Evolution in Electrical and Electronic Engineering Vol. 2 No. 2 (2021) 597-604
© Universiti Tun Hussein Onn Malaysia Publisher's Office

EEEE

Homepage: http://publisher.uthm.edu.my/periodicals/index.php/eeee
e-ISSN : 2756-8458

Automatic Garbage Segregation System

Muhammad Fathi Yakan Zulkifli[1], Noorhamizah Mohamed Nasir[1]*

[1]Faculty of Electrical and Electronic Engineering,
Universiti Tun Hussein Onn Malaysia, Batu Pahat, 86400, Johor, MALAYSIA

*Corresponding Author Designation

DOI: https://doi.org/10.30880/eeee.2021.02.02.071
Received 07 July 2021; Accepted 01 August 2021; Available online 30 October 2021

Abstract: Recently, the recycling program was given attention by the government because the landfill area has become increasingly limited at the same time waste material also increases. This indicates that recycling attitudes among the community are still low. Recycling is important to reduce the need for raw material extraction, refining, and processing, all of which pollute the air and water. Recycling saves energy while also lowering greenhouse gas emissions, which aids in the fight against climate change. This research is to develop a dustbin that can segregate different garbage materials which are plastic, paper and aluminium automatically. The idea for this bin is to solve landfill problems or to reduce garbage disposal to landfills. This dustbin is suitable to be placed in public and a kitchen for dry waste only specific for plastic, aluminium and paper. To classify the type of garbage, there are two components used, infrared sensor and inductive proximity sensor. Besides, this dustbin also equips with ESP8266 to send notification to the owner when the garbage is near the limit or full. The segregation success rate for plastic bags, bottle plastic, newspaper, tissue paper, money envelopes and aluminium cans after 50 attempts is 100%, 96%, 96%,100%,100% and 90%. It is concluded that the objective that has been achieved is to segregation garbage automatically and evaluate the performance of the using infrared sensor and inductive proximity sensor to classified plastic, paper and aluminium. In future work, wet sensors can be added to isolate wet material like food waste. This can make this bin multipurpose and suitable to be placed in the kitchen.

Keywords: Garbage Segregation System, Infrared Sensor, Inductive Proximity Sensor

1. Introduction

Recycling is the process of gathering and processing material that would otherwise be discarded as garbage and turning them into new products. Recycling has the potential to benefit both the community and the environment. Aluminium cans, comic books, glass containers, and trash bags are just a few examples of things that can be recycled. The importance of recycling is the manufacturing of new things from raw materials, recycling to reduces garbage, reduces the usage of new raw materials, reduces energy consumption, reduces air and water pollution, and lowers greenhouse gas emissions.

**Corresponding author: hamizahn@uthm.edu.my*

Recently, landfill space is becoming increasingly restricted and garbage material is rising. Because garbage is not classified, the expense of garbage disposal is rising [1]. Based on the amount of garbage at landfills, it is obvious that public awareness of the need for recycling is still low. The segregation process is mainly done manually utilizing human power to sort the types of garbage [1]. However, with the development of the age and the pace of garbage production rises, physical garbage segregation becomes less effective [2].

Automatic Garbage Segregation System is designed to segregate garbage like plastic, paper and aluminium automatically. There are two sensors used, infrared and inductive proximity sensor. Besides, this system also will send notification to the owner when the garbage is near the limit or full. Besides, ultrasonic sensors are placed over the dustbin to detect the garbage level and ESP8266 will be used to connect to Wi-Fi and Blynk applications.

1.1 Literature Review

1.1.1 Previous Project

i. Smart Recycle Bin (SRBin)

Researchers of Universiti Tun Hussein Onn Malaysia (UTHM) have collaborated with the Solid Waste Management and Public Cleansing Corporation (SWCorp) to produce the Smart Recycle Bin [3]. Smart Recycle Bin is a recycling material collection system that houses a smart bin that is able to measure and identify the recycled materials put in the dustbin. In addition, the barrel will also identify the owner of the material through a membership card and keep a record of accumulated reward points in the database online.Automatic material identification systems for plastic bottles and aluminium can thus reject non-recyclable waste and also protection systems for misuse prevention. SRBin can automatically separate the waste accordingly and convert weight/amount /type of recycle waste into monetary rewards or accumulated points.

ii. Smart Bin for Wet Waste Detection Using ESP8266 NoideMCU

The project is made by students from Universiti Teknologi MARA, January 2020 [4]. The objectives of this project are to develop a prototype of smart waste bin for wet waste and to evaluate the performance of ultrasonic and moisture sensors using ESP8266 NodeMCU. LEDs have been attached to the sensor for its function itself. The level of waste is monitored using the ultrasonic sensor, and a red LED will turn on when the waste reaches the threshold of the bin. The moisture sensor will measure the percentage of moisture content, and a green LED will light up. ESP8266 NodeMCU has Wi-Fi connection which is a mobile phone hotspot. Mobile phones were placed 10 meters far from the devices to see the performances of the mobile hotspot which is mobile phone.

1.1.2 Idea from Previous Project

This project is a combination and variation of reforms resulting from both previous projects. SRbin can identify two types of material: plastic bottle and aluminium can but the improvement from this project is that the bin can identify three types of material, plastic, paper and aluminium. Besides, an idea from Smart Bin for Wet Waste Detection Using ESP8266 NoideMCU is used as an addition to this project.

1.2 Aim of The Project

Aim of this project to develop dustbin that can identify different garbage material which is plastic, paper and aluminium automatically. Second is to design an automatic garbage alert system for proper garbage management with can inform through notification when garbage reach limit or full. Finally, to evaluate the performance of the sensor to classified paper and plastic using infrared sensor.

2. Materials and Methods

2.1 Methods

The flowchart in Figure 1 shows an overview of the circuit simulation from the beginning until complete the process. The processes start with putting the garbage in the container. At the container, there is an infrared sensor and an inductive proximity sensor. There will be a process of classifying the type of garbage material. If the infrared sensor detects the material is paper, the servo motor at the container will open and drop the garbage and if plastic the bin will rotate 90° first then the servo will drop the garbage. If it is aluminum or metal, the bin will rotate 180° and the servo will drop the garbage. When the garbage has dropped into the bin, the ultrasonic will detect the level of garbage, if it has reached the limit for example below 5cm, ESP8266 will send notification to the mobile phone via apps. After that, the bin will rotate back to its starting position (0°) and the container will close back.

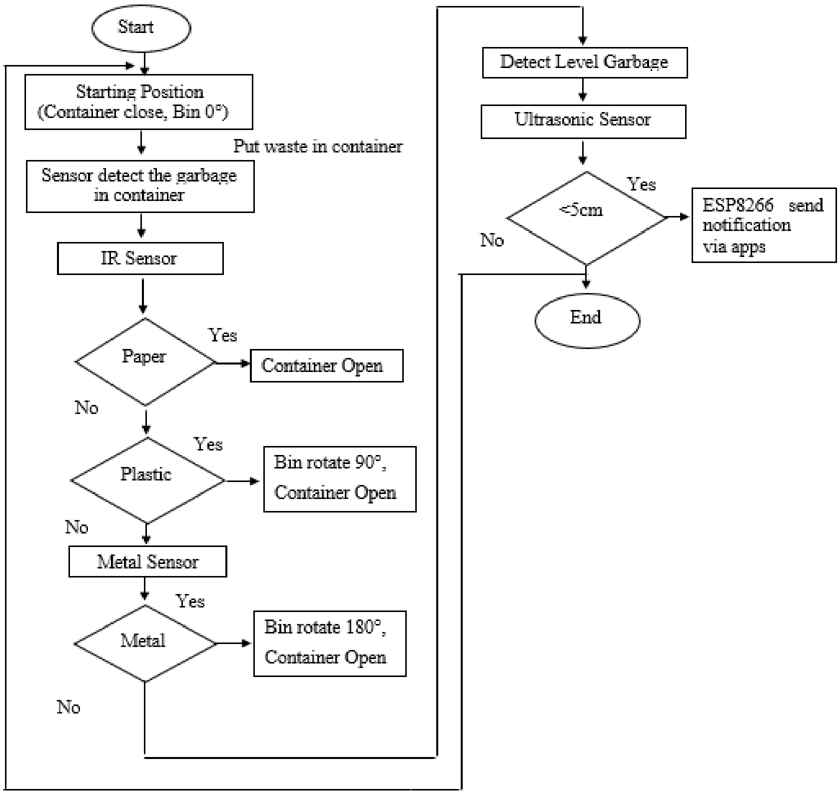


Figure 1: Flowchart simulation of circuit

2.2 Hardware Component

i. Arduino Uno

The Arduino is a programmable CIP Microcontroller. By simply inserting certain instructions (code) into the Arduino using software or Arduino IDE, Arduino will read Input information of the sensor include infrared and metal sensor to process that information to drive an Output such as servo motor and buzzer. For this project almost all ports on the Arduino will be used.

ii. Inductive Proximity Sensor

Inductive sensors use electromagnetic induction to detect metallic things. A wide range of applications is possible thanks to the various formats, housing materials, and switching distances [5]-[6]. These sensors are maintenance-free, waterproof, and impervious to contaminants and damage because no moving parts are used. The proximity switch is a high-frequency oscillation type that delivers a detection signal to operate the relay or logic gate quickly, without pressure, no pressure, and without a spark.

iii. Infrared Sensor

An infrared sensor is a type of electrical device that detects and measures infrared radiation in its surroundings. Almost all objects emit some type of thermal radiation form in the infrared spectrum. Because the wavelength of infrared is longer than that of visible light, it is invisible to the human eye. Infrared radiation is emitted by everything that emits heat with a temperature over roughly five degrees Kelvin[7].

Infrared sensors are divided into two categories, active and passive. Active infrared is emitted and detected the infrared radiation. Active infrared sensor has light emitting diode (LED) and a receiver. When object close to the sensor, the LED's emit infrared light reflects off of it and is detected by the receiver. Passive infrared sensors do not emit infrared radiation but they simply detect it. Absorption method is use to classified the paper and plastic material.

iv. Ultrasonic Sensor

An ultrasonic sensor is an electronic device which, by emitting ultrasonic sound waves, measures the distance of a target object, and converts the reflected sound into an electrical signal. Ultrasonic sensors have two primary components, the transmitter using piezoelectric crystals to emit sound and the receiver. The ultrasonic sensor monitors the level of garbage in the dustbin and sends a signal when garbage is full. There are three ultrasonic sensors used in this project that will be used for paper, plastic and aluminium parts.

v. Servo Motor Mg995

A servo motor is a type of motor consisting of a control circuit that provides feedback on the current position of the motor shaft. This feedback will allow the servo motors to rotate with great precision. For this project will use 2 servo motors, a container and dustbin. The rotation of the servo motor will be controlled by Arduino.

vi. ESP8266 ESP-01

ESP8266 ESP-01 is an ultra-low power UART-WiFi module that allows microcontrollers access to Wi-Fi. The module is a special design for mobile devices and Internet of Things (IoT). When devices connect to WiFi with ESP8266 module, it can process LAN communication. For signal reception via signal, this ESP8266 will communicate via Blynk application

vii. Mini Piezo Buzzer

This piezo buzzer will apply with 3V to 5V and will produce the sound as output. Unlike a plain piezo, this buzzer does not need an AC signal. This buzzer is suitable to fit in a small place. In this project, a buzzer will be used to give the signal whenever the sensor identifies the type of garbage material.

2.3 Arduino Ide

Arduino Ide is used to create or write the code, then uploads it to Arduino hardware which executes the code, interacting with inputs and outputs such as sensors, servo motors, and buzzer. Besides, in Arduino Ide there is a Serial Monitor. Its function is to send messages from your computer to an Arduino board (over USB) and also to receive messages from the Arduino. For this part, Serial Monitor is used to show the received or output value of infrared sensor and ultrasonic sensor.

2.4 Blynk Application

Blynk is an Internet of Things platform, which makes controlling hardware remotely and visualizing its data very easy. Using WiFi or Hotspot is able to connect to the Blynk apps. For this project, this app is used to receive signals from Arduino and then give the notification to mobile phones when the bin is full.

3. Results and Discussion

3.1 Data Analysis of Absorption Infrared Sensor

Figure 2 shows the sample used to obtain the value infrared radiation absorption. The samples used are different types of material which is plastic and paper. 5 samples of material will be used including newspapers, tissue paper, money envelopes, plastic bottles and plastic bags and each sample will be tested 50.

Figure 2: Sample of material, newspapers, tissue paper, money envelopes, plastic water bottles and plastic bags

Table 1 shows the results of the analysis that has been made as a result obtained. This range value will be included in programming to make the segregation system between paper and plastic not have any faults and overlap. If 40cm^{-1} and above is for paper and below 30cm^{-1} is for plastic. Between 30cm^{-1} and 40cm^{-1}, it will be made as invalid because of the overlap value that has occurred of plastic and paper.

Table 1: Range value for plastic and paper

Type	Value Absorption (cm^{-1})
Plastic	Below 30
Paper	Above 40
Invalid	31-39

Based on the observation, the value of paper is low, this is because of clumps of paper. Clumps of paper have many different depths for each angle. When placing paper on the sensor freely, sometimes the light reflects through the depth angle and sometimes to the plane angle of paper as in Figure 3. To get the ideal result, the paper must close to the infrared sensor or reflect at a plane angle. When the infrared sensor reflects to plane angle the value exceeds 40 cm^{-1} if reflect to depth angle the value below 40cm^{-1}.So, to avoid overlap happen, when invalid happen the position garbage in the container need to fix of the until the sensor knows whether the garbage is paper or plastic material. From here can conclude that, infrared sensors also can be used to identify paper and plastic material.

(a) (b)

Figure 3: (a) Light reflection to a depth angle (b) Light reflection to plane angle

3.2 Device Prototype

Figure 4 shows the whole prototype of the automatic garbage segregation system. Containers are spaces for placing garbage and bins are spaces for garbage segregation.

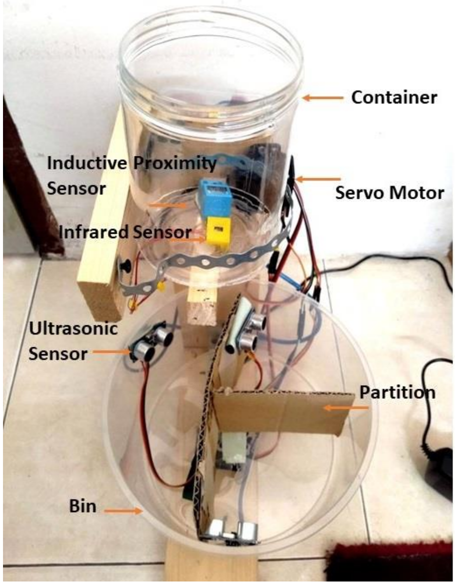


Figure 4: Full view of prototype

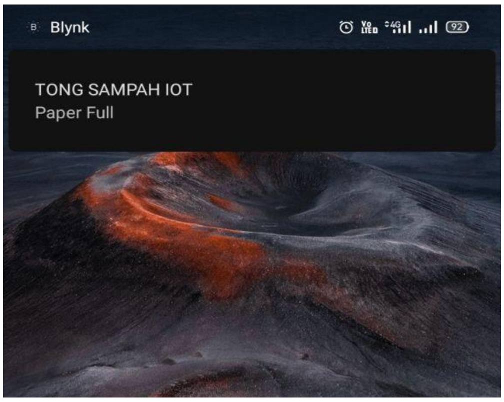
Table 2 shows the results of the garbage segregation test for each type of material for 50 times. This test to make an observation of the type of garbage falling on the right part or not. Based on the table, plastic bottle, newspaper and aluminum cans do not reach 100%, this sample entering another part not what it should be. This is because the size of the plastic bottles, newspaper and aluminium cans is large. Servo motor on the container rotates downwards, then the garbage will fall forward. To solve this problem, the area of the bin size required is larger than before to accommodate the large size of the garbage. The results show the percentage for test success rate is high, this means the segregation process is still successful.

Table 2: Garbage Segregation Test Results

Type	Sample	Success in 50 Attempts	Test Success Rate
Plastic	Plastic Bag	50	100%
	Plastic Bottle	48	96%
Paper	Newspaper	48	96%
	Tissue Paper	50	100%
	Money Envelope	50	100%
Aluminium	Aluminium Can	45	90%

3.3 Notification System

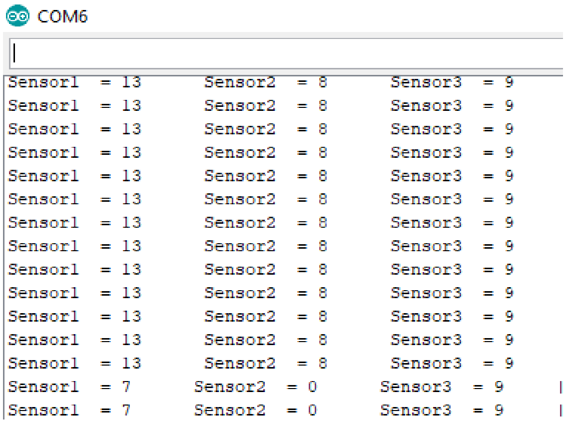
Figure 5 shows one example when a mobile phone gets a notification from the Blynk application. This notification will appear on the home screen layout and home lock screen. This notification can be programmed to remind every few minutes according to the user's demand until the trash can is cleaned.



TONG SAMPAH IOT
Paper Full

Figure 5: Notification from ESP8266 to mobile phone

Based on Figure 6, the results show the ultrasonic used is very precise and can be used to measure the garbage level distance for this project, but the ultrasonic is very sensitive to airwaves that can cause the measurement distance to be disturbed and get a notification on incorrect information [8]. To solve this problem, programming will be changed from if the sensor reads below 5cm and gets notification into if the sensor reads below 5cm five times and gets the notification.



```
Sensor1  = 13      Sensor2  = 8      Sensor3  = 9
Sensor1  = 13      Sensor2  = 8      Sensor3  = 9
Sensor1  = 13      Sensor2  = 8      Sensor3  = 9
Sensor1  = 13      Sensor2  = 8      Sensor3  = 9
Sensor1  = 13      Sensor2  = 8      Sensor3  = 9
Sensor1  = 13      Sensor2  = 8      Sensor3  = 9
Sensor1  = 13      Sensor2  = 8      Sensor3  = 9
Sensor1  = 13      Sensor2  = 8      Sensor3  = 9
Sensor1  = 13      Sensor2  = 8      Sensor3  = 9
Sensor1  = 13      Sensor2  = 8      Sensor3  = 9
Sensor1  = 13      Sensor2  = 8      Sensor3  = 9
Sensor1  = 13      Sensor2  = 8      Sensor3  = 9
Sensor1  = 13      Sensor2  = 8      Sensor3  = 9
Sensor1  = 7     Sensor2  = 0     Sensor3  = 9
Sensor1  = 7     Sensor2  = 0     Sensor3  = 9
```

Figure 6: Serial Monitor display the reading value from three ultrasonic sensor

4. Conclusion

In conclusion, the main objective has been achieved, that is, to develop a dustbin that can identify and separate different garbage material which is plastic, paper and aluminium automatically. This project also aimed to design an automatic garbage alert system for proper garbage management with sent signal or notification when the bin reaches limit or full. This system is suitable for use when placed in a public place to facilitate the owner of this recycling bin whether it is the national solid waste management department or a contractor appointed to check and collect the garbage. Another objective that has been achieved is to evaluate the performance of the sensor to classify plastic and paper using infrared sensors. The results of studies that have been done, the absorption value for plastic is below 30 $cm^{-1}$and paper is above 40 cm^{-1}, thus these two materials can be successfully separated. If want to add segregation material or better segregation, servo motor needs to replace with motor that can rotate 360°. The required motor is, a motor that can rotate based on a set angle. Finally, to make this bin can be used for wet waste, wet sensors need to be added to isolate wet material like food waste. This can make this bin multipurpose and suitable to be placed in the kitchen.

Acknowledgement

The authors would like to thank the Faculty of Electrical and Electronic Engineering, Universiti Tun Hussein Onn Malaysia for its support.

References

[1] P. Penderia, K. Jarak, and B. Kitar, “An Application of Capacitance Proximity Sensor for Identification of Recyclable Materials,” *J. Kejuruter. SI 1(5) 2018 37-41*, vol. 1, no. 5, pp. 37–41, 2018, [Online]. Available: https://www.ukm.my/jkukm/wp-content/uploads/2018/si1/5/6.pdf

[2] C. Zhihong, Z. Hebin, W. Yanbo, L. Binyan, and L. Yu, “A Vision-based Robotic Grasping System Using Deep Learning for Garbage Sorting,” *Proc. 36th Chinese Control Conf. July 26-28, 2017, Dalian, China*, pp. 11223–11226, 2017

[3] Universiti Tun Hussein Onn Malaysia, “Penyelidik UTHM berkolaborasi hasil ‘Smart Recycle Bin’ urus sisa pepejal dan pelihara alam sekitar,” *UTHM News*, 2017. https://news.uthm.edu.my/ms/2017/08/penyelidik-uthm-berkolaborasi-hasil-smart-recycle-bin-urus-sisa-pepejal-dan-pelihara-alam-sekitar/ (accessed Nov. 28, 2020)

[4] S. N. A. Ab Hamid, “Smart Bin for Wet Waste Detection Using ESP8266 NodeMCU,” *Malaysian Theses Online*, no. January, 2020

[5] A. V Matheoud, N. S. Solmaz, L. Frehner, and G. Boera, “Microwave inductive proximity sensors with sub-pm/Hz 1/2 resolution,” *Sensors Actuators A Phys.*, 2019

[6] P. Kejik, C. Kluser, R. Bischofberger, and R. S. Popovic, “A low-cost inductive proximity sensor for industrial applications,” *Sci. Direct*, p. 283, 2003

[7] V. P. Ajay, B. K. M, A. Kishanth, V. Kumar, R. S. Devi, and A. Rengarajan, “Automatic Waste Segregation and Management,” *2020 Int. Conf. Comput. Commun. Informatics (ICCCI -2020)*, pp. 20–24, 2020

[8] L. Reese, “The working principle, applications and limitations of ultrasonic sensors,” *MICROCONTROLLERTIPS*, 2019. https://www.microcontrollertips.com/principle-applications-limitations-ultrasonic-sensors-faq/