SCHOOL OF COMPUTING

FACULTY OF ENGINEERING

SECJ3553 ARTIFICIAL INTELLIGENCE

SECTION 10

ASSIGNMENT 1

Project Title: Smart Recycle Pick-Up Route Application

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Problem and AI Solution

There is a huge amount of waste generated in Malaysia every day and causes a lot of waste management problems. Therefore, the practice of recycling is encouraged to conserve natural resources. However, the current problem is there is no effective way for the citizens to manage the recycle waste as the recycle pick up system is not productive where not every region has the recycle centre. Besides, the current recycle pick-up system in some areas also does not provide a consistent route to collect the recycled waste from the citizens. It causes the driver of the recycle centre to do rounds without destination. It is also not an effective way and a waste of energy and money. Moreover, the user has the problem that the recycle bin is full and recycle waste accumulates in their places but there is no consistent pick up schedule.

Figure 1:
Overwhelming collected recycled bottles

Figure 2:
Overwhelming collected recycled carton

Figure 3: Example of the recycling services

In order to improve the efficiency of recycle waste pick up service, the AI solution is to propose a Smart Recycle Pick-Up Route with the use of the recycle smart bin that can provide an efficient predictive route for the recycle centre driver to the pick up destination. It is a mobile application that implements AI on smart recycle bin which integrates google cloud to monitor and analyze data collected to provide predictive routes generated through algorithms for recycling centre drivers. The smart recycle bin makes data available in real time to notify the recycle centre whether the smart recycle bin is empty or full and ready for pick up. Based on the data of bin fill-levels would allow the recycle centre driver to only travel out when needed. Hence, this AI solution is able to help the citizens efficiently manage the recycled materials collected. The figures below show the proposed prototype for the smart recycled bin and the application connected with the smart bin.

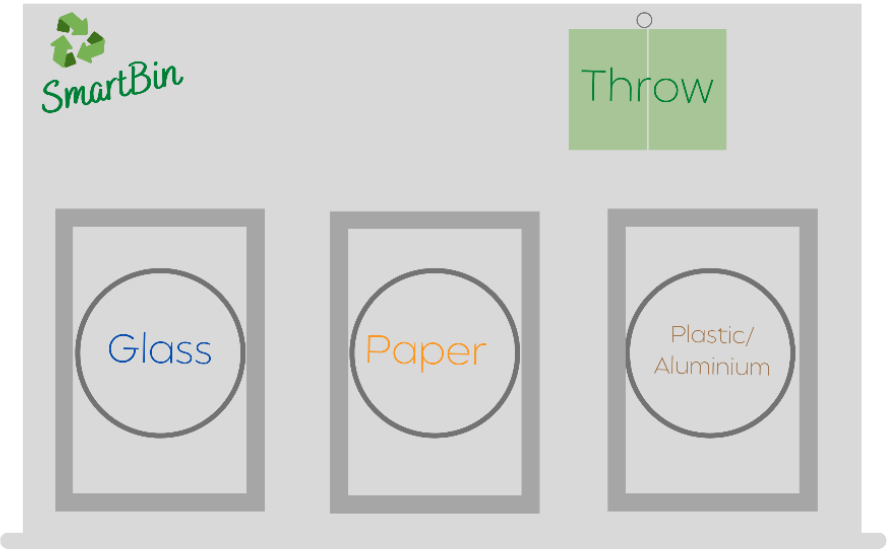

Figure 4: The front view of the Smart Bin prototype

Figure 5: The back view of the Smart Bin prototype

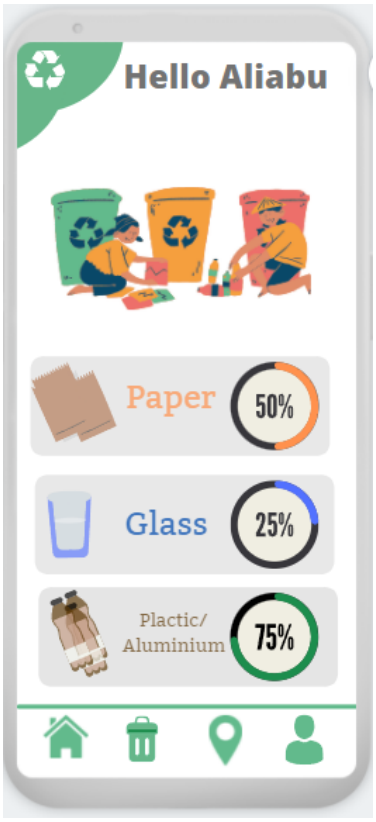

Figure 6: The prototype of the application connected with the Smart Bin

Knowledge Representation (KR)

Waste_Detector, D			**Full_level_ detector, L**	**SmartBin_ Respond, S**	**Notification_Respond, N**	
Orange, O (Paper)	**Brown, C (Glass)**	**Blue, B (Plastic, Aluminium)**			**Full level warning,F**	**Error material warning,E**
T	T	T	T	**T**	**T**	**T**
			F	**T**	**F**	**T**
T	T	F	T	**T**	**T**	**T**
			F	**T**	**F**	**T**
T	F	T	T	**T**	**T**	**T**
			F	**T**	**F**	**T**
T	F	F	T	**T**	**T**	**F**
			F	**F**	**F**	**F**
F	T	T	T	**T**	**T**	**T**
			F	**T**	**F**	**T**
F	T	F	T	**T**	**T**	**F**
			F	**F**	**F**	**F**
F	F	T	T	**T**	**T**	**F**
			F	**F**	**F**	**F**
F	F	F	T	**T**	**T**	**F**
			F	**F**	**F**	**F**

Route

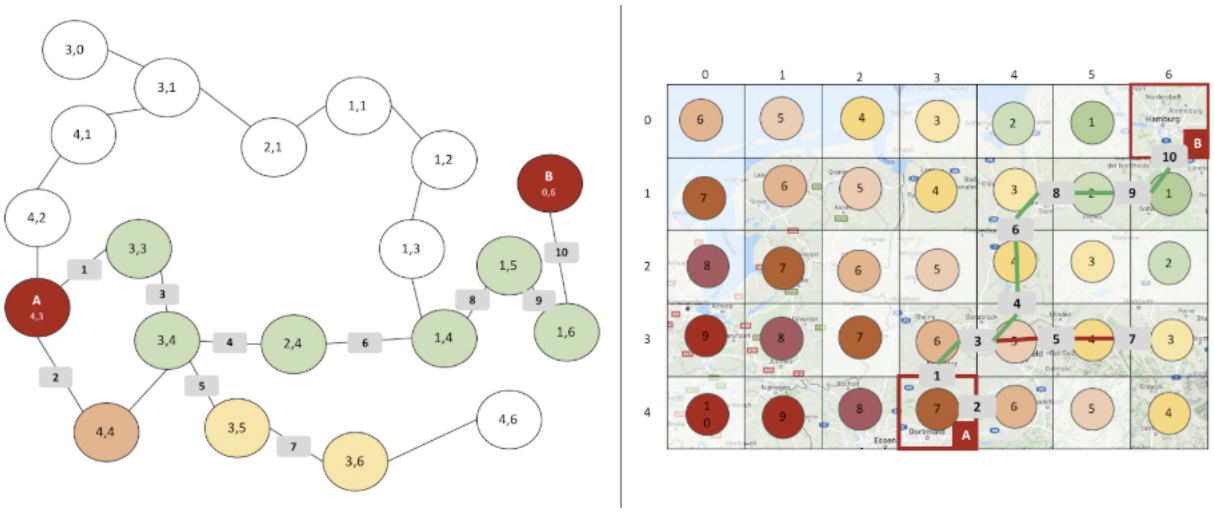

Figure 7: Example implementation of A algorithm walk from A to B*

The application is integrated with the google cloud to generate a predictive route by using this graph traversal algorithm.The A* algorithm will be used to determine the optimal paths between two known places by travelling from one to the other and using heuristics(meta-data) to predict the best path to the destination. The routing step is structured as follow (Bastian,2019):

Step 1: Push the source node into the priority queue with a priority of 0 (cost = priority)

Step 2: Loop until the queue is empty.

2.1: Get the minimum priority from the queue

2.2: Remove the minimum node from the queue and visit the node

2.3: If the target node is equal to minimum node, end the loop

2.4: Calculate the cost and add to the queue for the unvisited children of the node

Explanation of Knowledge Representation

KR1: IF (D=O) = TRUE AND (D=C) = TRUE AND (D=B) = TRUE AND L=TRUE THEN S=TRUE AND (N=F)=TRUE AND (N=E)=TRUE

Explanation: When the waste detector detects garbage made of two or more materials (**paper,glass and plastic /aluminium**), and the full-level detector of the recycling bin is **activated**, the recycling bin shows a **red light**, **is not open** and activates **full level and error material warning** notification.

KR 2: IF (D=O) = TRUE AND (D=C) = TRUE AND (D=B) = TRUE AND L=FALSE THEN S=TRUE AND (N=F)=FALSE AND (N=E)=TRUE

Explanation: When the waste detector detects garbage made of two or more materials (**paper,glass and plastic/aluminium**), and the full-level detector of the recycling bin is **not activated**, the recycling bin shows a **red light**, is **not open** and activates **error material warning** notification.

KR3: IF (D=O) = TRUE AND (D=C) = TRUE AND (D=B) = FALSE AND L=TRUE THEN S=TRUE AND (N=F)=TRUE AND (N=E)=TRUE

Explanation: When the waste detector detects garbage made of two or more materials (**paper and glass**), and the full-level detector of the recycling bin is **activated**, the recycling bin shows a **red light**, **is not open** and activates **full level warning and error material warning** notification.

KR4: IF (D=O) = TRUE AND (D=C) = TRUE AND (D=B) = FALSE AND L=FALSE THEN S=TRUE AND (N=F)=FALSE AND (N=E)=TRUE

Explanation: When the waste detector detects garbage made of two or more materials (**paper and glass**), and the full-level detector of the recycling bin is **not activated**, the recycling bin shows a **red light**, is **not open** and activates **error material warning** notification.

KR5: IF (D=O) = TRUE AND (D=C) = FALSE AND (D=B) = TRUE AND L=TRUE THEN S=TRUE AND (N=F)=TRUE AND (N=E)=TRUE

Explanation: When the waste detector detects garbage made of two or more materials (**paper, plastic/ aluminium**), and the full-level detector of the recycling bin is **activated**, the recycling bin shows a **red light**, **is not open** and activates **full level warning and error material warning** notification.

KR6: IF (D=O) = TRUE AND (D=C) = FALSE AND (D=B) = TRUE AND L=FALSE THEN S=TRUE AND (N=F)=FALSE AND (N=E)=TRUE

Explanation: When the waste detector detects garbage made of two or more materials (**paper, plastic/ aluminium**), and the full-level detector of the recycling bin is not activated, the recycling bin shows a **red light**, **is not open** and activates **error material warning** notification.

KR7: IF (D=O) = TRUE AND (D=C) = FALSE AND (D=B) = FALSE AND L=TRUE THEN S=TRUE AND (N=F)=TRUE AND (N=E)=FALSE

Explanation: When the waste detector detects the garbage made of **paper**, and the full-level detector of the recycling bin is **activated**, the recycling bin shows a **red light**, is **not open** and activates **full level warning** notification.

KR8: IF (D=O) = TRUE AND (D=C) = FALSE AND (D=B) = FALSE AND L=FALSE THEN S=FALSE AND (N=F)=FALSE AND (N=E)=FALSE

Explanation: When the waste detector detects the garbage made of **paper**,and the full level of the recycling bin is **not activated**, the recycling bin shows a **green light**, is **open**, and **does not activate notification response**.

KR9: IF (D=O) = FALSE AND (D=C) = TRUE AND (D=B) = TRUE AND L=TRUE THEN S=TRUE AND (N=F)=TRUE AND (N=E)=TRUE

Explanation: When the waste detector detects garbage made of two or more materials **(glass and plastic/aluminium**), and the full level of the recycling bin is **activated**, the recycling bin shows a **red ligh**t, **is not open**, and activates a **full level warning and error material warning** notification.

KR10: IF (D=O) = FALSE AND (D=C) = TRUE AND (D=B) = TRUE AND L=FALSE THEN S=TRUE AND (N=F)=FALSE AND (N=E)=TRUE

Explanation: When the waste detector detects garbage made of two or more materials **(glass and plastic/aluminium**), and the full-level detector of the recycling bin is **not activated**, the recycling bin shows a **red light**, is **not open**, and activates **error material warning** notification.

KR11: IF (D=O) = FALSE AND (D=C) = TRUE AND (D=B) = FALSE AND L=TRUE THEN S=TRUE AND (N=F)=TRUE AND (N=E)=FALSE

Explanation: When the waste detector detects **glass** material and the full level of the recycling bin is **activated**, the recycling bin shows a **red light**, **is not open** and **activates a full level warning**.

KR12: IF (D=O) = FALSE AND (D=C) = TRUE AND (D=B) = FALSE AND L=FALSE THEN S=FALSE AND (N=F)=FALSE AND (N=E)=FALSE

Explanation: When the waste detector detects **glass** material and the full level of the recycling bin is **not activated**, the recycling bin shows a **green light**, **is open**, and **does not activate notification response.**

KR13: IF (D=O) = FALSE AND (D=C) = FALSE AND (D=B) = TRUE AND L=TRUE THEN S=TRUE AND (N=F)=TRUE AND (N=E)=FALSE

Explanation: When the waste detector detects **plastic/aluminum** material and the full level of the recycling bin is **activated**, the recycling bin shows a **red light**, **is not open** and **activates full level warning**.

KR14: IF (D=O) = FALSE AND (D=C) = FALSE AND (D=B) = TRUE AND L=TRUE THEN S=FALSE AND (N=F)=FALSE AND (N=E)=FALSE

Explanation: When the waste detector detects **plastic/aluminum** material and the full level of the recycling bin is **not activated**, the recycling bin shows a **green light**, **is open**, and **does not activate notification response**.

KR15: IF (D=O) = FALSE AND (D=C) = FALSE AND (D=B) = FALSE AND L=TRUE THEN S=TRUE AND (N=F)=TRUE AND (N=E)=FALSE

Explanation: When the waste detector **does not detect** any recycled material and the full level of the recycling bin is **activated**, the recycling bin shows a **red light**, **is not open** and **activates full level warning**.

KR16: IF (D=O) = FALSE AND (D=C) = FALSE AND (D=B) = FALSE AND L=FALSE THEN S=FALSE AND (N=F)=FALSE AND (N=E)=FALSE

Explanation: When the waste detector **does not detect** any recycled material and the full level of the recycling bin is **not activated**, the recycling bin shows a **green light**, **is not open,** and **does not activate notification response**.

First-Order Logic (FOL)

KR 1:

$\forall x \forall y$ ((waste_detector (x) = P) $\wedge$ (waste_detector (x) = G) $\wedge$ (waste_detector (x) = PA) $\wedge$ (full_level_detector(y)) $\rightarrow \exists z$ ((smart_bin_respond(z)) $\wedge$ (full_level_notification(z)) $\wedge$ (error_material_notification(z)))

KR 2:

$\forall x \forall y$ ((waste_detector (x) = P) $\wedge$ (waste_detector (x) = G) $\wedge$ (waste_detector (x) = PA) $\wedge$ $\neg$(full_level_detector(y)) $\rightarrow \exists z$ ((smart_bin_respond(z)) $\wedge$ $\neg$(full_level_notification(z)) $\wedge$ (error_material_notification(z)))

KR3:

$\forall x \forall y$ ((waste_detector (x) = P) $\wedge$ (waste_detector (x) = G) $\wedge \neg$ (waste_detector (x) = PA) $\wedge$ (full_level_detector(y)) $\rightarrow \exists z$ ((smart_bin_respond(z)) $\wedge$ (full_level_notification(z)) $\wedge$ (error_material_notification(z)))

KR 4:

$\forall x \forall y$ ((waste_detector (x) = P) $\wedge$ (waste_detector (x) = G) $\wedge$ $\neg$(waste_detector (x) = PA) $\wedge$ $\neg$(full_level_detector(y)) $\rightarrow \exists z$ ((smart_bin_respond(z)) $\wedge$ $\neg$(full_level_notification(z)) $\wedge$ (error_material_notification(z)))

KR 5:

$\forall x \forall y$ ((waste_detector (x) = P) $\wedge$ $\neg$(waste_detector (x) = G) $\wedge$ (waste_detector (x) = PA) $\wedge$ (full_level_detector(y)) $\rightarrow \exists z$ ((smart_bin_respond(z)) $\wedge$ (full_level_notification(z)) $\wedge$ (error_material_notification(z)))

KR6:

$\forall x \forall y$ ((waste_detector (x) = P) $\wedge$ $\neg$(waste_detector (x) = G) $\wedge$ (waste_detector (x) = PA) $\wedge$ $\neg$(full_level_detector(y)) $\rightarrow \exists z$ ((smart_bin_respond(z)) $\wedge$ $\neg$(full_level_notification(z)) $\wedge$ (error_material_notification(z)))

KR7:

$\forall x \forall y$ ((waste_detector (x) = P) $\wedge$ $\neg$(waste_detector (x) = G) $\wedge$ $\neg$(waste_detector (x) = PA) $\wedge$ (full_level_detector(y)) $\rightarrow$ $\exists z$ ((smart_bin_respond(z)) $\wedge$ (full_level_notification(z)) $\wedge$ $\neg$(error_material_notification(z)))

KR8:

$\forall x \forall y$ ((waste_detector (x) = P) $\wedge$ $\neg$(waste_detector (x) = G) $\wedge$ $\neg$(waste_detector (x) = PA)) $\wedge$ $\neg$(full_level_detector(y)) $\rightarrow$ $\exists z$ ($\neg$(smart_bin_respond(z)) $\wedge$ $\neg$(full_level_notification(z)) $\wedge$ $\neg$(error_material_notification(z)))

KR9:

$\forall x \forall y$ ($\neg$(waste_detector (x) = P) $\wedge$ (waste_detector (x) = G) $\wedge$ (waste_detector (x) = PA)) $\wedge$ (full_level_detector(y)) $\rightarrow$ $\exists z$ ((smart_bin_respond(z)) $\wedge$ (full_level_notification(z)) $\wedge$ (error_material_notification(z)))

KR10:

$\forall x \forall y$ ($\neg$(waste_detector (x) = P) $\wedge$ (waste_detector (x) = G) $\wedge$ (waste_detector (x) = PA)) $\wedge$ $\neg$(full_level_detector(y)) $\rightarrow$ $\exists z$ ((smart_bin_respond(z)) $\wedge$ $\neg$(full_level_notification(z)) $\wedge$ (error_material_notification(z)))

KR11:

$\forall x \forall y$ ($\neg$(waste_detector (x) = P) $\wedge$ (waste_detector (x) = G) $\wedge$ $\neg$(waste_detector (x) = PA)) $\wedge$ (full_level_detector(y)) $\rightarrow$ $\exists z$ ((smart_bin_respond(z)) $\wedge$ (full_level_notification(z)) $\wedge$ $\neg$(error_material_notification(z)))

KR12:

$\forall x \forall y$ ($\neg$(waste_detector (x) = P) $\wedge$ (waste_detector (x) = G) $\wedge$ $\neg$(waste_detector (x) = PA)) $\wedge$ $\neg$(full_level_detector(y)) $\rightarrow$ $\exists z$ ($\neg$(smart_bin_respond(z)) $\wedge$ $\neg$(full_level_notification(z)) $\wedge$ $\neg$(error_material_notification(z)))

KR13:

$\forall x \forall y$ (¬(waste_detector (x) = P) $\wedge$ ¬(waste_detector (x) = G) $\wedge$ (waste_detector (x) = PA)) $\wedge$ (full_level_detector(y)) $\rightarrow \exists z$ ((smart_bin_respond(z)) $\wedge$ (full_level_notification(z)) $\wedge$ ¬(error_material_notification(z)))

KR14:

$\forall x \forall y$ (¬(waste_detector (x) = P) $\wedge$ ¬(waste_detector (x) = G) $\wedge$ (waste_detector (x) = PA)) $\wedge$ ¬(full_level_detector(y)) $\rightarrow \exists z$ (¬(smart_bin_respond(z)) $\wedge$ ¬(full_level_notification(z)) $\wedge$ ¬(error_material_notification(z)))

KR15:

$\forall x \forall y$ (¬(waste_detector (x) = P) $\wedge$ ¬(waste_detector (x) = G) $\wedge$ ¬(waste_detector (x) = PA)) $\wedge$ (full_level_detector(y)) $\rightarrow \exists z$ ((smart_bin_respond(z)) $\wedge$ (full_level_notification(z)) $\wedge$ ¬(error_material_notification(z)))

KR16:

$\forall x \forall y$ (¬(waste_detector (x) = P) $\wedge$ ¬(waste_detector (x) = G) $\wedge$ ¬(waste_detector (x) = PA)) $\wedge$ ¬(full_level_detector(y)) $\rightarrow \exists z$ (¬(smart_bin_respond(z)) $\wedge$ ¬(full_level_notification(z)) $\wedge$ ¬(error_material_notification(z)))

Knowledge Representation Involved to Achieve Goals

1. The major goal is to increase citizen awareness of recycling and the households' satisfaction with recycling services. By manipulating the waste detector, the material of recycled waste thrown by the resident will be detected. The waste will be classified into either paper, glass or plastic/aluminium and separated into specific bins. If the recycled waste is detected made up to two types of materials, the warning will be activated, and the user will not be able to toss the waste into the smart bin. It can assist the user in identifying recycled materials and expanding their recycling knowledge.

   Furthermore, the bin's capacity will be monitored, triggering a special alert to both consumers and the recycling company. It can prevent residents from continuing to toss rubbish into overflowing bins and alert drivers to collect recycled waste. If the smart bin detects either the error material of the recycled waste(Waste_Detector,D) or the full level of the smart bin(Full_level_detector,L), the SmartBin_Respond,S a red light to warn the user. If the smart bin does not detect any error, SmartBin_Respond remains green light and no special response. The Notification_Respond,N will send the specific warning(full level warning and error material warning) to the application.

2. This application is able to detect the recycle bin fill-level. If the bin fill-level is full, it will send the location to the recycling centre for the driver to pick up the recycled materials. KR1, KR3, KR5, KR7, KR9, KR11, KR13, KR15 shows the bin-filled is full, where Full_level_detector**,** L=TRUE. The mobile application that is connected with the recycle smart bin to send full level warning to the user and notify the driver to pick up. The mobile application will provide the best route for the recycle centre driver to the pick up location where the smart bin shows a full level. This will allow the citizens to easily manage the overwhelming amounts of recyclable waste collected as the driver will pick up the recycled waste consistently.

   KR1, KR2, KR3, KR4, KR5, KR6, KR7, KR9, KR10, KR11, KR13, KR15 shows S=TRUE, where SmartBin_Respond will display a red light and the recycle bin will not

open for throwing the waste. If the S=FALSE, the SmartBin_Respond will display a green light and the smart bin will allow the user to throw the recycle waste and the smart recycle bin can continue working.

3. To increase efficiency of the recycling work by notifying the users to avoid error material. For example, KR1, KR2,KR3 KR4, KR5,KR6, KR9,KR10 shows that the recycle bin detects the waste that cannot be classified as any kind of recycled waste material such as the non- recyclable waste or the waste that include two or more types of material. Then, S=TRUE, where SmartBin_Respond will display a red light and the recycle bin will not open for throwing the waste so it will ease the recycling work for the pick up while the Notification_Respond, Error material warning = TRUE where the system will also notify the the user by sending the error material warning to them so that the user will know that the waste is non-recyclable.

References

1. Bastian, B. (2019,December 12). *How routing works: 4 simple algorithms*. Medium.com. Retrieved December 20, 2021, from https://medium.com/omio-engineering/how-routing-works-4-simple-algorithms-5919a88c3648