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IoT-Based Reverse Vending Machine (RVM) for Recycle Station

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Abstract: Recycle our daily solid waste is a sustainable and effective way to reduce the problem of landfills saturation and pollution. In urban areas and smart cities, the reverse vending machine (RVM) recycle concept has been introduced to encourage recycle habits and increase awareness among the community. In this project, an Internet of Things (IoT)-based RVM for recycle station has been developed to resolve these issues. The proposed prototype consists of three main parts; input (the proximity inductive/capacitive and weight sensors) to detect three types of waste material and weighted the collection material, process (micro-controller Arduino Mega and NodeMCU) to process the data received from the sensor and transmit data to IoT platform via Wireless-Fidelity (WiFi) and output (Blynk IoT platform and Inter-Integrated Display (I2C) Liquid Crystal Display (LCD) as a graphical user interface (GUI)) to notify the workers and exhibit the rewarding system. Evaluation of the prototype shows that it is successfully to detect three types of waste materials which are aluminium can, plastic and glass, and notify the users when the RVM storage is full and show the reward system via I2C LCD display.

Keywords: Reverse Vending Machine, Internet of Things, Recycle Station

1. Introduction

Solid waste is produced because of our daily activities. Every year, the rate of solid waste produced growth rapidly and this situation will cause disaster in the future [1]. Rubbish or solid waste that ends up in dumpsites or landfills will produce dangerous chemicals such as methane which contribute to climate change and global warming [2]. Humans, animals, plants, and all creatures that live on the earth will be harmed and affected. Recycle is the only effective way to moderate this issue.

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Today, the development of the smart city is discussed as it offers a sustainable and innovative environment. Smart city uses various types of electronic devices, sensors, and Internet of Things (IoT) method to collect and exploit data to improve quality of life and the efficiency of urban operations and services [3] including solid waste management.

Automatic self-service machine or vending machine can be considered as one of the efforts to establish the concept of a smart city. The implementation of reverse vending machine (RVM) concept as a recycle station appear as an effective towards a better solid waste management. Instead of money is used to buy something using vending machine [4], with this idea the user will be able to exchange solid waste with rewarding points. This RVM will motivate the community to recycle solid waste easily and reduce solid waste in the city.

In the era of technology, disposal waste has increased every year which is bad trend for the environment. Data from Solid Waste Management and Public Cleansing Corporation (SWCorp) shows Malaysia generates for about 37,890 tones disposal waste and at least 1.17kg will produce by everyone. If this number increase continuously, the country will face the problem saturation of landfills nationwide. One of the effective solutions to overcome the issue is to encourage the community to recycle the item such as aluminum cans, plastic, and glass bottles.

However, current RVM recycle station unable to receive various type of solid waste. Most of the current RVM [5] recycle station reward system is limited by using token and RVM recycle station unable to notify workers when the storage full. Previous works [4] – [11] show there are room of improvement to be made in RVM design and implementation. Hence, this work aims to propose the RVM recycle station that capable to receive three (3) main types of solid waste and to enhance the user interaction and to notify the workers with the related apps development.

2. Methodology

2.1 Proposed System

An overview of the proposed RVM implementation, including the input, process and the output is given in Figure 1, whilst an explanation for it is tabulated in Table 1. With the RVM is located at the recreation park area, users will be able to recycle their plastic and glass bottles as well as aluminum cans.

In brief, an inductive proximity sensor will detect the items of plastic, glass bottles or aluminum cans and send the data to the processor. After that, the data will transmit to Blynk application and users will be able to see the notification via the liquid crystal display (LCD). At the same time, the operator can be also triggered with the status of the RVM.

To establish the RVM, connection of the electronic circuit is designed as the block diagram shown in Figure 2. In this system, two (2) analog inputs of sensors are configured with the Ardunio Mega microcontroller and NodeMCU via the software of Arduino IDE.

The main parts of the programming include the instruction to activate the sensors and motors, to realise real-time data operation with cloud and apps as well as display the required information of the RVM.

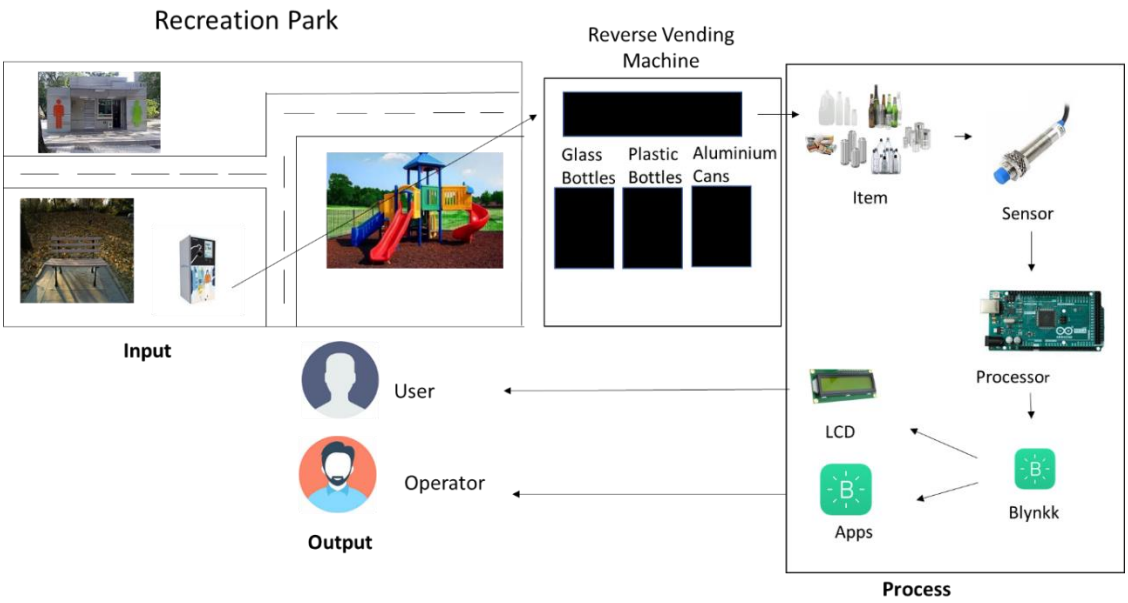


Figure 1: Overall proposed system

Table 1: Details of the input, process and output

Input	Process	Output
		Blynk Cloud Blynk Apps
Inductive Proximity Sensor • To detect the presence of metal objects without any physical contact.	Arduino Mega • Arduino mega as a microcontroller will process the data from the sensor to classify the item based on the category.	Blynk Cloud • To receive process data from NodeMCU and transmit data to apps Blynk Apps • To show the GUI for monitoring
		
Capacitance Proximity Sensor • To detect the presence of glass and plastic objects without any physical contact.	NodeMCU • To process and transmit the data to the cloud sever.	LCD • To display the information

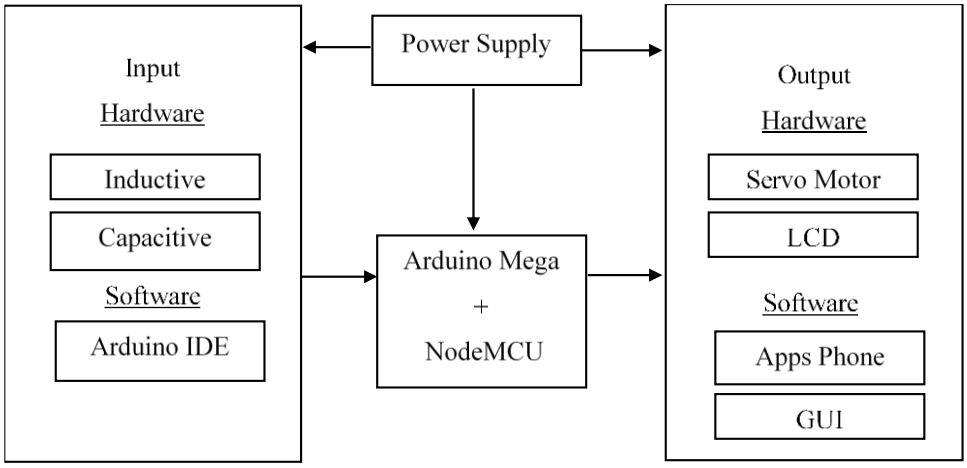


Figure 2: Reverse Vending Machine block diagram

2.2 Detection of Materials

Two (2) sensors, an inductive and capacitive proximity, will be used to validate the workability of the proposed RVM. It will be operated based on the input reading, either with logic HIGH (1) or LOW (0) as listed in Table 2 to detect different materials.

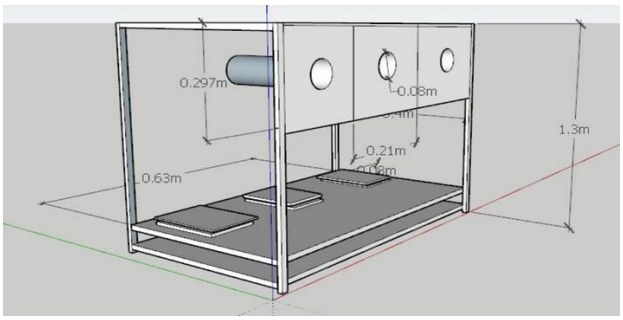
Table 2: Sensor operation for materials detection

Materials	Type of sensor	Operation
Metal	Inductive Proximity	If the inductive proximity sensor digital input reading HIGH = 1, then aluminum cans is detected.
Plastic	Inductive & Capacitive Proximity	If the inductive proximity sensor digital input reading LOW = 0, the capacitive proximity sensor digital input reading HIGH = 1, then plastic is detected.
Glass	Inductive & Capacitive Proximity	If the inductive proximity sensor digital input reading LOW = 0, the capacitive proximity sensor digital input reading HIGH = 1, then glass is detected.

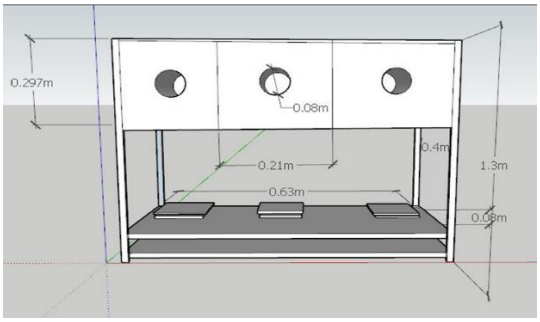
3. Results and Discussion

3.1 Prototype Development

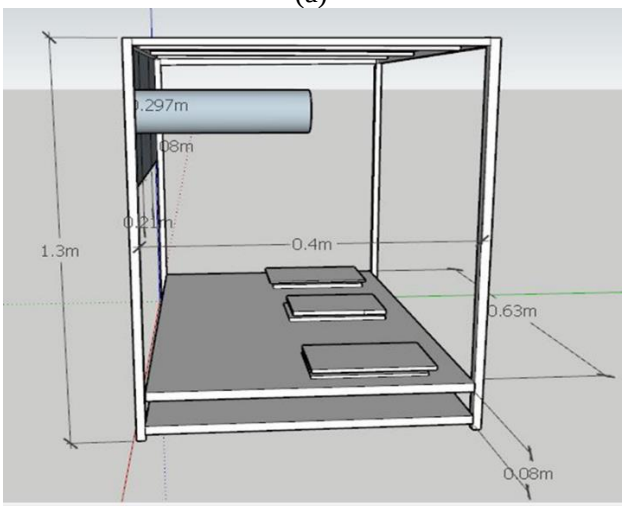
To develop the prototype of RVM, it has been started with the software implementation using Sketchup with details of the measurement as depicted in Figures 3 (a) – (f), whilst the final RVM implementation is shown in Figures 4 (a) and (b), with three (3) holes to accept either aluminum cans, plastic or glass bottles.



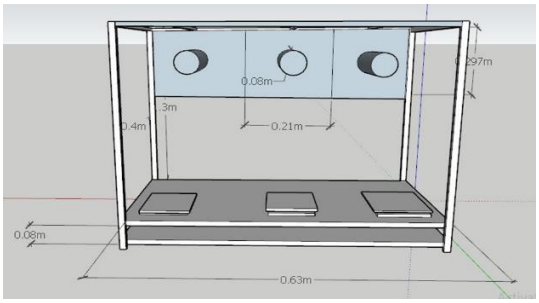
(a)



(b)



(c)



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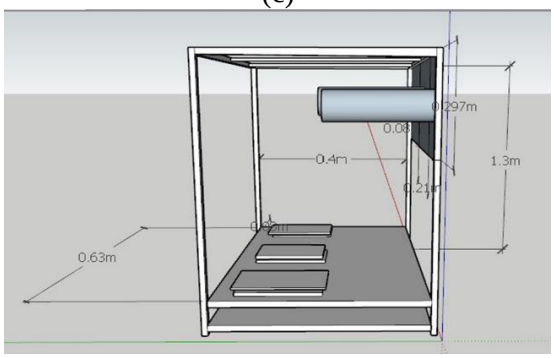
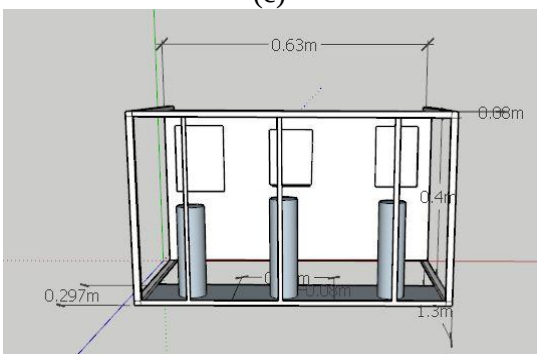
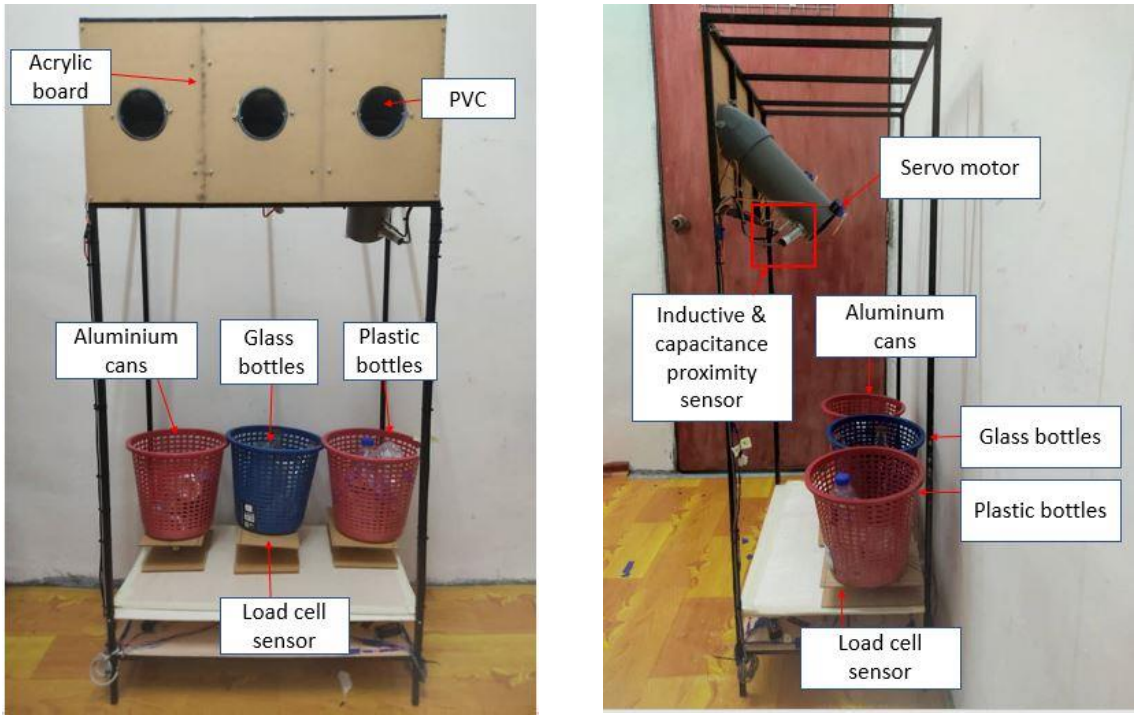


(e)



(f)

Figures 3 (a) – (f): Sketch up of the RVM with details of the measurement



(a) (b)

Figures 4 (a)-(b): Real implementation of the prototype

3.2 Rewarding Information to the Users

Figure 5 shows the display of rewarding information to the users. It exhibits the weight of three (3) types of the recycle items such as (T) for aluminum cans, (G) for glass, and (P) for plastic. The RM data displays the rewards collected based on the total weight of the item being recycled by the user. Rewarding calculation is based on the standard price of the recycle items, such as aluminum cans with RM2.60/kg, plastics bottle for RM0.50/kg and glass bottle with RM 0.00/kg.

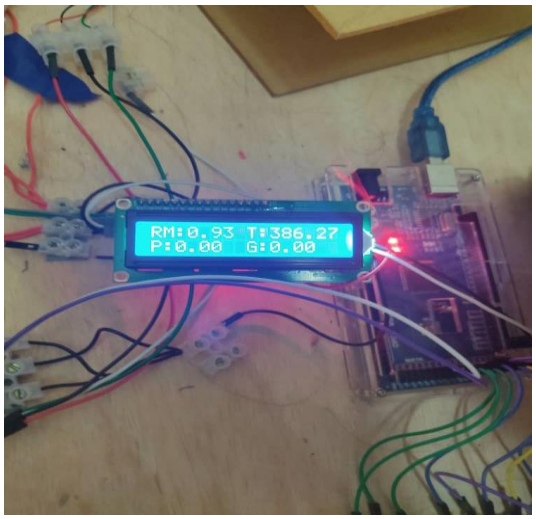


Figure 5: Notification to the users

3.3 Notification to the Workers

The recycle items such as aluminum cans, plastic and bottle glasses are collected through a basket, which will give force or pressure to the loadcell sensor. The loadcell could accommodate a weight of only 1kg. The data of the loadcell sensor will be processed and sent to the NodeMCU. The NodeMCU as an IoT platform acts to connect the loadcell sensor to the phone or computer and it requires an Internet connection. The display weight uses in the Blynk is Gauge and notification to the workers were shown in Figure 6.

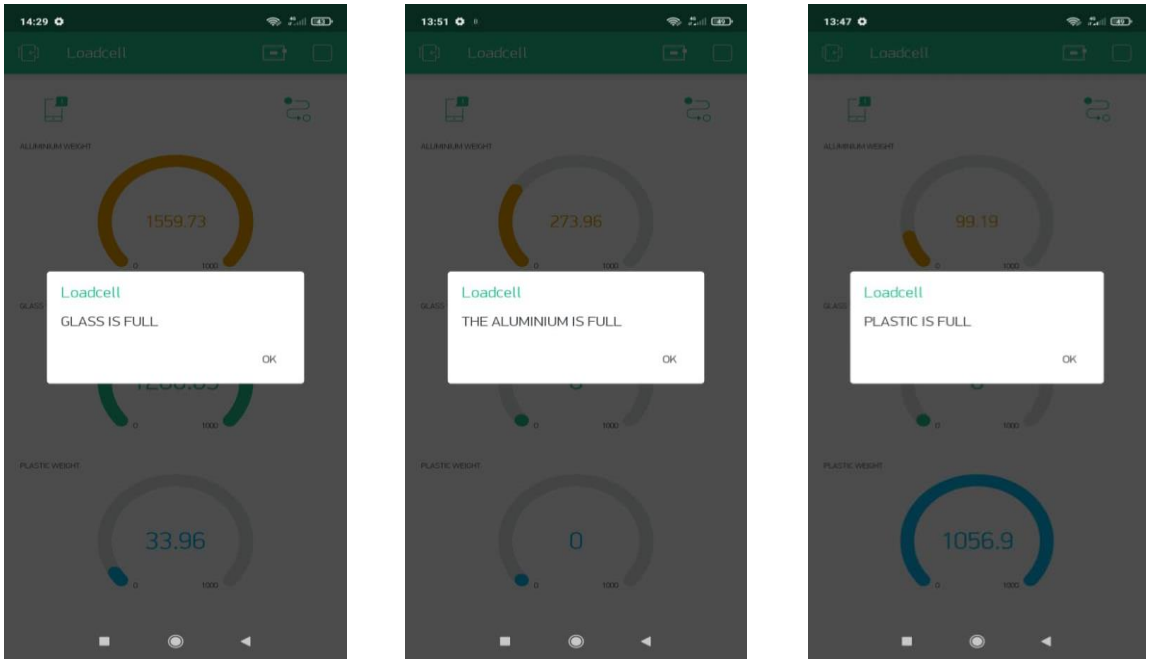


Figure 6: Display on Blynk for workers' notification

4. Conclusion

In conclusion, the RVM has been successfully design and developed. It capable to detect recycle material such as aluminum cans, plastic, and glass bottles, can collect recycle items up to 1kg for each types of materials, and the prototype also can notify the workers when the RVM storage is full via Blynk mobile apps. Additionally, it also calculates and display the rewarding point to the users via can the Liquid- Crystal Display. Hopefully, this proposed RVM will be able to educate and enhance the awareness to the society about the importance of recycling activity. This is not only for today, but for our future generation.

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