Borneo Engineering & Advanced Multidisciplinary International Journal (BEAM)
Volume 2, Issue 1, May 2023, Pages 47-51

Development of Automated Recycle Bin for Domestic Use using Arduino Uno

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Full Paper

Article history
Received
27 March 2023
Received in revised form
26 April 2023
Accepted
28 April 2023
Published online
1 May 2023

Abstract

Domestic waste is one of the biggest contributors to the nation's solid waste generation. It comprises of all solid waste material produced from household activities such as food waste, bottles, papers, plastic, and aluminum waste. The evolution of waste management has changed from time to time. Solid waste and public cleansing management that is efficient & effective is important to make sure the high quality of life environment stays clean and safe, as well as healthy. Therefore, an automated recycle bin has been developed to separate waste such as paper, plastic and aluminum then segregate it automatically and assign all the waste to its specific bin compartment according to their classes. This bin is operated by using an Arduino UNO microcontroller used together with three other sensors. The infrared sensor is used to detect the presence of paper waste, the LDR light sensor will detect the presence of plastic waste and the inductive proximity sensor will detect the presence of aluminum waste. The result from the test that was carried out shows that the automated recycle bin is reliable and can segregate domestic waste efficiently. It can detect and segregate an average of more than 83% of the waste that is being thrown away.

Keywords: - Automated recycle bin, smart bin, domestic waste, recycling, Arduino Uno

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1. Introduction

Society in Malaysia is increasingly producing a lot of waste. In an article report by Raja Hisyam from Astro Awani, it mentioned that the Chairman of the Solid Waste Management and Public Cleaning Corporation (SWCorp), Datuk Rizalman Datuk Mokhtar estimated that more than 38,000 tons of domestic waste are produced by Malaysians every day. In fact, the amount will increase up to 20 percent each time before the festive season. This problem requires a change in the public's attitude to ensure more effective solid waste management.

Solid waste includes any scrap material or other unwanted surplus substance or rejected products arising from the application of any process or any substance required to be disposed of as being broken, worn out, contaminated, or otherwise spoiled. Household solid waste means any solid waste generated by a household, and of a kind that is ordinarily generated or produced by any premises when occupied as a dwelling house and includes garden waste. Recyclable solid waste means controlled solid waste which is suitable for recycling as may be prescribed (Solid Waste and Public Cleansing Management Act, 2007).

The concept of reduce, reuse, and recycle are encouraged to be practiced. Reduce is an effective environmental management through reduction of solid waste making. It means cutting down the number of products and types of products that are used and consumed so that less waste is generated. This may also refer to the reduction of use of natural resources.

Reuse, on the other hand, refers to the repeated reuse

of goods, and by doing so waste generation and disposal can be reduced. This refers to making use of items again and again, and by doing so less waste will be created and discarded. Using the same product or goods several times will help to ensure an environment that stays safe and clean. The last one is recycle where the word recycle is made up from two words that is 're' which means to do again and 'cycle' refers to round or to go around. So, recycle refers to putting things in a cycle or loop. Recycle is done by separating wastes, and then channeling them to organizations or manufacturing plants, which can re-process them into new products for consumption. The international symbol for recycling is the Mobius Loop, a special circle that suggests a continuous cycle. (Ministry of Housing and Local Government Malaysia, 2006).

Statistics from the National Solid Waste Management Department show that last year, the country only recorded a recycling rate of 31.52 percent while most developed countries recorded at least 60 percent. The inefficient recycling solutions to handle this waste have led to air, water, and even soil pollution, thus affecting the environment. It was highlighted that solid waste management is based on solid hierarchy. This hierarchy consists of a few elements that are important as shown in Fig. 1.

Fig. 1. Hierarchy of solid waste management (The Waste Management Association of Malaysia, 2011)

Returning recyclable materials from household waste will reduce the consumption of raw materials and protect the environment. The Waste Management Association of Malaysia has recommended three different bins for recycling purposes which are blue for paper, brown for glass and orange bin for plastics and metals. However, according to Zaini et al. (2008), waste disposal still does not reach 40% percentage of disposal according to their correct class. Society still finds difficulties identifying the type of waste material to be put in the correct bin thus making these waste cannot be separated correctly according to their correct classes. To provide three different bins will also involve a more expensive cost and a larger space. Therefore, an automated recycle bin is developed to segregate all these wastes and separate them automatically into its specific bin compartment according to the respective classes.

Fig. 2. Types of recycle bin in Malaysia

2. Methodology

The main components used in the development of this automated recycle bin is the use of Arduino Uno and three material detector sensors. The material detector sensors are used mainly for identifying the type of recycle waste. The mechanical work involved is the use of a channel particularly for the movement and sorting of the recycle waste into its compartment.

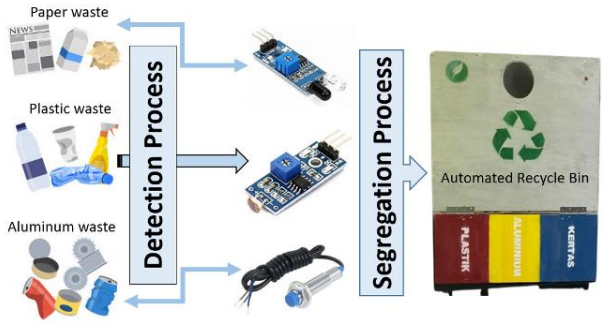

Fig. 3. Diagram of the system

2.1 Arduino UNO

Arduino UNO is a microcontroller development board and is known as the most basic board of the entire Arduino family. It is a simple sensor that is used to build the circuits and interfaces for interaction and telling the microcontroller how to interface with other components (Seneviratne, 2017).

Fig. 4. Arduino UNO

2.2 Infrared Sensor

An infrared (IR) sensor is an electronic device that emits and/or detects infrared radiation to sense some aspects of the surroundings. An infrared sensor can measure the heat of an object as well as detect the motion (Oyelami, Azeez & Abiyo, 2019).

The infrared sensor works the same way an object detection sensor does. This infrared sensor offers simple,

and fast obstacle detection via infrared reflection. As it is based on light reflection, the detection does vary with different surfaces. The output is digital signal, so it is easy to interface with Arduino UNO. This sensor typically has an IR LED & an IR photodiode.

Fig. 5. Infrared sensor

2.3 LDR Light Sensor

The LDR light sensor is a sensing device to detect the presence of plastic waste. It is used to capture the light intensity emitted by the LED attached opposite to it. Thus, when a plastic bottle which is a transparent object is thrown, the LDR will capture high light intensity and drop the plastic bottle into the plastic compartment. (Hassan et.al, 2018).

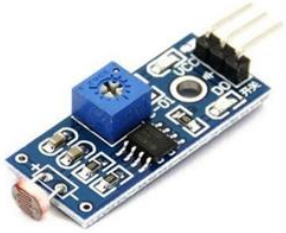

Fig. 6. LDR light sensor

2.4 Inductive Proximity Sensor

The inductive proximity sensor is a sensing device that detects metal targets using electromagnetic energy without any contact to the object. In this project, it is used to detect the presence of an aluminum can. The sensing range of an inductive proximity sensor changes based on the type of metal being detected. When the user throws the aluminum can into the bin, the sensor will detect the presence of the aluminum can and drop the aluminum can into the aluminum compartment.

Fig. 7. Inductive proximity sensor

2.5 Development of The Product

Figures below show the development of the product starting from the sketching process up to the completion stage. The bin is built based on the drawing design that was made. The framework of this bin uses iron material while the body of the bin was made from plywood. In order to make sure the sensors and the mechanical part can detect and segregate the waste, the programming part is required for the microcontroller. All the sensing circuit is connected to the Arduino Uno microcontroller board. The Arduino Uno will control the automated bin funnel system that eventually segregates the different types of recycle waste. Lastly, testing is done to make sure all the installation of the electronic part is perfectly fixed inside the bin.

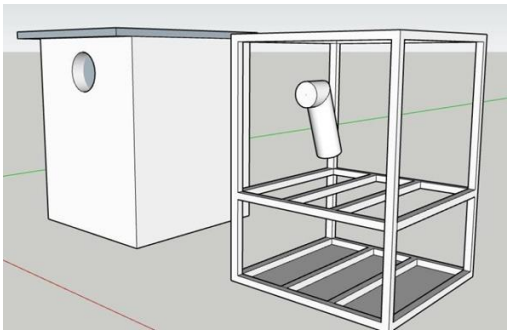

Fig. 8. Sketching and designing process

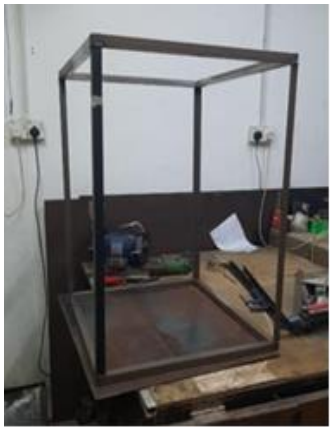

Fig. 9. Building the bin framework

Fig. 10. Installing the plywood to the frame

Fig. 11. Connecting all the electronic part to the bin

Fig. 12. Product setup and testing

Fig. 13. Final appearance of the product

3. Result and Discussion

Table 1 - 3 shows the results obtained from the tests that were carried out for all the three types of waste. The test was done by throwing ten samples of paper, ten samples of plastic bottle and ten samples of aluminum can into the bin. Three attempts were made for each sample. Only the sample that dropped into the correct compartment is counted as a successful attempt. Then the percentage is calculated to find out the detection and segregation effectiveness for the bin.

Table 1 shows the result for paper waste. For sample no.1 until sample no.7, all seven samples in all the three attempts were successfully detected and dropped into the correct compartment by the sensor. However, the sensor failed to detect all three attempts for sample no.8. For sample no.9 the first and second attempt were not successful but in the third attempt, the sensor managed to identify the presence of paper and segregate it correctly. Sample no.10 passed this test in all its three attempts.

Table 1. Test result for paper waste

Attempt	Paper Waste Sample									
	1	2	3	4	5	6	7	8	9	10
1	/	/	/	/	/	/	/	X	X	/
2	/	/	/	/	/	/	/	X	X	/
3	/	/	/	/	/	/	/	X	/	/

Table 2 shows the test result for plastic waste. Sample no.1 and no.2 were easily detected by the recycle bin. However, for sample no.3, the recycle bin failed to detect the presence of plastic in all the three attempts. Sample no.4, no.5 and no.6 were all successful in all the three attempts. For sample no.7, it failed the first and second attempt but passed on the third attempt. Sample no.8 and no.9 also failed the first attempt but the recycle bin managed to detect and segregate the sample correctly on the second and third attempt.

Table 2. Test result for plastic waste

Attempt	Plastic Waste Sample									
	1	2	3	4	5	6	7	8	9	10
1	/	/	X	/	/	/	X	X	X	/
2	/	/	X	/	/	/	X	/	/	/
3	/	/	X	/	/	/	/	/	/	/

The test result for aluminum waste was the most successful one. The automated recycle bin managed to detect and segregate correctly nine out of the ten samples that were thrown in the recycle bin. Although three attempts were made for sample no.4, the sensor still did not manage to detect the presence of aluminum or metal material for that sample.

Table 3. Test result for aluminum waste

Attempt	Aluminum Waste Sample									
	1	2	3	4	5	6	7	8	9	10
1	/	/	/	X	/	/	/	/	/	/
2	/	/	/	X	/	/	/	/	/	/
3	/	/	/	X	/	/	/	/	/	/

The percentage of successful attempts is calculated to determine the efficiency of the recycle bin. The table above shows the percentage of successful attempts for all the three types of waste material. Paper waste recorded a successful attempt rate of 83.3%, plastic waste recorded a successful rate of 76.7% and aluminum waste recorded a high success rate at 90%. On average, the success rate for the efficiency of the recycle bin was 83.3%.

Table 4. Successful attempt for each material

Waste Material	Successful Attempt (%)
Paper	83.3%
Plastic	76.7%
Aluminum	90.0%

4. Conclusion

From the test result, it can be concluded that the most successful attempt was from the aluminum material waste that recorded 90% of success rate. Out of 30 attempts, only three attempts did not drop into the correct compartment. This was because the aluminum material for that sample was too thin and light thus making the sensor could not detect the presence of metal for that sample. A better quality of inductive proximity sensor might be installed for better detection. Paper waste recorded a successful attempt rate at 83.3% while plastic waste was the least successful rate where it only recorded 76.7% success rate. It was then figured out that the LDR light sensor could not detect plastic material if the plastic bottle is covered with its wrapper. The wrapper will cause a low intensity light thus the sensor could not detect the presence of plastic.

The proposed concept and developed product have the potential to be utilized in improving solid waste disposal management in the future. This automated recycle bin is a new environmentally friendly product which provides a smart and convenient way for people to recycle. With the introduction of this recycle bin it will help society to promote recycle habits. At the same time, it benefits the environment, and this will reduce the impact on the environment.

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