Development of Measurement System via Deep Learning Based Inspection System

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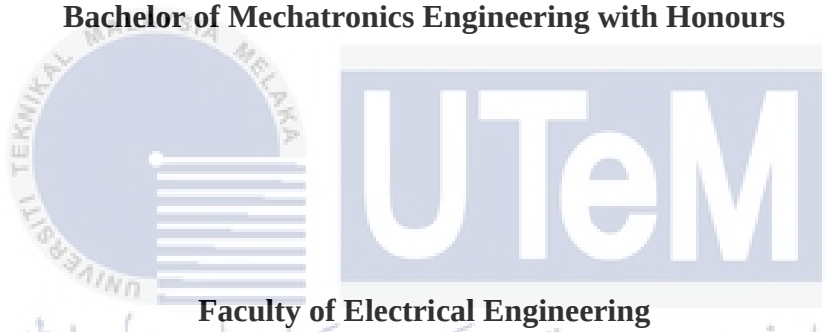
TO RUI XIANG

A report submitted
in partial fulfillment of the requirements for the degree of
Bachelor of Mechatronics Engineering with Honours



Faculty of Electrical Engineering

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2021

DECLARATION

I declare that this thesis entitled “Development of Measurement System via Deep Learning Based Inspection System” 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 : TO RUI XIANG

Date : 6/7/2021

APPROVAL

I hereby declare that I have checked this report entitled “Development of measurement system via deep learning based inspection system” and in my opinion, this thesis it complies the partial fulfillment for awarding the award of the degree of Bachelor of Mechatronics Engineering with Honours

Signature : .....

Supervisor Name : DR. SAIFULZA BIN ALWI @ SUHAMI

Date : 6/7/2021

DEDICATIONS

To my beloved classmate, friend, mother and father.

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First, I wish like to thank to my FYP supervisor, Dr. Saifulza Bin Alwi @ Suhaimi, who pushed me in this project. Thank you for your support, patience, and guidance me to ensure that this project is under good direction. This project would not have been well completed without his guidance and inspiration.

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ABSTRACT

The measurements system is very vital part to the manufacturing industry. The dimension of electronic device is important and should be consistent. Automatic measuring instruments can be used to measure the size of electronic device such as IC chip, resistor and other. Compared to traditional method, automatic measurement can measure the size of an object fast and accuracy. In this project, the focus is on the development of measurement system via deep learning based inspection system. The major problem to development a deep learning model to detect the electronic item is hard, it requires a larger data set of images to achieve faster and high accuracy. The five electronic item that choose to detect are resistor, IC, button, led and PCB. The first objective of this project is to investigate image acquisition, image processing and illuminating system for measure the dimension of electronic item while the second objective is to development a measurement system via deep learning based inspection system by using python. Measurement system via deep learning based inspection system proposed in this project will be using laptop connected with smartphone camera. The camera will be fixed at a position so that the dimension of the electronic components can measure accurately. The program will be write using python language. The YOLO models that used to develop the system is YOLOv3, YOLOv4, tiny-YOLOv3 and tiny-YOLOv4. The YOLO model is train using the online GPU via Google Colaboratory. To test the functionality of measurement system, there two experiments are conducted. In the first experiment, the performances of YOLO models are analyzed. The accuracy of the measurement system via deep learning based inspection system in real-time is the second experiment. The measurement system via deep learning based inspection system is successfully developed.

ABSTRAK

Sistem pengukuran sangat penting bagi industri pembuatan. Dimensi peranti elektronik adalah penting dan harus konsisten. Alat pengukur automatik boleh digunakan untuk mengukur ukuran alat elektronik seperti cip IC, perintang dan lain-lain. Berbanding dengan kaedah tradisional, pengukuran automatik dapat mengukur ukuran objek dengan cepat dan tepat. Dalam projek ini, fokusnya adalah pada pengembangan sistem pengukuran melalui sistem pemeriksaan berdasarkan pembelajaran mendalam. Masalah utama untuk mengembangkan model pembelajaran mendalam untuk mengesan item elektronik adalah sukar, ia memerlukan sekumpulan data yang lebih besar untuk mencapai ketepatan yang lebih cepat dan tinggi. Lima item elektronik yang memilih untuk mengesan adalah perintang, IC, butang, LED dan PCB. Objektif pertama projek ini adalah untuk menyelidiki pemerolehan gambar, pemprosesan gambar dan sistem penerangan untuk mengukur dimensi barang elektronik sementara objektif kedua adalah untuk mengembangkan sistem pengukuran melalui sistem pemeriksaan berasaskan pembelajaran mendalam dengan menggunakan python. Sistem pengukuran melalui sistem pemeriksaan berdasarkan pembelajaran mendalam yang dicadangkan dalam projek ini akan menggunakan komputer riba yang dihubungkan dengan kamera telefon pintar. Kamera akan dipasang pada kedudukan supaya dimensi komponen elektronik dapat mengukur dengan tepat. Program ini akan ditulis menggunakan bahasa python. Model YOLO yang digunakan untuk mengembangkan sistem adalah YOLOv3, YOLOv4, tiny-YOLOv3 dan tiny-YOLOv4. Model YOLO dilatih menggunakan GPU dalam talian melalui Google Colaboratory. Untuk menguji fungsi sistem pengukuran, terdapat dua eksperimen yang dijalankan. Dalam eksperimen pertama, persembahan model YOLO dianalisis. Ketepatan sistem pengukuran melalui sistem pemeriksaan berasaskan pembelajaran mendalam dalam masa nyata adalah eksperimen kedua. Sistem pengukuran melalui sistem pemeriksaan berasaskan pembelajaran mendalam berjaya dikembangkan.

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LIST OF SYMBOLS AND ABBREVIATIONS

PCB	-	Printed Circuit Board
LED	-	light-emitting diode
IC	-	Integrated Circuit
CCD	-	Charge Coupled Device
CMOS	-	Complementary Metal Oxide Semiconductor
YOLO	-	You Only Look Once
CNN	-	Convolution Neutral Network
R-CNN	-	Region Based Convolutional Neural Networks
ReLU	-	rectified linear unit
OpenCV	-	Open-Source Computer Vision Library
AP	-	Average Precision
mAP	-	Mean Average Precision
IoU	-	Intersection over Union
Fps	-	Frames per second
2D	-	Two-dimensional
3D	-	Three-dimensional

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CHAPTER 1

INTRODUCTION

1.0 Introduction

The consistently size of electronic item is vital in manufacturing industry to monitoring the production process. By using the automatic measurement system via deep learning inspection system, the operator will be easy to control and monitor the process. [1].

Automatic measuring instruments are extremely effective to measure the large quantities of electronic item together. Automatic measurement can be achieved immediately compared to traditional techniques because it can avoid human mistake. The human operators can reduce their work to check the parts one by one because the auto measurement system will do the detect and measure the part together. The workers are hard to measure the smaller size of electronic item, they need the help of tool to measure it. With the auto measuring system, worker just need to monitor on the screen, it will greatly reduce the error rate and increase the efficiency of work [2]. The implementation of machine vision technology will accurately determine width and height of objects in geometric measurement.

Next, the object detect is a technique to identify, recognize and local the object in real-time, video and image. The object detection can be categories to two type one is machine learning, and another is deep learning. The machine learning method is using the computer vision technique like edge detection and histogram while deep learning method is using the convolution neutral network (CNN). CNN uses 2D convolutional layers to blend learned features with input data, making it perfect for processing image. Nowadays, most of the people use the deep learning method such as faster R-CNN, YOLO, and Mobile Net to train the object detection. The deep learning model need to train by a large amount of image that has label.

In conclusion, the uses of machine vison are very important in this 4.0 industrial convolution. The use of machine vision can be used in measure the dimension and object

detection. By implementing the machine vision to the manufacturing industry, the operation can save the time, increase productivity, lower the capital cost and reduce the human error. The measurement system via deep learning based inspection system can measure the dimension of electronic item and classify it.

1.1 Motivation

Nowadays, computer vision technique has been widely used in manufacturing industrial to measure and detect the product. The traditional measurement method is low efficiency, and the measurement error are easy to occur. Hence, the uses of machine vision in industrial are vital to improve the efficiency and precision in measurement method. The measurement system via deep learning based inspection system can detect and measure the size of electronic item such as resistor, led, IC, button and PCB accurately and fast.

The demand quality of electronic components is increasing year by year, dimension calculation become one of the important process because it will require a higher inspection efficiency and means requirements. The auto measurement system can measure the component in high speed with accuracy, and it is very flexible can measure in various of shape in real time. Furthermore, the operator can reduce their work to check the component one by one manually, minimize or avoid the common human errors that often occur in the measurement process.

There are a lot of electronic components such as dc motor, sensor, resistor IC, push button, capacitor, potential meter and other. The electronic components are used in many ways, for instance the electronic device that used in house like television, phone, laptop and other. In several industries, such as electronics, industrial, medical, and automotive, electronic components are widely used. Nowadays, electronic components demand is rising steadily from year to year in world. In the reading process, the conventional approach for measuring the electronic components is cumbersome, long measurement time, high human error in workers, and low productivity. Hence, the measurement inspection system is important to check and identify the dimension of electronic component is consistent and accuracy.

1.2 Problem statement

Measurement inspection system plays an important role in manufacturing industry. For this project, machine vision technology and deep learning is used to identify and measure the dimension of electronic components using the camera. The electronic components that selected to measure and detect are PCB, led, resistor, button, and IC.

To development a deep learning model to detect these electronic components is hard, it requires a larger data set of images to achieve faster and high accuracy result. Besides, the dataset model needs to be train and test, the more the sample of data, the higher the accuracy of result obtained. Besides, some of the electronic component sizes are small such as resistor, the camera used are very hard to focus.

Next, is the calibration parameters of visual measurement system using a phone camera. To measure the dimension of electronic components, the camera is fixed in a location so it could detect the object. Moreover, the vibration and lighting problem, also will affect the result obtained. The experiment must conduct in the place that is stable so that the result obtained is consistent and accurate. In addition, methods of data analysis are fundamentally necessary and should be able to interpret information obtained accurately. In order to reduce noise for better processing, the process of acquiring the image of an object is important. The geometric characteristics derived from the images should be correctly defined if the precision of the measurement is not. Then, the different distance height between camera and table will also affect the accuracy of measurement and object detection. The light condition also is a main problem for this project. If there is poor lighting in condition, it will affect the accuracy of object measurement.

In a conclusion, it is important to design and build an autonomous measurement inspection system through this research project to overcome these concerns.

1.3 Objectives

The objectives:

1. To investigate image acquisition, image processing, illuminating system for object detect.

2. To development and program a measurement system via deep learning based inspection system by using Python.

3. To investigate and analyze the performances of measurement system via deep learning based inspection system in term of measurement and object detection.

1.4 Scope

The following segments will concentrate on the project:

1. Using the OpenCV library and machine vision, the software code will be written to detect electronic components.

2. The coding of computer vision and deep learning algorithms will be use, phone camera is used to conduct the experiment.

3. A laboratory experiment will be conducted to test the system's reliability and performances metrics to detect electronic components.

4. With various distance, the precision of the length and width of the electronic components will be measured.

1.5 Organization of thesis

A brief introduction to the project, including the motivation, goals, and issue statement, is given in Chapter 1 of this study. This project is aimed at solving all of the mentioned problem statements.

For similar studies performed by other researchers, Chapter 2 is the literature review. It provides the basic information needed for this project to be completed. Study compares the approaches and technology are used in problem solving.

The proposed methodology for solving the problem of developing the measurement system through the Deep Learning-based Inspection System is defined in Chapter 3.

In terms of developing the measurement method using a deep learning-based inspection system, Chapter 4 is the outcomes and discussion of the project outcome. There is a discussion of the predicted outcomes of the experiments.

Chapter 5 is the end of the project and the proposal for future work.

CHAPTER 2

LITERATURE REVIEW

In this chapter, the theoretical theories and review of relevant past works that involve in project is discussed. Machine vison is the basic theory that use to measure and detect the electronic components. Besides, the method of deep learning and type of camera will also be discussed in this part. Similar research on computer vision and deep learning technologies have also been addressed in the inspection framework.

2.1 Machine Vision

The machine vision is a subsystem of computer vision, which mean the machine system is the use of computer vision in real-time. For example, machine vision is the use of computer vision in real-time while the computer vision is used to processing image. Computer vision is a field of computer science that operates in the same way as human vision, allowing computers to see, recognize and process images and provide sufficient performance and output. Vision is the most advanced sense of human and hence images have the most important impact to human perception. Human beings can interpret the world's three-dimensional structure with apparent ease, such as object shape and translucency and the strength of the lighting and shading can also be readily interpreted. Besides, the machine vision technology can also uses measure the dimension of object with considerably high precision against a complex context [3][4]. It can make the inspection system more beneficial over manual methods using machine vision. Machine vision systems automate inspection to provide high levels or performance as they enable quick, reliable, time-saving, and cost-effective solutions to work [5][6]. Machine vision is already being applied today in many different sectors such as manufacturing, medical, construction and other [7]. The table below illustrate the main criteria for machine vision.

Table 2.1: Criteria of machine vision system

Criteria	Parameter
Camera and sensor	Resolution and size
Test Object	Size geometric
Illumination	Intensity Color of light distance
Environment	Environment (day light, vibration fog)
Machine vision system	Software algorithm Speed interface

2.2 Image processing in machine vision

Images are subjected to image processing, which involves the application of mathematical functions to them. Three computerized process steps, which are the low-level, mid-level and high-level procedures, can be categorized into image processing. The two major sector that use the image processing technique are store and communication area for the auto inspection system. The input and output of image are belonging to the low level of image processing. It has included many functions such as smoothing, contrast, sharpening and noise reduces.

Next, mid-level image processing involves segmenting the image definition of an image to transform its shape into another type that can be interpreted and labeled by a computer. Basically, mid-level processing feeds the computer with images while generating attributes and image characteristics. Besides that, the high-level processing includes describing a set of known objects and executing cognitive functions that are typically associated with human vision. With the image processing technique, the information image can be converted to a digital data that easy to figure the different between images. The imaging equipment encompasses allowing them to work on images produced by sources that are not used by human beings, such as ultrasound, electron microscopy, and images

generated by computers. Therefore, digital image processing is very vital and uses in most of automotive industries. [5]. The Figure 2.1 below show the image processing process.

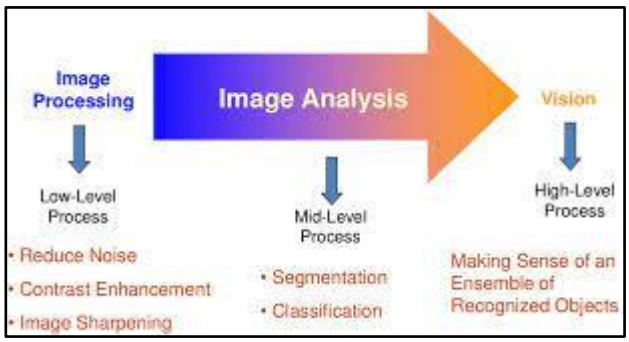

Figure 2.1: Image processing process.

2.3 Image acquisition techniques

The image acquisition techniques are to convert an image to a digital value that can read by computer. The main function image acquisition are segmentation and enhancement of image, and it can only apply to the image after the image has been acquired. To apply the image acquisition techniques, the use of camera is indispensable. The camera is used to capture the image [8]. The Figure 2.2 below shows the Simple arrangement for image acquisition.

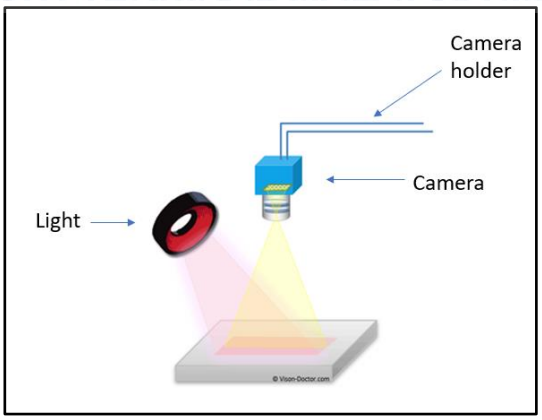

Figure 2.2: Simple arrangement for image acquisition.