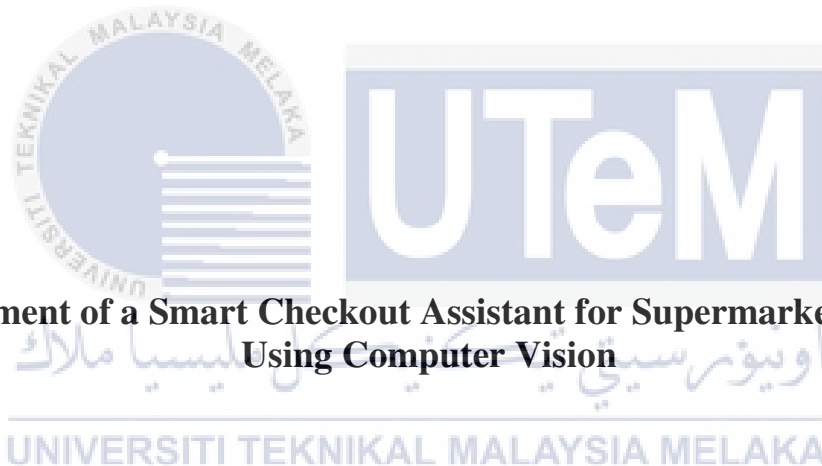




Faculty of Electrical and Electronic Engineering Technology



**Development of a Smart Checkout Assistant for Supermarket Products
Using Computer Vision**

NURIN QASHRINA BINTI HAZRAN

Bachelor of Computer Engineering Technology (Computer Systems) with Honours

2021

**Development of a Smart Checkout Assistant for Supermarket Products Using
Computer Vision**

NURIN QASHRINA BINTI HAZRAN

**A project report submitted
in partial fulfillment of the requirements for the degree of
Bachelor of Computer Engineering Technology (Computer Systems) with Honours**



Faculty of Electrical and Electronic Engineering Technology

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2021

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APPROVAL

I hereby declare that I have checked this project report and in my opinion, this project report is adequate in terms of scope and quality for the award of the degree of Bachelor of Computer Engineering Technology (Computer Systems) with Honours.

Signature :



Supervisor Name : TS. NUR ALISA BINTI ALI

Date : 11/1/2022

Signature :



Co-Supervisor :

Name (if any)

NADZRIE BIN MOHAMOOD

Date :

DEDICATION

To my beloved mother, FAIZA BINTI SHARIF, and father, HAZRAN BIN HASSAN,

My family,

To dearest My family

*(Fatin Dayana binti Hazran, Yasmin Irdina binti Hazran, Izz Rayyan bin Hazran, Su Aisya
binti Hazran*

To my supportive and caring supervisor

TS. NUR ALISA BINTI ALI

and

TS. SHAMSUL FAKHAR BIN ABD GANI



ABSTRACT

Self-checkout system is a great invention toward development of checkout service in supermarket. It is convenient approach toward improving a customer shopping experience. It is increasingly important now when the world needs to familiarize themselves toward contactless activity. However, most of the self-checkout system in Malaysia depend on barcodes, RFID tags and QR codes. This method requires a lot of procedure and time in maintain the quality of checkout and inventory process for supermarket. Hence this project proposed a development of a smart checkout system for Supermarket product that embedded with a single camera using computer vision. Computer vision is considered as a powerful field of artificial intelligent that allow a computer to analyse and interpret the visual world. There is a lot of technology that has implement a computer vision toward their invention which has contribute a lot to our society. Thus, computer vision will once again be implemented in this project. Furthermore, this project will be using a deep learning model to train the computer to detect object. Deep learning has proven to be an effective learning feature when training the computer toward working with computer vision task. For this project, the system able to achieve the accuracy of 0.891Ap and all the objects are successfully detected with the accuracy above 50%. The checkout system was able to compute a basic process of the checkout system which is to calculate the total price and display the product list of the checkout process.

ABSTRAK

Sistem kaunter pembayaran layan diri adalah penemuan hebat ke arah pengembangan perkhidmatan kaunter pembayaran di pasar raya. Ini adalah pendekatan yang mudah untuk meningkatkan pengalaman membeli pelanggan. Hal ini semakin penting sekarang apabila dunia perlu membiasakan diri dengan aktiviti tanpa sentuhan. Walau bagaimanapun, sebahagian besar sistem kaunter pembayaran layan diri di Malaysia bergantung pada kod bar, tag RFID dan kod QR. Kaedah ini memerlukan banyak prosedur dan masa dalam menjaga kualiti proses pembayaran dan inventori untuk pasar raya. Oleh itu, projek ini mencadangkan pengembangan sistem pembayaran pintar untuk produk Pasaraya yang disertakan dengan satu kamera menggunakan penglihatan komputer. Penglihatan komputer dianggap sebagai bidang kecerdasan buatan yang kuat yang membolehkan komputer menganalisis dan mentafsirkan dunia visual. Terdapat banyak teknologi yang menerapkan visi komputer terhadap penemuan mereka yang telah banyak memberi sumbangan kepada masyarakat kita. Oleh itu, visi komputer sekali lagi akan dilaksanakan dalam projek ini. Selanjutnya, projek ini akan menggunakan model pembelajaran mendalam untuk melatih komputer mengesan objek. Pembelajaran mendalam telah terbukti menjadi ciri pembelajaran yang berkesan ketika melatih komputer ke arah bekerja dengan tugas penglihatan komputer. Untuk project ini, sistem berjaya mencapai ketepatan 0.891AP dan berjaya mengesan kesemua object dengan ketepatan lebih daripada 50%. Sistem kaunter pembayaran boleh melakukan proses asas dalam sistem kaunter pembayaran. iaitu mengira jumlah harga pembelian dan memaparkan senarai produk hasil pembelian tersebut.

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LIST OF SYMBOLS



LIST OF ABBREVIATIONS

1. mAp	mean average precision
2. ms	millisecond
3. RFID	Radio Frequency Identification
4. QR	Quick Response
5. HOG	Histogram Orientated Gradient
6. CNN	Convolution Neutral Network
7. IBM	International Business Machines
8. ISCOS	Intelligent Self-Checkout System
9. AP	Average Precision
10. AR	Average Recall



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CHAPTER 1

INTRODUCTION

1.1 Project Background

Checkout system for supermarket and retail store has evolved over the years. Starting from barcodes system to RFID and then develop to QR codes system. This technology has contributed a lot on the development of checkout system. The method of these technology is almost the same in which the barcodes, RFID tags or QR codes was attached on the items to identify the product that is purchased. The purpose of this study is to conduct a project of the self-checkout system that is cashier-less. By implementing the computer vision into the system, it help to train the cashier-less checkout machine to detect and understand the object. The computer vision is a part of artificial intelligent that train the computer to understand the visual input.

To reduce the cost and time for attachment process, instead of attaching each item in the store with tag or barcode, the system could automatically identify whatever item that is put onto the conveyor belt of the checkout machine based on computer vision and deep learning implementation. It is then could automatically calculate the total price of the purchases including its discount and tax. Moreover, this project will be in demand now as the pandemic covid-19 hits the world. The world is required to familiarize with contactless activity as much as they can. Moreover, recently the cases related to clusters of covid-19 in Supermarket are increasing[26]. Thus, invention of smart cashier-less system in the supermarket would be one of the great and suitable approach toward prevention of covid-19 epidemic transmission.

1.2 Problem Statement

There are two type of behaviors that shopper possessed which are hedonist and utilitarian[2]. According to several studies that was conducted, it was found that there are a few factors that affecting the customer shopping experience. Franson highlight that shopper are reluctant to wait in the line for a payment [1]. Some of the factor stated by Jayasankaraprasad and Kumar are speedy check lines and effortless search of item could contribute to positive shoppers' experiences [1]. Moreover, Neilsen mention that shopper prefer to have self-checkout services [1]. Even with the existed self-checkout system that allows customer to scan the barcode of the items themselves has receive a good response among the customer, it is indirectly means that an owner of the Supermarket must take risks of mis-scanned item and theft. In 2005, there is an incident where a college student was suspected to switch the barcode of the cheaper item for an iPod [24]. Additionally, there other similar incident related to barcode and tags switching [25]. Indeed, it is importance for the customer to be able to finish their checkout a lot faster as they are usually busy. Moreover, self-checkout system a preferable approach among the customer in the Supermarket. However, with the invention of self-checkout system, a lot of problem has arise such as theft and dishonesty among the customers.

1.3 Project Objective

The objective are as follows: -

- I. To design a smart checkout assistant that can recognize and calculate the price for Supermarket products using computer vision

- II. To analyze the efficiency of the develop system and the time improvement it contributes as opposed to the standard barcode scanning cashier process.

1.4 Scope of Project

This project will detect each product that is put onto the conveyor belt of the checkout machines. The machines could detect multiple objects at a time however it must be far from each other. This project focused on one category of product which is fruit. The fruit was choose based on their shape that are different from one another. There are 4 type of fruit that would be recognize by the system and it will also save the descriptions and price of each products inside the database of the system. The product that will be recognize by the system are banana, apple, grapes, and lemon. The machines will be completed with conveyor belt that will be used to place the product. However, for the prototype, the product will only be display in front of the camera without conveyor belt. This project uses raspberry pi 4 with the size of 4 GB RAM and memory of 16GB SD card that could operate up to 98MB/s. This project also uses TensorFlow software to build program for system of this project.

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CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter discuss on the evaluation of machine learning algorithm from its early stage of its technology to the current algorithm used. It will also discuss about the advantages and limitation of each machine learning algorithm and the example of its implementation. This chapter will show a various type of image annotation and computer vision. From that, the suitable image or environment could be identified for each type of the image annotation method that should be used. Moreover, this chapter will elaborate more on the development of the existed self-checkout system and the implementation of the computer vision in its technology. It will also discuss on the change that has been made by that technology and its limitation.

2.2 Review on evolution of machine learning algorithm

Computer vision is a part of Artificial Intelligence (AI) that allow computer to extract an information and data from the digital image, video, or any kind of visual input. Thus, it is important to have machine learning algorithm to train a computer vision to observe and analyzed a visual input to obtain a meaningful information. A few tasks of computer vision are object localization, image classification and lastly, object detection which is the combination of those task. Machine learning algorithm had evolved over the years to match the needs and trend of technology that keeps developing every year.

2.2.1 Histogram of gradient oriented

In the year 2005, study by [3] Navneet. Dalal and Bill. Triggs design a new descriptor algorithm for pedestrian detection . After reviewing a several existing edge and gradient based descriptor, they found that distribution of local intensity gradient or edge direction can characterized the local object appearance and shape rather well even without exact knowledge of the corresponding gradient of edge position. In HOG algorithm, the input image is first presented in pixel. For one pixel, it will be compared with other pixel of their surrounding by their darkness. Then they will be computed it by replacing an arrow toward the darkest pixel. Thus, the process will be repeated until it forms a feature of an object. Figure 2.1 show the HOG descriptor process of extracting the information from an image. There are a lot of previous project that prove the effectiveness of HOG algorithm

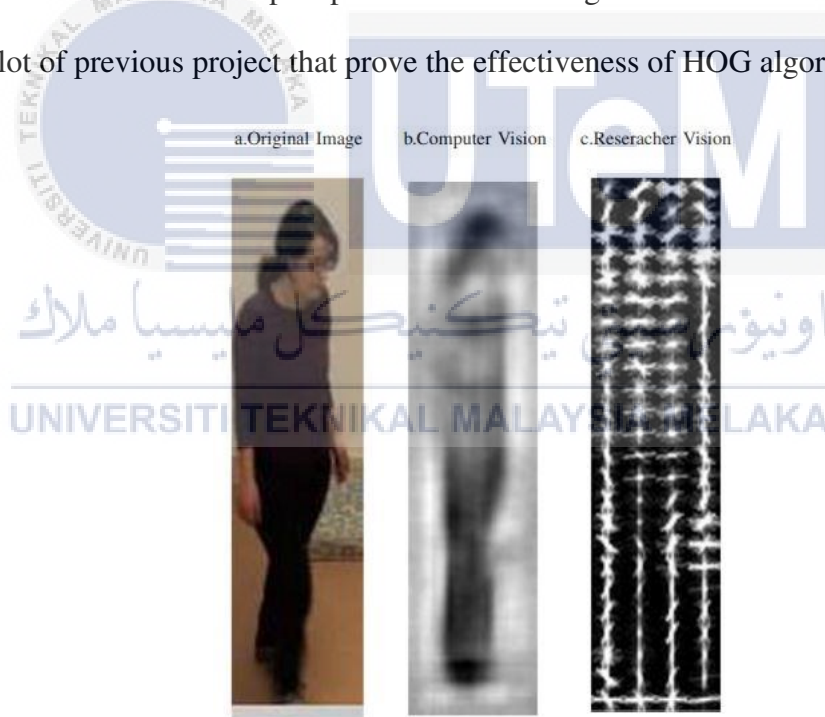


Figure 2.1 Example of Extraction process of HOG [4]

In the year 2003, a study was conducted for a system that will alert on falls movement of the elderly by detecting their body action and their faces [4]. HOG was used to allocate human in the video scene. The image is then divided into 16x16 block of 50 each block 2x2

cells. However, the system might fail to detect the failing person by a few conditions such as, condition where the person hide their face, or they fall in very begin of the video input. In the year 2015, HOG descriptor is also used to extract the vector of feature as an information for classification of the facial expression [5]. Noticed that there is limitation in term of accuracy to extract information. The accuracy for the system to detect emotion on person is depends on cell size which represent the dimension of patch the involve in histogram computational. Figure 2.2 shows the effect of HOG descriptor extraction process with different cell size (CS) of a process image. It can be seen that the smaller the size of the cell, the more different it from the original input. Thus it become hard to detect the facial expressions of the model.

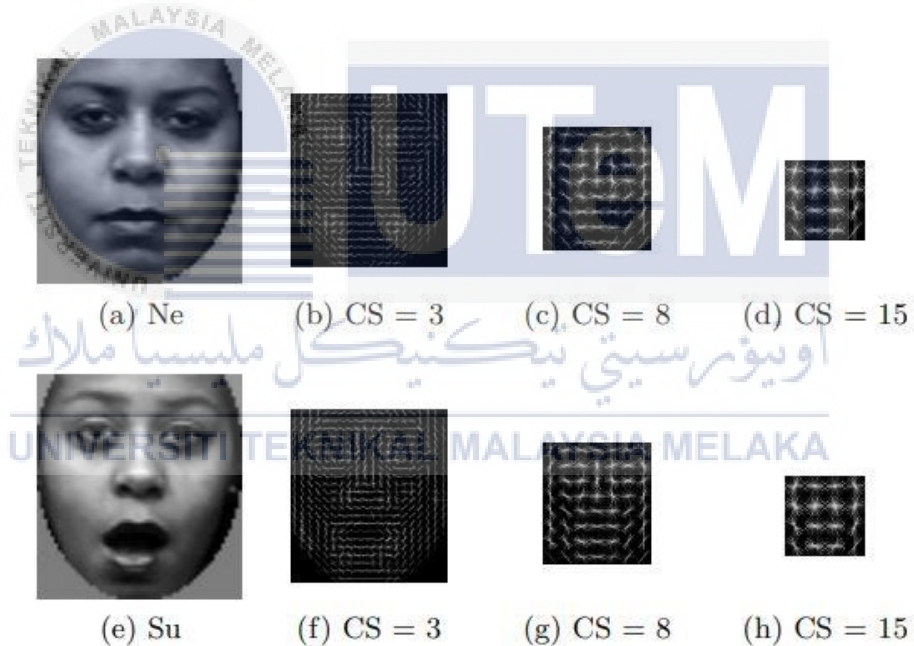


Figure 2.2 Example of sample expression that going through he HOG processing.[5]