magnetic particle, and penetrant testing (Ivanovic, 2013). These are top five techniques dominating the NDT market. Apart from that, it is common that manual visual inspection is conducted to identify welding defects. It is due to the reason that some types of defects are visible and could be seen with human eyes or naked eyes. Furthermore, conducting a visual inspection to identify defects could save time and increase consistency as NDT are only conducted in sampling basis. However, due to the advancement of technology, vision inspection can be used in welding surface defects inspection in order to produce the good product and more effective.

However, there are specific problems that are restricting the ability of automated vision inspection for the welding process. To our best knowledge, there is no study has been conducted to classify 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 a vision inspection system. 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 results with low computational requirement so that it may provide result in a timely manner.

1.4 Research Objective

This research would like to achieve the following objectives in order to achieve 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 investigate types of surface defects to identify features that will be used in classification.
ii. To identify suitable filter and segmentation method for identification of welded images.
iii. To assess and validate welding inspection system using vision system.

1.5 Research Scope

The research scope is provided in order to investigate the design and development of defects inspection through the vision system.

Defects inspection will be implemented continuously during welding process only. The welding process is a widely known process that involved in various industries especially in heavy industry. Therefore, the inspection of the welding part will be covering on an