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Research paper



Wastage Pay Smart Bin

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Abstract

The separation of waste materials into degradable and non-degradable waste is one of the major issues in our country. As the plastic materials cause major harm to the humans as well as the environment it should be separated and effectively recycled. The non-degradable plastic wastes do not allow the rain water to pass through it thereby decreasing the ground water level. If these wastes are burnt, it emits carbon monoxide which is harmful to the humans. Our project is to encourage the people to dump and segregate the waste materials in their households using smart bins. The separation of the plastic waste is done by using capacitive type proximity sensor and ultrasonic sensor. In order to encourage the people to collect and segregate the waste materials, in large amount, they are rewarded for the amount of waste that they collect and segregate. The amount of waste collected is displayed in the website and in their mobile phones with the amount of reward points earned. The customers redeem their reward points in the shops mentioned in the website.

Keywords: *Arduino, proximity sensor, reward points, ultrasonic sensor, waste segregation.*

1. Introduction

Collection, separation and disposal of waste materials in developing country like India are a major problem. Recycling of waste is one of the important methods adopted to manage the waste effectively [1-3]. There are no hard and fast rules in our country that force the people to collect and manage the waste. So creating awareness among the people to collect the waste and separate it into degradable and non-degradable waste is a difficult task [4-6]. RFID techniques are adopted in developing countries like India, China and Malaysia to manage the waste effectively [7-11]. This project encourages the people to collect the waste in the particular area by giving rewards to them as points depending on the amount of waste that they have collected.

Razali Tomari, Aeslina Abdul Kadir et al. [12] have developed a Reverse Vending Machine (RVM) concept which had a recycle bin to collect the waste and then awarded points depending on the type, weight and price of the recycle waste. The recycle bin is equipped with microcontroller and a number of sensors. The sensors are responsible to identify the user information, weigh the amount of waste and convert it into points based on the weight. The user can redeem the points by using RFID point card. This concept has been implemented in a small scale.

Mary Victoria, Bhuvaneswari et al. [13] have developed a system that segregates the recycle waste into glass, plastic, metal, paper and wood and dispose them in their proper bins. The segregation is based on the physical properties of the materials like dielectric strength, reflective, absorption and inductive properties. Here the recycle waste materials are moved through a conveyor in which different sensors are placed at the bottom. Based on the material properties they are separated and moved to the respective bins.

Subhasini Dwivedi et al. [14] have proposed a waste separation mechanism controlled by Program Logic Controller. In this mechanism hydraulic cylinder flaps and sensors are used to separate the collected waste and dumped into the respective dust bins. Proximity sensors, inductive and capacitive sensors are used in this mechanism.

S.M. Dudhal et al. [15] have developed a wastage separation mechanism controlled by Program Logic Controller in which metallic wastes are separated and is dumped into a bin. In this mechanism a robotic arm is moved over the conveyor which carries the waste. An electromagnet is attached to the robotic arm which attracts the metallic wastes and separates it from other wastes.

Ruveena Singh et al. [16] have proposed a waste separation mechanism controlled by a microcontroller which separates waste into bio degradable and degradable wastes. The microcontroller receives the signal depending on the type of waste and the corresponding dust bin lid is open for disposing the waste operated by a servo motor.

Pavithra et al. [17] have proposed a smart trash system with integration of communication technologies like Zigbee and sensors. This system prevents the emanation of toxic gases from the trash bin when it overflows. Infrared sensor is used to find out the level of the trash in the bins and a gas sensor is used to detect the amount of toxic gases.

M. K. Pushpa et al. [18] have designed an automatic waste segregator using microcontroller. In the proposed mechanism an inductive sensor is used to separate the metallic waste. Also a blower is implemented to separate dry and wet waste.

The paper is organized as follows: Section 1 describes the need for segregation of waste and the literature that describes about the waste collection and separation. Section 2 describes about the block diagram of the proposed system and its working. Section 3 portrays the importance of different components present in the proposed system and its working. Section 4 describes the code development and hardware implementation of the proposed system. Section 5 details about the results and discussion of the pro-

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posed system. Section 6 concludes the proposed work with its future scope.

2. Methodology

The Wastage Pay Smart Bin works on the basis of the reverse vending machine. In this project we had done a working model of the machine. In this Smart Bin the waste materials are dumped through the inlet. Then the sensors are used to separate the waste into plastic and non-plastic. There are two trays or bins placed on the either side of the machine. One bin is used to dump the plastic waste and the other bin is used to dump the non-plastic waste. Based on the nature of the waste material the stepper motor rotates either in clockwise or anti clockwise direction and the corresponding waste material is dumped into the respective bin. The stepper motor is also connected to an Arduino module.

The load cell is interfaced with the Arduino through the HX11 load cell module. The load cell module is used to calculate the weight of the waste material dumped. Depending on the amount of waste material collected and its type, reward points are calculated and are sent to the user mobile. The user redeems his reward points in any of the nearby stores. A website has been designed for this project. The user can log in and find his details, the amount of reward points earned and the address of the stores where he could redeem his points. An additional feature in this project is when the user is dumping the waste into the smart bin he could check his body weight. It is displayed on the LCD module in the front panel of the bin. Many numbers of such smart bins can be placed in different parts of the city and the amount of waste collected per day is viewed through the website with its location. Moreover ultrasonic sensor is used to intimate the status of the waste bin. If the waste bin is full, the ultrasonic sensor senses it and intimates to the working personnel through SMS to mobile phones or through a buzzer.

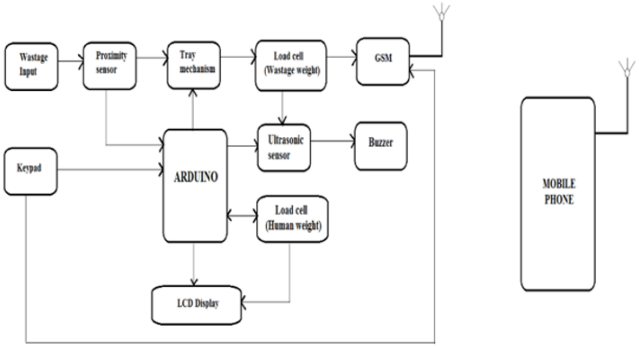


Fig. 1: Block Diagram of the Proposed System

3. Components Used in the Proposed System

The different components used in the proposed system and their functionalities are listed.

3.1. Arduino

Arduino is an open source computer hardware and software which is an important tool of this project. The Arduino of UNO model is used in this project. The Arduino consists of many pins which act as a transmitter and receiver. It is used for different operations through programming. This is programmed by using the Arduino software based on the requirements. In this project Arduino is used to measure the weight of the waste particles dumped into the bin. This is done by interlinking the load cell module with the Arduino. Finally the weight is displayed on the screen. Another purpose of this Arduino is it operates the stepper motor based on the type of waste to be dumped into the bin. The signals are transmitted and received with the help of the operation of different pins. This Arduino is interlinked to different modules.

3.2. GSM Module

GSM means Global System of Mobile Communication. The GSM module is used to communicate with other networks. It is like a modem, which requires an SIM card so that it can send messages to other networks. In this project, the GSM Module is used to send points to the mobile phones of the person who dumps the waste materials into smart bins. Once the user dumps the waste into the smart bin, it is separated into degradable and non-degradable wastes with their weights calculated. Depending on their weight points are calculated. To send this reward points to the user mobile a query is generated with Arduino and is displayed on the front panel of the machine and it requests the user to enter his phone number. Once the user has entered his phone number the points he has earned is transmitted to his mobile.

3.3. Ultrasonic Sensor

An Ultrasonic sensor is a device that measures the distance of an object by using sound waves. It measures distance by sending a sound wave at a specific frequency and listening for that sound wave to return back. By recording the elapsed time between the sound wave being generated and the sound wave returning back, it is possible to calculate the distance between the sonar sensor and the object. The ultrasonic sensor is used to indicate that the dust-bin is full. The ultrasonic sensor sends the sound waves inside the dust bin. If the dustbin is full, the sound waves will return immediately. Through this the user is able to find the status of the bin.

3.4. Load Cell

A load cell is used to measure the weight. When an object is placed on the load cell, a proportional force is created. Normally, a transducer converts this force into its equivalent electrical quantity. The magnitude of the electrical quantity is directly proportional to the force produced on it. The hx11 module is used to interlink the load cell with the Arduino. The output of the load cell is of analog signal which is converted into a digital signal. Hx11 amplifies the two analog input channels. It amplifies the low electrical output of load cell and then this amplified and digitally converted signal is fed into the Arduino to derive the weight.

3.5. Stepper Motor

Stepper motors are DC motors that can rotate in discrete steps. They have multiple coils that are organized in groups called "phases". By energizing each phase in sequence, the motor will rotate one step at a time. Two stepper motors are used to rotate the tray either in clockwise or anti clockwise direction so that the separated waste is dumped into the respective bins.

3.6. Capacitive type proximity Sensor

Capacitive proximity sensors sense the desired target objects with its nature of electrical charge. Plastic wastes are separated with this type of sensors.

4. Implementation

The important steps involved in the implementation of the proposed system are Code Development and Hardware design.

4.1. Code Development

The code development is one of the important aspects of this project. Arduino is used to control the smart bin. Through proper coding of Arduino the objective is implemented. The code is compiled and uploaded to the Arduino through the Serial Port. The entire process is illustrated in the Fig. 2.

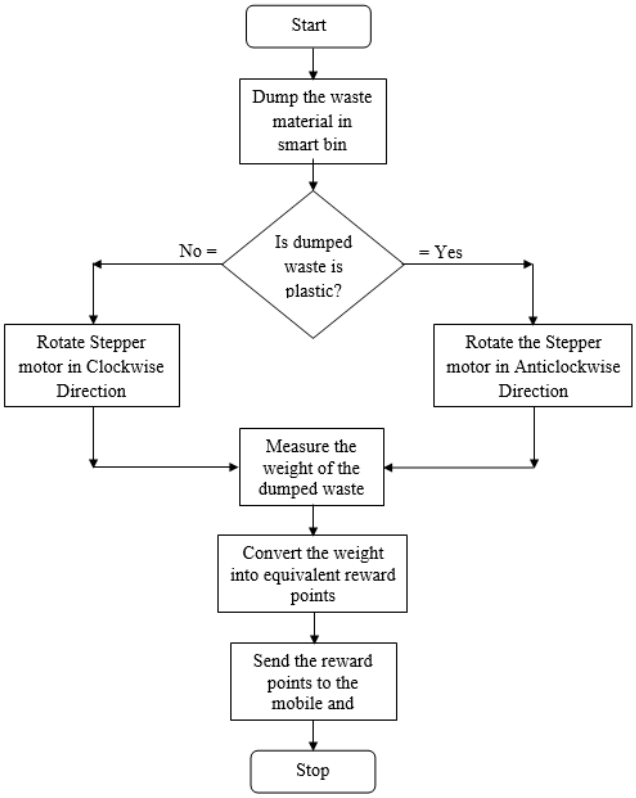


Fig. 2: Flowchart of the process carried out in the proposed system

4.1.1. Coding compiled in Arduino IDE environment

The LCD and load cell modules are interfaced with Arduino and initialized according to the specifications.

```
#include <HX711_ADC.h> // https://github.com/olkal/HX711_ADC
#include <Wire.h>
HX711_ADC LoadCell(6, 7); // parameters: dt pin, sck pin<span data-mce-type="bookmark" style="display: inline-block; width: 0px; overflow: hidden; line-height: 0;" class="mce_SELRES_start"></span>
#include <LiquidCrystal.h>
constintrs = 12, en = 11, d4 = 5, d5 = 4, d6 = 3, d7 = 2;
LiquidCrystallcd(rs, en, d4, d5, d6, d7);
constint threshold = 50;
```

The stepper motors are interfaced to the 8th and 13th pin of Arduino. The codes inside the void setup ( ) will be executed once, while the Arduino is turned on. This function is used to initialize the LCD, load cell, stepper motors and the parameters required for serial communication.

```
const int motor1  = 8;  // Pin 14 of L293
const int motor2  = 13;  // Pin 10 of L293
void setup()
{                                                    //Set pins as outputs
pinMode(motor1, OUTPUT);
pinMode(motor2, OUTPUT);
LoadCell.begin(); // start connection to HX711
LoadCell.start(2000); // load cells gets 2000ms of time to stabilize
LoadCell.setCalFactor(999.0); // calibration factor for load cell
 // set up the LCD's number of columns and rows:
lcd.begin(16, 2);
mySerial.begin(9600);   // Setting the baud rate of GSM Module
Serial.begin(9600);     // Setting the baud rate of Serial Monitor (Arduino)
Serial.println("GSM  BEGIN");
lcd.setCursor(0, 0);
lcd.print("Waste Seperator");
 }
```

The codes inside the *void loop ( )* will be repeated as long as the Arduino is in ON state. The dumped waste is checked for separation and depending on the status signal from the capacitive sensor the Arduino will send the command signals to the stepper motors.

```
void loop()
{
lcd.setCursor(0, 0);
lcd.print("..<<CHECKING>>..");    //Save income data to variable 'state'
if(Serial.available() > 0)
   {
state = Serial.read();
   }
```

If the dumped waste is plastic, the sensor sends the signal as “F” to Arduino and the stepper motor 1 rotates in anticlockwise direction.

```
if (state == 'F')                                    // Serial.println(state);
{ lcd.setCursor(0, 0);
lcd.print("Plastic Detect");
digitalWrite(motor1, HIGH);
digitalWrite(motor2, LOW);
delay(1300);
digitalWrite(motor1, LOW);
digitalWrite(motor2, HIGH);
delay(1300);
digitalWrite(motor1, LOW);
digitalWrite(motor2, LOW);
delay(10000);
load();
}
```

If the dumped waste is plastic, the sensor sends the signal as “G” to Arduino and the stepper motor 2 rotates in clockwise direction.

```
else if (state == 'G')
{ lcd.setCursor(0, 0);
lcd.print("Others Detect");          //Serial.println(state);
digitalWrite(motor1, LOW);
digitalWrite(motor2, HIGH);
delay(1300);
digitalWrite(motor1, HIGH);
digitalWrite(motor2, LOW);
delay(1300);
digitalWrite(motor1, LOW);
digitalWrite(motor2, LOW);
delay(10000);
  }
}
```

The function *void load ( )* is used to calculate the weight of the dumped waste using load cell. The calculated waste is displayed in the LCD. The weight is converted into reward points and it is transferred to the website and mobile number using GSM.

```
void load()
{  lcd.setCursor(0, 0);
lcd.print("Measure Weight");
LoadCell.update(); // retrieves data from the load cell
floati = LoadCell.getData(); // get output value
lcd.setCursor(0, 0); // set cursor to first row
lcd.print("Weight[g]:"); // print out to LCD
lcd.setCursor(0, 1); // set cursor to secon row
lcd.print(i); // print out the retrieved value to the second row
if (i >= threshold)
{
Serial.println("msg 1");
mySerial.println("AT+CMGF=1");    //Sets the GSM Module in Text Mode
delay(1000);  // Delay of 1000 milli seconds or 1 second
mySerial.println("AT+CMGS=\"+91xxxxxxxxx\"\r"); // Replace x with mobile number
delay(1000);
mySerial.println("1 point credited");// The SMS text you want to send
delay(100);
mySerial.println((char)26);// ASCII code of CTRL+Z
delay(1000);
Serial.println("msg 1 sent");
```

```
}
else if (i<=threshold)
{
mySerial.println("AT+CMGF=1");    //Sets the GSM Module in Text Mode
delay(1000);  // Delay of 1000 milli seconds or 1 second
mySerial.println("AT+CMGS=\"+91xxxxxxxxxx\"\r"); // Replace x with
mobile number
delay(1000);
mySerial.println("2 point credited");// The SMS text you want to send
delay(100);
mySerial.println((char)26);// ASCII code of CTRL+Z
delay(1000);
}
}
```

Figure 3 shows the Arduino IDE environment which is used to implement the software coding in the Arduino module. The Arduino IDE is open source software which is downloaded from their website www.arduino.cc.

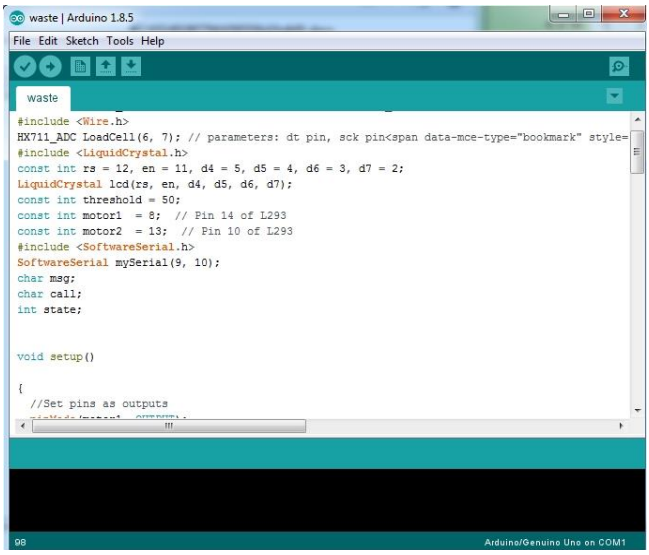


Fig. 3: Arduino IDE environment compiler used to run the coding

4.2 Hardware Implementation

The prototype of the smart bin is designed using solid works software. The design of the proposed system is modelled as a 2D sketch. Dimensions are added to the sketch to define the size and the geometry of the proposed model. Views are automatically generated from the sketch and a solid model is formed. The front view of the smart waste bin is shown in figure 4 and its inner view in figure 5. The smart bin has two inlets through which wastes are dumped. The dumped waste falls on the tray which is placed inside the smart bin. The sensors are placed at the bottom of the tray. Depending on the type of waste the tray is rotated clockwise or anticlockwise direction using two stepper motors.

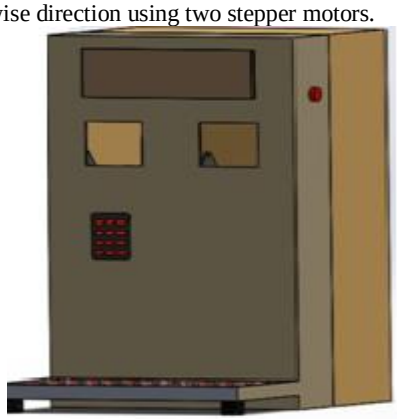


Fig. 4: Front Panel of the Wastage Pay Smart Machine

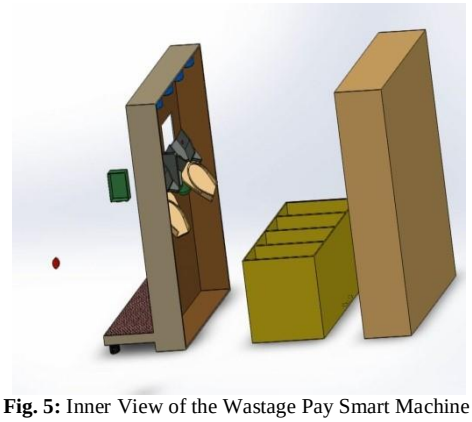


Fig. 5: Inner View of the Wastage Pay Smart Machine

The bins or collectors which are used to dump the plastic and non-plastic wastes are placed on the load cell. This load cell is used to weigh the amount of waste dumped and send the weight to Arduino that converts the weight into proportionate reward points. One more load cell is placed in front of the machine to calculate the weight of the humans who dump the waste. The reward points are then sent to the designed website and mobile phones of the user through GSM module. Also LCD display is provided in the front panel of the machine which displays the weight of the dump waste and the reward points earned. The hardware implementation of the proposed system is shown in Figure 6.

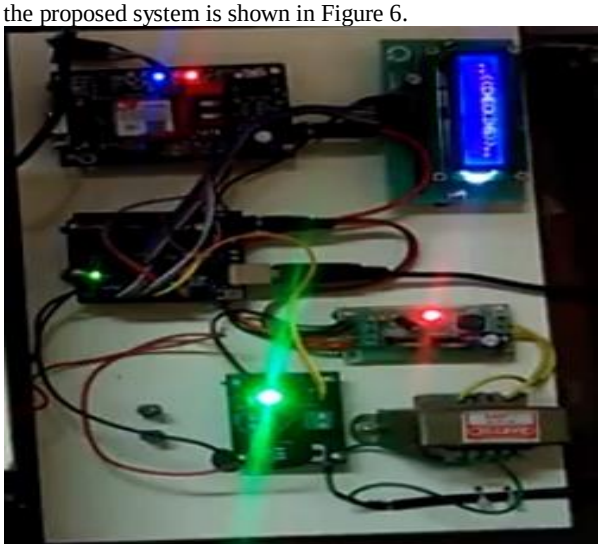


Fig. 6: Hardware implementation of the proposed system

5. Results and Discussion

Different types of wastes are dumped and the rotation of stepper motor is checked for each case. The findings are tabulated in Table 1. If the dumped waste is plastic the stepper motor rotates in anti-clock wise direction and if the dumped wastes are plastic the stepper motor is rotated in clockwise direction.

Table 1: Result of Waste Segregation

Type of waste	Condition of waste	Direction of rotation of stepper motor
Metal	dry	Clockwise
Plastic	dry	Anticlockwise
Wood	dry	Clockwise
Vegetable waste	wet	Clockwise
Glass	dry	Clockwise

The website is used to display the amount of waste collected from various smart bins, which are placed at different places in the city. The website is designed using Wix. Wix is a cloud-based web platform. The website is created without prior knowledge of web programming language in Wix and is free of cost. The screenshots of the created website are shown in Fig. 7, 8, 9 and 10.



Fig. 7: Home page of the Wastage Pay Smart Machine

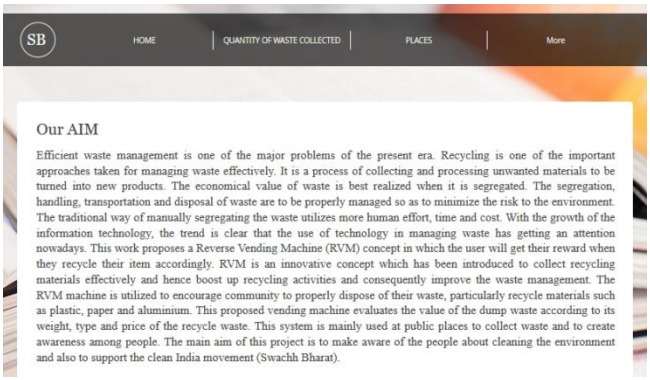


Fig. 8: Page showing the need for the proposed project



Fig. 9: Page showing the amount of waste collected per day

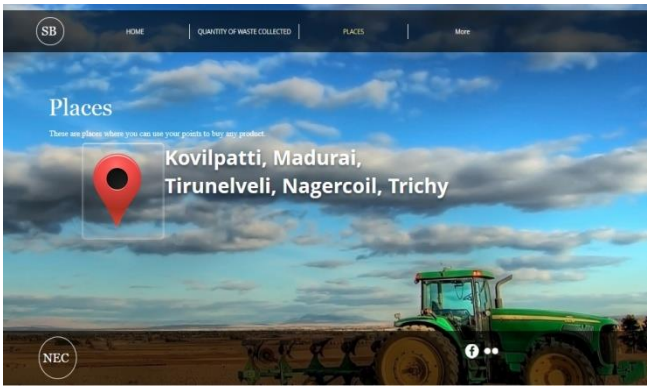


Fig. 10: Page showing the places where reward points can be redeemed

6. Conclusion

The main focus of this project is to create awareness among the people about recycling of plastic wastes. It is also aimed to support our Government campaign Clean India or Swatch Bharath. These types of smart waste bins have been started to be placed at few places. By implementing these types of projects Clean India will be a reality in few years. Implementation of this project and banning the usage of plastics will increase the ground water level, decrease the environmental pollution and improve the habitat of aquatic animals. The future scope of this project is linking the smart waste bins to internet and controlling them through IoT. This can also be extended to separate E-waste and biomedical waste through image processing techniques.

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