Design of Organic and Non-Organic Waste Detection Device

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Abstract— **In this study the author will focus on making a device that can perform waste sorting automatically, for sorting organic and non-organic waste types which aim to assist the waste sorting process which is expected to facilitate the recycling process. The results of testing the device that has been designed by the author, the device can sort waste automatically with the help of ultrasonic sensors and proximity sensors. The proximity sensor used is inductive and capacitive proximity sensor. Inductive proximity sensors are used to detect ferrous type waste, capacitive proximity sensors are used to detect non-ferrous type waste. The device that has been made has limitations, that is the incoming waste must be dry so it does not interfere with sensor readings, and also the dimensions of the waste must be of a certain size to fit inside the garbage can.**

***Keywords*: Waste detecting device, Proximity sensors, Sorting waste, Garbage can.**

I. INTRODUCTION

In this study the author will focus on making a device that can perform waste sorting automatically, for sorting organic and non-organic waste types which aim to assist the waste sorting process which is expected to facilitate the recycling process. This type of research was carried out using qualitative methods to see the results of sensor readings on the type of waste detected by a device designed.

The device can sort waste automatically with the help of ultrasonic sensors and proximity sensors. The proximity sensor used is inductive and capacitive proximity sensor. Inductive proximity sensors are used to detect ferrous type waste, capacitive proximity sensors are used to detect non-ferrous type waste. The device that has been made has limitations, that is the incoming waste must be dry so it does not interfere with sensor readings, and also the dimensions of the waste must be of a certain size to fit inside the garbage can

In this final thesis project, waste detection device design with installation of an inductive, capacitive and ultrasonic sensors which these sensors could differentiate between the types of waste. Which leads to the servo motor rotation to the correct angle, where it positions the trash into the correct bin.time.

II. THEORITICAL REVIEW

Experiment done on the waste with 10 organic waste and 10 non-organic waste has an accuracy of 95% where each waste had 5 recorded analog data with a total of 100 analog data. 50 of the organic waste analog data was correctly identified where only 45 of the non-organic waste analog data was correctly identified.

III. METHOD

A. Identify and sorting Waste

Organic waste comes from the remains of living organisms, for example leftover vegetables and fruits that are thrown away. Meanwhile, non-organic waste does not come from living organisms and is the result of human intervention. For example, waste plastic bottles, cardboard, plastic food packaging, and so on.

The use of inductive sensor LJ12A3-4-Z/BX to detect metal materials.The use of capacitive sensor LJC18A3-B-Z/AX to detect non-organic materials. The use of ultrasonic sensor HCSR-04 to detect all materials. The use of servo motor MG996R to emplace different types of waste to the correct bin. The use of Arduino Uno for the microcontroller. The use of 12V/2A adaptor for the power supply of the device.The use of step-down transformer LM2596 to lower the voltage from the power supply.

1. Inductive sensor

The inductive sensor LJ12A3-4-Z/BX as a non-organic waste (ferrous materials) detector that uses electromagnetic induction to detect the presence of a metallic object. The physical form and specifications of the inductive sensor LJ12A3-4-Z/BX

FIGURE 3.1
Inductive Sensor LJ12A3-4-Z/BX

2. Capacitive sensor

Capacitive sensor LJC18A3-B-Z/AX as a non-organic waste (non- ferrous materials) detector. consists a high-frequency oscillator along with a sensing surface formed by two metal electrodes. When a waste comes near the sensing surface, it enters the electrostatic field of the electrodes and changes the capacitance of the oscillator. The physical form and specifications of the capacitive sensor LJC18A3-B-Z/AX.

FIGURE 3.2
Capacitive Sensor LJC18A3-B-Z/AX

3. Ultrasonic Sensor

Ultrasonic sensor HCSR-04 uses sound waves to detect if there is waste inside of the garbage can. The physical form and specifications of the ultrasonic sensor HCSR-04.

Figure 3.3
Ultrasonic Sensor HCSR-04

4. Servo Motor

Servo motor MG996 produces torque and velocity to rotate the platform inside the garbage can which places the different type of waste to the correct bin. The physical form and specifications of the Servo Motor MG996.

Figure 3.4
Servo Motor MG996R

5. Microcontroller

The Arduino Uno microcontroller used in this system acts as a data processing centre generated by the sensors installed on the waste detection device. The physical form and specifications of Arduino Uno serves as the microcontroller

Figure 3.5
Arduino UNO

B. Confusion Matrix

Confusion matrix is a table that is used to define the performance of a classification model, in particular, in supervised learning. It is used to describe the performance of a classification algorithm, and it is also used to evaluate the prediction results. The confusion matrix is a table that is often used to describe the performance of a classification algorithm (or "classifier") on a set of test data for which the true values are known. It contains four different types of outcomes: true positives (TP), true negatives (TN), false positives (FP), and false negatives (FN).

- True Positives (TP) are the cases where the model predicted the positive class, and the true class is also positive.
- True negatives (TN) are the cases where the model predicted the negative class, and the true class is also negative.
- False positives (FP) are the cases where the model predicted the positive class, but the true class is negative.
- False negatives (FN) are the cases where the model predicted the negative class, but the true class is positive.

The confusion matrix is useful in understanding the performance of a classification model. It can help to identify the strengths and weaknesses of a model, such as which classes the model is having difficulty distinguishing.

IV. RESULTS AND DISCUSSION

This system has been designed in such a way as to make it easier for users to use this tool. This device features three sensors to aid in the waste detecting process. These sensors include ultrasonic sensor that serve as detectors for incoming waste and organic waste, capacitive sensor detects non organic waste such as non-ferrous materials, and inductive sensor detects non organic waste such as ferrous materials. The threshold of ultrasonic sensor is 0-5cm, inductive and capacitive sensors threshold is if the analog data is greater than 700.

A. Organic data

TABLE 1.
Organic Data

Organic Waste	Trail	Inductive	Inductive Current	Capaciti ve	Capacitive Current	Ultrasonic
Leather Wallet	1	1	5.32	101	4.98	4
	2	2	5.32	108	4.98	4
	3	3	5.32	107	4.98	4
	4	4	5.32	107	4.98	4
	5	4	5.32	112	4.98	4
Buffalo Paper	1	1	5.32	101	4.98	4
	2	8	5.32	108	4.98	4
	3	2	5.32	107	4.98	4
	4	4	5.32	105	4.98	4
	5	4	5.32	112	4.98	4
Cardboar	1	1	5.32	104	4.98	2
	2	3	5.32	107	4.98	2
	3	4	5.32	107	4.98	3
	4	4	5.32	103	4.98	2
	5	1	5.32	108	4.98	2
Cigarett e Care	1	1	5.32	106	4.98	3
	2	2	5.32	105	4.98	3
	3	8	5.32	105	4.98	3
	4	4	5.32	107	4.98	3
	5	1	5.32	108	4.98	3
Cap	1	1	5.32	112	4.98	5
	2	4	5.32	107	4.98	5
	3	4	5.32	107	4.98	5
	4	2	5.32	108	4.98	5
	5	3	5.32	101	4.98	5
Apple	1	2	5.32	108	4.98	3
	2	2	5.32	114	4.98	3
	3	1	5.32	105	4.98	3
	4	8	5.32	107	4.98	3
	5	6	5.32	108	4.98	3
Book	1	1	5.32	112	4.98	4
	2	6	5.32	104	4.98	4
	3	8	5.32	108	4.98	4
	4	0	5.32	110	4.98	4
	5	2	5.32	101	4.98	4
Orange	1	4	5.32	105	4.98	3
	2	2	5.32	107	4.98	3
	3	4	5.32	102	4.98	3
	4	8	5.32	105	4.98	3
	5	1	5.32	108	4.98	3
Wood	1	2	5.32	104	4.98	4
	2	2	5.32	107	4.98	4
	3	1	5.32	108	4.98	4
	4	8	5.32	110	4.98	4
	5	6	5.32	105	4.98	4
Avocado	1	2	5.32	102	4.98	3
	2	4	5.32	103	4.98	3
	3	1	5.32	110	4.98	3
	4	6	5.32	107	4.98	3
	5	2	5.32	108	4.98	3

Based on the data above, 10 organic trash gave different analog data outcomes but has the same conclusion, where the device detects the waste as organic waste. The output analog data based on Arduino Uno serial monitor where inductive sensor analog data ranges from 1-8, capacitive sensor analog data ranges from 101-112 and ultrasonic sensor analog data ranges from 2-5. The current data based on Arduino Uno serial monitor where inductive current is 5.32mA, capacitive current data is 4.98mA.

B. Non-organic data

Non-Organic	Trail	Inductive	Inductive Current	Capaciti ve	Capacitive Current	Ultrasonic
Smartphone	1	747	63.66	1021	42.76	3
	2	762	63.79	1021	42.80	3
	3	750	66.50	1019	42.67	3
	4	763	63.60	1023	42.72	3
	5	764	63.79	1022	42.72	3
Beverage Can	1	750	63.60	1022	42.80	3
	2	763	66.50	1021	42.72	3
	3	755	63.79	1019	42.76	3
	4	765	63.60	1017	42.67	3
	5	754	63.66	1023	42.72	3
Air	1	746	63.79	1021	42.80	3
	2	760	63.60	1022	42.72	3
	3	763	63.66	1019	42.67	3
	4	768	66.50	1021	42.76	3
	5	767	63.66	1020	42.76	3
Polishing Fluid	1	2	5.32	1017	42.72	4
	2	1	5.32	1021	42.80	4
	3	4	5.32	107	4.98	4
	4	2	5.32	1022	42.72	4
	5	2	5.32	1015	42.72	4
Metal Ashtry	1	762	63.66	1019	42.76	4
	2	760	63.79	1021	42.67	4
	3	767	63.66	1023	42.76	4
	4	754	63.60	1022	42.80	4
	5	765	66.50	1022	42.67	4
Facial	1	1	5.32	1015	42.76	6
	2	3	5.32	112	4.98	6
	3	8	5.32	1023	42.72	6
	4	4	5.32	1021	42.80	6
	5	4	5.32	108	4.98	6
Shampoo	1	1	5.32	1021	42.67	3
	2	4	5.32	1017	42.67	3
	3	6	5.32	1023	42.72	3
	4	8	5.32	1019	42.76	3
	5	3	5.32	1023	42.80	3
Liquid	1	1	5.32	109	4.98	3
	2	3	5.32	1021	42.67	3
	3	4	5.32	103	4.98	3
	4	1	5.32	1023	42.72	3
	5	4	5.32	1022	42.76	3
Axe Bodyspray	1	758	66.50	1021	42.72	4
	2	765	63.60	1019	42.67	4
	3	746	63.79	1020	42.76	4
	4	754	63.60	1023	42.72	4
	5	761	63.66	1022	42.80	4
Suizr	1	755	63.60	1022	42.80	5
	2	747	63.66	1019	42.72	5
	3	760	66.50	1021	42.76	5
	4	762	63.79	1022	42.67	5
	5	765	63.60	1023	42.72	5

Based on the data above, 10 non-organic trash gave different analog data outcomes but has the same conclusion, where the device detects the waste as non- organic waste. The output analog data based on Arduino Uno serial monitor where inductive sensor analog data ranges from 1-768, capacitive sensor analog data ranges from 103-1023 and ultrasonic sensor analog data ranges from 3-6. The current data based on Arduino Uno serial monitor where inductive sensor current data ranges from 5.32mA-63.66mA, capacitive sensor current data ranges from 4.98mA-42.80mA.

C. Confusion Matrix

A confusion matrix is a table used to evaluate the performance of the waste detector. It compares the predicted class labels to the true class labels for wastes. In the context of organic and non-organic waste, the confusion matrix would have four possible outcomes:

True positive (TP) represents the number of organic waste samples that were correctly classified as organic.

False positive (FP) represents the number of non-organic waste samples that were incorrectly classified as organic.

True negative (TN) represents the number of non-organic waste samples that were correctly classified as non-organic.

False negative (FN) represents the number of organic waste

samples that were incorrectly classified as non-organic.

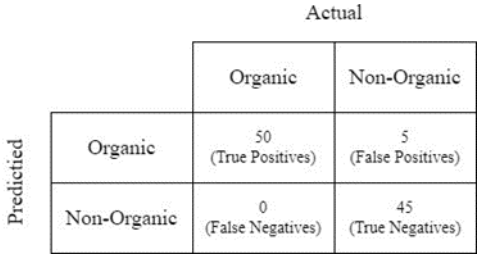

FIG 3.
Electrical Load Dataset Cluster

The values in the confusion matrix are used to compute various performance metrics such as accuracy, precision, recall, and F1 score, which help to assess the effectiveness of the classifier in different ways. The following are the formulas used to calculate performance metrics from a confusion matrix:

Accuracy: It is the ratio of the number of correct predictions to the total number of predictions. FP + FN) (50 + 45) / (50 + 45 + 5 + 0) = 0.95

Accuracy = (TP + TN) / (TP + TN + Precision: It is the ratio of the number of true positive predictions to the sum of true positive and false positive predictions.

Precision = TP / (TP + FP)
50 / (50 + 5) = 0.909

Recall = TP / (TP + FN)
50 / (50 + 0) = 1

F1 Score: It is the harmonic mean of precision and recall.

F1 Score = 2 * (Precision * Recall) / (Precision + Recall)
= 2 * (0.909 * 1) / (0.909 + 1) = 0.952

Precision = TP / (TP + FP)
50 (50 + 5) = 0.909

V. CONCLUSION

I. Conlusion

Experiment done on the waste with 10 organic waste and 10 non-organic waste has an accuracy of 95% where each waste had 5 recorded analog data with a total of 100 analog data. 50 of the organic waste analog data was correctly identified where only 45 of the non-organic waste analog data was correctly identified.

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