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# Development of Segregated Recycle Waste System

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**Abstract**: Waste recycling issues have been a common topic in recent decades. A dramatic waste stockpile is a concern due to its bad impact on the environment. This project aims to design a recycle bin that could identify and differentiate recyclable waste, there are aluminium can and plastic, split them into the respective trash bin, detect the trash level and transfer the real-time data to an online cloud. A recycling system with four sub-systems, entry system, detection system, segregation system with IoT feature was successfully created in this study. The entry system works to activate the three other sub-systems once trash placed into the system. Results suggest that the detection system works as expected to identify, differentiate and segregate different type of waste. It is concluded that the segregated system works well for recycling waste and it is anticipated that it could contribute towards an improved waste management system.

**Keywords**: Waste Segregation, Recycled Waste, Recycle Bin

## 1. Introduction

Until 2019, there is a lack of a specific recycle system in Malaysia although two official recycling programs had been launched by the Malaysian government. Several companies of major producers of recyclable materials were engaged by MHLG in the second recycling program. The recycling rate in Malaysia risen and reached 28% in 2019 but still unable to fulfill the demand of local companies on raw materials [1] – [3]. Currently, there are 14 sanitary landfills, 161 operated landfills and 141 abandoned landfills in Malaysia. Malaysia government has provided incentives in the form of investment tax allowance to purchase green technology assets and income tax exemption for green technology services to promote green technology to the society [4].

Recycle waste segregation system is composed of two separate mechanisms, detection system and segregation system. The detection system has sensors to sense and determine the type of recyclable wastes, whereas the segregation system, a microcontroller will open the dedicated bins according to the type of waste. There are a number of waste segregation systems reported that was able to segregate dry, wet and metal waste [5] – [8]. In general, the waste segregation has three separate mechanisms, which are entry and initialization, detection and segregation. The recent development of segregation systems features the capability of Internet of Things (IoT) to support efficient waste management [9] – [12]. On

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top of sorting waste into few categories such as dry, wet and plastic waste, those systems were able to collect important data to be analysed for systematic waste management.

## 2. Methodology

This section will present the methodology used to develop the proposed waste segregation system. The first subsection presents the overall block diagram of the system, followed by the flow chart of the process mechanism and finally the details of each mechanism.

### 2.1 Block diagram

The recycling system is formed by four parts from the entry system to the detection system, segregation system and IoT system. Initially, if waste is thrown into the bins, the sensor in the entry system will detect the waste and activate the onward system by a microcontroller. In the detection system, type of waste will be identified whether it is aluminium, plastic bottle and others. Finally, the segregation system sorts each waste into respective bins. The fullness of the bins is monitored and the level of waste in the bin will be uploaded to the Internet through the IoT system. Cleaner or waste collector can check the level of waste occupied from time to time and come to empty the bins when it is full. Figure 1 shows the block diagram for the whole recycling system.

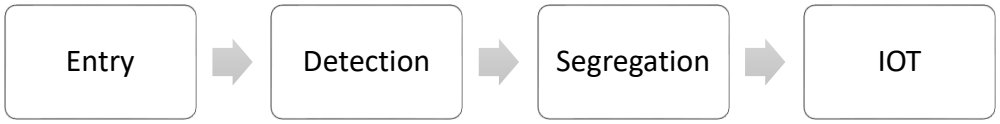



**Figure 1: Block diagram of the proposed system**

### 2.2 Flow chart

The flow of the recycling system is shown in Figure 2. The process starts by detecting the waste being put into the system. Then, the trash will be identified by a set of sensors to determine whether the waste is either aluminium or plastic. Once, identified, the aluminium and plastic waste are then directed into the specific bins accordingly. Recyclable waste other than both aluminium and plastic will be directed into a single bin. On top of that, the system has the capability to monitor the waste level in each bin in real-time for smart waste management purposes.

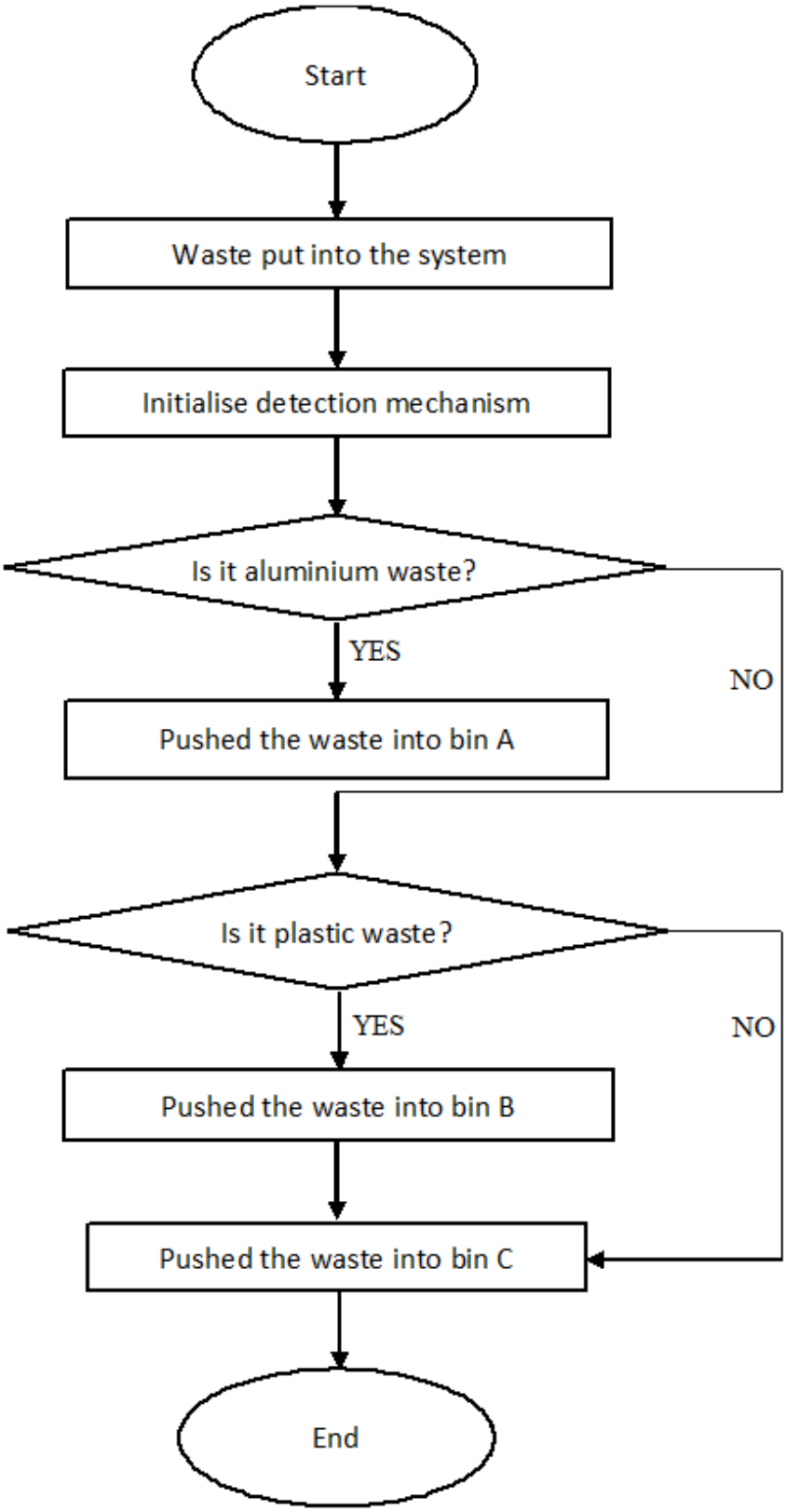



**Figure 2: Flow chart of the waste segregation**

## 2.3 Segregation mechanisms

### 2.3.1 Entry mechanism

The first mechanism is the entry, which is to sense if any trash being put into the system. Once the trash is put into the system, it will be detected by an infrared (IR) sensor and a signal will be sent to the microcontroller (Arduino Mega 2560). The signal received by the microcontroller will initiate the detection and segregation system. The working principle of waste detection is as follows; firstly, when IR ray is transmitted and none is received, the sensor considers there are no waste presents. Second, when IR ray is transmitted and fully reflected and received, then the sensor noted that waste presents. Figure 3 shows the principle of operation for the IR obstacle detection sensor.

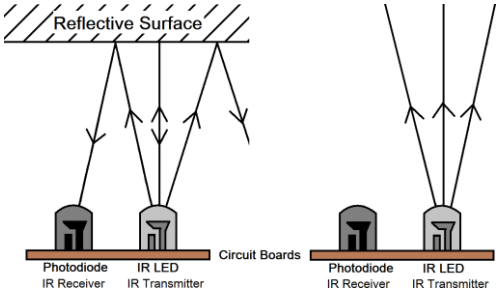
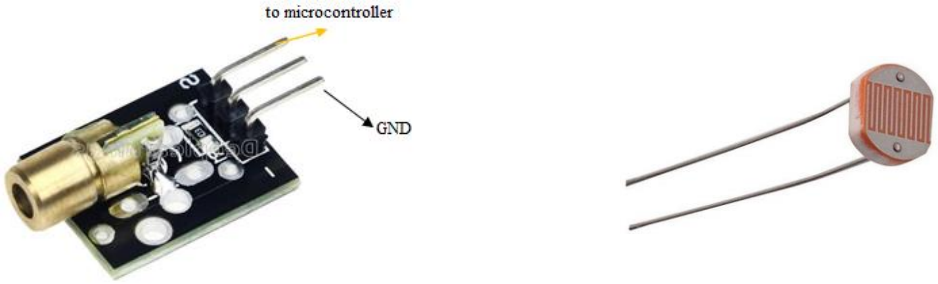



**Figure 3: Principle of operation of IR sensor**

### 2.3.2 Detection mechanism

In this mechanism, the type of waste put into the system will be identified In this system, there are two types of waste that will be detected; aluminium can and plastic bottle. The identification process is done by several components, which are inductive proximity sensor, laser transmitter module and photoresistor. An inductive proximity sensor (LJ12A3-4-Z/BX) is used to detect aluminium waste. The proximity sensor is a normally open NPN transistor with an operating voltage of 6 V. This sensor is able to detect the aluminium waste in the range of 4mm.

A combination of laser transmitter (KY-008) and photoresistor is used in plastic waste detection. The laser transmitter module is operating at 5 V and producing 650 nm red laser with an output power of 5 mW. The photoresistor is a device that producing current whenever being exposed to light and the current intensity is in proportional to the strength of the impinged light. To identify the plastic waste, the laser module will emit a focused beam of red light on the waste and the light pass through the trash will be detected by a photoresistor. Figure 4(a) and Figure 4(b) show the laser module and photoresistor, respectively.




(a) (b)

**Figure 4: (a) Laser transmitter module (b) photoresistor**

2.3.3 Segregation mechanism

In segregation mechanism, the microcontroller is used to control the servo motor rotation to a certain degree to open the bin lid. An opening lid will create a space for the waste to slide into the respective bin. In this system, the aluminium waste will be directed to Bin A whereas the plastic waste will go to Bin B. Servo motor is used since it has high power density with flatter torque at high speed and smooth operation at low speed. Figure 5 shows the connection of the servo motor with the microcontroller.

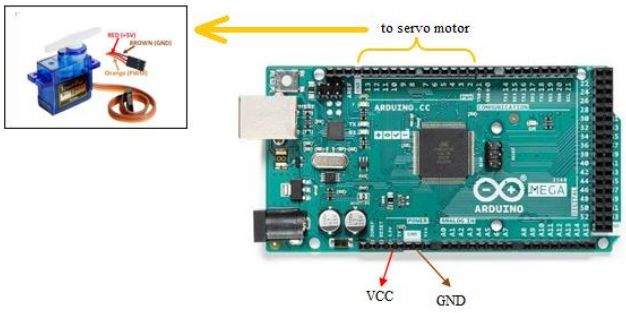



**Figure 5: Connection between microcontroller and servo motor**

2.3.4 Waste-level detection mechanism

An ultrasonic sensor is used to sense the level of waste in a bin and this the data will be sent to the microcontroller (ESP 32). The ultrasonic sensor works by sending out transmitting and receiving sound wave with the aid of the transducer. Once the microcontroller received the signal of waste level from the ultrasonic sensor, the microcontroller will transfer this data to the data cloud (Firebase). The data cloud is used to store the data stream of waste level for data analysis for waste management.

## 3. Results and Discussion

3.1 Physical system

Figure 6 shows the schematic diagram of the segregation system and Figure 7 shows the physical system built on a breadboard.

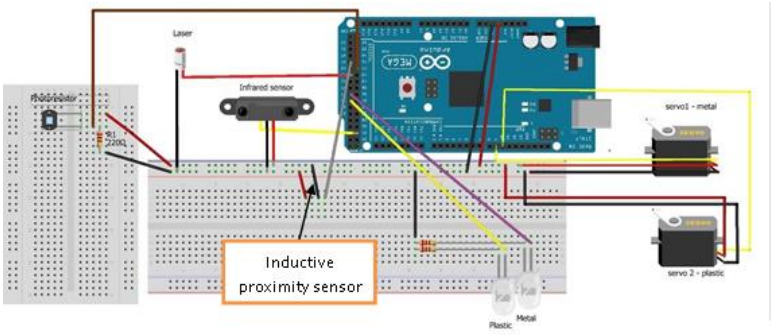



**Figure 6: Schematic diagram of system**

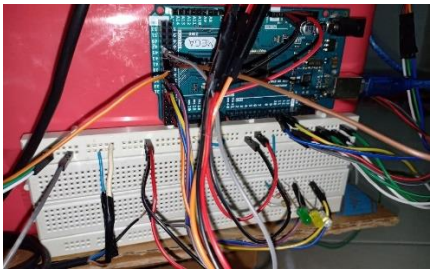
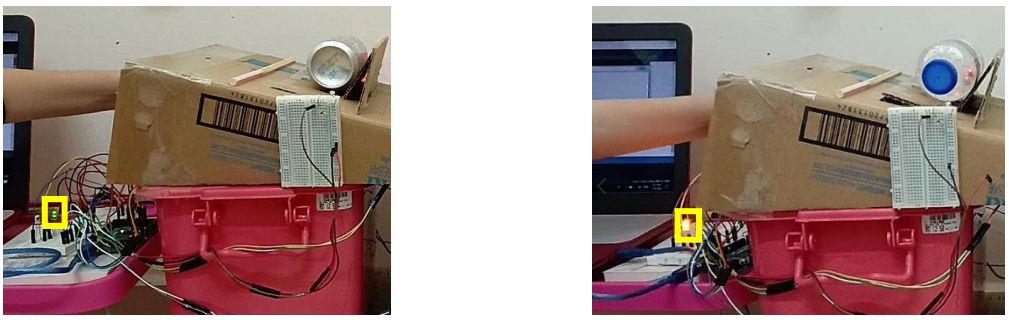


**Figure 7: Physical circuit of the system**

## 3.2 Results and Discussion

### 3.2.1 Waste detection

There were two cases from the detection mechanism. First, when an aluminium waste was detected, the green LED was light up as shown in Figure 8(a). Second, when a plastic waste was detected, the orange LED was light up as illustrated in Figure 8(b).



(a) (b)

**Figure 8: (a) Detection of aluminium waste (b) detection of plastic waste**

### 3.3.2 Waste segregation

The segregation mechanism has structures of ‘gate’ and ‘opener’ in the physical system as shown in Figure 9. In the first case, when an aluminium can present, it was supposed to be detected as aluminium waste and directed into Bin A. Once it was detected, servo motor 1 will rotate anticlockwise for 3 seconds to push the opener downward and at the same time, servo motor 2 will also rotate anticlockwise for 3 seconds to loosen the gate so it can be pushed downward by the opener. After the aluminium can have slid into Bin A, both motors returned to their original state for the next segregation process. Figure 10(a) – 10(c) shows the segregation process of aluminium can in the system.

In the second case, when a plastic bottle was load in the system, it was supposed to be detected as plastic waste and segregated into Bin B. In this case, the plastic bottle reached opener for Bin A first. Here, servo motor 1 rotated clockwise for 3 seconds to loosen the opener and servo motor 2 rotated clockwise for 3 seconds to tighten the gate to push the plastic bottle into the second opener. Both servo motors then return to their original position. Next, once the plastic bottle reached opener 2, the opener 2 were opened when servo motor 2 rotates anticlockwise for 3 seconds. Once the plastic bottle drops into Bin B, both servo motors return to their original position. Figure 11(a) – 11(e) shows the segregation process of the plastic bottle in the recycle system.


**Figure 9: 'Gate' and 'opener' structures on physical segregation mechanism**

(a)

(b)

(c)

**Figure 10: (a) Opener 1was lifted (b) opener 1 pushing aluminium waste (c) aluminium waste completely went into Bin A**

(a)

(b)

(c)

(d)

(e)

**Figure 11: (a) Plastic waste reached gate 1 (b) plastic waste pushed towards opener 2 (c) plastic waste reached gate 2 (d) opener pushing plastic waste (e) plastic waste completely went into Bin B**

### 3.3.2 Waste-level detection

The final part of this segregation system is the detection of waste level in each bin. As illustrated in Figure 12(a) – 12(d), those are the examples of four different scenarios of waste level in both bin A and B.

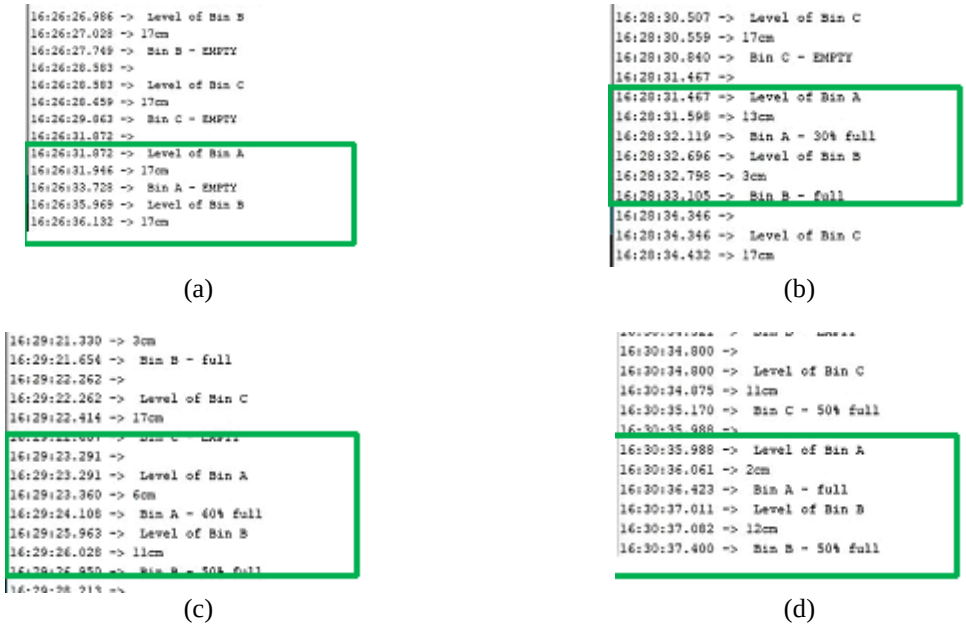



**Figure 12: Four different scenarios of waste level in each bin**

## 4. Conclusion

Overall, the proposed segregated waste system was able to identify, differentiate and segregate two types of waste, which are aluminium and plastic, automatically. However, there are limitations in the segregation process such as large detection area required for plastic waste. Besides, the segregated system also able to detect the waste level in the bin and store those data onto an online cloud.

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