Chapter 4
Development of an Automated Segregator for Solid Waste

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4.1 Introduction

According to the Solid Waste Management and Public Cleansing Corporation (SWCorp), Malaysians generated a whopping of 38,142 tonnes of waste per day, an increase from 19,000 tonnes of waste a day in 2005 [1]. Malaysia's population in 2020 is estimated at 32.7 million as compared to 32.5 million in 2019 with an annual growth rate of 0.4%. The decline of population growth rate is attributed to the decrease in the number of non-citizens from 3.1 million (2019) to 3.0 million (2020). This is in line with the closure of our national borders and the return of foreigners to their respective countries during the Movement Control Order following the spread of the COVID-19 pandemic worldwide. The growth rate of citizens remained stable at 1.1% with the population increasing from 29.4 million in 2019 to 29.7 million in 2020 [2].

In general, recycling is the method by which materials are gathered and recycled or otherwise be thrown away as waste and converted into new items. Recycling will help the environment and your neighborhood [3]. The recycling policy of Malaysia helps conserve valuable natural resources as it can save the biodiversity and the climate. Moreover, Malaysia recycle effort also generates jobs opportunities. It is a comparatively economical waste management process for urban areas because the process of recycling produces more jobs compared to landfills or incinerators. As

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landfills grow, there is not much space left in Malaysia's urban regions and the capital unless everyone has a minor landfill in their back yard. It also reduces the amount of solid waste that goes into landfills [4].

Based on previous work done by other researchers, this project proposes an automated segregator for solid waste powered by an Arduino microcontroller. The aim of this project is to automatically sort recycled waste into four separate compartments. The waste is sorted based on the type of material being detected. Thus, the consumer does not need to decide which bin is correct for the recycling waste. The recycling bin will focus exclusively on four different common materials that the students throw away, papers, aluminum cans, plastic bottles and glass. In addition, material sorting depends on the type of material detected by the sensors, where the metal detector sensor is used to detect cans of metal, the force sensor for glass weight detection, the LDR sensor for calculating the light intensity that is penetrated through plastic. If none of the sensors detects something, that material is classified as paper.

4.2 Methodology

Figure 4.1 shows the flowchart of waste classification through each sensor. The process flow of the system starts when the user puts the waste inside the bin. After that, the sensor detects continuously the waste, if the metal sensor senses the waste is metal, the bin will rotate and drop the waste inside the metal container and close the lids. For glass, it will be sensed by using the force sensor. The force sensor senses the weight of the waste either it is heavy or light. The bin will rotate to the glass container if the force sensor senses a heavy object and closes the lid. To verity that waste is paper, the LDR sensor is used. If the waste cannot be detected by sensors, the system declares the waste as paper.

4.3 Results and Discussion

4.3.1 Electronic Circuit Design

This part shows two electronic circuits that have been install on the prototype, which is the Arduino Mega circuit and the NodeMCU circuit.

Figure 4.2 show the schematic circuit for the process. It contains three sensors, which are the force sensor, metal sensor and LDR sensor. Other than that, there were three actuators which act as the servo motor. Besides that, two indicators where installed in the system.

Figure 4.3 shows the connection for the NodeMCU Esp8266, where there are four ultrasonic sensors connected to the NodeMCU. This system will be monitored by the Blynk application.

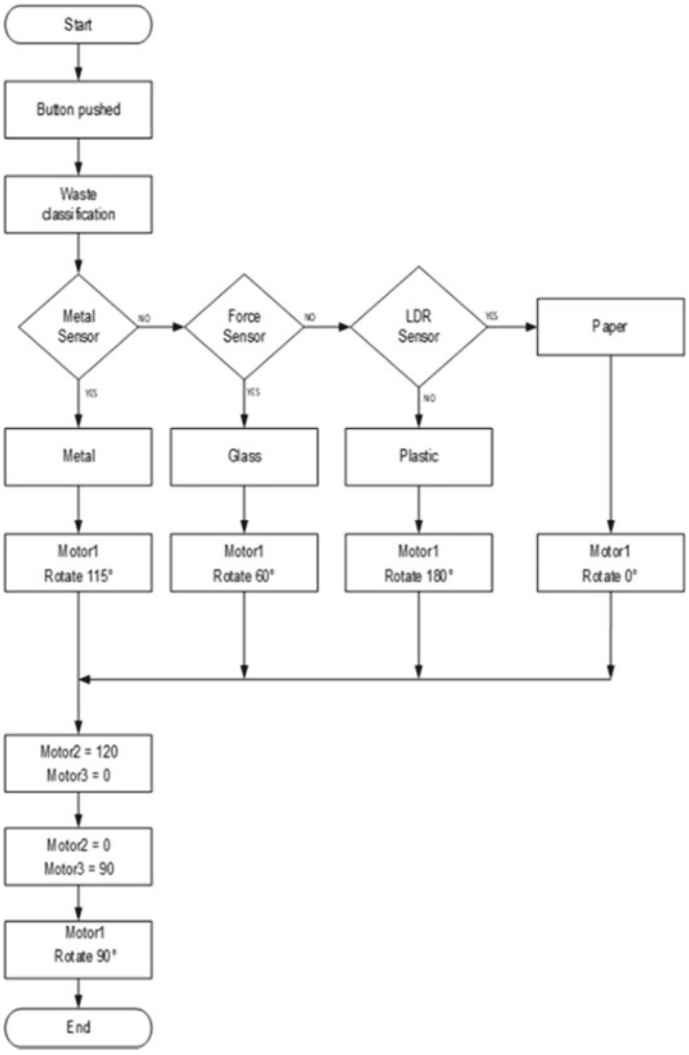

Fig. 4.1 Process flowchart

4.3.2 Sensor Behavior

This part shows the sensor behavior when it detects materials. There will be three sensors tested in this section which are the force sensor, metal sensor and LDR sensor.

Figure 4.4 shows the reading that has been taken by the force sensor for 8 s. The reading changes when there is a force applied on it, by using a glass bottle it creates some force from the weight of it.

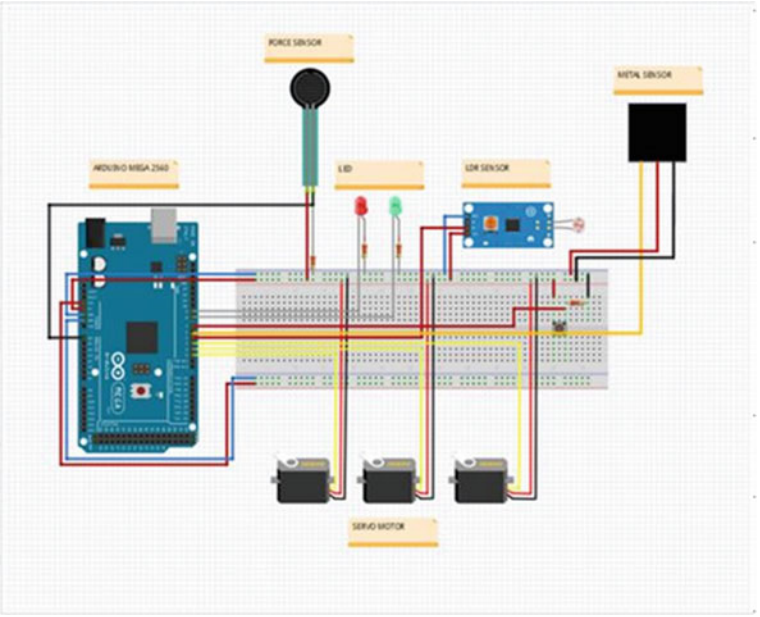

Fig. 4.2 Arduino Mega circuit

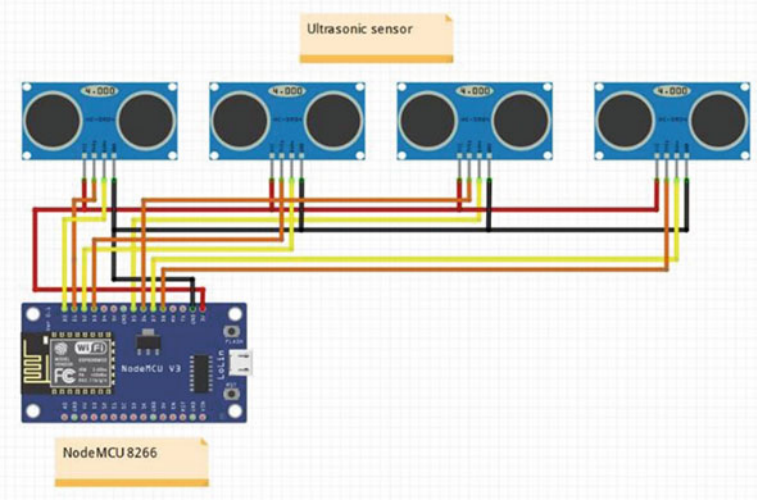

Fig. 4.3 NodeMCU Esp8266 circuit

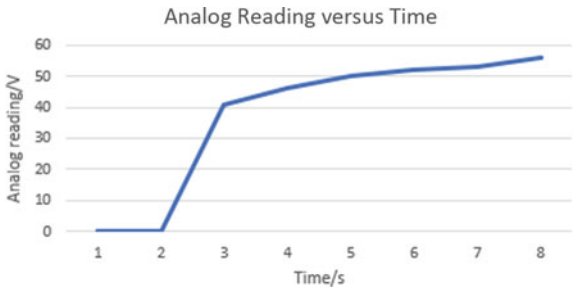

Fig. 4.4 Force sensor reading

Figure 4.5 shows the metal sensor reading that occurs when there is metal type or conductive material. The fundamental principle is that the sensor will create an electromagnetic field around the object. The sensing range is 5 mm for this sensor. The digital value will be 0 if the sensor detects metal. Table 4.1 shows the conversion of digital output to voltage.

Figures 4.6 and 4.7 show two different types of materials used to test the LDR sensor. For Fig. 4.6 the sensor detects paper, the voltage turns to 0 when it detects the paper. Figure 4.7 shows that the sensor detects a plastic material. This happens because the LDR sensor detects the light intensity. The difference between these two types of material is that plastic is transparent and light can go through it, but paper

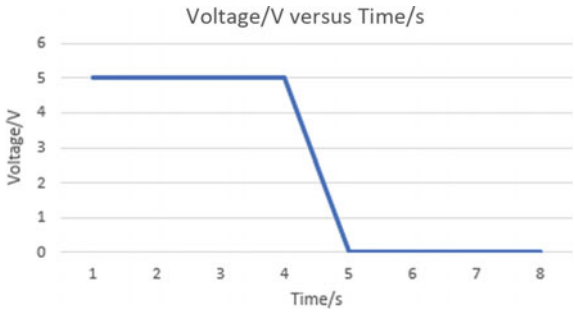

Fig. 4.5 Metal sensor reading

Table 4.1 Conversion of digital output to voltage for the metal sensor

Time/s	Digital output	Voltage/V
1	1	5
2	1	5
3	1	5
4	1	5
5	0	0
6	0	0
7	0	0
8	0	0

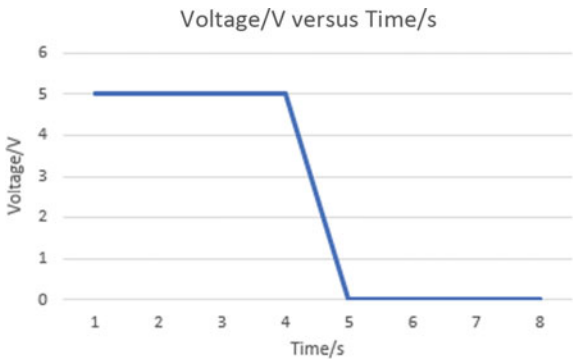

Fig. 4.6 Paper detection by LDR sensor

is an opaque type, so the light is hard to go through. Tables 4.2 and 4.3 show the conversion of digital output to voltage for the LDR sensor.

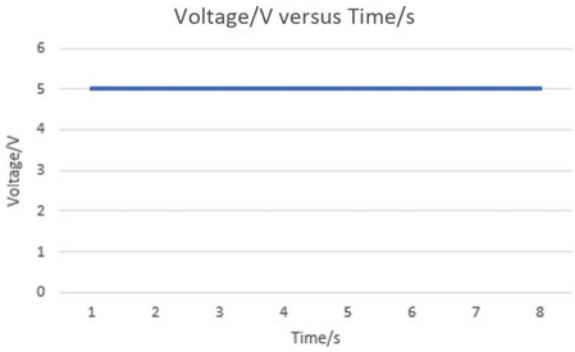

Fig. 4.7 Plastic detection by LDR sensor

Table 4.2 Conversion of digital output to voltage for the LDR sensor in case of paper

Time/s	Digital output	Voltage/V
1	1	5
2	1	5
3	1	5
4	1	5
5	0	0
6	0	0
7	0	0
8	0	0

Table 4.3 Conversion of digital output to voltage for the LDR sensor in case of plastic

Time/s	Digital output	Voltage/V
1	1	5
2	1	5
3	1	5
4	1	5
5	1	5
6	1	5
7	1	5
8	1	5

4.3.3 Monitoring System

This part shows the monitoring system that has been applied by using the Blynk app to monitor the level of the material inside the dustbin.

Figure 4.8 shows the Blynk app for the dustbin monitor. Each of the bins has an ultrasonic sensor installed for measuring the height of the material inside the dustbin. Figure 4.9 also shows the notification that will be sent to our phone if the dustbin is full.

Fig. 4.8 Blynk apps

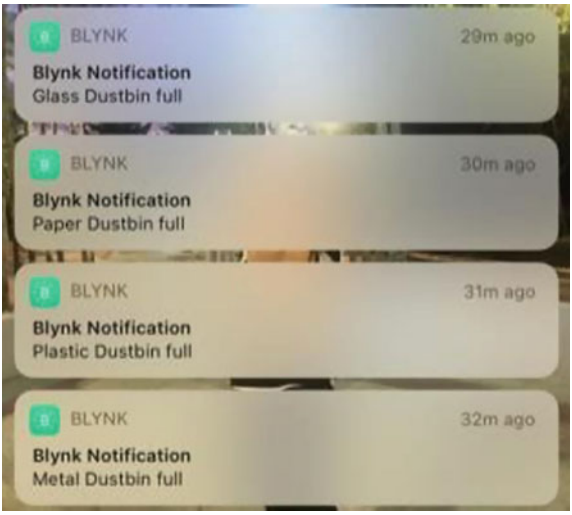

Fig. 4.9 Blynk notification

Table 4.4 Error for classification

Type of solid waste	Success	Fail
Metal	5	0
Plastic	4	1
Paper	4	1
Glass	3	2

4.3.4 Error for Classification

There are several tests that have been done to test the sensor sensibility for each material. For metal there is no error since the sensor will detect the presence of the metal. For plastic and paper there will be a slight error happening because there is a disturbance that may occur. The disturbance from the surrounding light will affect the measurement of the LDR sensor. Finally, the glass has some error happening because of the sensor itself.

The sensor will detect the force if the glass is placed at the correct position. From Table 4.4, it can be concluded among the four types of waste, metal could be automatic segregated and followed by paper and plastic but with a small error.

4.3.5 Discussion

Based on the data collected from the project outcome, the development of an automated segregator for solid waste can be summarized as a well functioning project. The classification of the solid waste based on their type was functioning well as the

servo motor rotates according to the type of solid waste class after the sensor sensed it. The detection of solid waste is based on the sensor behavior, i.e. the metal sensor will detect metal, force sensor will detect glass and the LDR sensor will detect paper or plastic. For the monitoring system, by using an ultrasonic sensor that is connected to NodeMCU and linked to the Blynk app to monitor the level of the solid waste inside the storage works well.

4.4 Conclusion

This study is about the design and development of an automated segregator for solid waste by using a non-contact technology. The main objective of this project prototype was achieved. The system is divided into several parameter controls which is the detection of metal, plastic, glass and paper waste. A few major components and devices are needed in order to create and develop this system. The crucial component is the sensor and the servo motor. The servo motor act as the output to open the lids and to rotate the waste storage based on the type of material that the sensor detects. This is done to ensure that the waste is separated according to their respective type, hence classifying it. For the monitoring part, the Blynk app is used to monitor the level of waste inside the bin and display it to the phone and give notification if the storage is full. There are three types of sensors used in detection of materials. The metal sensor was used to detect metal. The LDR sensor was used to detect plastic or paper. The force sensor was used to detect glass. All components may not function adequately without the Arduino Mega microcontroller that acts as the brain of the system.

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