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GARBAGE SORTER ROBOT FOR CAFÉ AMAZON

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ABSTRACT

The objective of this project is to design and build a trash separating robot with an image processing technique to identify types of trash. In this project, we mainly focus on the trash in café Amazon because of a huge amount and variety of trash along with an inappropriate waste management which leads to environmental degradation. Surveying types and quantity of trash in the actual location along with inspecting how people use bins, we can design the robot and identify types of trash to be separated by the robot. According to the pollution control department in Thailand, types of trash include compostable waste, recycle waste, non-degradable waste and dangerous waste.

Introduction

Waste management is one of the biggest problems in the world. There are 14 million tons of trash per day in Thailand but approximately 70 percent of it are not managed and eliminated properly [1]. As a result, serious environment problems occur including air pollution from burnt trash, water pollution which are contaminated by trash, diseases spreading from dirty areas covered with trash and smelling problem. One of the most obvious causes of problems mentioned before is a mixture of all types of trash which leads to inefficient waste management. To solve this issue, waste separation from a trash separating robot improves waste management efficiency and reduces labors whose job is to separate trash. Moreover, useful waste such as recyclable trash can be utilized more for the green environment.

Objective and scopes of the project

The main objectives of this project are as follows.

1. The robot can be installed in Amazon café.
2. The robot can separate recyclable trash including plastic bottles, aluminum cans, paper cups and other type of trash.

The secondary objectives of this project are as follows.

1. The robot can identify food waste.
2. The robot can separate water and food from the packaging.

The scopes of the project mainly focus on the trash from Amazon café because of a huge amount and variety of trash. Most importantly, the brand has many branches in Thailand so it is easy for us to get feedbacks from our users.

Data collection

In order to design the robot, we need to know types and quantity of trash in Amazon café so we asked for those data (Fig. 1) from the Amazon café which is located near our faculty. After that, we collected some example of trash (Fig. 2). As a result, types of trash and the number of bins and robot's specifications are identified.

Type of trash	1 Oct 2019	5 Oct 2019	10 Oct 2019	15 Oct 2019	21 Oct 2019	26 Oct 2019	Average (21 days)
Paper cup	22	19	20	18	13	16	20
Plastic cup	269	102	160	219	178	125	207
Plastic bag	20	9	23	18	25	14	24
Plastic bottle	4	5	9	5	8	10	12
Glass bottle	2	1	2	1	0	3	2
Paper bowl	1	2	0	1	2	0	1

Fig. 1 The amount of different types of waste in 21 days from the survey

Fig. 2 Types of trash found in Amazon Café

Design and Specification

1. Prototype 1

According to data collection, there were 4 bins which were categorized by types of trash (plastic, aluminum, paper and others). The robot's specifications are automatic system, identifying trash using object detection [2], transferring trash into the right bin, system's notifying, lighting, tracking system using Netpie, multiple trash prevention and easy to use. The main mechanisms were linear motion with a belt and lifting with a pulley driven by DC motors, IR sensors and an ultrasonic sensor to control the tray's position and the slope of the lifting plate respectively and the servo motor for opening and closing a trash receiver as shown in Fig. 3. One cycle of operation include 1. Initial position ; The tray positioned at the dome and the lifting plate remained level to the ground. 2. Identifying trash. 3. driving the tray to the bin's position and leaning the plate to dump the trash. 4. Returning to the initial position, the dome and tray design are displayed in Fig. 4.

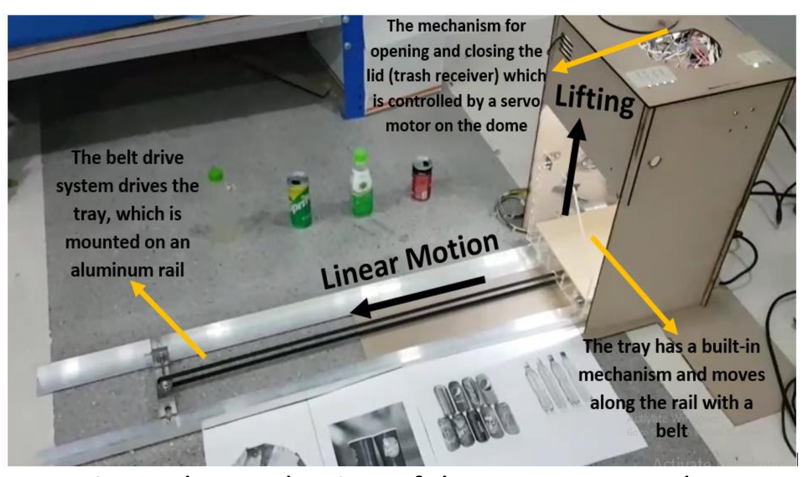

Fig. 3 The mechanism of the prototype 1 robot

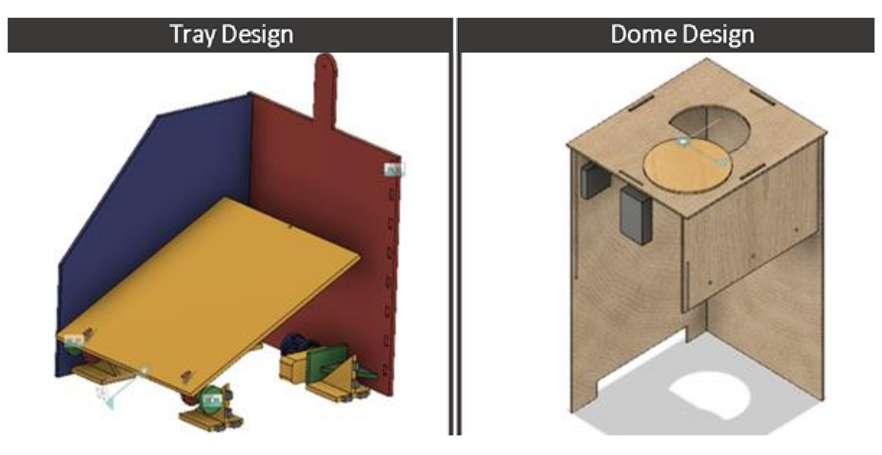

Fig. 4 Design of tray and dome of prototype 1 in Fusion360

Design and Specification

2. Prototype 2

This prototype is the revised version of the previous one. The robot's specifications are almost the same with the previous model with some additional features such as reduce operating time per 1 cycle, can increase number of bins in the future, reduce space required for installing the robot, save energy from unnecessary light required for the camera by using a relay, more precise positioning control and more user friendly. Operating cycle concepts remain the same (Fig. 5) but the robot's mechanisms have been changed into a rotation of the tray instead of linear motion and limit switches for controlling the tray's positions instead of using IR sensors. In addition, The main actuators are a DC motors for rotating the tray and a servo motor for adjusting the slope of the lifting plate. The positions of the bins are below the robot, in front of the robot, at the left side of the robot and at the right side of the robot as shown in Fig. 6.

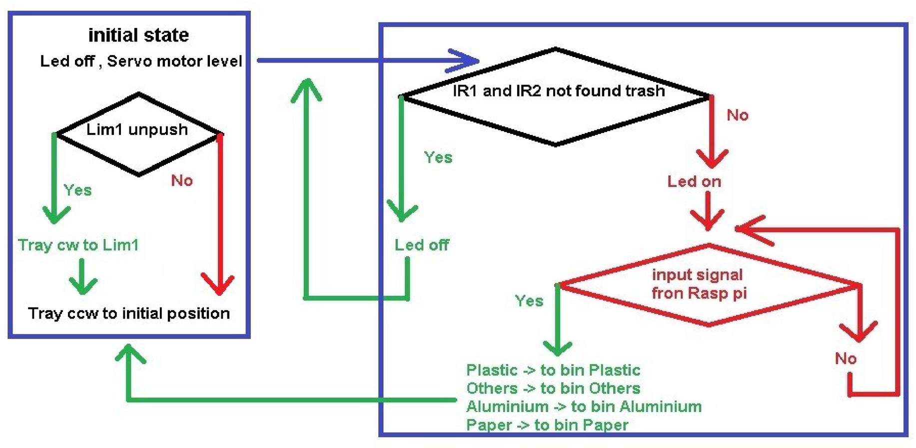

Fig. 5 Schematic of the program

Fig. 6 The actual operation of the robot

Results

Prototype 1 worked fine with it's specifications with some cons as follows:
1. One trash per one cycle only 2. The tray could hit with the dome causing undesired motion 3. Untidy wiring 4. Hard to move the robot 5. The trash receiver opened and closed dangerously 6. Maximum time per cycle was 30 second and 7. Hard to upgrade in the future

Prototype 2 worked fine with it's specifications with some improvement from the previous model as follows: 1. More accurate motion control 2. Smaller installing space 3. Faster operation (4.88 second per cycle in average) 5. More energy saving and 6. Can be upgraded in the future

The efficiency test in the prototype 2 was conducted to measure the accuracy of the separation system and the operating time per cycle. There were 4 sections which were divided into types of trash (aluminum, plastic, paper and others). Each section was divided into 3 thresholds which mean minimum percentages of the robot's confidence to put the target trash into the right bin. The results are shown in table 1, 2, 3 and 4.

Table 1 Efficiency of aluminum waste separation

60% threshold			70% threshold			80% threshold		
Type	confidence	Time (sec)	Type	confidence	Time (sec)	Type	confidence	Time (sec)
Can			Can			Can		
1	0.85	5.84	1	0.99	5.12	1	0.92	5.4
2	0.68	4.83	2	0.91 (plastic)	2.1	2	0.88	4.44
3	0.9	5.83	3	0.73	5.25	3	0.98	5.26
4	0.97	5.69	4	0.99	5.7	4	0.95	4.4
5	0.98	4.32	5	0.74	4.72	5	0.99	5.17
6	0.91	6.08	6	0.78 (plastic)	2.11	6	0.88	4.57
7	0.72 (paper)	5.49	7	0.93 (paper)	5.11	7	0.96	4.98
8	0.90 (paper)	4.58	8	0.79	6.16	8	0.95	5.31
9	0.94	5.15	9	0.99	5.5	9	0.94	6.09
10	0.91	5.29	10	0.83 (paper)	5.11	10	0.8	4.37
avg	0.8925	5.37875		0.871666667	5.4083333		0.925	4.999

Table 2 Efficiency of plastic waste separation

60% threshold			70% threshold			80% threshold		
PlasticBottle	confidence	Time (sec)	PlasticBottle	confidence	Time (sec)	PlasticBottle	confidence	Time (sec)
1	0.67	4.73	1	0.76	5.43	1	No	No
2	0.61	5.18	2	0.73	7.39	2	0.95	2.96
3	0.7	4.06	3	0.82	5.28	3	0.85	4.6
4	0.8	3.67	4	0.79	4.26	4	0.89	5.05
5	0.86	4.39	5	0.93	5.31	5	0.81	8.59
6	0.64	4.01	6	0.79	4.79	6	0.91	4.66
7	0.91	4.65	7	0.82 (can)	7.99	7	0.93	6.23
8	0.7	5.17	8	0.88	3.61	8	0.84	4.45
9	0.75	2.95	9	0.91	1.71	9	No	No
10	0.72	3.21	10	0.71	6.65	10	No	No
avg	0.736	4.202		0.813333333	4.9366667		0.882857143	5.22

Table 3 Efficiency of paper waste separation

60% threshold			70% threshold			80% threshold		
PaperCup	confidence	Time (sec)	PaperCup	confidence	Time (sec)	PaperCup	confidence	Time (sec)
1	0.98	6.73	1	0.82	7.28	1	0.99	5.7
2	0.98	6.02	2	0.98	6.09	2	0.97	6.62
3	0.84	6.13	3	0.97	5.11	3	0.93	5.98
4	0.61	4.72	4	0.72	5.45	4	0.98	6.88
5	0.99	6.41	5	0.99	6.2	5	0.99	6.09
6	0.97	6.2	6	0.98	6.03	6	0.99	5.84
7	0.98	6.42	7	0.9	5.84	7	0.89	6.09
8	0.99	6.49	8	0.93	5.97	8	0.83	6.28
9	0.94	6.48	9	0.84	5.8	9	0.99	5.76
10	0.92	5.68	10	0.99	6.36	10	0.99	5.7
avg	0.92	6.128		0.912	6.013		0.955	6.094

Table 4 Efficiency of other waste separation

60% threshold			70% threshold			80% threshold		
Others	confidence	Time (sec)	Others	confidence	Time (sec)	Others	confidence	Time (sec)
1	0.88	2.63	1	0.99 (paper)	3.74	1	No	No
2	0.81	3.22	2	0.71	5.04	2	No	No
3	0.68 (paper)	4.66	3	0.83	3.43	3	0.94	1.71
4	0.69 (plastic)	2.81	4	0.80 (paper)	3.73	4	No	No
5	0.92	2.76	5	No	No	5	0.87	2.43
6	0.97 (plastic)	2.57	6	0.76	3.28	6	No	No
7	0.85 (paper)	4.2	7	0.99 (paper)	5.5	7	No	No
8	0.95	3.35	8	No	No	8	0.97	2.5
9	0.96	3.73	9	0.98 (paper)	3.35	9	0.85	4.99
10	0.86	3.48	10	No	No	10	0.82	5.51
avg	0.896666667	3.195		0.766666667	3.9166667		0.89	3.428

In terms of accuracy in 60%, 70% and 80% threshold, aluminum had the accuracy of 8/10 6/10 and 10/10 respectively, plastic had the accuracy of 10/10, 9/10 and 7/10 respectively, paper had the accuracy of 10/10 in all thresholds and others had the accuracy of 6/10 3/10 and 5/10 respectively. It can be concluded from the results that the average operating time per cycle of the entire system was 4.88 second. The average operating time per cycle of aluminum, plastic, paper and others were 5, 4.85, 6.08 and 3.57 second respectively. In terms of threshold, 80% was suitable for aluminum as the other two had some errors identifying the object, 60% to 70% was suitable for plastic as the confidence rate sometimes didn't reach 80%. All thresholds were suitable for paper as there were no sign of errors and less than 60% was suitable for others as there were sign of errors in every thresholds.

Conclusion

Both prototype 1 and prototype 2 are acceptable in terms of the main objective of the project but Prototype 2 is better than the previous model in aspects mentioned in Results. However, both prototypes are not meet the requirements of the secondary objective.

References

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