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UNIVERSITI TEKNOLOGI MALAYSIA

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SCSJ 3553: ARTIFICIAL INTELLIGENCE

SECTION 11

PROJECT

SMART RECYCLING BIN

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Contents

1.0 AI Solution

In order to reduce pollution, slow global warming and reduce waste products in landfills because when we recycle, recyclable materials are reprocessed into new products, and as a result the amount of rubbish sent to landfill sites decreases which reduces emissions of methane, a powerful greenhouse gas. The world should practice recycling saves and conserves energy because it takes far less energy to reprocess recycled materials into new materials than to process virgin materials like more trees. Malaysians produce an average of 30,000 tons of waste every day. Only 5 percent of it is recycled hence the problem of poor waste management in Malaysia is one of the nation's biggest issues to date.

Feel responsible as Malaysian, we form our group to develop an artificial intelligence which can help each Malaysian to learn and manage their waste by separating them into five types of rubbish such as paper, plastic, glass, tins and other waste. We plan to implement this AI on a smart recycle bin where it can scan the rubbish and classify them into the rubbish type. Hence, we can avoid the unpleasant smell around the bin because all waste is mixed. The smart recycle bin also will indicate the volume of the recycle bin so users will notice it is already full or not. The indicator will show three states which are empty, half-full, and full. This method is very useful for clean work later.

2.0 Goal of AI Solution

1. To create an AI that can separate the rubbishes into five types which are paper, plastic, glass, tins and other waste.

2. Reduce the unpleasant smell around the bin.

3. Make cleaning work easier.

4. Enhance consciousness of citizens about recycling campaigns.

3.0 Process of Emphasize In DT

People nowadays are paying attention and their effort to take care of the environment. They start to not throw the rubbish everywhere, and even have the consciousness of recycling the garbage to protect the environment. There are a lot of recycling bins in the society. However, some of the people may not have the same consciousness as the majority, or they have some difficulties on garbage classification. Therefore, it is clear that there are two categories of users that face the stated issues, which are the user that cannot understand about the materials of garbage, and the user who lacks understanding about the information shown on the recycling bin. The issue is able to cause the user to throw the rubbish arbitrarily to any recycling bin. This situation disobeys the aim of putting recycling bins which are enhancing the recycle consciousness, and classifying the garbage accordingly. A solution should be come out with to ensure that the two users that are facing the problem are able to carry out their roles to throw the garbage to a correct recycling bin.

The first situation, the user is difficult to understand the made up materials of the garbage. For example, garbage can be made up of paper and plastic at different parts. At that point, they started to confuse which recycling bin that they should throw. Consequently, they will throw the garbage randomly to either paper or plastic recycling bins. Secondly, some users are lacking understanding about the information shown on the recycling bin, especially the children and teenagers. This group of users are lacking information about the function of each type of recycling bin. Thus, the innocent user will throw the garbage into any recycling bin as they think all types of bin are the same.

The users are looking forward to an alternative solution to solve their problem. They will be glad to use a recycling bin that has the functionality to guide them where the garbage should throw. The guidance system of the recycling bin will be able to help them to make the decision on where they should choose the garbage.

With the guidance system, the user will be able to learn and understand more on how the garbage should be classified, at the same time, the recycle consciousness of the user enhanced.

In conclusion, the user wants to be able to throw the garbage without thinking much to decide which recycling bin they should throw the garbage. They think that the garbage disposal step should be much easier without having tough decisions. Therefore, it is important to

develop a smart recycling bin with the features of identifying the materials of garbage, as well as navigate the user on which recycling bin they should throw their garbage. This will ensure that our environment can be protected in a more effective way.

3.1 Summary of Users

Lack of knowledge on the material to be discarded:

- Confuse due to various materials on garbage
- Different parts of the garbage can be made up of different materials
- Do
    - Throw garbage into any related material recycling bin

Lack of understanding on information displayed on recycle bin:

- Happened especially on teenagers and children
- Lack of knowledge on the function of each type of trash can
- Do
    - Throw garbage into one of the recycling bins randomly

4.0 Process of Defined In DT

According to the descriptions of people at different levels in modern society, most of them face the problem of not knowing how to sort garbage. They are confused about the types and materials of the garbage, and then they give up sorting or throw away the garbage at will. There are actually many types of garbage, and other substances in garbage can also be converted into resources. If humans throw all the garbage together without sorting, those "resources" that can be recycled and reused will be regarded as "garbage". A large amount of unsorted garbage will cause environmental pollution, and over time will also pose a threat to human health. Therefore, in order to allow people to respond to environmental protection and contribute to the society, the AI system can help people sort the recyclable garbage by scanning the material of the garbage. People can scan the garbage through the AI scanner, and the smart recycle bin will open the corresponding recycle bin lid by distinguishing the garbage materials so that people can throw the garbage into the correct recycle bin. Thus, people no longer have to worry about wrong garbage classification.

4.1 Summary Needs of User

Lack of knowledge on the material to be discarded	**Lack of understanding on information displayed on recycle bin**
● Confuse due to various materials on garbage ● Different parts can be made up of paper or plastics	● Happened especially on teenagers and children ● Lack of knowledge on the function of each type of trash can
● Needs: 1. Helping to identify the material of garbage 2. Helping to sort the recyclable garbage	● Needs: 1. Helping to choose which type of recycle bin to use 2. Guiding users classifying the type of garbage

5.0 Knowledge Representation

5.1 Problem

Current Situation

It is common to see the recycling bin placed in the public area. The aim of placing the recycling bin is to enhance the awareness of the public on recycling. The thing behind the scene is, the recycled rubbish will be processed by the recycling and reuse industry. However, there are the problems for the user to do recycling contribution, which are the difficulties to understand the information shown on the recycling bin and the made-up material of the garbage.

Figure 1 Insufficient information shown on the recycling bin

Figure 2 The recycling bin that have the contradiction in terms of information shown

In Figure 1, the recycling bin uses the colour to classify the recycle garbage materials. It is insufficient information for the user who does not have enough awareness to recognize each functionality of the recycling bin, especially for the person who does not have the recycling practice before. This situation becomes a challenge for them to choose the bin to put their garbage in. At the same time, the information that displayed on the recycling bin can be contradicting as Figure 2. In the figure, there are 4 types of the recycling bin which are paper, plastic, glass, and bottle. The situation can be contradicting the user when they want to throw a bottle which is made up of plastic materials. Thus, the recycling bin needs a clear guideline to indicate which recycling bin for users to throw their rubbish.

Figure 3 The garbage which made up of plastic and paper

Figure 4 The bottle which made up of the paper and plastic

Next, the user faces the difficulties of identifying the materials of the garbage. Take the example from Figure 3, the cover of a mobile battery can be composed of plastic and paper. Therefore, the user tends to throw the garbage to either the plastic or paper recycling bin. The same situation occurs as shown in Figure 4, the bottle is made up of the paper and plastic. Thus, it makes the ambiguity situation for the user to throw the garbage. In order to solve this situation, the recycling bin needs to have a feature to identify the materials of the garbage.

Suggested Solution

In order to solve the problem, we proposed a solution which is a smart recycling bin. The smart recycling bin should have 2 important features, which are recognize the materials of the garbage and guide the user of the bin to throw the garbage.

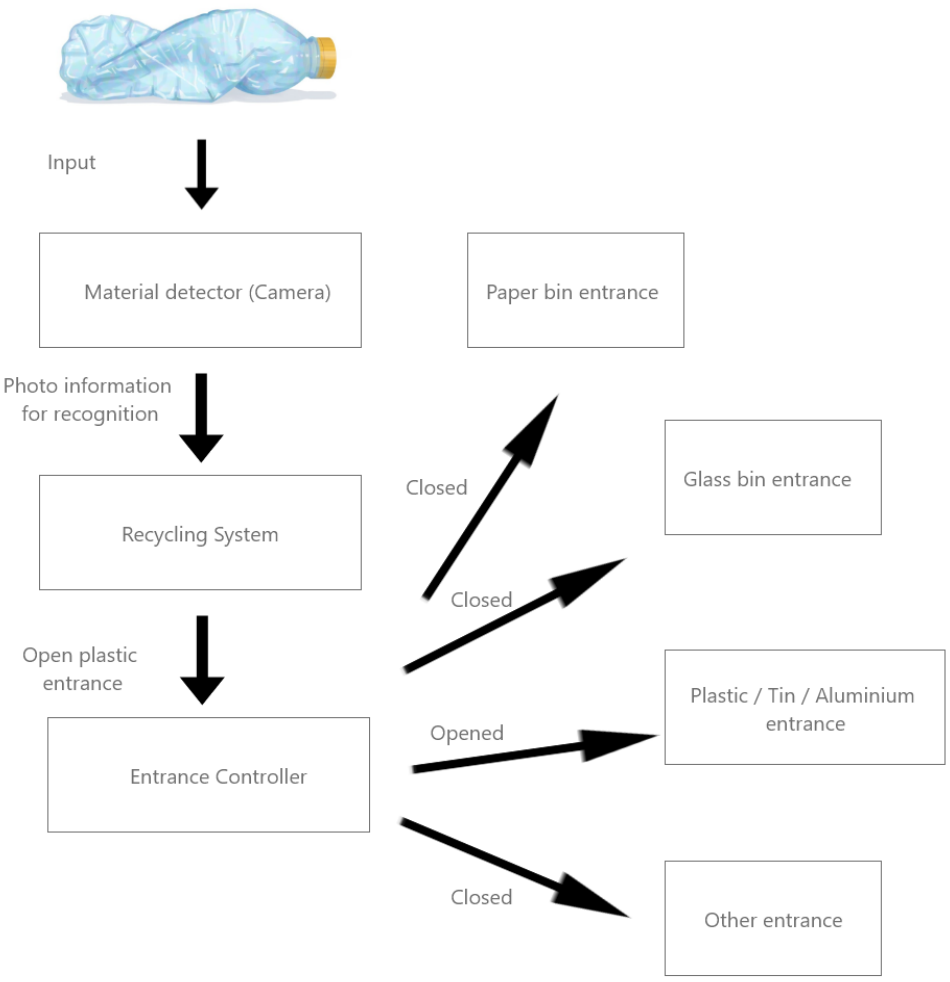


Figure 5 Work operation of smart recycling bin

Figure 5 shows the workflow of the smart recycling bin. A material detector is required to recognize the material of the garbage. A camera can be acted as a material detector. When the user places the garbage in front of the camera, the camera starts to capture the details and data of the garbage. After the camera captures the image of the garbage, the result will be sent to the recycling bin system to recognize the material of the garbage. Then, the recycling system will have sent the signal to the slot entrance controller to open the related bin for the user to throw the garbage. After the user throws the rubbish, the slot entrance closes again.

The smart recycling bin has 4 slots to classify the recycle material, which are

Slot	**Materials**
Blue slot	Paper
Brown slot	Glass
Orange slot	Aluminum / tin / plastic
Green slot	The garbage which cannot be classified into blue, brown, and orange slots.

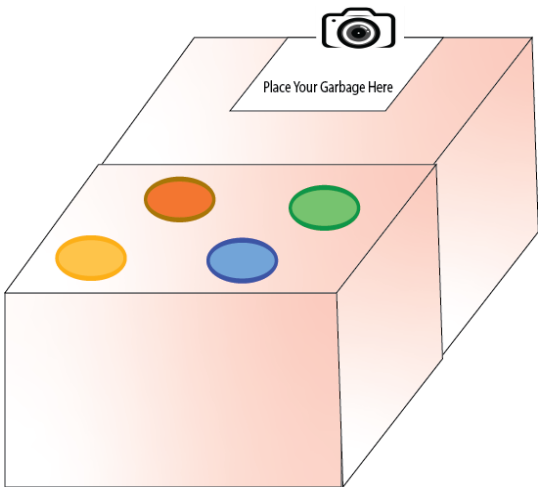


Figure 6 Prototype of the smart recycling bin

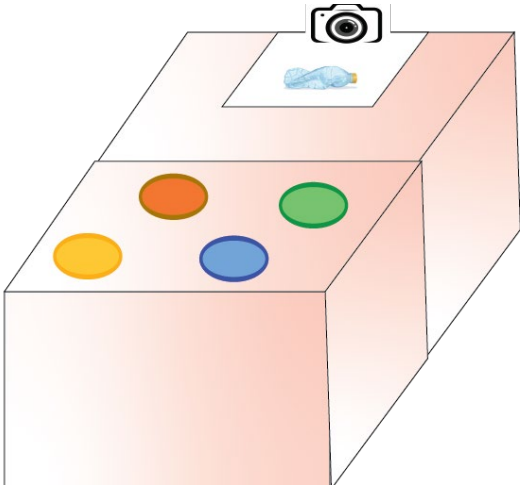


Figure 7 Place the garbage in front of the camera

Initially, the smart recycling garbage waits for the user to place the garbage in front of the camera for data collection. All of the slots closed to prevent the user from throwing the garbage to the wrong slot. In Figure 7, a garbage placed in front of the camera and the camera starts to collect the image of the bottle as the input. Thus, it is able to solve the problem for the identification of the garbage material.

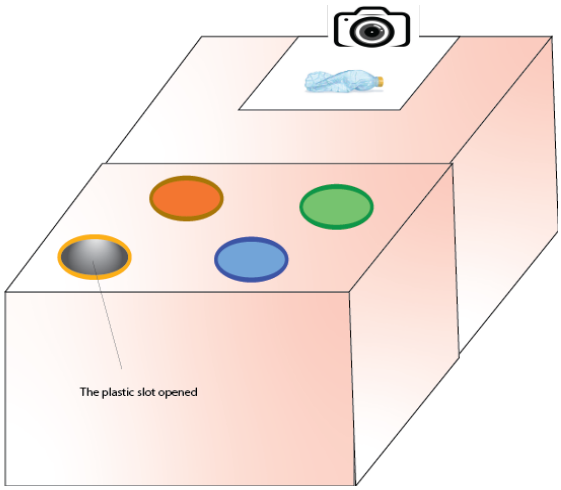


Figure 8 Only the related slot will be opened, other slots closed

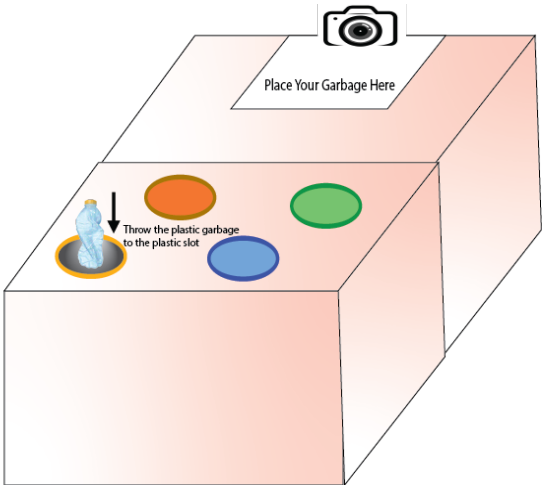


Figure 9 User throw the garbage to the related slot

After the plastic is recognized by the machine, the entrance controller will open the related slot of the recycling bin for the user to throw the garbage as shown in Figure 8. Therefore, users do not need to be confused about which slot or bin they should put as only the related slot will be opened.

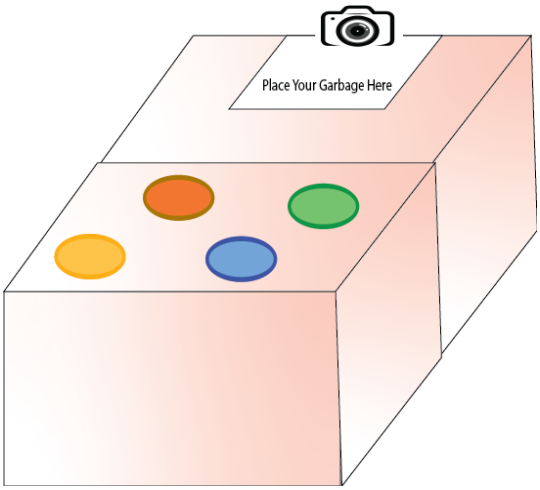


Figure 10 After the garbage thrown, the slot closed again

After the garbage is thrown, the slot will be closed again and back to its initial stage.

5.2 Knowledge Representation (KR)

Material_Detector (Camera), F			Capacity_Detector, CD	Respond_Of_Recycling_Bin, R
F = Paper (P)	F = Glass (G)	F = Plastic/Tin/Aluminium (PTA)		
0	0	0	0	No Respond
			1	No Respond
0	0	1	0	No Respond
			1	Orange Lid Open
0	1	0	0	No Respond
			1	Brown Lid Open
0	1	1	0	No Respond
			1	Green Lid Open
1	0	0	0	No Respond
			1	Blue Lid Open
1	0	1	0	No Respond
			1	Green Lid Open
1	1	0	0	No Respond
			1	Green Lid Open
1	1	1	0	No Respond
			1	Green Lid Open

KR 1:

IF (F=P) = **FALSE AND** (F=G) = **FALSE AND** (F=PTA) = **FALSE AND** CD=**FALSE THEN** R=**No Respond**

KR 2:

IF (F=P) = **FALSE AND** (F=G) = **FALSE AND** (F=PTA) = **FALSE AND** CD=**TRUE THEN** R=**No Respond**

KR3:

IF (F=P) = **FALSE AND** (F=G) = **FALSE AND** (F=PTA) = **TRUE AND** CD=**FALSE THEN** R=**No Respond**

KR4:

IF (F=P) = **FALSE AND** (F=G) = **FALSE AND** (F=PTA) = **TRUE AND** CD=**TRUE THEN** R=**Orange Lid Open**

KR5:

IF (F=P) = **FALSE AND** (F=G) = **TRUE AND** (F=PTA) = **FALSE AND** CD=**FALSE THEN** R=**No Respond**

KR6:

IF (F=P) = **FALSE AND** (F=G) = **TRUE AND** (F=PTA) = **FALSE AND** CD=**TRUE THEN** R=**Brown Lid Open**

KR7:

IF (F=P) = **FALSE AND** (F=G) = **TRUE AND** (F=PTA) = **TRUE AND** CD=**FALSE THEN** R=**No Respond**

KR8:

IF (F=P) = **FALSE AND** (F=G) = **TRUE AND** (F=PTA) = **TRUE AND** CD=**TRUE THEN** R=**Green Lid Open**

KR9:

IF (F=P) = **TRUE AND** (F=G) = **FALSE AND** (F=PTA) = **FALSE AND** CD=**FALSE THEN** R=**No Respond**

KR10:

IF (F=P) = **TRUE AND** (F=G) = **FALSE AND** (F=PTA) = **FALSE AND** CD=**TRUE THEN** R=**Blue Lid Open**

KR11:

IF (F=P) = **TRUE AND** (F=G) = **FALSE AND** (F=PTA) = **TRUE AND** CD=**FALSE THEN** R=**No Respond**

KR12:

IF (F=P) = **TRUE AND** (F=G) = **FALSE AND** (F=PTA) = **TRUE AND** CD=**TRUE THEN** R=**Green Lid Open**

KR13:

IF (F=P) = **TRUE AND** (F=G) = **TRUE AND** (F=PTA) = **FALSE AND** CD=**FALSE THEN** R=**No Respond**

KR14:

IF (F=P) = **TRUE AND** (F=G) = **TRUE AND** (F=PTA) = **FALSE AND** CD=**TRUE THEN** R=**Green Lid Open**

KR15:

IF (F=P) = **TRUE AND** (F=G) = **FALSE AND** (F=PTA) = **FALSE AND** CD=**FALSE THEN** R=**No Respond**

KR16:

IF (F=P) = **TRUE AND** (F=G) = **TRUE AND** (F=PTA) = **TRUE AND** CD=**TRUE THEN** R=**Green Lid Open**

5.3 Explanation of KR

KR1: When the material detector does not detect any garbage made of either paper or glass or plastic or tin or aluminium, and the capacity of the recycling bin is full, the recycling bin has no response and remains closed.

KR2: When the material detector does not detect any garbage made of either paper or glass or plastic or tin or aluminium, and the capacity of the recycling bin is empty, the recycling bin has no response and remains closed.

KR3: When the material detector detects the garbage made of plastic or tin or aluminium, and the capacity of the recycling bin is full, the recycling bin has no response and remains closed.

KR4: When the material detector detects the garbage made of plastic or tin or aluminium, and the capacity of the recycling bin is empty, the orange lid of the recycling bin will open.

KR5: When the material detector detects the garbage made of glass, and the capacity of the recycling bin is full, the recycling bin has no response and remains closed.

KR6: When the material detector detects the garbage made of glass, and the capacity of the recycling bin is empty, the brown lid of the recycling bin will open.

KR7: When the material detector detects garbage made of two or more materials (glass and plastic or tin or aluminium), and the capacity of the recycling bin is full, the recycling bin has no response and remains closed.

KR8: When the material detector detects garbage made of two or more materials (glass and plastic or tin or aluminium), and the capacity of the recycling bin is empty, the green lid of the recycling bin will open.

KR9: When the material detector detects the garbage made of paper, and the capacity of the recycling bin is full, the recycling bin has no response and remains closed.

KR10: When the material detector detects the garbage made of paper, and the capacity of the recycling bin is empty, the blue lid of the recycling bin will open.

KR11: When the material detector detects garbage made of two or more materials (paper and plastic or tin or aluminium), and the capacity of the recycling bin is full, the recycling bin has no response and remains closed.

KR12: When the material detector detects garbage made of two or more materials (paper and plastic or tin or aluminium), and the capacity of the recycling bin is empty, the green lid of the recycling bin will open.

KR13: When the material detector detects garbage made of two or more materials (paper and glass), and the capacity of the recycling bin is full, the recycling bin has no response and remains closed.

KR14: When the material detector detects garbage made of two or more materials (paper and glass), and the capacity of the recycling bin is empty, the green lid of the recycling bin will open.

KR15: When the material detector detects garbage made of two or more materials (paper and glass and plastic or tin or aluminium), and the capacity of the recycling bin is full, the recycling bin has no response and remains closed.

KR16: When the material detector detects garbage made of two or more materials (paper and glass and plastic or tin or aluminium), and the capacity of the recycling bin is empty, the green lid of the recycling bin will open.

5.4 First Order Logic (FOL)

KR1:

$\forall x \forall y ((material\_detector(x) \land \neg(material\_camera(x) = P) \land \neg(material\_camera(x) = G) \land \neg(material\_camera(x) = PTA)) \land (capacity(y) = 100\%)) \rightarrow \exists z (recyle\_bin(z) \land no\_response(z))$

KR2:

$\forall x \forall y ((material\_detector(x) \land \neg(material\_camera(x) = P) \land \neg(material\_camera(x) = G) \land \neg(material\_camera(x) = PTA)) \land \neg(capacity(y) = 100\%)) \rightarrow \exists z (recyle\_bin(z) \land no\_response(z))$

KR3:

$\forall x \forall y ((material\_detector(x) \land \neg(material\_camera(x) = P) \land \neg(material\_camera(x) = G) \land (material\_camera(x) = PTA)) \land (capacity(y) = 100\%)) \rightarrow \exists z (recyle\_bin(z) \land no\_response(z))$

KR4:

$\forall x \forall y ((material\_detector(x) \land \neg(material\_camera(x) = P) \land \neg(material\_camera(x) = G) \land (material\_camera(x) = PTA)) \land \neg(capacity(y) = 100\%)) \rightarrow \exists z (recyle\_bin(z) \land orange\_lid(z))$

KR5:

$\forall x \forall y ((material\_detector(x) \land \neg(material\_camera(x) = P) \land \neg(material\_camera(x) = G) \land (material\_camera(x) = PTA)) \land (capacity(y) = 100\%)) \rightarrow \exists z (recyle\_bin(z) \land no\_response(z))$

KR6:

∀x∀y ((material_detector (x) ∧ ¬(material_camera(x) = P) ∧ (material_camera(x) = G) ∧ ¬(material_camera(x) = PTA)) ∧ ¬(capacity(y) = 100%)) → ∃z (recyle_bin(z) ∧ orange_lid(z))

KR7:

∀x∀y ((material_detector (x) ∧ ¬(material_camera(x) = P) ∧ (material_camera(x) = G) ∧ (material_camera(x) = PTA)) ∧ (capacity(y) = 100%)) → ∃z (recyle_bin(z) ∧ no_response(z))

KR8:

∀x∀y ((material_detector (x) ∧ ¬(material_camera(x) = P) ∧ (material_camera(x) = G) ∧ (material_camera(x) = PTA)) ∧ ¬(capacity(y) = 100%)) → ∃z (recyle_bin(z) ∧ green_lid(z))

KR9:

∀x∀y ((material_detector (x) ∧ (material_camera(x) = P) ∧ ¬(material_camera(x) = G) ∧ ¬(material_camera(x) = PTA)) ∧ (capacity(y) = 100%)) → ∃z (recyle_bin(z) ∧ no_response(z))

KR10:

∀x∀y ((material_detector (x) ∧ (material_camera(x) = P) ∧ ¬(material_camera(x) = G) ∧ ¬(material_camera(x) = PTA)) ∧ ¬(capacity(y) = 100%)) → ∃z (recyle_bin(z) ∧ blue_lid(z))

KR11:

∀x∀y ((material_detector (x) ∧ (material_camera(x) = P) ∧ ¬(material_camera(x) = G) ∧ (material_camera(x) = PTA)) ∧ (capacity(y) = 100%)) → ∃z (recyle_bin(z) ∧ no_response(z))

KR12:

$\forall x \forall y ((material\_detector(x) \wedge (material\_camera(x) = P) \wedge \neg(material\_camera(x) = G) \wedge (material\_camera(x) = PTA)) \wedge \neg(capacity(y) = 100\%)) \rightarrow \exists z (recyle\_bin(z) \wedge green\_lid(z))$

KR13:

$\forall x \forall y ((material\_detector(x) \wedge (material\_camera(x) = P) \wedge (material\_camera(x) = G) \wedge \neg(material\_camera(x) = PTA)) \wedge (capacity(y) = 100\%)) \rightarrow \exists z (recyle\_bin(z) \wedge no\_response(z))$

KR14:

$\forall x \forall y ((material\_detector(x) \wedge (material\_camera(x) = P) \wedge (material\_camera(x) = G) \wedge \neg(material\_camera(x) = PTA)) \wedge \neg(capacity(y) = 100\%)) \rightarrow \exists z (recyle\_bin(z) \wedge green\_lid(z))$

KR15:

$\forall x \forall y ((material\_detector(x) \wedge (material\_camera(x) = P) \wedge (material\_camera(x) = G) \wedge (material\_camera(x) = PTA)) \wedge (capacity(y) = 100\%)) \rightarrow \exists z (recyle\_bin(z) \wedge no\_response(z))$

KR16:

$\forall x \forall y ((material\_detector(x) \wedge (material\_camera(x) = P) \wedge (material\_camera(x) = G) \wedge (material\_camera(x) = PTA)) \wedge \neg(capacity(y) = 100\%)) \rightarrow \exists z (recyle\_bin(z) \wedge green\_lid(z))$

5.5 Explanation of KR That Solved the Goal

1. The first goal is to create an AI that is able to separate the garbage into certain types which are paper, plastic/tin/aluminium, glass, and unclassified garbage. This is done by manipulating Respond_Of_Recycling_Bin, R that depends on two variables which are Material_Detector (Camera), F to detect the material of the garbage and Capacity_Detector, CD for detecting the capacity of the bin.

   If the material recognized is paper and the bin is empty, then the Respond_Of_Recycling_Bin will open the blue lid. If the material recognized is plastic and the bin is empty, then the Respond_Of_Recycling_Bin will open the orange lid. If the material recognized is glass and the bin is empty, then the Respond_Of_Recycling_Bin will open the brown lid. If the material recognized consists of multiple materials and the bin is empty, then the Respond_Of_Recycling_Bin will open the green lid. However, if the bin is full, there will be no response from the bin.

2. Reduce the unpleasant smell around the bin by preventing the bin from open when it is full to ensure users do not throw garbage into a full bin. KR1, KR3, KR5, KR7, KR9, KR11, KR13, and KR15 shows that whenever the capacity of the bin is empty which is CD = FALSE.

3. Make cleaning work easier by separating recyclable waste and waste to be disposed of, so the waste collector can easily collect the non-recyclable waste. KR8, KR12, KR14, KR16 shows that garbage with multiple materials or non-recyclable materials will be thrown into a green bin.

4. Increase awareness of people about recycling campaigns by guiding users to dispose of the garbage according to the right bin, so people gain information on the materials of the garbage and the right colour of bin to throw it. KR4, KR6, KR8, KR10, KR12, KR14, and KR16 shows that the lid will be open according to the material of the garbage.

6.0 State Space Search

6.1 Details of State and Action

1st State: Material detector will detect whether there is any garbage material or not. If no any material is detected, the recycling bin has no response and remains closed.

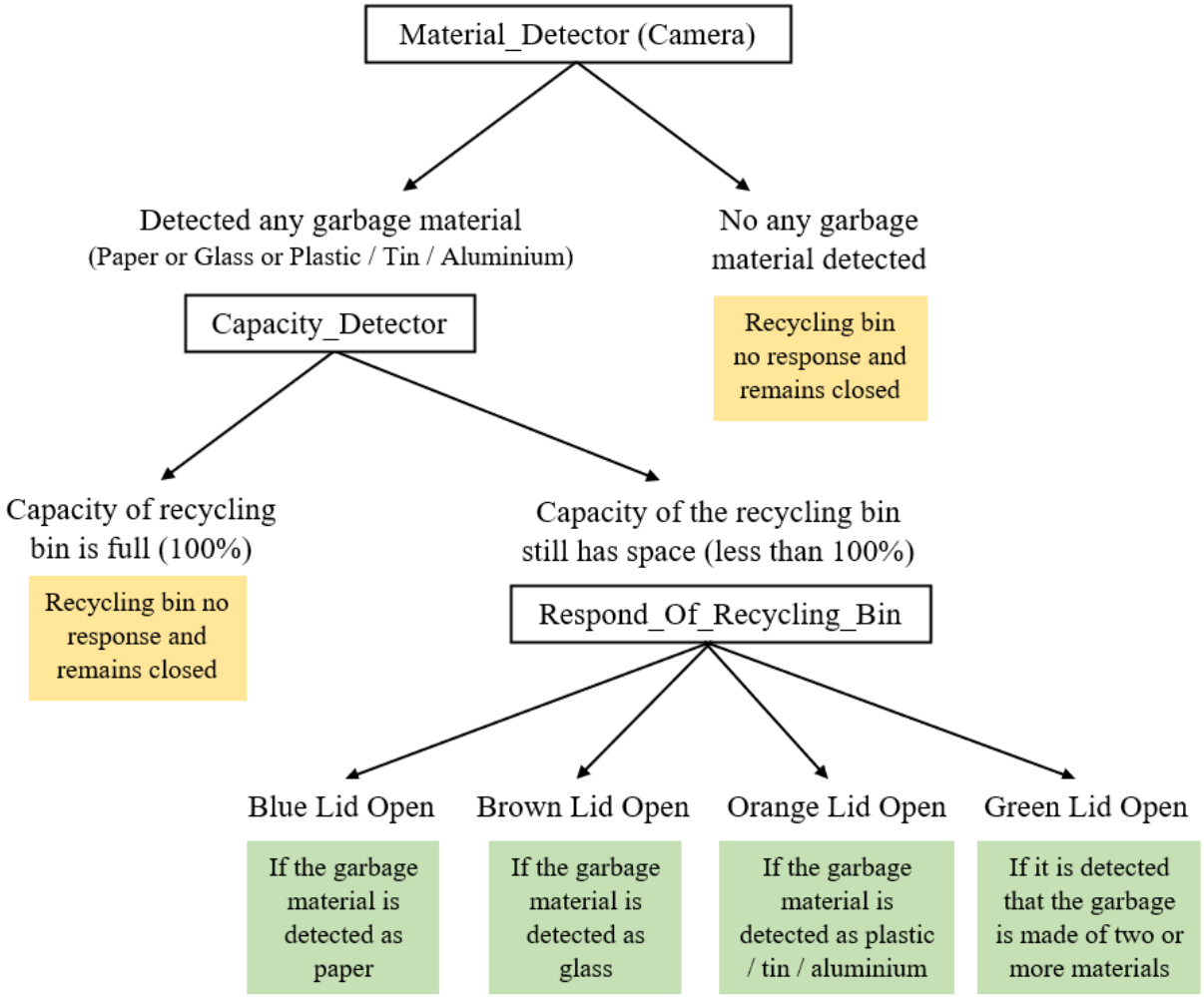
2nd State: Material detector will detect whether the material of garbage is paper or glass or plastic/tin/aluminium or the garbage is made of two or more materials.

3rd State: After checking the material of garbage, the capacity detector will detect whether the capacity of the recycling bin is full or not. If the capacity of the recycling bin is full, the recycling bin has no response and remains closed.

4th State: After checking that the capacity of the recycling bin still has space, the lid of the recycling bin will open.

- If the garbage material is detected as paper, then the blue lid of the recycling bin will open.
- If the garbage material is detected as glass, then the brown lid of the recycling bin will open.
- If the garbage material is detected as plastic or tin or aluminium, then the orange lid of the recycling bin will open.
- If it is detected that the garbage is made of two or more materials, the green lid of the recycling bin will open.

Overview Action Graph



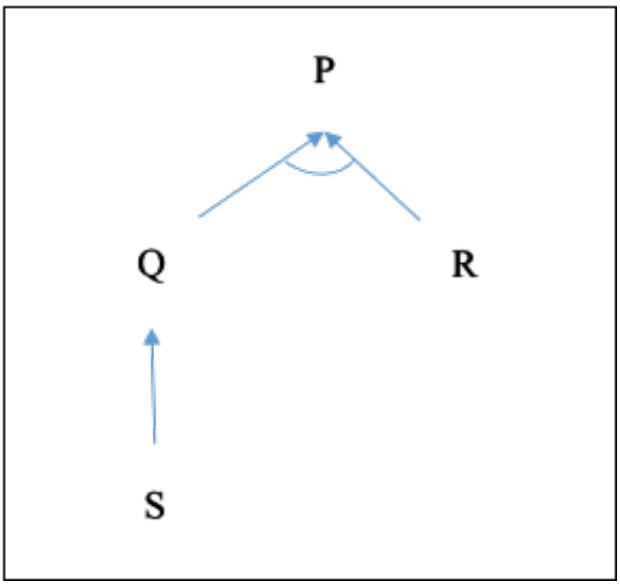
6.2 Hypergraph

P = Recycle bin have no response

Q = Capacity detector notice capacity < 100%

R = Material detector did not notice any material

S = Current Recycle bin have no response

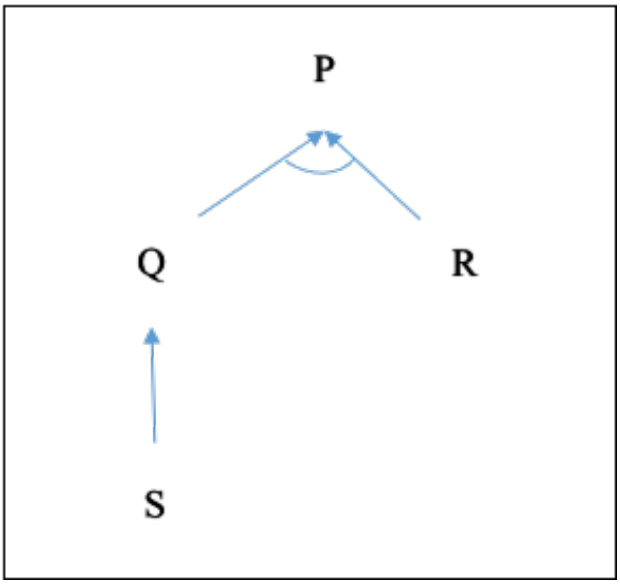


P = Recycle bin have no response

Q = Capacity detector notice capacity = 100%

R = Material detector notice any material (Paper/Glass/PTA)

S = Current Recycle bin have no response

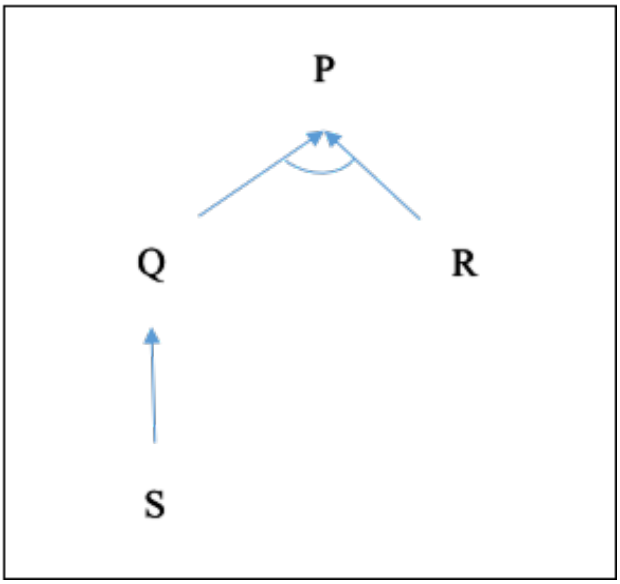


P = Recycle bin open Paper slot

Q = Capacity detector notice capacity < 100%

R = Material detector notice any Paper material

S = Current Recycle bin have no response

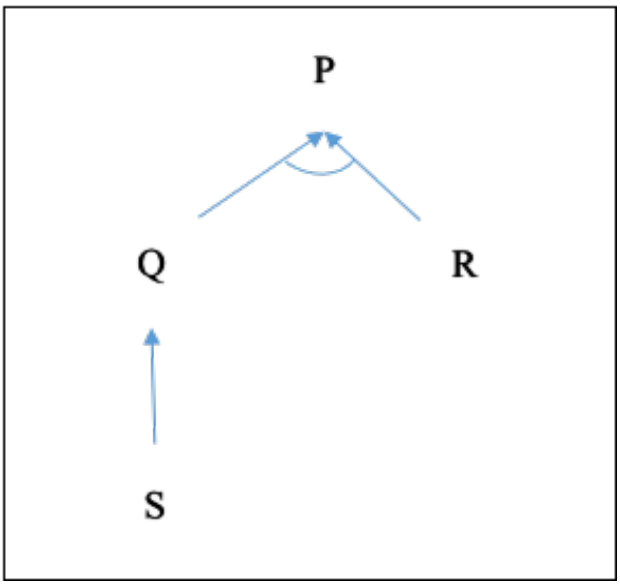


P = Recycle bin open Glass slot

Q = Capacity detector notice capacity < 100%

R = Material detector notice any Glass material

S = Current Recycle bin have no response

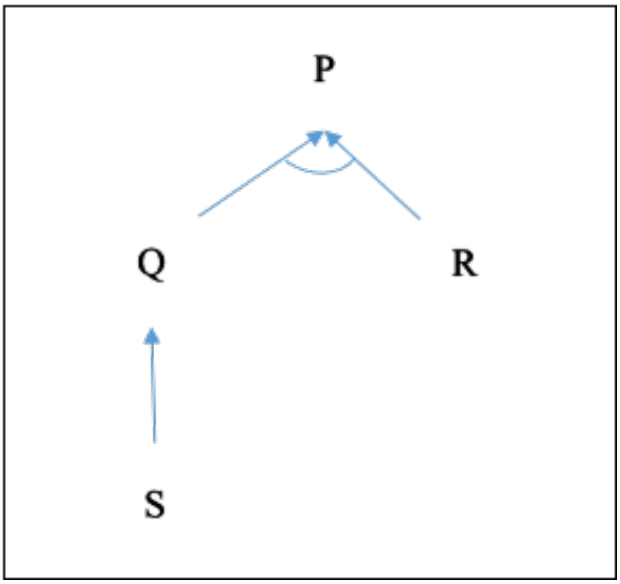


P = Recycle bin open PTA slot

Q = Capacity detector notice capacity < 100%

R = Material detector notice any PTA(Plastic/Tin/Aluminium) material

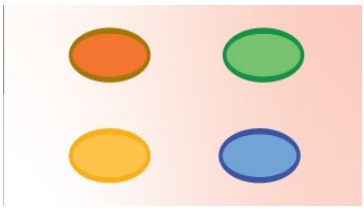
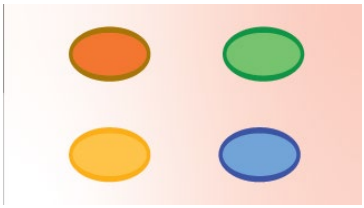
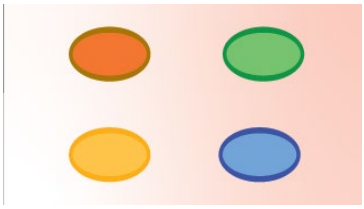
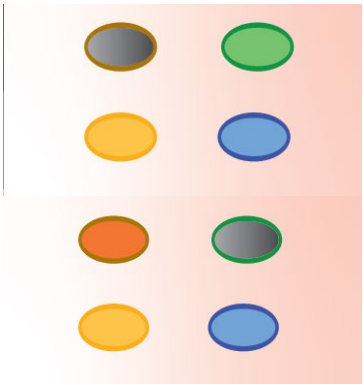
S = Current Recycle bin have no response

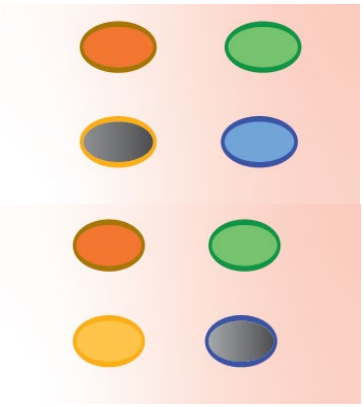


6.3 Problem Formulation

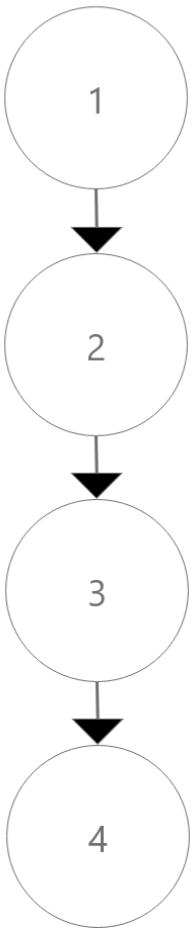
1. Initial State: The entrance slot of the recycling bin closed.
2. Action: The entrance slot of the recycling opened and remains closed.
3. Goal: The garbage thrown into the recycling bin based on its materials.
4. Path Cost: 1 unit per action.

6.3.1 Table of Problem Formulation

No.	Correspond KRs	Material Detector	Capacity Detector	Action
1.	KR1	 Not detected	 Full	 Closed
2.	KR2	 Not detected	 Empty / Not fully occupied	 Closed
3.	KR3, KR5, KR7, KR9, KR11, KR13, KR15	 Detected	 Full	 Closed
4.	KR4, KR6, KR8, KR10, KR12, KR14, KR16	 Detected	 Empty / Not fully occupied	

				 One of the slots opened.

6.4 Sequence of Actions Leading from Initial State to Goal State



Initial State: All of the entrance slots closed

Goal: 1 of the slot opened to throw the garbage

6.5 Explanation of Formulate Problem to Support the Proposed KR

Based on the table of the problem.

1. The entrance slot will not be opened if there is no material detected by the material detector and the capacity detector detected full in the bin as shown in KR1.

2. The entrance slot will not be opened if there is no material detected by the material detector although the capacity detector detected empty or not fully occupied in the bin as shown in KR2.

3. Material detector detected a material, however, the capacity detector detected that the bin was full. The entrance slot will not be opened as shown in KR3. KR5, KR7, KR9, KR11, KR13, and KR15.

4. The entrance slot will open one slot according to the type of the material detected by the material detector and the capacity detector detected the selected bin is empty or not fully occupied. The situations are shown in KR4, KR6, KR8, KR10, KR12, KR14, and KR16.

7.0 PEAS Model

7.1 Formulate the Solution by Using PEAS Model

	Before Applying Smart Recycling Bin	**After** Applying Smart Recycling Bin
P: Performance Measure	• It is difficult for users to understand the information displayed on the recycling bin. • It is difficult for users to identifying the materials of the garbage.	Recycling bin recognize the materials of the garbage automatically and guide the user of the bin to throw the garbage.
E: Environment	• The user randomly throws the garbage into the recycling bin, and does not decide which related recycling bin should be thrown into based on the garbage material. • Failed to achieve the effect of garbage classification.	• Prevent the user from throwing the garbage to the wrong slot. • Users do not need to be confused about which slot or bin they should put as only the related slot will be opened.
A: Actuators/Effectors	The recycling bin does not work automatically, users need to select the relevant recycling bin and open it by themselves.	The recycling bin will work automatically when any material of garbage was detected and the capacity of recycling bin still has space.

S: Sensors	No sensor detects any garbage material and the space of the recycling bin.	• Material detector detect whether the material of garbage is paper or glass or plastic/tin/aluminium or the garbage is made of two or more materials. • Capacity detector detect the available space of the recycling bin. • If the material detector (camera) detects garbage materials, and the capacity detector detects that the capacity of the recycling bin still has space, the relevant recycling bin lid will be opened.

7.2 PEAS Model

Agent: Material recognizer

Performance measure: Accuracy of garbage material classification

- A material recognizer in smart recycling bin system able to guide the user for the garbage classification.
- The probability of the garbage material being thrown by user to the correct slot is improved.

Environment: Garbage, a well-lit environment

- The material detector or the camera operated when the garbage involved.
- A well-lit environment will improve the quality of the garbage recognition by the camera.

Actuators: Recycling bin slot

- There are 4 recycling bin slots will take action based on the signal provided by the agent. The action of the recycling bin slot will be either remain closed, brown slot opened, green slot opened, orange slot opened or blue slot opened.

Sensors: Camera, capacity detector.

- Camera will capture and analyze the image content.
- Capacity detector will detect the current capacity of the recycling bin, either it is fully filled or remain empty space.

7.2.1 PEAS Model Diagram

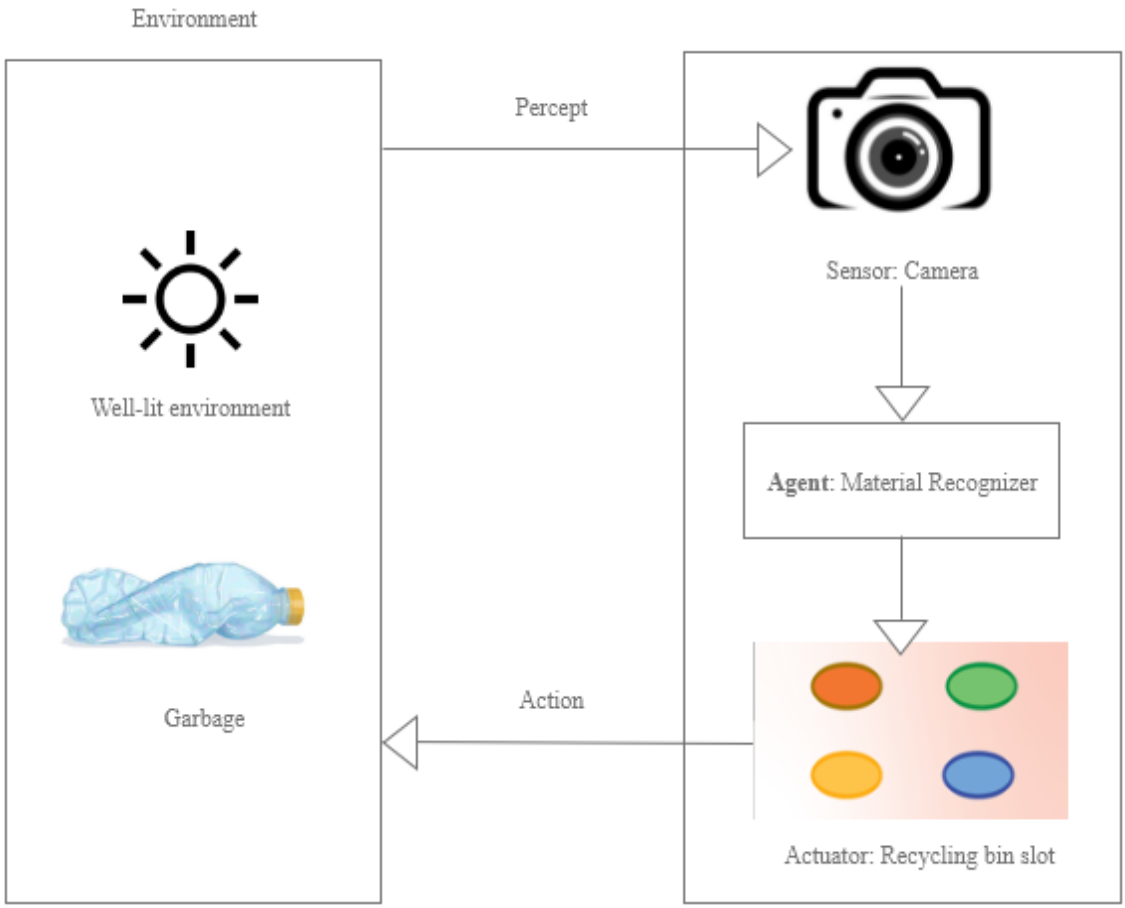


Figure 11 PEAS Model Diagram

7.2.2 Property Representation in Proof of Concept (POC)

How every element will be present in POC?

Performance

- The goal is to improve on classification of the garbage based on its material. After implementing A.I, it is expected to be able to guide user on classifying the garbage. This also improves the probability on throwing the garbage into the correct slot.

Environment

- Garbage model will be used to show to operation of the material detector and the camera. The agent will be placed in well-lit environment to improve on the quality of the garbage recognition by the camera.

Actuator

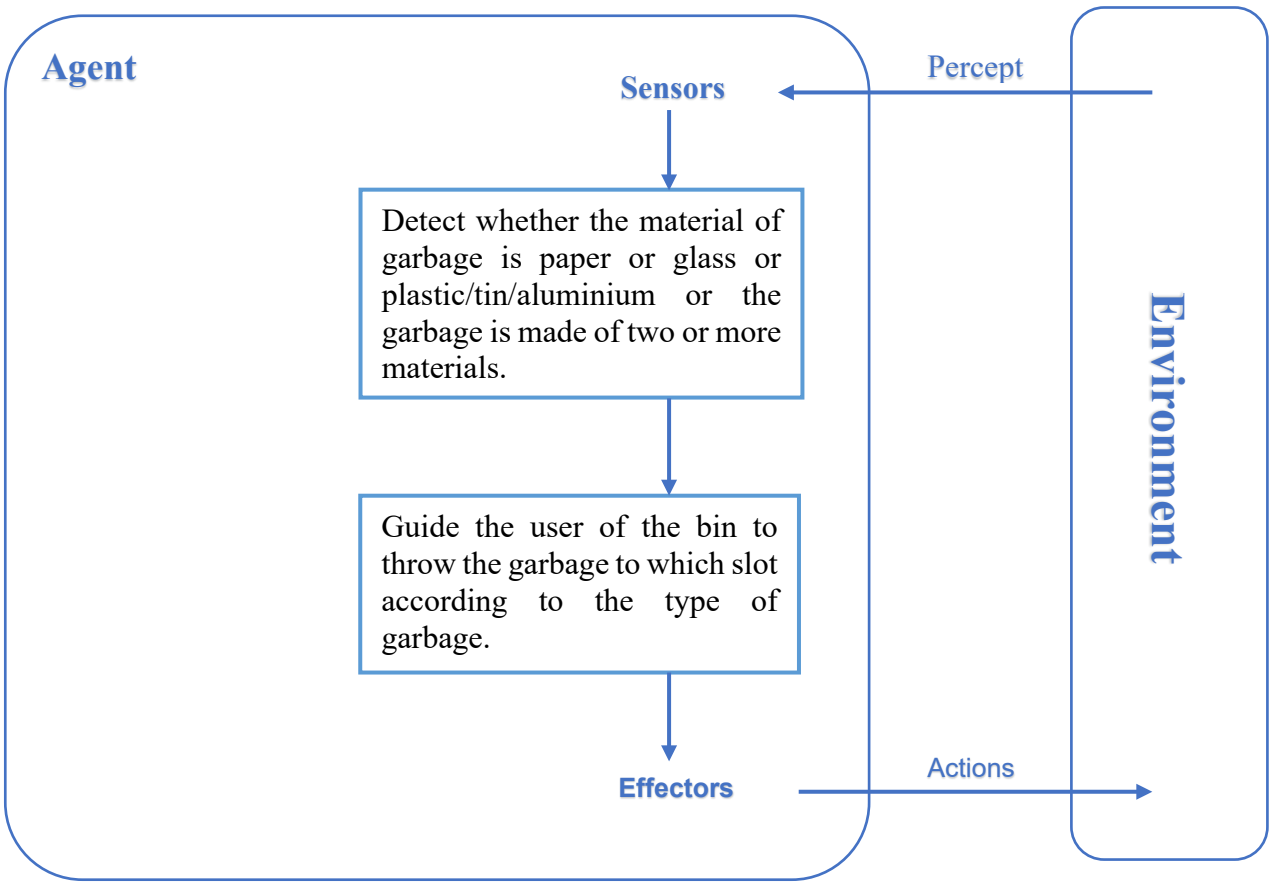
- The action that will be shown is whether the recycling bin slot remain closed or one of the four slots which are brown, green, orange, or blue slot will be opened. These actions are determined by the type of material detected on the garbage and the condition of the capacity of the slot. A simulation will be prepared for POC to show the classification of garbage.

Sensors

- The image content detected from the material and the current capacity detected in the slot will be used as input data for garbage classification. A simulation will be used to show the situation when data input was received.

7.3 Explanation of The Behaviour of The Agent to Achieve the Goal

The agent for this material organizer is a simple reflex agent because it takes an action based on only the current environment situation. There are various types of garbage such as plastic/tin/aluminium, glass and paper. So, the agent will identify the material of garbage using the sensors they have and detect the environment to differentiate the garbage. After that, the actuators will move and take action by selecting the recycling bin using his knowledge that has been implemented according to the condition rules.



8.0 Proof of Concept

8.1 Problem Formulation

Smart Recycling Bin has an initial state and changes to many other states based on the material detector and capacity detector.

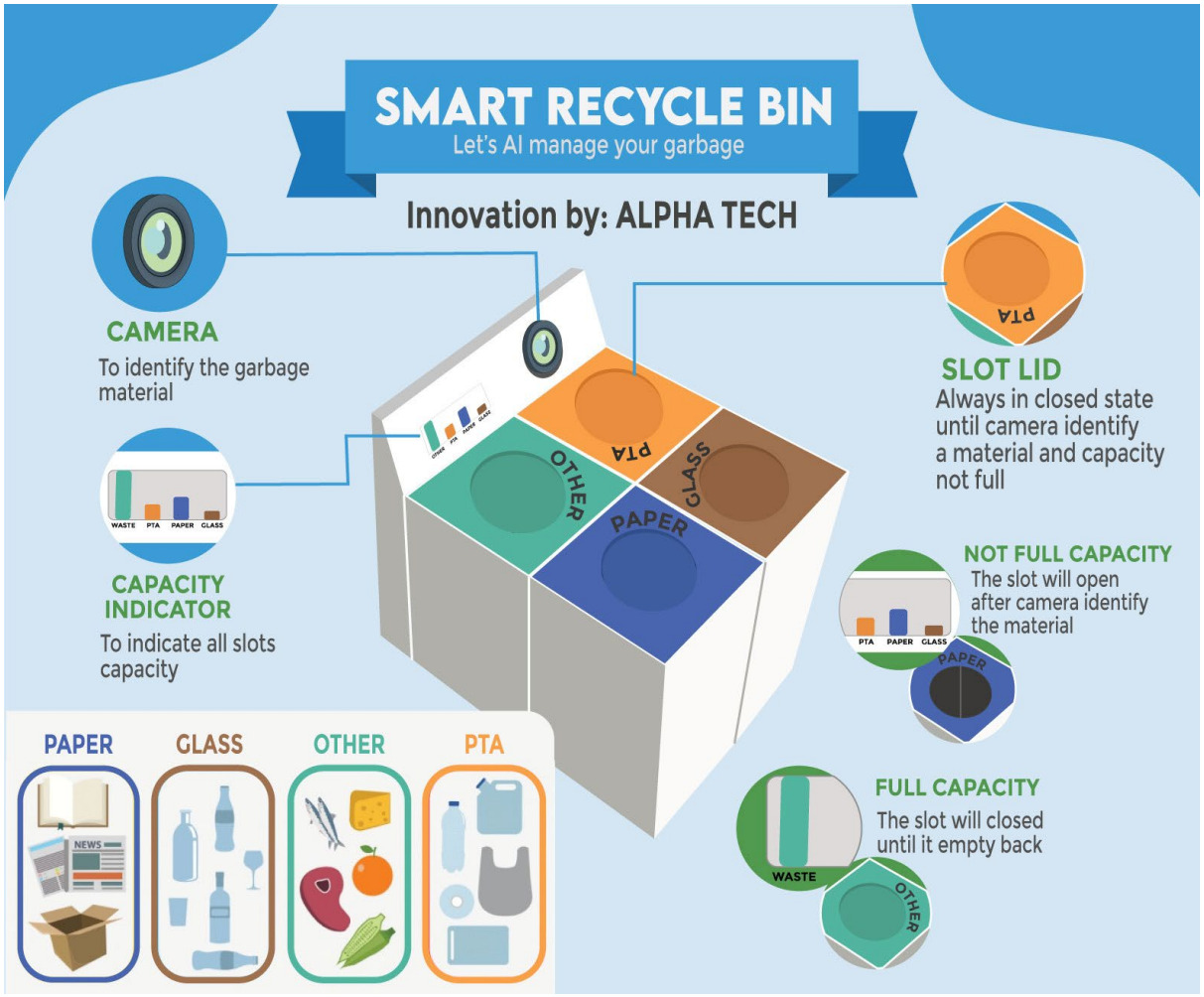
When the material detector does not detect any material, the recycling bin will be no response and remain closed.

When the material detector detected the material, the detector will scan the materials of the garbage based on four materials which are paper, glass, plastic/tin/aluminium and multiple materials.

After detecting the material, the recycling bin will check whether the bin related to the type of their material is on full capacity or not. If the capacity of the related bin is full, the recycling bin will be no response and remain closed.

If the capacity of the related bin still has space, the recycling bin will open based on the material detected. The blue lid of the recycling bin will be opened if the material detected is a paper. The brown lid of the recycling bin will be opened if the material detected is a glass. The orange lid of the bin will be opened if the material detected is a plastic or tin or aluminium. The green lid of the bin will be opened if the material is made up of multiple materials.

8.2 Design Concept



1. Sometimes it is difficult for users to understand the material of garbage, so the AI solution will scan and analyse the garbage materials before the user throws the garbage into the recycling bin.

2. Some users are lacking understanding about the information shown on the recycling bin, especially the children and teenagers. Thus, after the AI solution scans and analyses the garbage materials, it will directly help the users determine which recycling bin to put in and automatically open the lid of the relevant recycling bin.

3. The AI solution will automatically detect the capacity of the recycling bin, and open it after ensuring that the recycling bin still has capacity.