A Smart Trash-bin based on Automatic Recycling and Segregation of Household Waste (STARS-HW)

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Received 03.06.2023 **received in revised form** 04.11.2023, **accepted** 06.11.2023
DOI: 10.47904/IJSKIT.13.2.2023.47-53

***Abstract*—Sustainable growth is severely hampered by the rising amount of waste produced in urban areas. Intelligent waste management systems have been created as a solution to this issue. The purpose of this research study is to develop a Smart Trash-bin based on Automatic Recycling and Segregation of Household Waste (STARS-HW) using IoT-based technology. The suggested technique separates dry and wet waste automatically. The device uses ultrasonic sensors to measure the amount of garbage currently present inside the system and whether a user is nearby or not. After processing the collected data, an Arduino microcontroller opens the trashcan's lid and lets the trash inside. The STARS-HW system promotes household waste recycling and encourages users to separate their waste. The suggested technology has undergone testing and validation in a domestic setting, and the outcomes demonstrate that the STARS- HW system is effective and efficient at classifying and separating household waste.**

***Keywords*—Smart waste management, Arduino, Sensors, Recycling, Segregation, Household waste, Technology.**

1. INTRODUCTION

Numerous researchers have put forth numerous approaches to garbage segregation and recycling that make use of diverse technologies, including sensor-based systems, computer vision, and machine learning presented by Ali, T., Irfan, M., Alwadie, A.S. et al. [1] explores the application of Internet of Things (IoT) technology in creating a smart waste management system for cities. The proposed system utilizes IoT devices and sensors installed inside waste bins to keep track of their capacity levels and optimize waste collection processes. Real-time data from the sensors is transmitted to a central monitoring system, enabling waste management authorities to schedule collection routes based on the actual capacity levels, reducing unnecessary collection trips, and optimizing resource allocation.

An intelligent garbage segregation system utilizing machine learning and a robotic arm was proposed by Anjali et al. [2]. The waste is photographed by the system using a camera, and machine learning techniques are then utilized to determine the type of waste. The waste is then divided by categories and placed in various bins by the robotic arm.

Another strategy is to identify and categorize garbage using computer vision techniques. A smart trash management system that employs a camera and a Raspberry Pi microprocessor to detect and categorize trash was presented by Kalaivani et al. [3] Garbage can be divided into three groups by the system: organic, recyclable, and non-recyclable garbage.

Waste segregation and recycling have both been presented as applications for sensor-based systems. A smart trash bin that can detect and classify waste using a mix of infrared and ultrasonic sensors was proposed by Li et al. [4]. Plastic, metal, paper, and other garbage can all be categorized by the system into one of these four groups.

Smart trash bins have emerged as a promising solution to enhance waste management practices. In the work of C. Kolhatkar et al. [5], a smart bin prototype was developed using IoT protocol and ultrasonic sensor to automate waste segregation. The study demonstrated improved accuracy in waste sorting and reduced human effort.

Similarly, Chen et al. [6] proposed a smart waste bin system that employed infrared sensors and machine learning algorithms to automatically categorize and sort waste. The system demonstrated efficient waste segregation and helped educate users about properdisposal methods.

Various waste management systems have been explored to optimize waste segregation and recycling. In the study by K. Belsare et al. [7], an IoT-based waste management system was developed in which medical waste was separated as dry and wet waste. The system improved waste collection efficiency and provided real-time monitoring of waste levels.

A smart trash can that uses sensors and radio frequency transmitter to prevent garbage overflowing the container was developed by Adil Bashir et al. [8]. This smart dustbin reduced the requirement for the vehicles and manpower deployed, as a result, lowering the risk to the workers' health as the trash dumped is heavily contaminated.

B. Chowdhury and M. U. Chowdhury [9], presented a research study on the development and implementation of an RFID-based real-time smart waste management system. The authors address the challenges associated with traditional waste management practices and propose an innovative solution that leverages RFID technology to monitor and manage waste collection processes efficiently. The RFID readers installed in the waste collection vehicles communicate with the RFID tags on the bins, collecting data on fill levels and bin locations. This real-time data is transmitted to a central management system, enabling efficient route optimization and scheduling of waste collection. The paper emphasizes the advantages of the RFID-based system, such as improved operational efficiency, reduced costs, and optimized waste collection processes. Furthermore, the authors highlight the potential for integrating additional technologies, such as GPS (Global Positioning System) and GIS (Geographic Information System), to enhance the system's capabilities.

A. Tripathi, C. Pandey, A. Narwal, and D. Negi proposed a cloud-based smart dustbin system that is specifically designed for metro stations equipped with fill-level sensors [10]. With the help of RFID tags, an RFID reader, an ultrasonic sensor, dc and servo motors, an Arduino UNO, a Raspberry Pi, and a solar module for power supply, this technology offered a workable solution for the dustbins at metro stations. For waste monitoring, the system makes use of a cloud-based monitoring system. Routine bin checks are unnecessary with the deployment of cloud-based systems. The metro system incorporates a small solar panel for power supply to make the system environmentally friendly and maintain its carbon neutral impact.

Arduino, an open-source electronics platform, has been widely used in the development of smart systems. Several studies have explored its application in waste management. Zhang et al. [11] developed an Arduino- based smart trash bin system that used ultrasonic sensors and a mobile application to monitor and manage wastedisposal.

In this article, STARS-HW system is based on the design of a smart waste can control system. The system uses sensors to detect the type of waste and segregates it accordingly. The result of the research show that the waste bin control system is effective in segregating waste and increasing the recycling rate. The proposed system is also cost-effective and can be easily implemented in household.

Based on Arduino technology, the STARS-HW system has been developed. For the system to function properly, it requires two sensors: one to measure the amount of trash in the trash bin and another to measure the distance between people.

2. DESIGN

A. Methodology

The project is based on IOT. Here, we are utilizing an Arduino microcontroller to run code and an ultrasonic sensor to detect the user and the amount of trash in the trash can. When a user is in the range of 12 cm from the trashcan, the ultrasonic sensor recognizes and opens the trash lid. All the trash is manually moved to PVC tubing after a movable tray (constitutes of minutes holes at equal distances) present at the bottom of the trash can is removed. Waste is divided into its solid and liquid components with the aid of a sieve linked to a main pipe. While solid waste is crushed and ground into smaller bits, the liquid passes through a secondary pipe and is filtered by the application of a water filter based on the sedimentation process. The Arduino microcontroller (ATmega328P), servo motor, and ultrasonic sensor, DC motor are all used to automate the smart trash can, and they are all managed via the Arduino IDE.

Solid and liquid waste can be distinguished by putting them into separate PVC pipes. If the waste is liquid, it will pass through the sieve attached at the bottom of the main pipe and flow into the secondary pipe, falling into a container after passing through the water filter. If the waste is solid, it will flow through the main pipe and crushed into smaller pieces.

STEP-1: Detection of human being and opening of dustbin lid.

STEP-2: Detection of level of bin and compressing thewaste using piston.

STEP-3: Removing the tray at bottom of the bin manually and garbage flows into pipes.

STEP-4: Separation of solid and liquid waste takes place and further it will segregate to different compartments.

STEP-5: Solid waste will be crushed, and liquid will befiltered

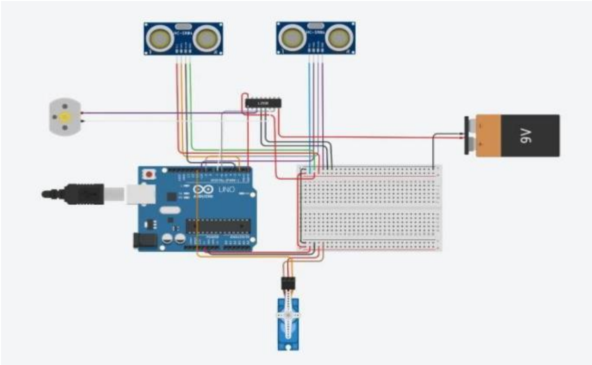

Figure 1: Simulation Diagram

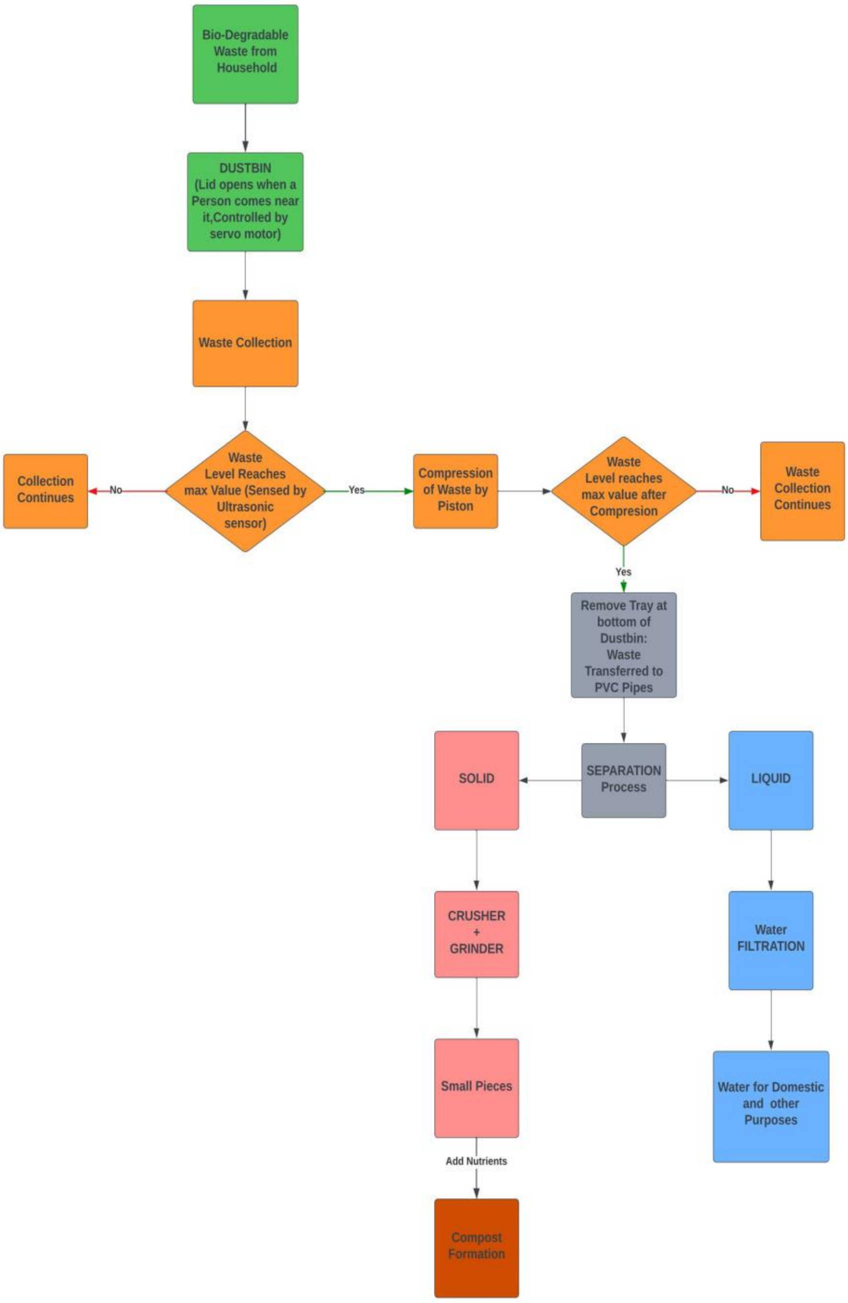

Figure 2: Control Flow Diagram

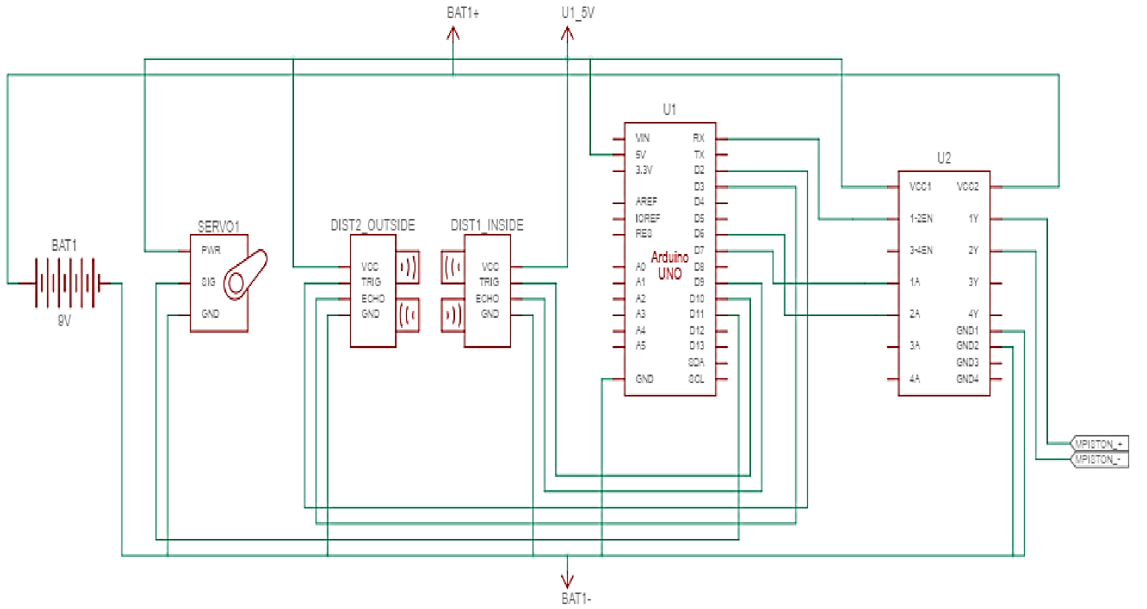

Figure 3: Circuit Diagram

B. *Components Used*

Arduino Uno: Arduino Uno is built on ATmega328P microcontroller. It is more convenient to use Arduino uno as compared to other boards, such as Arduino Nano board, Arduino Mega board, etc. The board comprises of digital and analog input and output pins, shields, and other additional circuits. The Arduino UNO board as shown in Fig. 4 contains 14 digital and 6 analog pins, a Barre jack for power input, a USB connector and an ICSP (In-Circuit Serial Programming) header. It is programmed built on Integrated Developed Environment.

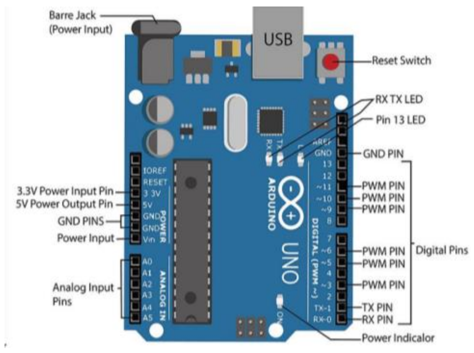

Figure 4: Arduino UNO Board

Servo Motor: The control circuit of a servo motor includes a feedback loop on the current position of the motor shaft, which allows the servo motors to rotate with high efficiency and extreme precision. The servo motor is used to rotate an object between 0 and 180 degrees. [13].

Figure 5: Servo Motor

DC Motor: An electromechanical device known as a DC motor, converts electrical energy into rotational energy by developing a magnetic field that is driven by supplied direct current. When a DC motor is energized, a magnetic field is generated in the stator. This magnetic field is attracted and repelled by magnets on the rotor, which makes the rotor rotate. To keep the motor's wire windings current-driven and maintain the rotor's regular spinning, the commutator, which is hooked to brushes and plugged into the power supply, is used. [14].

Figure 6: DC Motor

L298N Motor Driver: A motor driver is employed to regulate the motion and direction of a motor simultaneously by providing current in accordance. The output signal from the motor driver is in digital form, so it uses PWM (Pulse Width Modulation) input to direct the speed of a motor. Relays, solenoids, transformers, and other inductive loads can also be driven by it. [15].

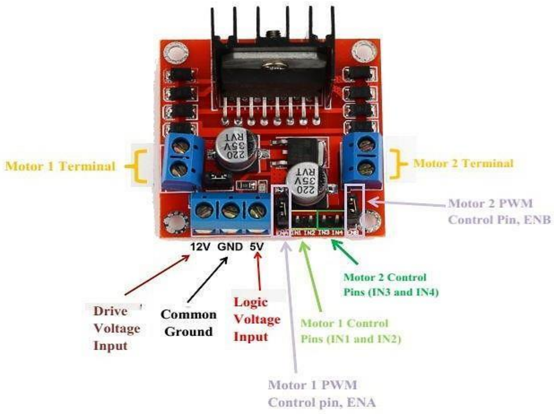

Figure 7: Motor Driver

Ultrasonic Sensor: By generating ultrasonic waves, which travel faster than audible sound waves (i.e., sound that humans can hear), a target object's distance can be determined. The two fundamental parts of an ultrasonic sensor are the transmitter (which generates sound waves using crystals with piezoelectric properties) and the receiver (which collides with the sound waves after they have travelled from the source to the target). [16].

Figure 8: Ultrasonic Sensor

3. ARDUINO CODE

```
#include <Servo.h>
int servopin=11;
Servo myservo;

int speedpin=0;//Piston Motor
int dir1=7;
int dir2=6;



int echopin1=9; //Sensor:Inside
int trigpin1=10;
long duration1;//Waste Level Detection
long distance1;

int echopin2=3;//sensor:Outside
int trigpin2=2;
long duration2;//Object Detection
long distance2;

void setup(){
  pinMode(echopin1,INPUT);
  pinMode(trigpin1,OUTPUT);
  pinMode(echopin1,INPUT);
  pinMode(trigpin2,OUTPUT);

  myservo.attach(servopin);

  pinMode(speedpin,OUTPUT);
  pinMode(dir1, OUTPUT);
  pinMode(dir2, OUTPUT);


  Serial.begin(9600);
}
```

```
void loop(){

digitalWrite(trigpin1, LOW); //Sensor:Inside
delayMicroseconds(2);
digitalWrite(trigpin1, HIGH);
delayMicroseconds(2);
digitalWrite(trigpin1, LOW);

duration1=pulseIn(echopin1, HIGH);//Waste level

distance1 = duration1 * (0.034)/2;
Serial.print("Distance1: ");
Serial.print(distance1);
Serial.println(" cm");

digitalWrite(trigpin2, LOW); //Sensor:Outside
delayMicroseconds(2);
digitalWrite(trigpin2, HIGH);
delayMicroseconds(2);
digitalWrite(trigpin2, LOW);

duration2=pulseIn(echopin2, HIGH);//Object Detection

distance2 = duration2 * (0.034)/2;
Serial.print("Distance2: ");
Serial.print(distance2);
Serial.println(" cm");

  if (distance2<=80){ myservo.write(179);

}
  else{myservo.write(0);

```

```

  }

 if((distance1<15))
 {

   digitalWrite(6,LOW);
   digitalWrite(7,HIGH);
   delay(3000);
   digitalWrite(6,HIGH);
   digitalWrite(7,LOW);
   delay(3000);
 }






  else if(distance1>15)
 {
   digitalWrite(7,LOW);
   digitalWrite(6,LOW);


 }
  }

```

4. RESULTS AND DISCUSSION

Different household garbage was used to evaluate the STARS-HW system, including wet waste (leaves, paper) and culinary waste (vegetables, fruit peels, tea waste, etc.). According to the type of trash (dry and moist), the system was able to automatically separate and recycle it. The recycling mechanism was engaged when the bin was full, and once the bin was full, we manually removed the ray to execute dry waste segregation. The ultrasonic sensors were used to observe the level of trash in the bin and to detect human presence nearby.

The piston installed in the dustbin is used to compress the waste and manages space inside the dustbin by suppressing the trash and, with the help of a compression procedure, separating the liquid waste existing in the dustbin through a moveable tray.

The DC motor on the end of the PVC pipe used for dry waste moves the blades, breaking the waste into smaller bits that can be utilized. One of the earliest and most basic methods of water treatment is sedimentation, and sedimentation filters are still commonly used today. Sand, silt, and clay suspended in water can be removed using a sedimentation filter. It functions by letting water flow into a tank or basin, where it is left to stand still for a while. During this period, the water's heavier constituents sink to the tank's bottom while its lighter constituents float to the top.

Figure 9: Prototype model

5. CONCLUSION

A Smart Trash Bin Based on Automatic Recycling and Segregation of Household Waste (STARS-HW) is a project that automates garbage segregation and recycling in homes using IOT technology. The system employs an Ultrasonic sensor to identify users and automate opening of lid and waste level detection.

The STARS-HW project, in conclusion, offers a creative and useful solution to the issue of trash segregation and recycling in homes. The system at waste and separates dry and moist garbage, opens the dustbin lid, senses the amount of waste, and sorts it into different compartments for recycling using sensors, motors, and a microcontroller.

Making recycling easier and more practical encourages people to recycle while also increasing the effectiveness oftrash management.

The STARS-HW initiative might significantly reduce the quantity of trash dumped in landfills and could make a big contribution to building a more sustainable future. This strategy could be adapted for use in more extensive waste management systems in cities and towns with additional research and development.

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