# THE STUDY OF LUMINANCE EFFECT ON SURFACE ROUGHNESS OF METALLIC SURFACE BY USING VISION SYSTEM TECHNIQUE

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**UNIVERSITI TEKNIKAL MALAYSIA MELAKA**
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# THE STUDY OF LUMINANCE EFFECT ON SURFACE ROUGHNESS OF METALLIC SURFACE BY USING VISION SYSTEM TECHNIQUE

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

by

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# UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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Tajuk: **THE STUDY OF LUMINANCE EFFECT ON SURFACE ROUGHNESS OF METALLIC SURFACE BY USING VISION SYSTEM TECHNIQUE**

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# APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of Universiti Teknikal Malaysia Melaka as partial fulfilment of the requirements for the degree of Bachelor of Manufacturing Engineering (Robotics and Automations) (Hons.).The members of the supervisory committee are as follow:

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(DR. RUZAIDI BIN ZAMRI)

# ABSTRAK

Penglihatan mesin adalah salah satu teknologi yang terlibat dalam penyediaan spesimen yang berkaitan dengan penangkapan imej yang biasanya digunakan untuk menganalisa imej seperti pemeriksaan kualiti, kawalan proses dan juga untuk sistem robot berpandu industri. Dalam kajian ini, kaedah pemprosesan imej merupakan salah satu kaedah tanpa sentuhan untuk mengukur nilai min keabuan (Ga) yang bertujuan untuk mengira nilai kekasaran permukaan (Ra) pada spesimen. Semua imej spesimen yang ditangkap mengikut sumber cahaya yang berbeza mengunakan LED merah, pendarfluor putih dan mentol kuning dengan menggunakan kamera CCD OMRON. Imej ditangkap mengikut setiap spesimen diproses dengan menggunakan perisian MATLAB untuk mengira Ga di tempat yang kecacatan pada imej specimen yang ditangkap. Dalam usaha untuk berbuat demikian, *Graphic User Interface* (GUI) boleh dibangunkan oleh perisian MATLAB oleh dengan menggunakan *Image Acquisition Toolbox* untuk mengira Ga. Pengukuran asal Ra setiap spesimen diambil dengan menggunakan teknik *stylus* yang menjadikan MITUTOYO sebagai alat yang juga salah satu kaedah tanpa sentuhan. Apabila semua data spesimen Ga daripada sumber cahaya yang berbeza dan kekasaran sebenar diambil, ini lebih mudah untuk mencari perkaitan antara kedua-dua data dan garis regresi juga boleh dibentuk. Dengan menggunakan garisan regresi, model, $Y = m X + C$ boleh dibangunkan, $Y$ adalah mewakili kekasaran permukaan Ra dan $X$ adalah mewakili Ga, Ra yang baru berdasarkan setiap sumber cahaya yang berbeza. Ra yang baru mengenai pada garisan regresi linear akan dikaitkan dengan nilai yang diukur menggunakan kaedah *stylus* untuk menentukan sumber cahaya yang manakah model terbaik untuk mengira kekasaran permukaan Ra. Bagi menentukan model cahaya yang terbaik, korelasi setiap model sumber cahaya telah dikira lampu LED merah dengan nilai R = 0.7459, pendaflour putih dengan nilai R = 0.9565 dan mentol kuning dengan nilai R = -0.9584. Dalam kajian ini mendedahkan bahawa dengan menggunakan Ga daripada

imej yang ditangkap, ini adalah tidak mustahil untuk mengira Ra pada setiap specimen yang berlaku kecacatan.

# ABSTRACT

Machine vision is a one of technology and method that applied in preparation of specimen regarding capturing image that usually for analysing image such as the application for production quality check-up, production process control and also for robot-guided system in the industry. In the other hand, machine vision commonly implemented a larger area which accordingly on what type of application based on their purposes. In this study, the image processing method which is one of the non-contact method is applied to measure the mean gray value (Ga) used to predict and calculate the value of defected surface roughness (Ra) on the specimen. All the specimens image are captured in different light source environment exposure which are Red LED light, white fluorescent and yellow bulb by using OMRON CCD camera. The captured image of each specimen are processed by using MATLAB software as to calculate Ga on the defected area on the captured image. In order to do so, the *Graphical User Interface* (GUI) could be developed by MATLAB software by implementation of *Image Acquisition Toolbox* to measure and calculate the Ga. The actual measurement of Ra of each specimen are taken by using stylus technique as the tool used is MITUTOYO surface measurement also the one of the contact method. When all the data, Ga specimen from different light sources and actual surface roughness are taken, it is easier to find the relationship between both data and a regression line can be generate. By using the regression line, model, $Y = m X + C$ can be developed, which $Y$ is represent Ra and $X$ is represent Ga, so that the new Ra based on each different light source can be calculated. The new Ra regarding on the linear regression line will be compared with the value measured using stylus method as to determine which light source is the best model for calculating Ra. In order to determine which light is the best model, the correlation of each light source model was calculated for red LED light with R = 0.7459, white fluorescent with R = 0.9565 and yellow bulb with R = -0.9584. In this study reveals that by using the Ga from the image captured, it is possible to calculate the surface roughness of defected area on each specimen.

# DEDICATION

Only

My beloved father, Hamdan Bin Tahir

My appreciated mother, Zakiah Binti Salleh

My adored sister and brothers,

Fatin Nur Adilah Binti Hamdan

Mohammad Noor Aiman Bin Hamdan

Mohammad Noor Amin Bin Hamdan

Mohammad Noor Rafiuddin Bin Hamdan

# ACKNOWLEDGEMENT

In the name of ALLAH, the most gracious, the most merciful, with the highest praise to Allah that I manage to complete my project titled "The Study of Luminance Effect on Surface Roughness of Metallic Surface by Vision System Technique" successfully without any major difficulties.

First things first, I would like to express my deepest appreciation to all those who provided me the possibility and efforts to complete this final year project report especially to my beloved father, Hamdan Bin Tahir and my mother, Zakiah Binti Salleh who are always be there for me, supporting and giving me some motivation along conducting this project.

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Last but not least, I have to appreciate the guidance given by other lecturers as well as the panels especially in our project presentation that has improved our presentation skills. Thanks to their supportive comment and useful advices.

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# CHAPTER 1
# INTRODUCTION

## 1.1 Background

Nowadays, machine vision is one of the equipment and method that applied the vision-based automatic measurement and experimental investigation for instance applications as production check-up, production process control, and robots-guided in advanced industries. The potential of this machine vision technology is very wide and it depends on what type of purpose that can be used.

However, some of conventional machine vision are still developing such as markets-metrology, defect recognition, image tracing, and bar-code reader. Unfortunately only at a pace reflecting the maturity of the technology give a lot of advantage to its consumers. Besides that, the latest machine vision algorithms depend on controlled parts presentation, lighting and optics for robust and faster processing. Users have been considering *Graphical User Interface* (GUI) on new machine vision applications that work flexible in generally independent situations.

For example, the camera captures and freeze the image of the object placed on a moving conveyor. The crucial information of parameter is acquire from the image of the object and a script file or algorithms is generated by the software and the image is saved as a template for further measurements. When the measurement starts, the images of the objects which come under the camera are captured and the script is run which compares the images with the template and reflects status either accept or unaccepted on the GUI depending on how many the crucial dimensions of the image matches with the template.

The apparent and material colour of the experiment matters have a vital associated and usually are the main factors on the subsequent of camera image. Colours engross a

huge amount of the most visible occurrence light in addition to the revealed surface effects so that the reflection proportion is additionally condensed. In this respect it is also significant whether there is only a simply penetrable thin coat of paint on the object or the experiment item is completely coloured.

## 1.2 Problem Statement

There are many aspect to be tackle in the study of luminance effect on surface roughness of metallic surface by vision system technique such as the measurement of reading of surface roughness (Ra) of material on different type of light exposure on the metal sheet *JIS G3141* which could give different result to be analyse later by using developed *Graphic User Interface* (GUI) that measure and calculate the mean grey value (Ga). Then, from the collected data will be developed the different surface roughness models and lastly how to determine which model is the best represent the surface roughness using vision based technique.

## 1.3 Objectives

The objectives of this study are:

a) To measure surface roughness of metal sheet *JIS G3141* by using white fluorescent light, bulb light and LED light.
b) To develop surface roughness models from collected data to represent Ga and Ra relationship.
c) To determine the best model which represent the surface roughness using vision based technique.

## 1.4 Scope

The scope of this project is to study the effect of the types of luminance light such as Red LED light, White florescent lamp and Yellow Bulb on the defect metal sheet shown

in Figure 1.1: Metal Sheet *JIS G3141* surface that commonly used in industry, by using OMRON CCD camera and MITUTOYO Surface Measurement tools as the apparatus of the machine vision system to measure the intensity of light with the surface roughness (Ra) each of specimens that will be analysed by using certain parameter algorithm developed in GUI of MATLAB *Image Acquisition Toolbox*.

Figure 1.1: Metal Sheet *JIS G3141* (Source: Google Image)

## 1.5 Summary

Chapter 1 explain about the introduction in machine vision system technique as the platform to investigate the consequence of different types of luminance light on the surface roughness of the defected metal. There are also have objectives to be achieve at the end of this study based on the problem statement stated in this chapter.

# CHAPTER 2
# LITERATURE REVIEW

## 2.1 Introduction

In Chapter 2, many previous studies related to this project are discussed that involve in surface roughness on the object and the method that be used in measurement. All the information are used to design the methodology in Chapter 3 included reference book, journal and etc. In this chapter will focus on surface roughness measurement on defected specimen by using machine vision system.

## 2.2 Surface Roughness Measurement

All the surfaces of the specimen may not fulfil functional requirements and no need to be equally finished or called as defected. The geometrical specifications of a surface measurement include, macro-deviations, surface waviness and micro irregularities. The surface roughness is measured by the height, $R_t$ and mean roughness index $R_a$ represent the micro-irregularities. The evaluation are normally made on along a line, running at right angle $90^o$ or perpendicular to the general direction of tool marks on the surface. It can be conclude that the mean roughness index ($R_a$) is the arithmetic mean of the absolute value of the highest $h_i$ between the actual and mean profile of the surface of the specimen measured.

Gadelmawla et al (2002) discussed about the surface roughness parameters are normally categorized into three main aspect that should be considered which are amplitude, spacing and hybrid. Roughness parameters can be calculated in either 2D or 3D forms. The most important parameters to characterise surface topography is the

amplitude parameter that used to measure the vertical characteristics of the surface deviations.

Dumazet et al (2006) found that the measurement of surface, optical simulations, samples realization of gilded surfaces were made for studying the visual appearance and the substrate colour influence of the gilded surfaces mainly encountered in sculpture.

## 2.3 Image Processing

The first step in recognizing structures in an object consuming machine visualisation process is to acquire images instead of the object itself. Many methods are used to gather data that is altered into binary in term of Black and White images representing the image that scanned from an object. Once an image or images have been composed using several technique, certain processes must be taken place to choice and recognize the several features are correlated. These processes are allocated into contact and non-contact method. Ballard and Brown (1982) stated that after several form of emission, which has been imitated after or spread over an object records in a device, image formation happens.

The image itself characterized in different dimension and illumination resolution. All the different dimension shows the quantity of pixels representing the whole image. The illumination levels develops the grayscale image so that image pixels mix together by increasing the number of represented bits later the image of different dimension and illumination resolution be influenced by on the purpose. This situation is essentially which is the most accurate resolution need to be matched for the application so that separation and sorting methods work properly. The defect recognition on the specimen, it is mostly established that a single desires doubled the different dimension resolution of the lowest piece to be discovered and a lowest of 8 bits of illumination resolution.

Bhanu (2013) explained that the techniques are used to process the image called image processing. Then the resulted image is used to decode the information embedded in the image using analysis techniques. In principle, machine vision includes acquiring an image, process it using digital image processing and analysis techniques and take

decision based on extracted information. But, in practice, it is more than the above process.

Vilbett et al (2006) explained the methods on how the surfaces were examined for roughness by using laser scanning microscopy, colour, and glossy image. When a device gathers a captured image, the image is shattered up into distinct parts of figures which is acknowledged as pixels, which are the parameter within the image of the examples and the illumination values correlated with it.

Megahaed et al (2011) during a symposium they discovered and highlighted some application opportunities available in the use of control charts with image data and provide some advice to practitioners. They also give some guideline to other researcher to conduct towards their research study.

## 2.4 Contact Method

For this method, in order to acquire the data of measurement process of surface roughness, the sensor of the measurement tools comes in contact with the surface of the specimen and calculate the actual parameter of the desired surface. This method is normally used as it is the most accurate in taking data for measurement surface roughness.

Li'Via et al (2007) discussed the surface measurement when the surface is scanned by moving a probe sphere of a given radius along a large set of test lines that are perpendicular to the plane of the interface. The proposed method of identifying the truly interfacial molecules is based on moving fictitious probe spheres of a given radius along straight lines that are perpendicular to the interface, starting from a given phase. Once this fictitious probe sphere hits a molecule of the other phase, it is stopped, and the molecule that stopped it is regarded as interfacial.

### 2.4.1 Stylus Method

The stylus sensor comes in contact to the surface roughness to scans the surface and the input converts the mechanical movement of the stylus sensor into the output via transducer which is an electrical signal later will be transfer to the computer. This method has finite dimension, by other means it is not mathematical point. According to ISO standards a stylus sensor might have an included angle of 60 or 90 degrees and a tip radius of curvature about of 2, 5 or 10 micrometres. The stylus sensor tip radius is very crucial part in measuring the surface profile.

## 2.5 Non-contact Method

This method is said to be a lot safer because of without any contact to the surface of specimen which mean there is no contact between the sensor and surface with any of these technique. This method is prevent the specimen from additional unexpected defect.

### 2.5.1 Light Scattering

. Manoj & Shivakumar (2010) stated that a beam of light with a certain wavelength is occurred as incident light on the surface of testing object at the angle which can be as the controlled variable. Once the surface is ideally exposed, the incident light beam is reflected in the secular direction, at the specific angle of the incidence represent the similarities of the angle of reflection. Once the surface is declared as rough, an originality or all of the incident light beam are scattered off from the reflective surface area, creating a diffuse beam.

Changhui et al (2004) discussed a 3D finite method in different time domain model that is used to solve for all the optical properties of the scattered. Light scattering has been applied of study the surface specifications of object-machined surfaces and it is used plane polarized light and a scatter light sensors for surface characterization. It also have two methods which are angular-resolved scatter (ARS) and total integrated scatter

(TIS). These two methods based on light scattering to predict the roughness of object surface.

### 2.5.2 Machine Vision Based Technique

The illumination such a very important role within the machine vision system itself in order for capturing image. Measuring the influence of lighting source, such as the angle of grazing and distance between surface specimen and the light source, optical surface-finished parameters extracted from the original-captured image (Z. Zhang, Chen, Shi, Ma, & Jia, 2009). In several advanced manufacturing, machine vision system has been very excellent employed to be implement including to material handling, assembly and product quality inspection (Manoj & Shivakumar, 2010).

Machine vision based techniques covered the area unit appropriate for on-line evaluation of surfaces of machined specimens included the area unit safe on surfaces being measured by the measuring instrument. Implementation of a vision system to get surface image and quantified the surface roughness employing a multivariate analysis. The mean gray value (Ga) of the surface image was calculated and calibrated with the various average surface roughness (Ra) of the surface measured by the stylus technique. By using the Gray Level Co-occurrence Matrix (GLCM), this method considered the unique relationship of pixels on the surface image. The surface roughness is extracted by discovering the correlation of average surface roughness (Ra) with the options of GLCM of the surface image (Jeyapoovan & Murugan, 2013).

Yu-Chieh et al (2008) explained that the inspection algorithm is based on the two value image provided by the machine vision system. Besides, by using the method it is very cost effective during manufacturing operation,

## 2.6 Luminance Light

The term of luminance defined as photometric measurement of the brightness concentration per unit area of light get through in a given way. It portrays the amount of light that passes through, is produced or reflected from an appropriate area, and drops within a given solid angle. The SI unit for luminance is candela per square metre (cd/m2). A non-SI term for the same unit is the "nit". The Centimetre-Gram-Second (CGS) unit of luminance is the stilt, which is similar to one candela per square centimetre or 10 kcd/$m^2$. Dörband et al (2012) stated that luminance is frequently used to specify issuance or reflection from flat and diffuse surfaces.

Dror et al (2001) explained the spatial structure of real-world illumination possesses some of the statistical regularities observed in the natural image statistics literature. Besides, the illuminance specifies how much luminous power will be distinguished by an eye staring at the surface from a particular angle of vision. Luminance is thus a sign of how bright and clear the surface will appear. In Figure 2.1 shows the parameter of defining luminance of light. In this case, the firm angle of interest is the solid angle subtended by the eye's pupil. Luminance is used in the video industries to illustrate the illumination of displays.

A normal computer show releases between 50 and 300 cd/$m^2$. In addition, the sun has luminance of about 1.6×109 cd/$m^2$ at noon. Luminance is said as invariant in geometric optics. In the other words, for an ideal optical system, the luminance at the output is the equal as the input of luminance. For actual, passive, optical systems, the output luminance is at most equivalent to the input. For instance, if one consumes a lens to produce an image that is smaller than the source object, the luminous power is concentrated into a smaller area, that’s mean the luminance is greater at the image. However, the light at the image plane, fills a larger solid angle so the luminance comes out to be the same assuming there is no loss at the lens. The image can never be "brighter" than the light source. Figure 2.1 shows the parameter of defining the luminance.