SUPERVISOR ENDORSEMENT

I hereby declare that I have read through this report entitled "Development of Waste Segregator to Enhance Waste Classification based on Deep Learning Approach" and found that it has complied the partial fulfilment for awarding the degree of Bachelor of Mechatronics Engineering.

Signature : .....
Supervisor's Name : .....
Date : .....

DEVELOPMENT OF WASTE SEGREGATOR TO ENHANCE WASTE CLASSIFICATION BASED ON DEEP LEARNING APPROACH

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A report submitted in partial fulfilment of the requirements for the degree of Bachelor of Mechatronics Engineering

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DECLARATION

I declare that this report entitled “Development of Waste Segregator to Enhance Waste Classification based on Deep Learning Approach” is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in the candidature of any other degree.

Signature : .....

Name : .....

Date : .....

DEDICATION

To my beloved Family

ACKNOWLEDGEMENT

First of all, I am grateful to GOD for giving me the strength and health in completing this project. I also would like to express my gratitude to Pn. Nursabillilah Binti Mohd Ali my supervisor for final year project. Apart from being dedicated herself, she never fails to guide me through the entire project from the beginning until the end of the project. Although she is busy with her packed schedule, she always puts an additional effort to find a slot to review my progress and also guide on what to do next. I hereby thank her for all the knowledge and guidelines that she passed down to me.

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ABSTRACT

Malaysia is certainly one of the most successful nations in the changeover. The growth in industrialization and human population causes an increment in the solid waste materials. The intention of this research is to find an alternative way for waste disposal and develop a semi-automated recycling process. The common recycling method is manually picking and sorting the solid waste into categories, but due to the high cost to manage the waste generation and limited access to the recycling bin, deep learning based waste classification technique was proposed to solve this problem. The extent of this project is to use the depthwise separable convolutional neural network (MobileNets) for the plastic bottle and aluminium can classification. The system is also supported by Raspberry Pi and also python programming language. As a summary, the MobileNets based object detection is used to develop the waste segregator and able to achieve about 90% rate of success of waste detection. Aluminium can have a higher detection accuracy compare to the plastic bottle due to the transparency and also light reflectivity. The detection and segregation able to work as standalone but the aim to make fully automated is still not achieved.

ABSTRAK

Malaysia sememangnya merupakan salah satu negara yang paling berjaya dalam perubahan. Pertumbuhan perindustrian dan populasi manusia menyebabkan kenaikan dalam bahan buangan pepejal. Tujuan penyelidikan ini adalah untuk mencari satu cara alternatif untuk pembuangan sisa dan membangunkan proses kitar semula separa automatik. Kaedah kitar semula biasa adalah dengan memetik dan mengasingkan sisa pepejal ke dalam kategori, tetapi kerana kos yang tinggi untuk menguruskan sisa buangan dan akses terhad kepada tong kitar semula, teknik klasifikasi sisa berasaskan "deep learning" telah dicadangkan untuk menyelesaikan masalah ini. Idea projek ini adalah menggunakan "depthwise separable convolutional neural network" (MobileNets) untuk mengklasification botol plastik dan tin aluminium. Sistem ini juga disokong oleh "Raspberry Pi" dan juga bahasa pengaturcaraan "python". Sebagai ringkasan, pengesanan objek berasaskan MobileNets digunakan untuk membangunkan segregator sisa dan dapat mencapai kadar kejayaan pengesanan sisa sebanyak 90%. Tin aluminium mencatat peratusan pengesanan yang tinggi berbanding dengan botol plastik ini disebabkan oleh ketelusan dan pemantulan cahaya.Pengesanan dan pemisahan dapat befungsi secara mandiri tetapi, matlamat untuk pemisahan automatik sepenuhnya masih belum tercapai.

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CHAPTER 1

INTRODUCTION

1.1 Motivation

Municipal solid waste management (MSW) become splendid obstacles when setting up for advancement throughout the universe, specifically in rapidly developing towns. Solid waste can be any discarded or abandoned materials. It can be categorized into solid, semi-solid, liquid or gaseous materials. As per a report from World Bank's Urban Development division estimates that quantity of the solid waste materials will have bullish from 1300 million tonnes per year to 2200 million tonnes per year by 2025 [1].

Malaysia is certainly one of the most successful nations in the changeover. Steady political circumstances and lots of assets ensuring good economic development and low unemployment rates thus, making it on par with a developed country [2]. The Multi-cultural nation is experiencing fast industrialization and urbanization offering an undesirable effect to the surrounding from the raising of waste materials [3]. Due to the industrialization excessive items are being manufactured and the majority of the people have a tendency to replace the items rather than restoring it. Therefore increasing the waste generated. In statistic based on Utusan Online, there are around 37000 tonnes of waste is being produced in one day, averagely 13.5 million tonnes per year. Table 1.1 below indicates the composition of waste in Malaysia for the year 1975 to 2005.

Table 1.1: Waste composition in Malaysia (% wet weight) [4]

Waste composition	1975	1980	1985	1990	1995	2000	2005
Organic	63.7	54.4	48.3	48.4	45.7	43.2	44.8
Paper	7	8	23.6	8.9	9	23.7	16
Plastic	2.5	0.4	9.4	3	3.9	11.2	15
Glass	2.5	0.4	4	3	3.9	3.2	3
Metal	6.4	2.2	5.9	4.6	5.1	4.2	3.3
Textiles	1.3	2.2	NA	NA	2.1	1.5	2.8
Wood	6.5	1.8	NA	NA	NA	0.7	6.7
Others	0.9	0.3	8.8	32.1	4.3	12.3	8.4

In the state of Malacca itself, each resident generates about 250kg of waste per year. The population of this state is around 872,900, it means that 218225 tonnes of waste are thrown per year [5]. Table 1.2 below displays the waste treatment procedure practised in Malaysia.

Table 1.2: Waste treatment methods practised in Malaysia [4]

Treatment Method	2002	2006	2020 (target)
Recycling	5 %	5.5 %	22 %
Composting	0 %	1 %	8 %
Incineration	0 %	0 %	16.8 %
Inert landfill	0 %	3.2 %	9.1 %
Sanitary landfill	5 %	30.9 %	44.1 %
Other sites of disposal	90 %	59.4 %	0 %
Total	100 %	100 %	100 %

The another cause of waste generator is the city population which constitutes more than 65% of the overall population [4], in 1980, Malaysia populace was 13 million, increased tremendously to 17 million in 1991, 22 million in 2000 , 27 million in 2010 [6] and predicted 2017 populations are 32 million [7].

As the population of the country increases, the waste generated per year also increases. The figure 1.1 below shows the recycling rate for each country for the entire year of 2015, from that people, can know that Malaysia only have 17.5% recycling rate and in fact, it is considered to be very low. Another that we can see from that is our neighbourhood country Singapore, even smaller than Malaysia but still able to achieve 59% of recycling rate [8].

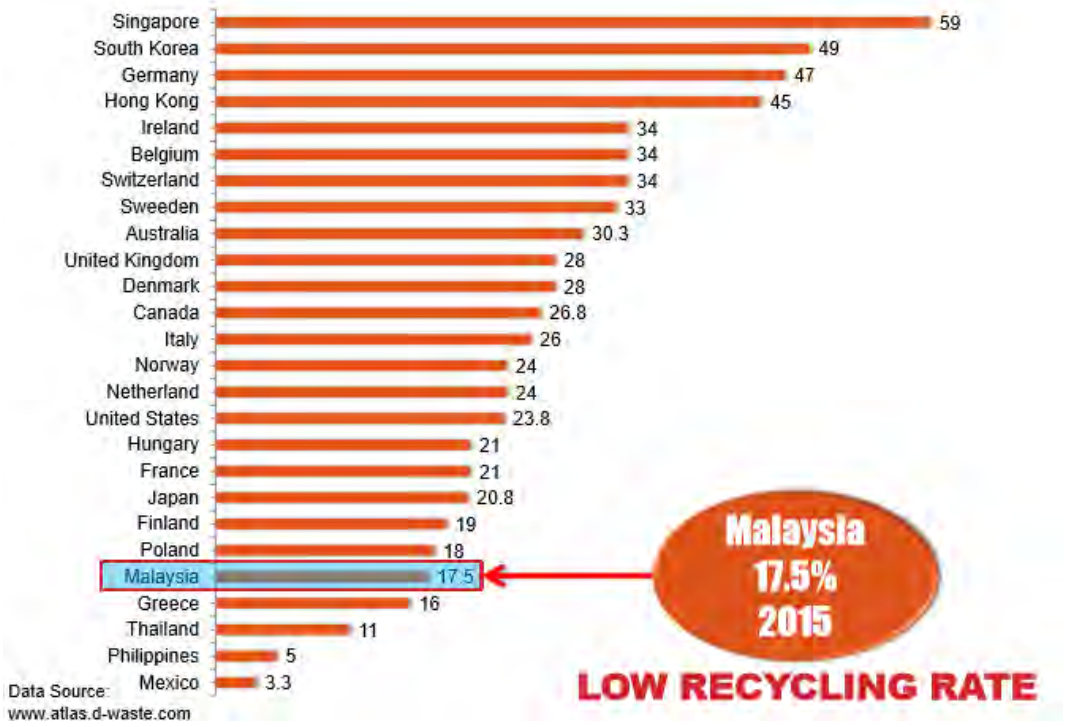

Figure 1.1: Recycle Rate for countries [8]

Solid waste and public cleansing management believe that effective and efficient way fairly vital to ensure the high-quality lifestyle environment to stay clean, secure, and healthful. Regarding National Strategic Planning for solid waste Management Plan (2005), it had been highlighted that solid waste management is certainly founded on solid hierarchy as shown in figure 1.2. This hierarchy contains some of a few components that are essential [9].

Figure 1.2: Hierarchy of solid waste management [9]

Efficient sorting of waste is a major issue in today society. Selective sorting is another approach, which is often implemented to improve recycling and reduce the environment [10]. When the waste is segregated into simple stream such as plastic bottles, metal cans it becomes easier to recycle and reuse. All of these are the proof shows that why need an alternative method to reduce the waste and increase the recycling rate. The "Development of Waste Segregator to Enhance Waste Classification based on Deep Learning Approach" might be one of the suitable systems to be used.

1.2 Problem Statement

Malaysia is very famous for the multi-ethnic festival celebration. When coming to any festivals, or celebration the soft drink becoming a compulsory drink. Not only during festival time, during sports also. For examples is energy drink such as 100plus, Revive and others. The soft drinks mostly manufactured and packed in aluminium cans, plastic bottle. A huge amount of waste is created if the used plastic bottle and cans are not disposed of using proper waste management.

The common approach of waste disposal is by unplanned and uncontrolled open dumping at the landfill sites. This technique is definitely injurious to living organisms such as humans, animal, and plants. This harmful approach of waste disposal can generate liquid leachate which contaminates surface and ground waters; can harbour disease vectors which separate harmful disease; can degrade the aesthetic value of the natural environment and it is an unavailing use of land resources [11].

When wants to throw a trash, basically there are 2 problems. First one is the unavailability of the specific bin for the trash, and the second one needs to identify the type of the waste and put in each bin manually. Some places like universities, downtowns, subways, and malls have a different container for specific kind of a waste. Figure 1.3 below specify the recycling bins in Malaysia. The blue colour bin is used for the paper. The brown colour is used for the glass and the orange colour is used for aluminium, steel, and plastic [9]. But in most of the places, there only providing with one kind of bins and all the thrash being stuff inside it. Unfortunately, if even there are specific bin provided, there are some people who do not place waste incorrect bin [12]. Figure 1.4 proves the misuse of the recycling container.

Figure 1.3: Recycling bins in Malaysia [9]

Figure 1.4: Improper use of recycling cage [13]

In order to overcome the recycling problem, the initiative has been taken to implement a pre-trained convolutional neural network to replace the human brain to classify the waste and Raspberry Pi with Pi camera and with a set of the servo motor to segregate the waste automatically. The neural network will be trained with the custom dataset. The image of the waste will be captured and stored in a database. Then the database will be used to train the neural network.

1.3 Objective

The project will embark on the following objective:

1. To design a waste separation mechanism for non-deformed objects.
2. To classify plastic bottle and aluminium can using deep learning method.
3. To analyze the total loss during training process, detection accuracy and determine the reliable distance for the detection.

1.4 Scope and Limitations

Based on the process of designation and the consideration of limited time the scope of the project is limited as:

The system will work on a depthwise separable convolutional neural network (MobileNets) to identify regular shapes bottles and cans. The system emphasizes on unbent 500ml F&N Season brand plastic bottle and 100plus bottle, 325ml and 300ml aluminium cans. Only 4 plastic bottles and 4 aluminium cans are used to do the analysis. Image of the waste object is captured and used for the detection. Black background is used throughout the whole project. The limitation of the project is the performance of the actual test will be affected by the intensity and reflectivity of the light. The classification and segregation of the waste is done one at a time. Area of application is limited to indoor area use such as small shops, restaurants, and malls.

CHAPTER 2

LITERATURE REVIEW

2.1 Theoretical Background

The chapter will explain the studies that have been conducted about the "waste segregation method". The studies start with the method used, the controller used, and the waste transmission method and suggested a place where the project will be implemented. There have been a lot of studies carried out in order to make the segregation as an automated process. This chapter will show all the previous study and comparison of the methods that related to the waste segregation. This chapter also will contain some explanation of machine learning and deep learning and comparison of the deep learning framework.

2.2 Literature review of the previous study

2.2.1 PLC based automatic waste segregator

The researcher makes use the inductive sensor, photoelectric sensor, and a capacitive proximity sensor to identify the metal, plastic, glass/paper waste and Programmable Logic Controller (PLC) together with the mechanical actuator is used to segregate the waste accordingly [10]. A circuit interfacing used to connect between PLC and sensors. Sensor interfacing is performed to convert the analog transmission result from sensors into digital transmission before feeding into the controller. The PLC allows the separation to occur at the time of choice based on the sensors and coding embedded within it. The conveyor belt is used to transport the waste materials while 4 hydraulic cylinders are utilized as the mechanical flap.

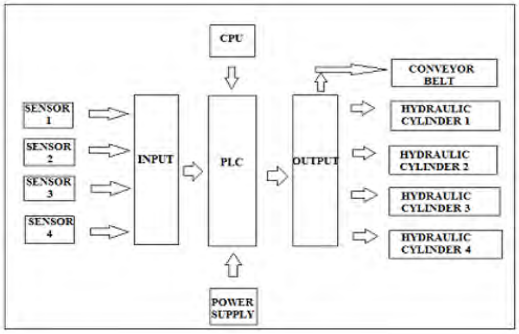

Figure 2.1: Block diagram of the AWS [10]

The system mainly concentrating on replacing the existing manual solid waste segregation as to decrease the waste that getting dumped as landfill. This reduces the manpower, period for the segregation. The usage of the hydraulic cylinder can be very expensive as the need to set up a small hydraulic system to power up the cylinder. Only 1 waste is being separated at the same time and also the limited option of I/O pin in the PLC cause issues in upgrading the task for future endorsement.