UNIVERSITI TEKNIKAL MALAYSIA MELAKA

A Study On Calibration Technique Required For Optical Component In Non-Contact Measuring System

This report submitted in accordance with requirements of the Universiti Teknikal Malaysia Melaka for the Bachelor Degree of Manufacturing Engineering (Manufacturing Process) with Honors.

by

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TAJUK: A Study On Calibration Technique Required For Optical Component In Non-Contact Measuring System

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Yang benar,

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Penyelia Projek Sarjana Muda,
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DECLARATION

I hereby, declare this report entitled "A Study on Calibration Technique Required for Optical Component in Non-Contact Measuring System" is the results of my own research except as cited in the references.

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APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of University Technical Malaysia Melaka (UTeM) as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (Manufacturing Process) with Honours. The member of the supervisory committee is as follow:

……..

(Mr. Khairul Anuar Bin A. Rahman)

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TAJUK: **A Study on Calibration Technique Required for Optical Component in Non-Contact Measuring System**

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ABSTRACT

Nowadays, the machined parts manufactured by machine tools constantly need to be inspected for their dimensional accuracy. Many measurement techniques have been thoroughly investigated. Such measurement techniques include the use of rulers, gages, micrometers, optical sensors, acoustic sensors and laser interferometers. Because the geometry of machine parts is often complex, how to use dimensional measurements to reconstruct object geometry becomes a complicated metrology problem. Dimensional measurement methods that would sufficiently solve complicated metrology problems are frequently explored. These optical components shall be calibrated before being used. Thus, a study on calibration technique of these components is essential. The main objective of this PSM is to find the calibration technique that can be use,, before applying the technology. There are many factors need to be consider in order to avoid problems concerning the measurement accuracy and effectiveness of CCD camera imaging systems.

ABSTRAK

Masa kini bahagian-bahagian yang sudah di proses oleh mesin,perlu diuji tahap ketelitian atau ketepatan ukurannya secara konstan. Banyak teknik-teknik pengukuran yang telah disiasat selia. Antaranya adalah, penggunaan pembaris, pengukur, mikrometer. Optikal sensor dan juga laser interferometer. Oleh kerana bahagian-bahagian yang hendak diproses selalunya dalam bentuk yang rumit, cara untuk menentu ukur dimensi untuk menyusun semula geometri produk terus menjadi masalah pengukuran yang rumit. Kaedah pengukuran yang dapat menyelesaikan permasalahan ini terus diselidiki. Semua komponen-komponen optikel ini perlu ditentukan terlebih dahulu sebelum digunakan. Oleh itu, satu bentuk teknik penentu ukur wajar dijalankan pada komponen-kompenan ini. Matlamat utama dalam penyediaan PSM 1 ini, adalah untuk mencari teknik penentu ukur yang boleh digunakan sebelum teknologi ini dapat diguna pakai. Terdapat banyak faktor-faktor yang perlu diambil kira untuk menghindari masalah-masalah yang melibatkan ketelitian dan keberkesanan sistem gambar kamera CCD.

DEDICATION

For my beloved father and mother

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LIST OF ABBREVIATIONS, SYMBOLS, SPECIALIZED NOMENCLATURE.

ANOVA	-	Analysis of Variance
CCD	-	Charge-Couple Device
CAD	-	Computer Aided Design
DLT	-	Close Form Solution
DOE	-	Design of Experiment
MANOVA	-	Multivariate Analysis of Variance
PCER	-	Per-comparison Error Rate
SPSS	-	Statistical Package Social Sciences
S/N	-	Signal to Noise Ratio
TM	-	Taguchi Method

CHAPTER 1
INTRODUCTION

1.1 Background

Machined parts manufactured by machine tools constantly need to be inspected for their dimensional accuracy. Many measurement techniques have been thoroughly investigated. Such measurement techniques include the use of rulers, gages, micrometers, optical sensors, acoustic sensors and laser interferometers. Because the geometry of machine parts is often complex, how to use dimensional measurements to reconstruct object geometry becomes a complicated metrology problem. Dimensional measurement methods that would sufficiently solve complicated metrology problems are frequently explored. Recently, the development of high performance CCD (Charge Coupled Device) image cameras allows advanced imaging measurement in many areas of application1. Use of these CCD cameras is still new for part inspection in the manufacturing industry. Many problems concerning the measurement accuracy and effectiveness of CCD camera imaging systems need to be clarified with experimental studies. A primary goal of the work on the workstation is to conduct an investigation on how CCD imaging cameras would add new capabilities to dimensional measurement of machined parts. Capabilities such as object feature recognition, simultaneous multi-dimensional position and orientation measurements, and 2D and 3D object geometry mapping, are somewhat unique to CCD cameras. To see how a CCD imaging camera will perform in the measurement of dimensions and features of a machined part, experiments need to be done. But before a camera can be put in use for measurement, it must be calibrated. Conducting a camera calibration will serve many purposes. First, the correctness and effectiveness of a camera calibration procedure will be verified with experimental data. Since a camera calibration procedure may be used for many

camera setups in various experiments, the calibration done with our camera setup may also serve as a demonstration of the calibration procedure for others. Most importantly, a camera calibration determines the measurement accuracy of the camera imaging system. Throughout the calibration process, possible sources of measurement errors may be identified. Doing a camera calibration will also verify the measurement repeatability and capability of the camera imaging system.

1.2 Problem Statement

There were a lot of problem regarding the dimension and quality of the product itself. Most of the technique used nowadays is based on sampling method. This technique is good because it can save the production cost and time, but when facing the electronic and electrical components, the sampling method can not give good result. All this kind of product needs an accurate result because there was a lot of critical part need to inspect carefully. This only can be solve using the advance technology such as CCD camera. Most of the previous research about CCD camera measurement is emphasizing on the variety of CCD parameter to optimize the parameter value in order to determine the measurement accuracy. Without a good calibration technique, we can not ensure the accuracy of any product. With awareness of producing good quality checking in term of dimension and defects, this project is focusing on the calibration technique required for optical components in non-contact measuring system. On the other hand, parameter value determination also consisted in this project difficulty. Hence, the optimum parameters should be estimated in order to determine the best measuring performances such as dimensional accuracy and defects. By using this kind of technology, the entire problem regarding the quality checking can be reduce rapidly and also can decrease the cost come from production field.

1.3 Objectives

Those objectives evaluated are to assist and complete this project:

(a) To determine suitable calibration technique based on the camera selection.
(b) To analyze the selected calibration technique based on the study.

1.4 Scope

This paper has a limitation and scope of research. This project is emphasizing on the calibration technique require for optical components in non-contact measuring system. The CCD camera for measuring part shall be studied in order to fulfill the measurement gap between millimeter and micrometer. All the necessary calibration technique such as using checker board grid object and so on will be studied through this project.

1.5 Project Outline

(a) Chapter 1 describes about project, problem statement, objective and scope of the study. Before conducting camera calibration, the problem statement should be identifying, in order to have clear target on the project.
(b) Chapter 2 briefly explained about the literature review related to the study which includes description on CCD camera, the functionality, calibration technique and so on.
(c) Chapter 3 defined the methodology in conducting the calibration technique.
(d) Chapter 4 consists of the result and analysis towards the experiments carried out.
(e) Chapter 5 construct by the discussion of the analysis gathered on the experimental process.
(f) Chapter 6 concludes the project did and recommends for future improvements.

CHAPTER 2
LITERATURE REVIEW

2.1 Overview

This chapter will briefly introduce the literature research of this project. It is consisted of the CCD camera, concept, functionality and calibration method involve in CCD camera measuring system.

2.2 Charge-Coupled Device (CCD camera)

Charge Coupled Devices (CCDs) were invented in the 1970s and originally found application as memory devices. Their light sensitive properties were quickly exploited for imaging applications and they produced a major revolution in Astronomy. They improved the light gathering power of telescopes by almost two orders of magnitude. Nowadays an amateur astronomer with a CCD camera and a 15 cm telescope can collect as much light as an astronomer of the 1960s equipped with a photographic plate and a 1m telescope. CCDs work by converting light into a pattern of electronic charge in a silicon chip. This pattern of charge is converted into a video waveform, digitised and stored as an image file on a computer. (Mackay, 1986)

2.2.1 A Review of Current Research of CCD camera

Charge Couple Device (CCD) camera is one of the option for measuring part and detecting defect quickly. There are various types of products which can be measure using this kind of technology such as electrical and electronic parts. According to Abbas *et al.* (2006), the current research trends in CCD are on the parameters and calibration method which recently studied all these years.

In recent years, CCD camera researchers have explored a number of ways to improve the measuring efficiency including some unique experimental concepts that depart from the CCD traditional phenomenon. Despite a range of different approaches, this new research shares the same objectives of achieving more efficient measuring system with a structured illumination technique to determine the shape of 3D objects (C.W. Liao *et al.*, 2007).

In CCD camera development, commonly calibration technique used in manufacturing area is by using the simplest calibration target image pattern which is a checkerboard image that consists of adjacent black and white squares. The easily identifiable features of this type of calibration image are the corners between the black and white squares. The pixel coordinates of the corners on the calibration image can be retrieved by corner finding computer algorithms. And the physical coordinates of the corners on the calibration target object can be determined by measuring the position of the corners with a scale or other more accurate methods. (Tsai, 2005)

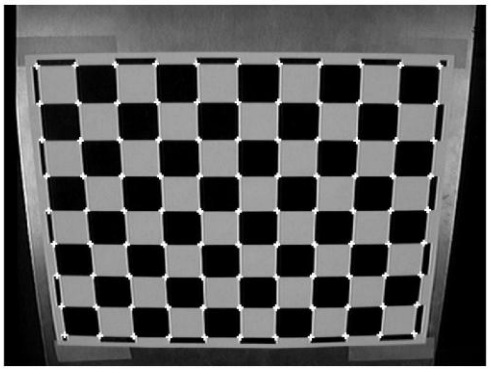

Figure 2.1: Original image zoom at grid (6,5)

2.2.2 Basic Principles of CCD camera measurement

The basic principle of CCD camera measurement is where the CCDs are quite linear, in the sense that the signal they produce in response to light is directly proportional to the number of photons collected. By contrast, photographic emulsion suffers famously from nonlinearities, collectively called “reciprocity failure,” that make it hard to calibrate accurately the conversion between signal and amount of incident light (Falls, 2000).

Therefore, the accuracy of the measurement depends on the lights that reflect back to the CCD camera after hit the object or product.

2.2.3 CCD camera functionality.

Manual inspection is limited when it comes to identifying objects, and the reason is that a person’s vision is easily influenced psychologically, physiologically, or by the external environment. Moreover, since using human eyes to measure the external appearance of the product is more time consuming, and different in standard each time under different inspectors, it does not meet the demand for automatic mass production. The quality control is unstable, and the inspection is not effective either; it could not even achieve the requirements for 100% inspection. Some of the product can’t be inspected using contact measurement, because most of it is made of elastic products. Therefore, a machine vision system is set up for a non-contact 3D range data measurement system by integrating a visual module with image processing, mechanism module, and a control module, and anticipates reducing measurement errors and the human inspection error factor. In other words, a development an inspection algorithm with 3D sensing of the cone geometry and feature analysis concerning the shape and concentricity need to be carrying out to meets customers’ demand that helps achieve an automated visual inspection system to replace manual inspection (C.W. Liao *et al.*, 2007).

CCD camera is one of the important technologies use widely in medical field. The geometry of the human spine is very important from medical and social points of view .Any alteration of the spine can affect on long term internal organs and as a

result the human activity .The respiratory, circulatory and digestive systems will suffer and pain will be produced at various levels of intensity. All these aspects justifies early concern for the human spine geometry by means of constant 3D non contact measurements .The CCD camera is one solution to this problem .It helps to locate several reference points on the spine both in dynamic or static modes (Marius. M).

Photogrammetric measurements are used in several Hi Tec industries like building simulators for low altitude air navigation. People who are experts in mathematics or computer sciences but not in photogrammetry prefer to do almost all of the photogrammetric works by themselves, using a full automatic procedure, based on computer programs for the all photogrammetric works, from conjugate point measurement, till DEM and orthophoto generation (U. Ethrog). By using sun's trajectory, we can determine the co-ordinate (place) effectively.

Very sensitive imaging detectors such as CCDs are currently use in astronomy at practically all wavelengths from far-infrared (as long as 200 μm) to X ray (as short as 0.1 Å) (Falls, 2000). So, in term of astronomical functionality, the CCD usage is going grow day by day like a telescope usage.

2.2.4 CCD camera calibration technique.

There is several technique mentions by researchers, which may be used as a reference in order to complete the project. Some of the idea generate by the researcher implement good possibility of accurateness which can be used as a guide.

Most previous work on camera calibration for vision based tracking deals primarily with the problem of lens calibration or calibration of camera intrinsic parameters of focal length, image center and a few radial distortion terms. The calibration of the camera extrinsic parameters (position and orientation in space) is not treated as separate from the problem of pose tracking. For the integrated vision/inertial system, it is necessary to know the position of the lens nodal point and the orientation of the optical axis quite precisely relative to the origin and axes of the inertial sensors. The camera (CCD) is first mounted inside a precision machined aluminum calibration