



UNIVERSITI TEKNIKAL MALAYSIA MELAKA

**DEVELOPMENT OF A PCB CONTINUITY
INSPECTION SYSTEM FOR QUALITY CONTROL
USING COMPUTER VISION**

This report is submitted in accordance with the requirements of Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Computer Engineering Technology (Computer Systems) With Honours

by

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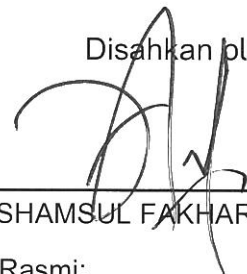
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I hereby, declared this report entitled “Development of A PCB Continuity Inspection System for Quality Control Using Computer Vision” is the results of my own research except as cited in references.

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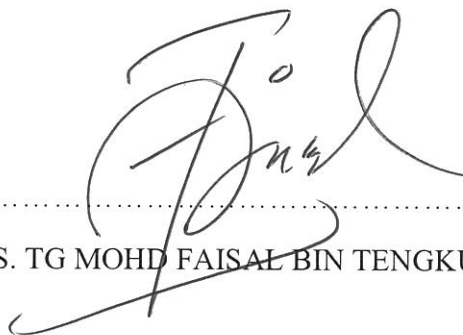
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ABSTRAK

Projek ini berfokuskan kepada industri dimana penilaian boleh dilakukan hanya menggunakan kamera tanpa perlu menggunakan ketelitian pancaindera manusia. Sebuah jig dicipta untuk mengekalkan kedudukan PCB tanpa menggerakkannya walaupun seinci. Web kamera digunakan sebagai mata kepada keseluruhan projek berfungsi sebagai mesin pancaindera. Ini adalah disebabkan dengan menggunakan mesin pemeriksaan PCB, ia secara tidak langsung dapat mengurangkan tenaga kerja sejurus menepatkan lagi pemeriksaan pada luaran PCB. Mesin ini diproses dengan menggunakan MATLAB dimana ia sebagai pemproses gambar untuk memastikan spesifikasi PCB dalam keadaan baik ataupun tidak. Kaedah yang digunakan untuk memproses gambar termasuklah pengesanan pinggir, pemotong, dan morfologi. Sistem ini dikuatkan lagi dengan keselamatan yang menggunakan kad RFID sebagai pengakses untuk masuk ke aplikasi. Hanya yang berkeelayakan sahaja boleh menggunakan aplikasi ini. Gambar yang ditangkan dikumpulkan sebagai data yang disimpan dalam sebuah fail yang dicipta. Segala perlaksanaan dan reka bentuk telah dibentangkan di dalam laporan ini.

ABSTRACT

This project is focused on an industry where inspection can be done using only cameras without the need to use human senses. A jig is designed to maintain the position of the PCB without moving it even in detail. Web camera is used as the point of the whole project as a sensing machine. This is because by using a PCB inspection machine, it can indirectly reduce the manpower while further inspecting the PCB exterior. This machine is processed using MATLAB where it acts as an image processor to ensure that the PCB specifications are in good condition or not. Methods used for image processing include edge detection, crop, and morphology. This system is further enhanced by the security of using RFID cards as access to the applications. Only qualified people can use this application. The images in question are collected as data stored in a created file. All the implementation and design are presented in this report.

DEDICATION

First and foremost, I would like to dedicate this whole study to my creator Allah Almighty, the source of wisdom, patient, inspiration, and through his blessing, I had finally completed this study. I also dedicate this study to my family whom had supported and encourage me throughout the making and completing this study. I would also like to dedicate this whole project for my supervisor Mr. Shamsul Fakhar Bin Abd Gani and co-supervisor Mr. Tg Mohd Faisal Bin Tengku Wook, due to their willingness of cooperation and guidance on the path of completing this study project.

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LIST OF ABBREVIATIONS

PCB	Printed circuit board
RFID	Radio-frequency identification
RGB	Red, Green, and Blue
SMT	Surface-mount Technology
CPU	Central Processing Unit
RAM	Random-Access Memory
GB	Gigabyte
MHz	MegaHertz
SSD	Solid-State Drive
PCIe	Peripheral Component Interconnect Express
HD	High Definition
LED	Light-Emitting Diode
HDMI	High-Definition Multimedia Interface
kHz	kiloHertz
USB	Universal Serial Bus
GUI	Graphical User Interface
X-Ray	X-Radiation
ID	Identification

CHAPTER 1

INTRODUCTION

1.1 Project overview

Vision inspection is quite important nowadays. Most factories are very concerned about the quality in which the product produced must be prioritized. This is because demand from customer that need perfection on a finishing product quality.

There must be several units that have defect in bare eyes that human will be overlooked. So, this job needs to give to a machine that precisely checking without any error. Based on image processing that have intelligent process, a quality control department can perform on checking the visual quality that usually many companies emphasize. Image processing was widely used to check product defect which is very straight checking without any error to be released to the next manufacturing section. This machine is not to perform functionality of the circuit but more to the cosmetic issue that happen often when the product is not all perfect after etching process is completed.

In this project, camera is important part as an input of the machine that will capture an image of the PCB and define it same as specification or not. A desktop computer is the brain of this project which is the main part of the project that control and process the image precisely. The performance of image that has been captured will be process after operator insert product perfectly into machine. Field-testing will be performed to compare the results between good product and bad product.

1.2 Problem statement

There is trouble when process occurs after etching in production. There is a quality issue when some parts of the PCB did not follow the specifications specified. The problem that usually happen is cosmetic issues that most operators do not care about the problem happen when cosmetic issues is the main thing to emphasize because it is based on first impression to the customer.

The defects in the PCB occur in small form and appear to be perfect but vice versa. If according to test conditions using human senses, all test results will indicate that all tests have passed the specified level. Additionally, if there is a slight defect on a PCB then it will be affected in the assemble process or worse will be missed to the test process. It only hurts time to complete a product, which is further detrimental to the cost of manufacturing.

In order to complete the project, a solution should be done over which in terms of the cost of doing a machine might take a substantial amount. Furthermore, if not using a system otherwise the operator's energy would necessarily require the cost to teach and pay the employee's salary. And of course, as mentioned before, where the accuracy of an operator doing a test is incorrect. So, a study should be done whether image processing is appropriate or not used as a test tool.

1.3 Project objectives

The objectives of this project are as follows:

- i. To develop a PCB vision inspection system for quality control.
- ii. To automatically detect the defects that happen on PCB using image processing.
- iii. To analyze the effectiveness of using image processing as a machine tester system.

1.4 Project scope

The scope of this project is to perform a quality control among PCB product in manufacturing industry. In addition, this project is made to inform the features and components used. The important part in this project make whole scope of the project which is using a desktop computer as a brain to control all the components used in this project. Furthermore, the camera is function as an eye of the project and make sure the eyes to the brain is function perfectly. In addition, this project will use an RFID scanner as one of security that will detect the user that use this machine. The software that take an affect will be simulate using MATLAB.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Inspection is the main thing emphasized by the industries. So, this chapter will study some related project to make improvement to make it success. Furthermore, the case study that will use on this project is related to image processing. The idea and concept will study from experience, guidance, book, and reference. The technology that growing rapidly from manual checking which is human checking to camera checking. The camera is the main important part which is input to process. A desktop computer is selected as brain to process the image thus identified it if “PASS” or “Failed”.

2.2 Existing model

The research of the project will be referred on other project research to make it as reference. The idea and concept will study precisely and will add the future improvement.

2.2.1 Technology Movement Research

There are many papers that implement the concept of vision inspection system based on PCB checking. Author (Hua et al. 2018) present the latest technology based on the research model finding. Author emphasize that this project which is image registration technology is the field of image processing. Image recognition has various implications, which is the point at which the

pictures have a similar substance, however between these pictures there has been some geometric change, image registration implies precise coordinating between these pictures or adjustment of the changed pictures to the reference image. At the point when certain pieces of the pictures have a similar substance, enlistment of pictures implies consistent joining between pictures. In summation, if pictures are shot in various sensors, the enlistment of pictures suggests that distinctive picture data is combined. Author characterized that image registration process separated into three classes which is image gray-scale data, image transformation domain information and image feature information.

Author emphasizes that the gray-scale image registration technique is the soonest and most uncomplicated way to experience a registration method. It doesn't require ahead of time complex image pre-processing. This method takes the registration parameters when the maximum closeness esteem is found in the hunt activity, as per the chose likeness estimation work. This present technique's exactness can be profoundly exact, yet extraordinarily impacted by the capacity of the comparability measure. Successive similarity detection algorithm, cross-correlation (C-C), mutual information, etc are ordinarily utilized comparability estimation capacities. In the meantime, in finding out the most extreme similitude esteem between pictures, this method can devour a lot of calculation and time.

The other method that author highlighted is image transformation domain information. By utilizing Fourier transform or discrete Fourier transform, wavelet transform, Walsh transform, and other transform methods, the image registration method dependent on image transformation domain information transforms the image data into corresponding transform domain information. This technique can work out the transformation parameters to enter the pictures as indicated by the particular execution in the transform domain of rotation, displacement and different characters of image transformation. Now and again, this kind of method can accomplish image registration, yet with incredible confinements.

The last technique that creator depicted is image feature information. The image registration method dependent on the image feature extracts

information and first matches the attributes of the reference picture and the transformed image, at that point figures the transformation parameters to record the picture from the directions of these coordinated component focuses. This technique is hearty and versatile, as the picture's notable component data can be kept up in geometric change, for example, corner focuses, straight lines, etc. In the meantime, since this calculation just needs to play out the coordinating estimation between the separated element focuses, computational multifaceted nature is extraordinarily foreshortened, and image registration effectiveness is improved.

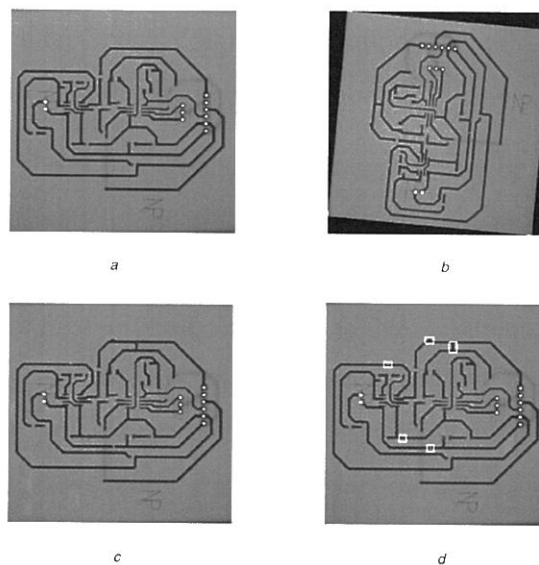


Figure 2. 1 PCB defect detection was tested

One PCB was tested, and result taken to survey with various geometric transformations, including rotation, scale and 3D transformation. The author used root-mean-square error as the evaluation standard for recording accuracy to show the advantages of the proposed method in image registration. The cross-correlation method is added to provide a more accurate recording result that can fulfill the need for PCB detection of errors. The PCB image detection was well recorded, and all the defects were seen. It shows that the suggested algorithm in this paper can be applied to the detection of PCB defects. To match the high-precision need for detection of PCB defects, the cross-correlation method was added. Experimental results prove that the source

algorithm is quite usable and with a more robust and accurate performance can be applied to the detection of PCB defects.

Otherwise with author (Raihan and Ce 2018) that used OpenCV as image processing tools. Through OpenCV, this report will concentrate on computer vision technology, enabling organizations to capture, make out and analyze images to obtain user information in which Computer Vision will be used to detect defects from bare printed PCBs using OpenCV's image subtraction method based on a reference image. The review system will be based on Image Subtraction technique to detect residual properties on the result of subtraction, which will be declared as result defects. All methods used in the arrangement are based on OpenCV library, including Image Processing, Image Subtraction, and method of detection of the Blob.

Furthermore, the author directs the system to provide a small system capable of performing a quality inspection to determine any faults on the PCB's bare printed boards that automatically detect defective parts, supply the PCB status and show where the faulty pieces are along the PCB boards to the system user. The inspection system uses the methods and functions of OpenCV library, in particular Image processing techniques including Gaussian Blurring, Thresholding, Image Morphology, Image Subtraction, and Blob detection.

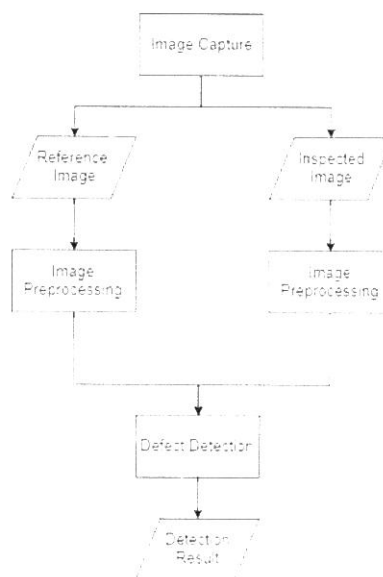


Figure 2. 2 System Flowchart

Image Capture is the first process where the reference image and the image of the inspected PCB are inserted into the system. The method of taking the PCB image is done manually from the code through the program within this project. Images are placed in the program folder and then automatically picked up by the system. The next process is the Image Pre-processing stage where each Image will be prepared using multiple Image Processing processes to become the new images into binary form that will be utilized to detect defective PCB parts. The last process included in the system is the process of detection of defects, which will get an output of the PCB inspection image result. Both the processed reference and the inspected PCB image will remove the same step as Image Subtraction to find out the divergences between the two images, creating a new image which is the absolute difference between the reference image and the inspected PCB image. After that, the image will become through the process of blob detection where the system rests in the difference image looking for any blobs of the target. If blobs remain, the system will notice them and then get the key levels where the faulty parts of the PCB are to be covered to the user.

In that respect are different defects for a PCB panel, which can move the pattern printed on the PCB. It is possible to categorize various types of defects as functional defects and visual flaws. Functional defects have a decisive effect on the parts of the PCB as they damage the PCB due to misalignment of design and product to the extent of the malfunction. On the other hand, as expressed in its name, Visual Defects are just small defects that in the short time do not harm the PCB. Yet, in the long term, the functionality of the PCB will also be touched on by visual defects as misalignment between design and current product can contribute to potential defects. Thus, an inspection is critical to assure that the PCB has no fault whatsoever.

Author make two types of icons which are utilized to examine system performance, a low-resolution image under 720p image resolution, and a high-resolution image of 720p or higher. Images are obtained from an online repository with artificial defects applied to icons for testing purposes.

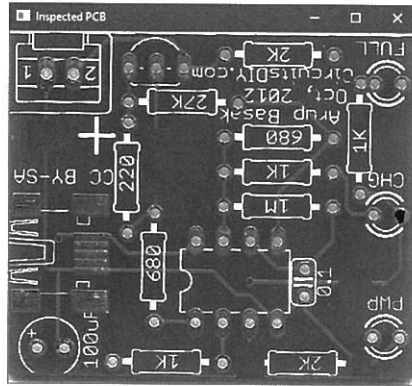


Figure 2. 3 Low resolution image inspected

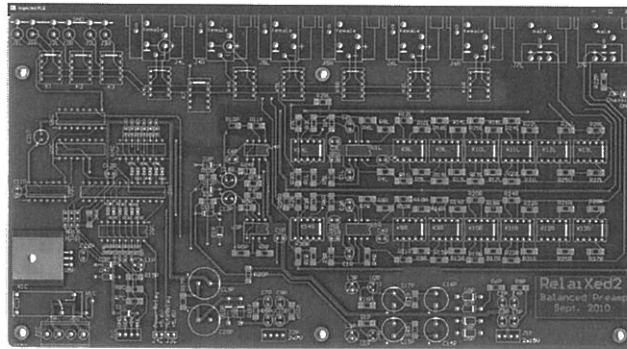


Figure 2. 4 High resolution image inspected

Below is the result of the system of detection of flaws from the two images tested.

Table 2. 1 Testing Result

Picture	Time	Accuracy	Status
Low-Resolution	0.856s	40%	Detected
High-resolution	2.68s	80%	Detected

From the above information, the current method of using image subtraction to find defective parts on a PCB is proven to be accomplished in a very quick rate, drifting from 0.856 minutes for low-resolution image to 2.68 seconds for high-resolution, which is quicker than manual review by humans. The image size represents how long each inspection takes to finish the

inspection process as the larger the picture, the more pixels that are treated. The system's accuracy is also symbolized by the image size or resolution, as the image resolution becomes more accurate or higher, the program's accuracy will also increase. The organization was able to detect defective parts on all tested boards, which is the project's main objective.

Nevertheless, the next author defines the other way to find a PCB defect which is changed to a binary image by using OTSU threshold method. (Raj and Sajeena 2018) construct a different research and complete model of project which is used 3-axis positioning camera. Author said that PCB inspection could be split into two main phases which is a detection of defects and classification of faults. Recognizing the type of flaws is not important when detecting defects. Only it is necessary to recognize the type of detecting flaws in the classification of faults. Classification of defects will take office after the mechanism for detecting defects has been executed. The Author takes an industrial site which is a production facility measurement usually takes place in two ways, contact-less and contact-less. The operations are done completely visually in the contact measurement approach and the amount of error is rather big. This method's performance is very depressed, especially in areas requiring precise measurement. These operations are performed through one or more cameras and a machine vision software in the non-contact measurement approach.

Primarily for machine vision applications, object detection and defect detection processes are built up in this report. The methods of Otsu thresholding and Hough transformation are applied in the extraction of features. The results obtained from this procedure are stored for later use for a character image. The same procedure is given to the test images that stick with this process and together with the matching process, the defects on the PCB are finally discovered. Author presents a block diagram which summarizes the steps of the proposed attack.