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Creation of a Material Disposal Device with a Microcontroller

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Abstract

The National Solid Waste Management Department (JSPN) published data in 2021 showed millions of Malaysian dollars were spent on trash removal during this time period. The elimination of waste by garbage disposal has grown yearly. The lack of public understanding of recycling is the cause of this situation. To tackle this issue, an incentive element is suggested in order to motivate individuals to recycle. Thus, a reverse vending machine (RVM) concept is proposed. This machine has an Arduino microcontroller and a number of sensors installed. Throughout the process, the input waste is recognized and the RVM converted into points automatically. Then, the user can exchange their points for cash at a nearby merchant. The prototype is expected to increase waste recycling among Malaysians and serve as a platform for leveraging the waste to wealth concept to combat urban poverty.

Keywords: Waste Management, Recycling, Reverse Vending Machine, Material Disposal Device, Microcontroller Technology

Introduction

Since 2011, Malaysia's population has expanded by over 91% due to a rise in the country's economy and corporate activity (Shakil et al 2023; Manaf et al 2009; Behzad et al 2011). Malaysia's population growth has led to a rise in trash production (Vijayan 2023). As of 2020, Malaysia produced more than 37,770 tons of trash every day. But by 2026, this amount is predicted to increase to over 41,035 tons, as Figure 1 illustrates (Agamuthu & Victor 2011; Moh & Manaf 2017).

When waste management or waste treatment are not planned for, the environment and public health suffer (Ali & Yusof 2018). Sadly, Malaysia does not practice efficient and organized solid waste management. The 3Rs reduce, reuse, recycle are rules that are being implemented in the new era of waste management. These policies are more appropriate and

flexible. Malaysia suffers from little stakeholder participation and awareness of recycling. (Arenibafo 2023)

One of the most crucial waste management strategies is recycling (Yong et al 2019). It involves gathering and processing waste items to create new goods. The recycling program started in 1993, however because to a lack of community involvement and sincere program implementation, it has not achieved its goals. In contrast to other nations, Malaysia now has a meagre 10% recycling rate. At the moment, consumers are required to gather and sort recyclables in large quantities at home. The challenging process is one of the obstacles Malaysians encounter when recycling (Pariatamby & Bhatti 2020; Halim & Suharyanti 2020). However, residents have little knowledge of recycling rubbish, as seen by their mishandling of the facilities that are offered. The Department of Housing and Local Government wants recycling to reach 22% by 2021 (Zainu & Songip 2017). Implementing material handling machines is a concept where users are paid for properly recycling their items. This is an alternatives way to make sure desired goals are accomplished. The recyclable material can then be sent to an industry for recycling.

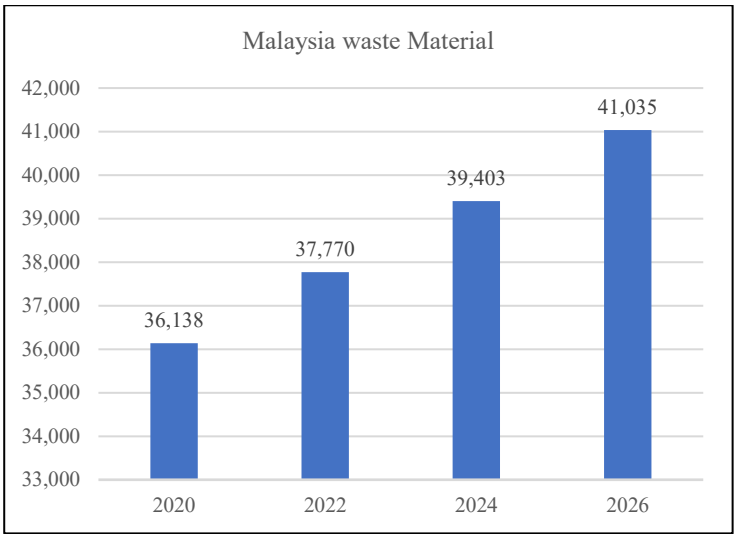

Figure 1. Malaysia Waste Material

The idea of reward in recycling has recently gained importance in studies. In conjunction with the vending machine concept, it can attract people in waste management strategies. The following paragraph will be a discussion of some of the research issues that are related in this discipline.

Pavan et al 2021 using Mechatronics principles to mass produce paper via sensors and microcontrollers. This technique will be more economical and cost-effective, and college and high school students will benefit much from it. By entering the right currency into the machine, it is intended to deliver sheets. It will replace manual labor and save us time. Cut down on needless crowding and time wastage at stationery stores, especially during exam season. Provide a coin-based dispatch system to expedite paper delivery.

Researchers, Rahim and Khatib, 2021, suggested system that takes pet plastic bottles, crushes them into tiny pieces, and gives consumers treats in return. The E-eco Bin's output can be utilized for a variety of tasks, including building roads and recycling. Finding out if the input

item is a desirable plastic pet bottle is the goal. Sensors from detecting systems and industrial lasers are employed. After the item is introduced, the microcontroller turns on the crusher motor for three seconds, depositing the output grains in the collection. The user gets a sweet as a reward and the controller turns on the vending machine at the same time. The monitoring device will keep track of how much crushed plastic is in the collector.

Lopez et al 2021 proposed in Image processing was used in this study to ensure that the input polyethylene terephthalate (PET) bottles were recyclable. The YOLOv3 framework algorithm is utilized to locate its images (Kumar et al 2020). The advantage of this method is that it is accurate and fast in detected the image by taking a picture with the camera. After that, the Raspberry Pi will receive the data and classify the input bottles. The signal will be sent to the DC motor, which will activate the PET bottle base, if the input bottle satisfies the requirements. The PET bottle equivalent time and the relevant bottle type will be shown on the LCD panel. Everything about the probe went smoothly.

In 2016, Karin et al conducted additional research to create a prototype that enables users to recycle plastic bottles and earn reward points. The Altera DE2-115 board and Verilog HDL were used in the development of this project. This was selected because hardware-based FPGA implementations are frequently slower than technology microcontroller implementations. When creating reliable, real-time applications, FPGAs perform better than microcontrollers because the former can, albeit somewhat more quickly, execute several, concurrent operations at once. It's because the product is affordable and environmentally friendly.

Another important research done by Dumpayan et al 2017, proposed encourage proper solid waste management at Colegio de San Juan de Letran. A microcontroller serves as the brains of the system; it controls the different input sensors, keypad, output display, and motor devices that are attached to it. Plastic bottles are recognized by the machine, which then turns them into points that may be redeemed for goods. Accurately identifying RFID accounts, distinguishing plastic from non-plastic bottles, storing or updating account points, and dispensing goods were all done by the machine. The machine could run on solar or commercial power. The battery and solar array offer backup power in addition to renewable energy in the case of a commercial power outage. This system which is the RVM concept was accepted by Colegio.

Subsequently, the approach presented by the author Gaur et al 2018 will enable point accumulation during the recycling process. The reward coins and plastic weight increase with each system input. When a user enters an invalid item or item type into the system, the material is rejected and the system is reset. The hardware-based detection system of the recycling machine will be implemented in a way that is both efficient and economical. It will make use of three widely accessible and reasonably priced sensors: a strain gauge weight sensor, an infrared photoelectric sensor, and a capacitive proximity sensor. The complete system will be implemented on hardware as part of the reverse vending machine's planned future scope.

After completing the literature review, a concept was generated to create a recycling device that the general people might use. Therefore, a material disposal device (MDD) that makes

use of a microcontroller is created. It's a creative approach to promote recycling and decrease rubbish at the same time. The design of this project will be described in the upcoming chapter.

Research Motivation

The MDD is a final year project from a student at the Technical University Malaysia Melaka. The project aims to teach students how to use a variety of technology devices for learning. The following is a generic description of the MDD that is the foundation of RVM.

During this material disposal, waste is dumped into the inflow. The sensors are set up to distinguish between waste from plastic and can drinks. The item that the user selects will be dispensed by pushing it using a servo motor. The load cell and Arduino are connected using the HX711load cell module. The load cell module is used to calculate waste weight, support the amount, and calculate reward points, which are then communicated to the LCD and thermal printer. Redeeming reward points at participating retailers is possible for the user. In the Figure 2 is the overall system of a material disposal device (Aceleanu et al 2019).

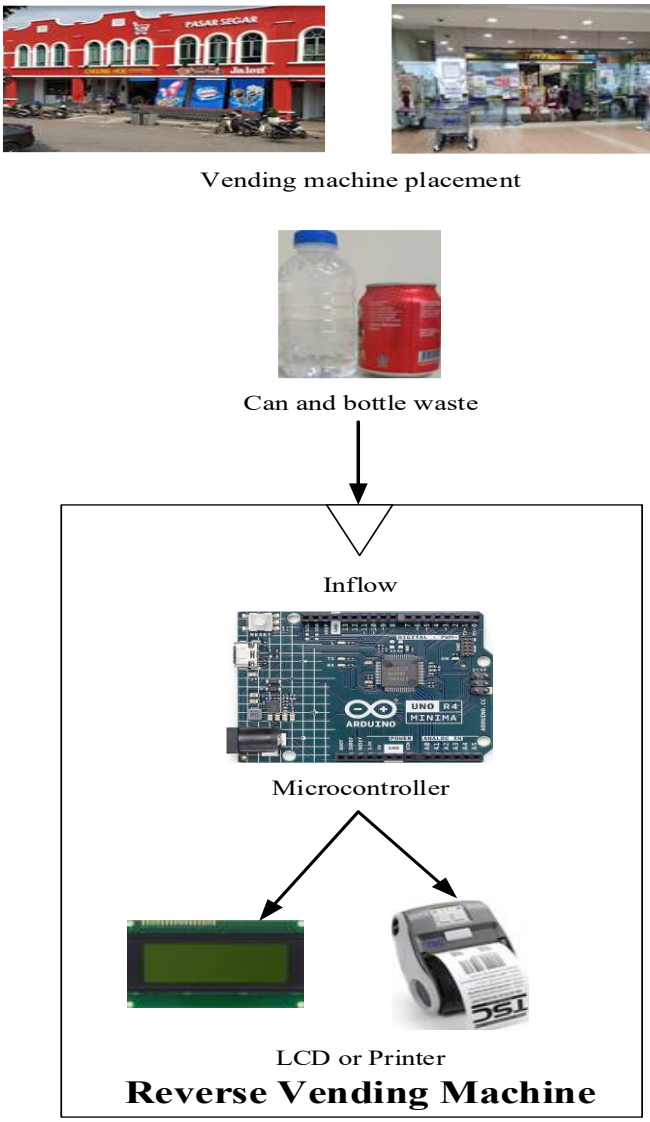

Figure 2: Overall purpose MDD system

The fundamental electronic parts of the MDD are inductive proximity sensor, KY-032 infrared proximity sensor, Load Cell and Hx711 Weight Sensor, microcontroller Arduino Uno, Servo Motor MG995, 2-line 16-character LCD module and embedded thermal printer.

The functioning of the electronic parts for this project is summarized in the paragraph that follows.
Inductive proximity sensors can identify the presence of metal or tin objects without making physical contact. Electromagnetic radiation is the technology used in inductive proximity sensors to identify metal objects. An inductive proximity sensor's sensing range varies according to the metal it detects.

The Ky-032 Infrared Proximity Sensor can identify the presence of plastic objects. This sensor uses infrared light to identify obstacles. The photodiode reflects and detects infrared light as it is released.

The load cell measures the mass and sends an analogue electrical voltage to the HX711 Load Amplifier Module. The load cell output is amplified and digitally converted using the HX711 ADC. Next, the Arduino receives the amplified value. The output of the HX711 is now calculated by Arduino, which then weighs it in grams and shows it on the LCD.

The Arduino Corporation is an open source computer hardware and software company that focuses on creating easy-to-use and low cost products. The Arduino UNO is an open-source microcontroller board built on the Microchip ATmega328P microprocessor (Badamasi 2014). This microcontroller features an 8-bit reduced instruction set computer with a modified Harvard architecture. Its purpose is to make the computer's individual instructions or code easier to understand so that it can do a task. The ATmega328 on the board is pre-programmed with a bootloader that allows new code to be uploaded to it without the use of an external hardware programmer. Hence, users can upload programs to it as often as they choose. This microcontroller is employed because it is affordable and user-friendly. Receiving and analyzing sensor data before sending a signal to the LCD or printer is the primary task.

The Servo Motor MG995 is a medium-sized servo with a 180-degree range, good torque, and a moderate speed. It's a cheap motor with little power. Designed for industrial use, the MG995 is a twin shock-proof ball-bearing servo with a metal gear. The motor responds quickly and rotates at a high speed. It has excellent holding power and a consistent torque range. The task is to bring the recycled waste from the inlet to the bin.

The LCD module displays the input and output messages while using the MDD. The thermal printer prints the receipt so the user can change it to money

In the Figure 3 illustrates the flowchart of the MDD system. "Insert Item & Press Add" is the first message displayed by the MDD. The users hit the button after placing the recyclable rubbish. Next, the substance is scanned by the inductive proximity sensor and the infrared sensor. If any material metal or plastic is recognized, the load cell weighs it and sends the information to the Arduino microcontroller. The motor that moves the material into the bin is turned on by an output signal coming from the microcontroller. Simultaneously, the

microprocessor translates the weight into the amount of reward and shows it on an LCD display. When the button is pressed, the user can obtain the redemption receipt.

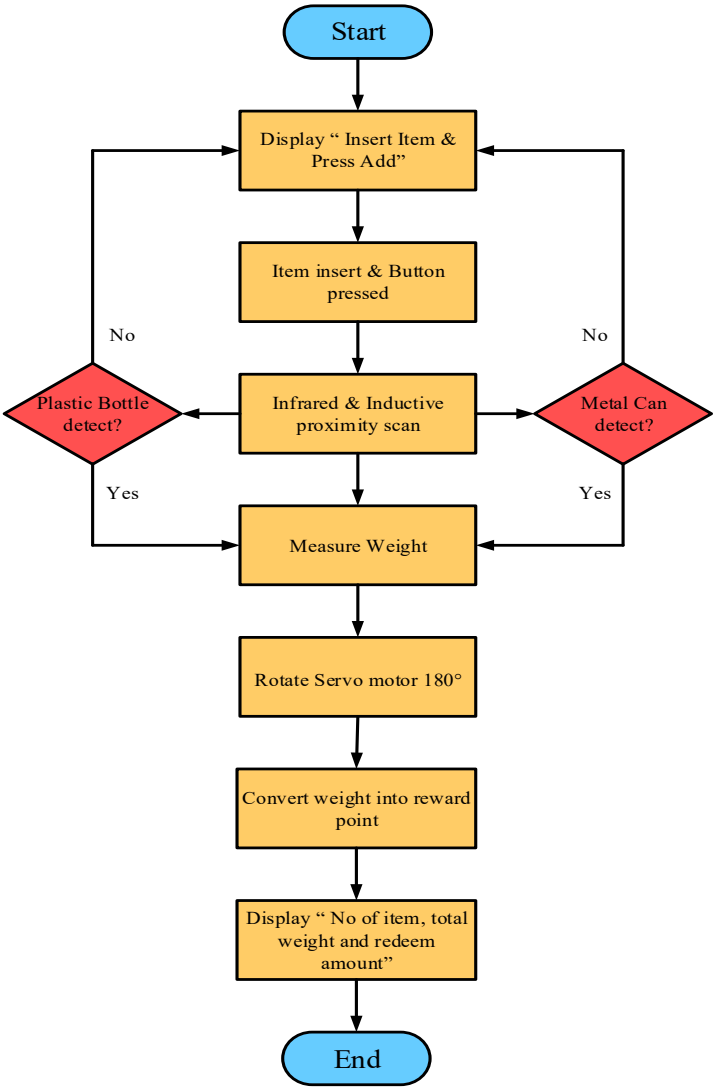

Figure 3: Flowchart of whole MDD system

Arduino is an open-source electronics platform with a built-in programming environment (IDE) that is used with various operating systems. The IDE's primary function is to convert C-language code into executable code, which the programmer loads into the Arduino microcontroller so it can run. Pushbuttons and sensors are examples of inputs that Arduino boards can read and translate into desired outputs, like turning on an LED or starting a motor. By providing a set of instructions to the microprocessor board, the user can command or steer the device. The purpose of the programming language is to carry out a particular function. Aside from that, Arduino also makes dealing with microcontrollers easier. Arduino has numerous advantages. A few of them are multiplatform, reasonably priced, and have easily navigable programming environments.

A sample of C code to use the proximity sensor to identify the presence of an object nearby is shown in Figure 4.

```
const int Pin=2;

void setup() {
   pinMode(Pin, INPUT);
   Serial.begin(9600);
}

void loop() {
   int sensorValue = digitalRead(Pin);
   if(sensorValue==HIGH){
      Serial.println("no Object");
      delay(500);
   }
   else{
      Serial.println("Object Detected");
      delay(500);
   }
}
```

Figure 4: Coding for Ky 032 infrared proximity sensor

In Figure 5 (Ismailov & Jo'rayev 2022), the circuit schematic is displayed. Three pins make up the PNP construction of the sensor, two of which are linked to a 6 V power source. The output pin, which is typically normally open (NO), is the other pin. It has a detection distance of 0 mm to 4 mm and only can detect metal objects like can drinks. Through the use of the pull-down resistor, lower the Arduino's input voltage from 9 V to 4.5 V. Next, attach an Arduino input pin to the middle of the voltage divider circuit. Uploading the code to Arduino is the following process. If it is LOW, no object is near the sensor; if it is HIGH, an object has been detected. This happens once every 0.5 seconds.

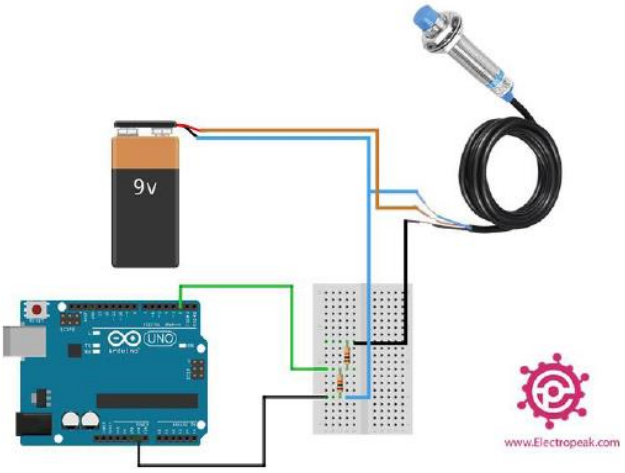

Figure 5: Schematic circuit for infrared proximity sensor

The heart of the MDD system is an Arduino microcontroller. Block diagram Figure 6 depicts the structure of this microcontroller link to the electronic equipment. An inductive proximity sensor and an infrared proximity sensor scan metal and non-metal objects without the need for physical contact. Subsequently, the Arduino Uno microcontroller will evaluate the sensor data and classify the object according to its category. The HX711 amplifier is a breakout board that makes it simple to read load cells for weight measurement. After evaluating the data, the servo motor arrangement pushes the waste material into the machine bin. To show the

information, the Arduino transmits data to the LCD backpack. Since the Arduino is interfaced with a thermal printer, the output data can be printed.

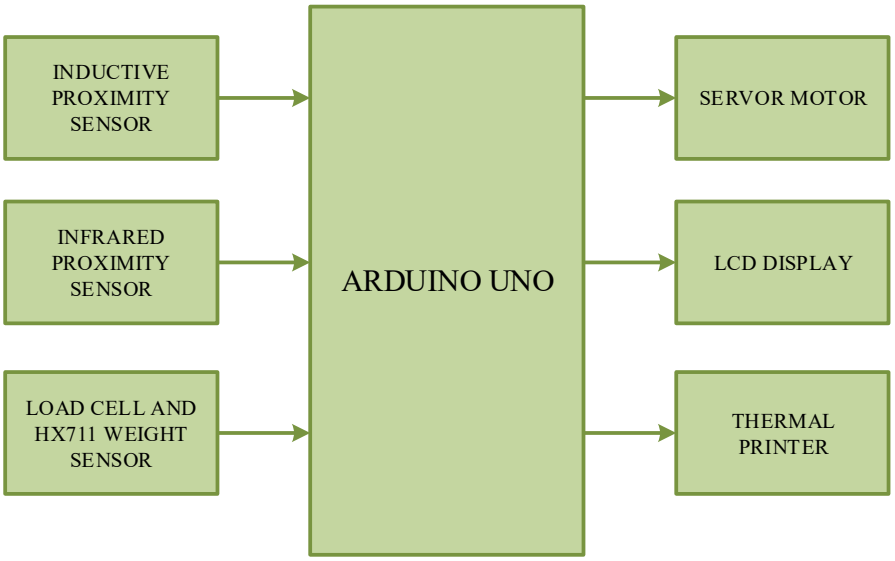

Figure 6: The block diagram of Arduino Uno task

The full simulation circuit in Figure 7 is constructed using Fritzing software. The component used in this circuit include an Arduino Uno, battery 9v, button, capacitor, hx711 inductor obstacle sensor, buck converter, im0167, load cell, motor servo, thermal printer and PCF 8574. The 5V supply voltage is connected to the VCC inductive proximity sensor, button, LCD and servo motor. The 9V supply voltage is connected to the battery with thermal printer, ky-032 infrared proximity. Each connected device's ground is connected to the Arduino Uno and buck converter ground.

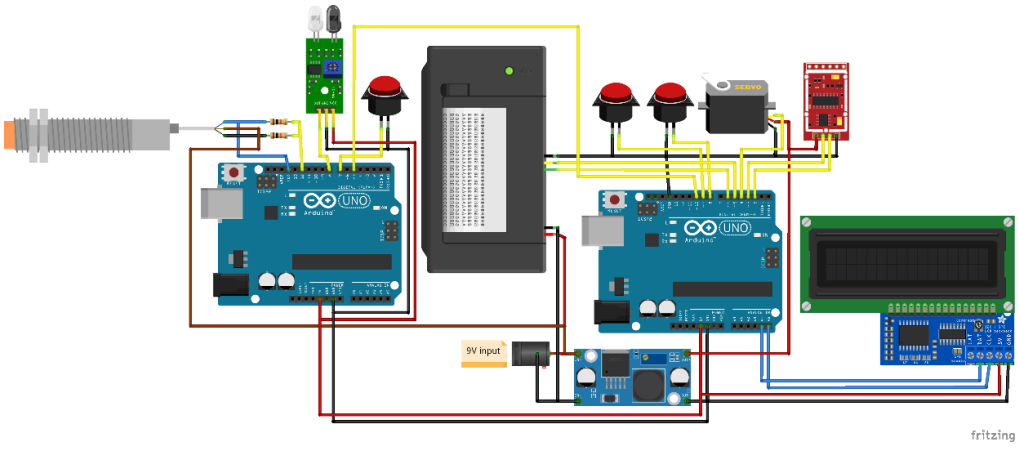

Figure 7: The full schematic circuit

As for interfacing of proximity sensor, a pull-down resistor is added to the connection. A 10k pull-down reduce the Arduino input voltage from the sensor output voltage from 9V to 4.5V. Due to overvoltage, 9V will damage the Arduino. It is required to use a 10k resistor in series. Pull down resistor are resistor with a fixed value that are connected between a voltage source and a specific pin in a digital logic circuit. The purpose is to ensure the voltage between ground and voltage VCC is actively controlled.

Results and Discussion

The LCD message "Disposal Vending Machine" will show up while the machine is in idle mode, as shown in Figure 8. Proceed with the instruction "Insert ITEM & Press ADD" that appears on the LCD, as illustrated in Figure 9.

Figure 8: LCD message in idle mode

Figure 9: LCD message before insert ITEM

In the recycling procedure, the customer puts a plastic or can in the designated hole. The sensors alert Arduino when they identify waste stuff and when the button is pressed.

The HX711's output is calculated by Arduino and translated into weight values in grams. The weight is displayed on the LCD. Turn on the motor to transfer waste to the bin at the same time. "To Press Receipt Press REDEEM" then shown on the LCD Figure 10 and Figure 11 depict this.

Figure 10: Next instruction after inserting item

Figure 11: Total Redeem appears at LCD

The MDD prototype shown in Figure 12 has one hole for taking plastic bottles or aluminum cans. The container is 30 cm by 43 cm. Since MDD is self-financial, a rather inexpensive project is anticipated. The inside of the prototype is shown in Figure 13.

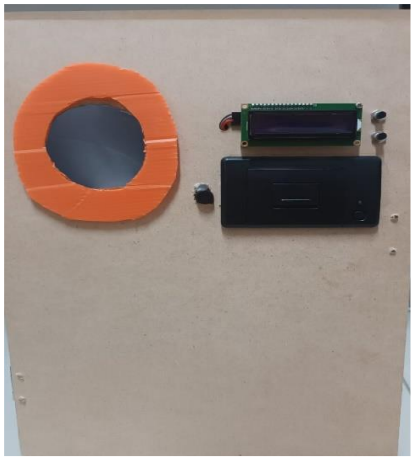

Figure 12: The MDD prototype

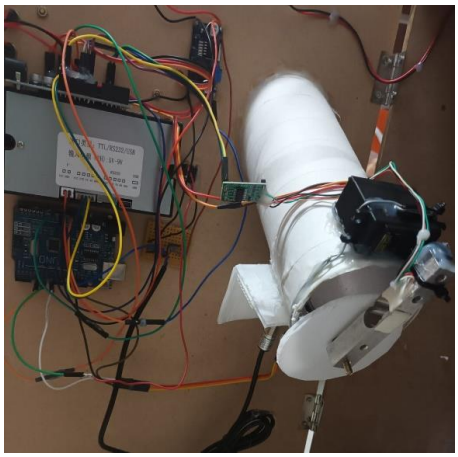

Figure 13: Hardware circuit inside MDD prototype

The Arduino microcontroller is the brains behind the MDD system. The data produced by the load cells was collected by the Arduino software. The Arduino has been configured to translate the voltage data from the module into mass values. Another task of Arduino is to provide voltage 5V to HX711 module and the load cells. An Arduino Uno, which has mass-load applications, was used in this study as a data gathering system.

One suggestion for this system is to use the ESP 32 microcontroller board, which is superior to the Arduino board in terms of power. In contrast to the Arduino Uno, the ESP 32 operates at a frequency of up to 160 MHz with two cores. Moreover, it can support more sensors and modules because it has more GPIO pins than the Arduino Uno. In addition, it features additional PWM and analogue pins. Table 1 present a comparison of the Arduino Uno and ESP 32 microcontroller boards.

Table 1
Comparison between Arduino Uno and Esp. 32

Specs/board	**Esp32**	**Arduino Uno**
Number of cores	2	1
Architecture	32 bit	8 bit
CPU frequency	160 Mhz	16 Mhz
Wifi	Yes	No
Bluetooth	Yes	No
Busses	SPI,12C, UART,12S, CAN	SPI, 12C, UART
ADC pin	18	6
DAC pin	2	0

As an additional suggestion for this project, researchers could concentrate on creating an internet of things (IOT) system that would allow consumers to apply mobile applications (App) like "Duit Now," "Scan & Pay," or "E-Wallet" to receive cash payments straight into their bank accounts. It is advised that researchers create new sensors and LCD devices that will enable MDD to be improved in the future.

Conclusion

The prototype MDD was constructed well, and the system is working. The Arduino Uno microcontroller board was successfully built to provide messages and user prompts for the development display system of the MDD. This system receives data from sensor circuits and controls the LCD. The microcontroller was programmed using the Arduino programming language. The software includes all of the user prompts and messages that appear as a result of the event conditions. Moreover, the program allows for point accumulation throughout the recycling process.

By accumulating reward points, the thermal printer achieved its objective. Engage with the microcontroller, which the material recognition system uses to obtain sensor inputs. Both items' weights are measured by the HX711 load cell module. The appropriate reward point is then obtained by converting the weight of the waste material. After receiving their receipts, the user can claim their money. There are certain restrictions with the prototype, though. The system still has problems, including with how smoothly it operates. It is possible to

successfully develop and implement the system. Overall, the MDD provides a low-cost and simple solution for implementing Reverse Vending Machines in our country.

By giving them points, MDD aims to encourage recycling among its users. The machine should therefore be positioned in public areas like homes, colleges, and retail centers. A significant role can be played by the private sector in addition to funding the machines. For instance, the college paid for the equipment and then promotes recycling among its students. Students can get their reward points back in return.

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