Smart Disposal Machine

Organizer: Robotics Club

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Final Submission Report

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1 Abstract

This project introduces a Smart Disposal Machine (SDM) designed for real-time waste monitoring and efficient waste management. Utilizing sensor-based detection, the system optimizes trash collection schedules, minimizing overflow and ensuring hygienic operations. Advanced mechanisms extend operational time by reducing the frequency of manual interventions. Optional IoT integration enables remote monitoring and automation, enhancing efficiency. Additionally, the system can incorporate automated waste segregation to streamline recycling. By addressing key inefficiencies in traditional waste disposal, the SDM promotes a cleaner and more sustainable waste management approach in high-traffic environments.

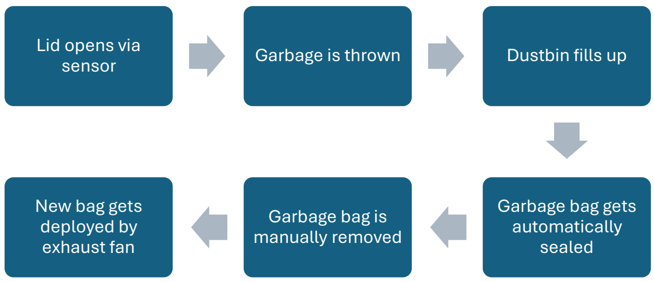
2 Problem Understanding

- **Smart Waste Monitoring System:** Develop a system that continuously monitors waste levels in real-time to optimize collection schedules and prevent overflow in high-traffic areas.
- **Hygienic and Efficient Waste Disposal:** Design a solution that minimizes human exposure to unsanitary waste conditions during disposal and maintenance.
- **IoT-Enabled Automation:** Incorporate remote monitoring and automated alerts to enhance operational efficiency and minimize manual intervention.
- **Automated Waste Segregation:** Develop an intelligent system to classify waste into biodegradable, recyclable, and non-recyclable categories.

Each of these components contributes to a robust and scalable waste management system aimed at improving sanitation, efficiency, and sustainability.

3 Approach

In this section, we outline the approach adopted for developing the Smart Disposal Machine (SDM) to enhance waste management efficiency and hygiene. We begin by describing the ultrasonic sensor-based waste level monitoring system, which categorizes fill levels at 33%, 66%, and 100% and provides real-time notifications through a web application. This is followed by an overview of the automatic lid mechanism, which utilizes ultrasonic sensors to minimize human exposure and maintain hygiene. Additionally, an automatic sealing mechanism is implemented to prevent waste exposure. To enhance waste classification, methane and alcohol sensors are incorporated to differentiate between biodegradable and non-biodegradable waste before disposal. Furthermore, an automated bag deployment system is integrated, where a vacuum exhaust fan deploys a new bag once the previous one is sealed and removed. This integrated approach ensures efficient waste management, improved sanitation, and enhanced automation. Following is the workflow.



3.1 Electronics

This system incorporates a total of three microcontroller boards to manage various functions. An Arduino Uno is responsible for hand detection, lid operation, and new bag deployment via the exhaust mechanism. An Arduino Mega 2560 controls the sealing mechanism and level detection, while a NodeMCU is integrated for IoT connectivity.

3.1.1 Lid opening:

The lid opens in response to an ultrasonic sensor which detects hand proximity and is actuated by a TowerPro MG90S micro servo motor.

3.1.2 New bag deployment:

A new bag is deployed using a vacuum mechanism powered by an exhaust fan, which is driven by an EMAX 1400KV BLDC motor which is switch operated. A big single piece garbage bag is used for multiple refills.

3.1.3 Sealing mechanism:

For the sealing process, a nichrome sealing element, fixed on one side, is utilized. A rod, connected to a prismatic joint driven by a lead screw powered by an RMCS 1023 stepper motor, pulls the filled bag toward the sealing element, facilitating both sealing and cutting. A relay will be used for the switching mechanism, and the entire system is powered by a LiPo battery.

3.1.4 Waste classification:

Alcohol and methane sensors will be integrated into the system to classify waste as either biodegradable or non-biodegradable before disposal. This classification ensures that users can dispose of waste appropriately based on its composition, promoting efficient waste segregation and management.

3.2 Arduino Code

Following are the code snippets of every mechanism:

3.2.1 Lid opening:

```
#include<Servo.h>

Servo servo;
const int _USOutsideTrig = 10;
const int _USOutsideEcho = 9;
float time = 0;
const int maxTime = 15;

float _USOutsideDur, _USOutsideDist;

void setup() {
  servo.attach(3);
  servo.write(0);
  pinMode(_USOutsideTrig, OUTPUT);
  pinMode(_USOutsideEcho, INPUT);
  Serial.begin(9600);
}

void servoOpen() {
  time = 0.001;
  servo.write(90);
}
```

```
void servoClose() {
  time = 0;
  servo.write(0);
}

void loop() {
  digitalWrite(_USOutsideTrig, LOW);
  delayMicroseconds(2);
  digitalWrite(_USOutsideTrig, HIGH);
  delayMicroseconds(10);
  digitalWrite(_USOutsideTrig, LOW);

  _USOutsideDur = pulseIn(_USOutsideEcho, HIGH);
  _USOutsideDist = (_USOutsideDur*.0345)/2;
  delay(100);
  if (_USOutsideDist < 100)
  {
    Serial.print("Opening Lid");
    servoOpen();
  }
  else if (time !=0 ){
    time += 0.5;
  }
  if (time >= maxTime){
    servoClose();
  }
}
```

3.2.2 New bag deployment:

```
#include<Servo.h>

Servo ESC;
int speed;

void setup() {
  // put your setup code here, to run once:
  Serial.begin(9600);
  ESC.attach(9);
  delay(1);
  ESC.write(10);
  delay(5000);
}

void loop() {
//   put your main code here, to run repeatedly:
  while(Serial.available() > 0)
  {
    speed = Serial.parseInt();
    Serial.println(speed);
    ESC.write(speed);//45 limit
  }
}
```

3.2.3 Sealing element:

```
// Ultrasonic sensor pins
const int trigPin = 2;
const int echoPin = 3;

// Relay pin
const int relayPin = 4;

// Detection distance threshold (in cm)
const int detectionDistance = 20;

void setup() {
  // Initialize ultrasonic sensor pins
  pinMode(trigPin, OUTPUT);
  pinMode(echoPin, INPUT);

  // Initialize relay pin
  pinMode(relayPin, OUTPUT);
  digitalWrite(relayPin, HIGH); // Turn off relay initially

  // Start serial communication for debugging
  Serial.begin(9600);
}
```

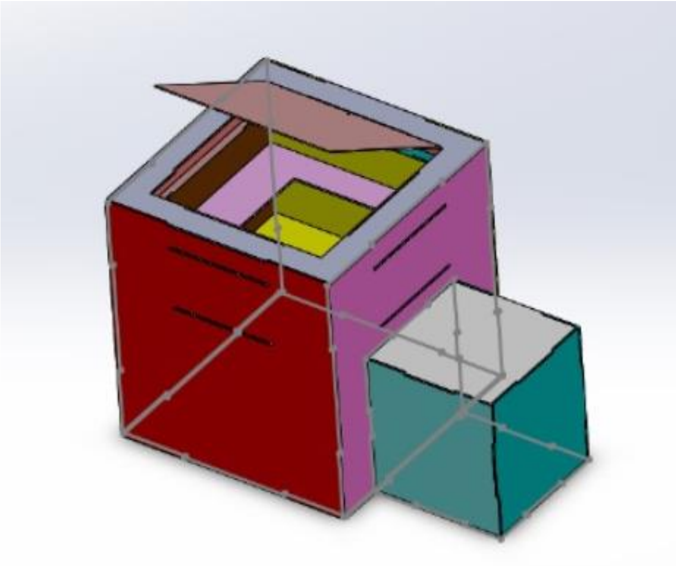
3.2.4 Level detection and stepper motor (sealing):

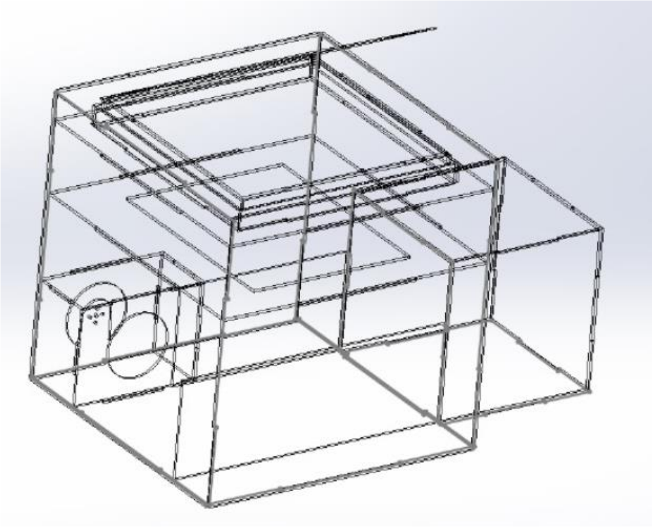
```
#define TRIG_PIN 30
#define ECHO_PIN 28
#define LED_33 26
#define LED_66 24
#define LED_FULL 22
#define NICHROME 32
#define X_STEP_PIN 2  // Pin for step signal (X-axis)
#define X_DIR_PIN 5   // Pin for direction signal (X-axis)
#define X_ENABLE_PIN 8 // Pin to enable/disable the motor
int dist = 5;
bool run = false;


void setup() {
  pinMode(X_STEP_PIN, OUTPUT);
  pinMode(X_DIR_PIN, OUTPUT);
  pinMode(X_ENABLE_PIN, OUTPUT); // Enable the motor (LOW to enable)
  digitalWrite(X_ENABLE_PIN, LOW); // Set direction of rotation
  digitalWrite(X_DIR_PIN, HIGH); // HIGH for one direction, LOW for the
other
  pinMode(TRIG_PIN, OUTPUT);
  pinMode(ECHO_PIN, INPUT);
  pinMode(LED_33, OUTPUT);
  pinMode(LED_66, OUTPUT);
  pinMode(LED_FULL, OUTPUT);
  pinMode(NICHROME, OUTPUT);
  Serial.begin(9600);
}
long getDistance() {
    digitalWrite(TRIG_PIN, LOW);
    delayMicroseconds(2);
    digitalWrite(TRIG_PIN, HIGH);
    delayMicroseconds(10);
    digitalWrite(TRIG_PIN, LOW);
    long duration = pulseIn(ECHO_PIN, HIGH);
    long distance = duration * 0.034 / 2;  // Convert to cm
    return distance;
}
```

```
void runStepper(int distance)
{
  for (int i = 0; i < distance * 200; i++) { // Assuming 200 steps per
revolution
            digitalWrite(X_STEP_PIN, HIGH);
            delayMicroseconds(1000); // Adjust speed by changing the delay
            digitalWrite(X_STEP_PIN, LOW);
            delayMicroseconds(1000);
        }
}
void loop() {
    long distance = getDistance();

    Serial.print("Distance: ");
    Serial.print(distance);
    Serial.println(" cm");

    // Turn on LEDs based on distance thresholds
    if(distance !=0){
      digitalWrite(LED_33, (distance <= 37) ? HIGH : LOW);
      digitalWrite(LED_66, (distance <= 29) ? HIGH : LOW);
      digitalWrite(LED_FULL, (distance <= 20) ? HIGH : LOW);
    }

    if ((distance < 20)&& (distance !=0)) {
        run = true;
        runStepper(dist);
        digitalWrite(NICHROME, HIGH);
        delay(10000);
        digitalWrite(X_DIR_PIN, !digitalRead(X_DIR_PIN));
        digitalWrite(NICHROME, LOW);
        runStepper(dist);
        digitalWrite(X_DIR_PIN, !digitalRead(X_DIR_PIN));
    }
}
```

3.3 Chassis and dimensions

Acrylic sheet cutouts with a thickness of 4mm have been used to create the entire chassis of the bin. And all this fits in a 45x45x45mm volume. The storage fits in 25x25x25mm volume.





4 Future Scopes and Applications

The Smart Disposal Machine (SDM) has the potential for significant advancements and widespread applications in various sectors. Future enhancements and potential applications include:

4.1 Integration with AI for Smart Waste Sorting: By incorporating artificial intelligence and machine learning, the SDM could autonomously classify waste more accurately, distinguishing between different types of biodegradable and non-biodegradable materials for optimized recycling and waste processing.

4.2 IoT-Enabled Data Analytics and Smart City Integration: The SDM can be connected to cloud-based IoT platforms, allowing real-time waste monitoring and predictive analytics. This data could help municipalities optimize garbage collection routes, reducing fuel consumption and operational costs while preventing overflow.

4.3 Solar-Powered Operation for Sustainability: To enhance eco-friendliness, future versions of the SDM could be equipped with solar panels, reducing reliance on external power sources and making the system more sustainable in remote and off-grid areas.

4.4 Industrial and Commercial Applications: The SDM can be deployed in hospitals, malls, airports, and office buildings to improve waste management efficiency in high-footfall areas. It can also be used in industrial settings to segregate hazardous and non-hazardous waste.

4.5 Public Awareness and Incentive-Based Recycling: A future version of the SDM could include an incentive system where users are rewarded for responsible waste disposal. This could encourage better waste segregation habits and increase recycling rates.

4.6 Robotic Waste Handling and Automation: Integrating robotic arms or conveyor mechanisms could further automate waste handling, reducing human intervention in the disposal and processing stages.

4.7 Accessibility for People with Disabilities: The SDM could be designed with accessibility features such as voice commands, motion sensors, and automated waste disposal mechanisms to assist individuals with disabilities. This would make waste disposal more inclusive and convenient for everyone.

By implementing these advancements, the Smart Disposal Machine can contribute to a more sustainable, efficient, and technologically advanced waste management ecosystem.

5 Results and Conclusions

The development of the Smart Disposal Machine (SDM) resulted in a working prototype that demonstrates the feasibility of automated waste management. The system successfully implements ultrasonic sensor-based waste level monitoring, categorizing fill levels at 33%, 66%, and 100%, with real-time notifications through a web application. The automatic lid mechanism minimizes human contact, promoting better hygiene, while the methane and alcohol sensors classify waste into biodegradable and non-biodegradable categories before disposal.

The prototype effectively automates waste disposal by sealing waste and deploying a new bag when the bin reaches full capacity. Through multiple tests, the system has shown that it can streamline waste segregation, reduce manual intervention, and enhance sanitation.

While this version serves as a proof of concept, there is significant potential for further development. Future improvements, such as AI-driven sorting, IoT-based data analytics, and expanded automation capabilities, could enhance its efficiency and scalability. With continued refinement, the SDM could play a key role in modern waste management, contributing to cleaner and more sustainable environments.

References

[1] https://ppubs.uspto.gov/dirsearch-public/print/downloadBasicPdf/20240327111?requestToken=eyJzdWIiOiIzNTQ0N2E2Mi1jYzI3LTQ4MGEtYjdiYi0xODE3NDBmODBhYzEiLCJ2ZXIiOiIyYzc0N2U3ZC0wY2UzLTRiZDItOTFkYi01NDA2NDY5MTk2MWUiLCJleHAiOjB9

[2] https://youtu.be/5tFnOZyDE_Q?si=TQ6Yb1H6t06FDDJ1

[3] https://youtu.be/vW-OW67hcNQ?si=MEajZLCJ3xpwDdPy