UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DEFECT DETECTION ON THE METAL SURFACE BY USING MACHINE VISION SENSOR

This report is submitted in accordance with requirements of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Robotics & Automation) (Hons.)

By

MUHAMMAD ISMAIL BIN AHMAD
B051110049
890728145403

FACULTY OF MANUFACTURING ENGINEERING
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ABSTRACT

This report presents a defect detection system to replace the conventional method of inspection done by human operator. In using manual inspection, several problems were countered where by human inspector cannot maintain long-term consistency due lack of knowledge and experience. Standardization is impossible because depends on their understanding of the individual inspector. A defect detection is very important to control the quality of the products, as scratches are the most common defect in industry. The objectives of the current study is to develop an automation system by using vision sensor that can detect scratch defect on the metal surface and to develop the algorithm for defect detection system. The method involved five procedures : (1) obtaining desired image by using cropping, (2) adjusting the images to more suitable display for analysis using Image Enhancement, (3) converting image condition into binary, (4) removing unwanted point by shape filtering using morphological filter with new structuring elements defined based on the shape of characteristic of scratches and (5) analyzing the defect by calculating the area of scratch. The MATLAB software was used to build this system and GUI Interface used as user interface. From this experiment, 104 sample images have been inspected and the efficiency of system achieved is 99%. The environment for the inspection should be controlled by reducing the illumination of the area avoiding any glare or reflection from occurring to the product. Finally, the ability of this system needs to be upgraded to detect another defects so that the system can perform better to control the quality of the product.

ABSTRAK

Laporan ini menerangkan tentang sistem pengesan kecacatan bagi mengantikan kaedah konvensional yang dijalankan oleh manusia. Dalam menggunakan pemeriksaan manual, antara masalah yang dihadapi adalah pemeriksa tidak dapat mengekalkan konsistensi untuk jangka masa yang lama mengikut pengetahuan dan pengalaman individu tersebut. Keselarasan adalah mustahil kerana bergantung kepada pemahaman individu permeriksa tersebut. Pengawalan kecacatan adalah penting bagi mengawal kualiti produk dan calar merupakan kecacatan paling kerap dihadapi oleh industri. Matlamat kajian ini adalah untuk membangunkan sistem automasi dengan mengunakan mesin sistem penglihatan yang boleh mengesan kecacatan calar pada permukaan logam dan mewujudkan algoritma untuk sistem pengesanan kecacatan. Kaedah yang terlibat terbahagi kepada lima bahagian : (1) memperolehi kawasan yang ingin dianalisa di dalam gambar, (2) melaraskan imej mengikut perkara yang ingin dianalisa, (3) menukarkan imej ke binari, (4) menapis dan membuang entiti yang tidak diperlukan di dalam gambar dan (5) sistem menganalisa kecacatan dengan mengira kawasan calar yang dipaparkan. Perisian MATLAB digunakan bagi membangunkan sistem ini dan GUI dijadikan antaramuka kepada penggna. Sebanyak 104 imej produk telah diuji dan kecekapan yang dicapai oleh sistem ini adalah sebanyak 99%. Persekitaran semasa pemeriksaan haruslah dikawal bagi mengurangkan pencahayaan kawasan bagi mengelakkan pantulan berlaku kepada produk. Pada akhirnya, sistem ini perlu dinaiktaraf bagi mengesan kecacatan lain supaya keupayaan sistem ini dapat dipertingkatkan bagi mengawal kualiti produk.

DEDICATION

Special thanks to my beloved parents, Ahmad bin Berahim and Habibah binti Jamaludin also my supervisor Encik Ruzaidi bin Zamri who have encouraged, guided and inspired me throughout the study process.

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LIST OF ABBREVIATIONS

SVM	-	Support Vector Machine
ANN	-	Artificial Neural Network
GUI	-	Graphical user interface
PSM	-	Projek Sarjana Muda (Final year project)
UTeM	-	Universiti Teknikal Malaysia Melaka
RGB	-	Red, green and blue
3D	-	Three dimensional

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CHAPTER 1
INTRODUCTION

1.1 Background of the study

Defect control is important in manufacturing because it is the critical part of quality control. F.W Taylor introduced the first product inspection in 1990 for the purpose of accepting or rejecting. Quality control has become a need in weapon industries during Second World War and has comprised safety with simple techniques for inspection. After the end of war, the 'Quality Assurance' is applied by professionals and engineers to study the benefits in training of quality control. Philip Crosby in 1960 developed the concept of 'Zero Defect' to focus on motivation and awareness among employees. The human inspection by using conventional way uses raw human senses such as vision, hearing, touch, and smell to check the quality of a products. A specialized equipment, training and certification uses the Quality Inspector. However, the problem of using the quality inspector is judgment of every single inspector is not consistent depend on their knowledge and experienced, the implement action of zero defect concept is difficult tobe achieved.

By a using small integrated circuit as visual inspection of eyes model the duration of trained inspector was about 200 ms. The inspection speed led to variation of speed between one to another inspector and proved that inspection time consumption depending by individual and not consistent. By using 100% inspection by human inspector it does not find 100% of defective items in manufacturing industry. After this situation happened, statistical quality control has been introduced to solve this problem because more directly into the production processes. In manufacturing, defect must be avoided at all costs and normally products are repeatedly inspected by human inspector until all defect are completely removed. Using two inspectors can perform better judgment compared to one inspector. When manufacturing deals with mass production, the tolerance is so tight and manual inspection is not suitable hence defect tracing using computer assistance is mandatory. With recent advance technology, a machine vision inspection system has been introduced in the late of 1970. A huge capital has been invested in upgrading the machine vision system has been done to make sure the system was completely satisfactory (Sylla, 2002).

The machine vision system is growing rapidly to improve product quality and reduce cost in manufacturing industries. The machine system perform fast speed of inspection, accurate hence it good repeatability and is the good way to eliminate human error to guarantee the good quality. The machine vision system can be programmed to determine the results of inspection for every feature checked on product compared to manual inspector that collects the same data but high potential laced with errors. The inspector works in shifts but this machine can working for all days without additional costs, so manufacturing costs also can be reduced. Without the machine vision system it is unable to cope with wide range product configuration and defect. The machine vision is applied because the cost of processor and memory is lower in market price. The advantages of using the machine vision system is the machine can quantify variables such as angle, dimension and measurement of product (Llc, 2005).

The beginning detection of surface on the metal parts is a critical stage in the automotive industry. Typical defect on raw metals like dents, bumps and waviness are invisible at the early work stages and defect becomes perceptible after the next production steps. The defect becomes visible and disturbs only after the later production in which the parts get painted and varnished, meaning that they become specular-reflecting. The defect may be internal and external. The machine vision system involves of optical non-contact sensing to acquire and clarify images to process the information. Video camera, lighting and vision hardware are typical hardware whereby the vision software is a typical software used in this machine system. The inspection system can be run with two dimensional and three dimensional images by using grayscale or RGB analysis. The current technology has advanced to include 3D imaging to processing the images.

The bottleneck technique is used in production process as surface finishing or surface defects is attempted such hot steel, steel strip and plastic plates. The visual inspection for metal components in manufacturing processes depends mainly on human inspector whereby the performance is generally inadequate, subjective and variable. The inspection performs slow speed, expensive, subjective and creates a lot of quality issues (Zheng, Kong, & Nahavandi, 2002). In conventional methods such as artificial visual detection and frequency flashlight detection provide the disadvantages of low random inspection rate, bad real-time capability, low inspection confidence and bad inspection environment, hence they cannot follow the requirement of industries properly. As a result, the development of online vision bases system that can perform inspection task have been promoted (Xue-wu, Yan-qiong, Yan-yun, Ai-ye, & Rui-yu, 2011).

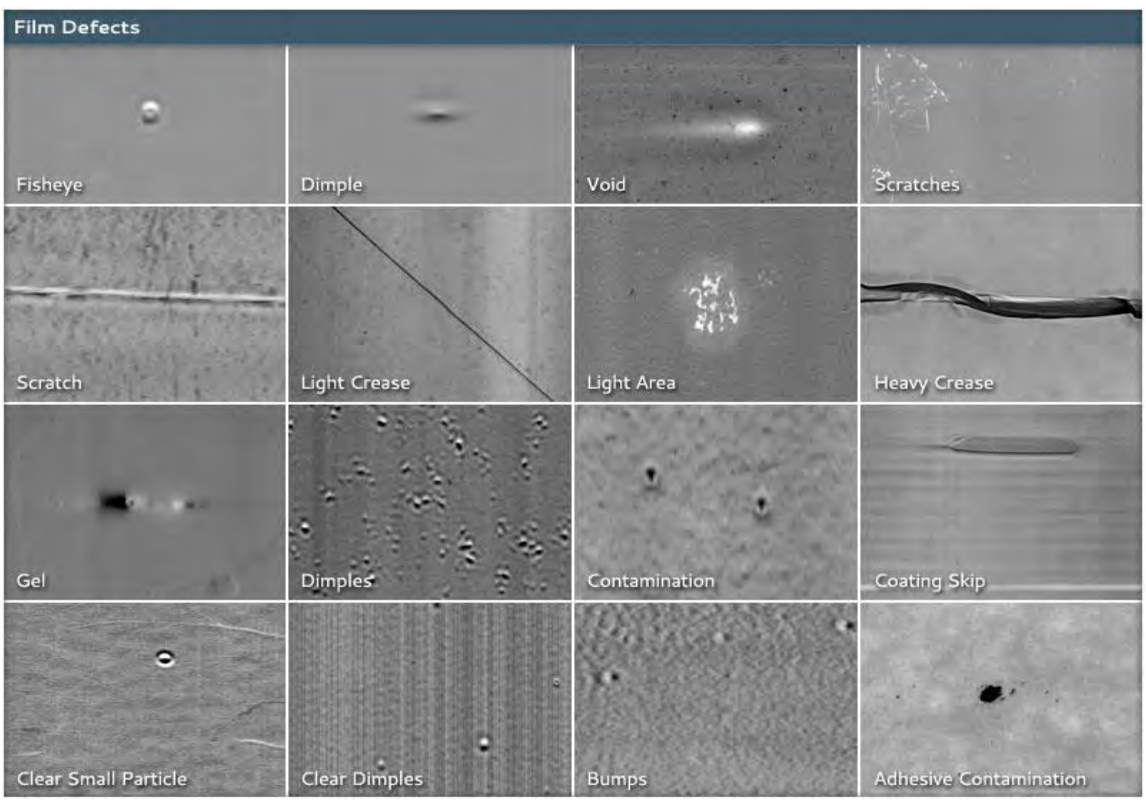

Figure 1.1 : Types of defects on metal surface

1.2 Statement of the problem

In using the manual inspection, several problems were encountered since the human inspector cannot maintain long-term consistency according to the inspector knowledge and experience. The inconsistency between different inspectors on defects happen when the inspector overlooked the rejects depends on their understanding of the individual inspector. Standardization is impossible to be achieved by using the manual inspection. In other situation, a new hired workers need time and training to identify the defections and the total of inspectors need to be enough on all shifts. When dealing with mass production, manual inspection is not the best way because time duration using the manual is slower than the automatic inspection. Using the manual inspection will delay the manufacturing operation and increase labor costs. Human inspector also needs break and recess time that human error can be reduced.

1.3 Objectives of the study

The goal of this project is to detect the defect on metal. The specific objectives that need to be achieved are:

i) To develop system that can detect scratch defects on metal surface by using vision sensor.
ii) To develop the algorithm for defect detection system.

1.4 Scope of the study

In developing defect detection and localization algorithm for automated defect detection on metal surface, the scope of the project have been defined as follows:

i) This project focus on the detection of the defect only on JIS G3141 Carbon Steel.
ii) The system is designed to detect straight line scratch defect.

1.5 Organization

Chapter 1 is an introduction chapter that consists of the background of the study involved in defect detection, problem statement, objectives, scope and organization of report. Chapter 2 provides literature reviews, mainly on the methods approach of the automated defect detection by the research methodology of the project. In this chapter the best method that can be implemented on this project is defined. Chapter 3 describes the detailed methodology used for this project. This chapter explains the analysis of the journal and related methods used in journals experimental. In chapter 4, the results and discussion involved are analyzed. Finally, Chapter 5 elaborates conclusion of this project and provides some recommendations had proposed to improve this project.

CHAPTER 2
LITERATURE REVIEW

2.1 Introduction

This chapter starts with a review of approaches existed in defect detection inspection. The advantages and disadvantages of these technique are also addressed. Previous work related to this project is also highlighted in this chapter. At the end of this chapter, the selected technique for the metal surface detection is proposed to overcome the weaknesses of existing techniques and algorithms experimentally in terms of the defect detection, defect localization and overall inspection time.

2.2 Overview of defect defection on metal surface

The metals have been widely used in dissimilar areas, and being the important part in industries technology such as automobile, heavy industries and construction because of the capability and quality of the surface material in the final product. Hence, defect detection on metal are strongly reflected in terms of repeatability and accuracy. In conventional ways like artificial visual detection and frequency flashlight detection, they faced some problems of low random sample inspection rate, bad real-time capability, low quality and bad inspection procedure that did not followed the industrial quality standard (Xue-wu et al., 2011).

Traditionally, dimensional quality inspection and control in the metal industry, as well as many other quality inspection and control tasks, were performed by humans. Expert technicians were trained to visually determine whether a product deviated from a given set of specifications. However, even skilled technicians occasionally provided biased responses due to fatigue. Human related issues were reduced with the introduction of dimensional quality inspection by machine vision devices. Moreover, skilled technicians still provide visual-based quality information in some manufacturing lines in the metal industry. In rolled-product manufacturing lines, 3D imaging systems have multiple uses. Among them, 3D surface reconstruction, mainly with the objective of dimensional quality inspection and control, is one of the main uses (Molleda et al., 2013).

On the other hand, using the human inspectors provide a number of problems such as subjectivity in gauging quality variably and accuracy. Furthermore, automatic defection of those tiny metallic surface defects becomes an main issue (Sun, Tseng, & Chen, 2010). The bottleneck inspection is normally used in most manufacturing process. Surface defects is mostly used in manufacturing process to check the quality of the surface finishing such as steel strip, hot steel and tile surfaces. The dependent of human inspectors of visual inspection in manufacturing process is inadequate, subjective and variable. Using human visual inspection needs a lot of time to analyze the defect and become more expensive because it needs to hire more human inspectors to cover in manufacturing process. The visual inspection needs to analyze the images type with good repeatability while the automatic visual inspection performs more better than human inspector to conduct the inspection to control the quality (Zheng et al., 2002).

2.3 Methods for defect detection on the metal surface

The method used to detect defect on the metal surface are shows on Table 2.1 in the journal mapping. The journal mapping is the overall method selection from 40 journals selection where it shows the common methods use buy the previous researcher and the methods as the guidance for this project.

2.3.1 Wavelet transform

Wavelet transform can be classified as time-frequency transform. Before this technique was developed, frequency domain was used to analyze the signals and not preserve the time aspect for the signal. Time information not necessary to find the stationary and time-invariant signals, but non-stationary and time varying such ECG and EEG are most useful in real life. Although other techniques such as the Short Time Frequency Transform (STFT), Gabor transform, and Rayleigh transform are available, but wavelet transform is the most popular technique compared to other techniques. The wavelet transform can be localized to be on concentrate the time data with low frequency and can be concentrated with high frequency to get the frequency information. Wavelet transform is flexible and useful to perform time frequency information.

2.3.2 Contrast stretching

Contrast enhancement is the important characteristic in image processing that classified the difference in luminance reflected from the images results. The contrast can be define as color and brightness of one object into another in visual perception (Irianto, Lee, & Knight, 2014). By using contrast stretching, original digital value will linearly expand by remotely sensed data into new allocation. The total range of sensitivity of the display device can be measure by increasing the original input value. In opposite way, by increasing linear contrast will change the data to more obvious. Some types of enhancements suitable to use to remotely sensed images using Gaussian, so the brightness value decreasing within a narrow range and allow to apparent a single mode (Al-amri, Kalyankar, & Khamitkar, 2010).

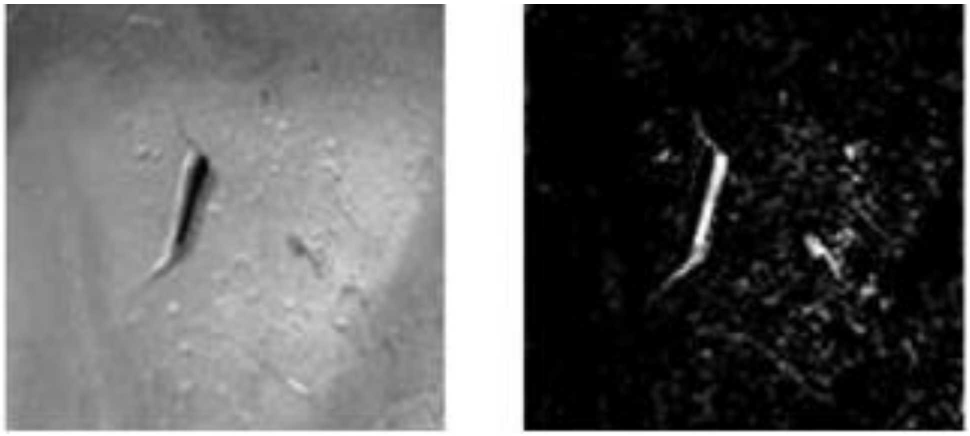

Figure 2.1 : Original image and contrast image of crack defect

2.3.3 Multilevel threshold and contour region

Multilevel threshold is generally used in image processing technique. By changing into gray-level image, the process of segmentation are changed into another distinct region. This technique shows that by controlling the brightness region by using one or more threshold to the image and segment of the images. The different characteristic of algorithm by clustering method is applied to determine the optimal values and to threshold the image into categories. To simplify the defect, multilevel threshold need to be perform after getting the features into gray-level regions. One of the function of contour is to express the roughness level of the defects. The system can be simple by using multilevel threshold and the method are divided the surface defect to the contour region (Prabuwono, Rachmat, & Besari, n.d.).

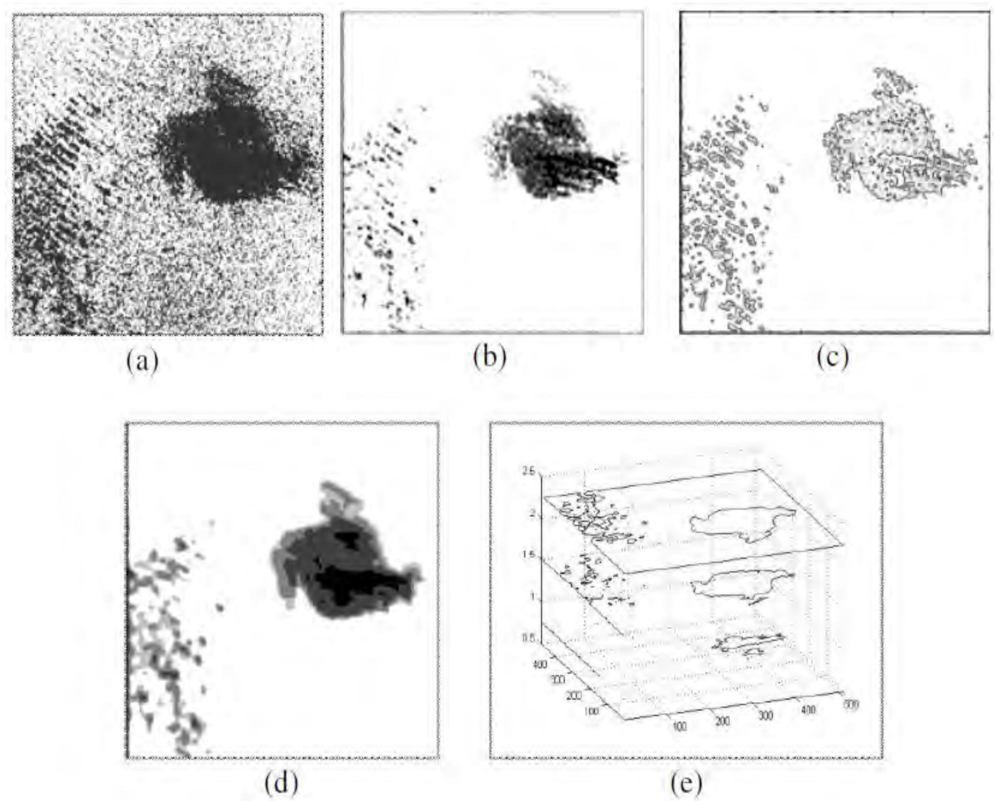

Figure 2.2 : Surface defect classification process (a) Detect image with non-uniform noise (b) Defects filtering from the noise (c) Defects segmentation from image (d) Multi-level threshold of defects (e) Contour region in some levels of defects.

2.3.4 Image filtering

The noise can affect the quality of edge detection, so neural approach is applied to reduce the effect of the latter and to effectuate low-pass filtering. The low-pass lead to elimination of isolation. Filtering should ne interactively to serve the different interest of users in prioritized information, which require specialized interaction techniques. Texture mapping performs image filtering to texture mapping by decoupled deferred texturing. It is simple and effective method without requiring modifications of the original filter algorithms (Semmo & Döllner, 2015).

Figure 2.3 : Before and after filtering

2.3.5 Edge detection

In image processing, edge detection is the main process that provides primary information about the subject present in scene and the bound arise. This is the first can be applied (Ray, 2013). The function of edge detection to search the edges of the light stripe along horizontal line by the first and second derivatives of gray represent the first derivative, the trailing edge of transition and constant gray level. The transition associated represent the second derivative with the dark side of the edge, negative for the transition (Su, Yang, Wu, & Lin, 2011).

2.3.6 Binary

Binary is technique using black and white colors to select the defect area. Generally the object will represent in black pixel and white color represent the background (Zhu & Brilakis, 2010). Binary images can detect the object and the characteristic of the object has linked in edge boundary. There are two types of boundaries such 4 or 8 connected neighborhood and in 4 connectivity the object comprises as object boundary that involved the connected point with background, compared with 8 connectivity connected neighbor point to background and considered of object binary that really useful in many applications (Su et al., 2011).