Incentive Based Smart Garbage Monitoring System Using IoT

Report submitted by

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19CCE384 – Design and Innovation Lab

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1. **Motivation:** Waste disposal is one of the major concerns in our society. Lack of proper waste disposal led to the degradation of environmental assets throughout the world. Not being mindful of how much waste is being generated by individuals is one of the key reasons for waste accumulation and improper disposal of waste in the world. Our group, impacted by the adverse effects of improper waste disposal in the environment wanted to come up with a solution, to ensure proper segregation of waste and disposal, to motivate people to work for the cause as well as help being mindful of how much waste is being generated by each household.
2. **Problem Statement**: To come up with a solution for proper waste disposal and segregation system while promoting and motivating individuals working towards the cause while being mindful of how much waste is being generated.

   Design Specifications:

   - The system should be able to detect trash that is shown in front of the camera.
   - The system should open the respective lid that has been partitioned for the waste.
   - The rewards should be transferred to the database.
   - The system should be able to indicate as well as display whether the dustbin is full or empty based on the ultrasonic sensor data.

   Evaluation:

   The success of the system will be measured by the following metrics:

   - The number of partitions to categorize the waste.
   - The opening of the respective lid is based on object detection and classification of waste.
   - The amount of trash that is collected by the smart dustbins from a user and indicating whether the dustbin is full or empty.
   - The rewards to the user account.
   - Any unrecognized waste should be displayed in the LCD Display wisely.
3. **Design Procedure:**

   Choice of components:

   1. Raspberry Pi 4B – 1
   2. SG90 Servo motors – 4
   3. HC SR04 Ultrasonic sensors – 4

4. LED Indicators – 8
5. Infrared sensor – 1
6. Breadboard – 2
7. 16x2 LCD Display – 1
8. External power bridge – 1
9. Jumper wires – Required count.

Design Flow:

The design flow of our project is broken down into segments of the process involved in designing the smart garbage management system.

1. **QR Code scanner:**
   - QR code is generated using the user application.
   - Camera captures the information encrypted by the QR code to log onto the database of the respective user and stops working once captured.
2. **Bin Level:**
   - Level of the bins are indicated using the LEDs and LCD Display.
   - Ultrasonic sensor calculates the distance between the waste and the lid.
   - If the value calculated is less than a threshold, the bin is said to be full and indicated by RED lights.
   - Else, the lights remain GREEN, allowing the user to dispose the waste in the appropriate bin.
3. **Bin Mechanism:**
   - The respective servo motor for the bin opens the lid when a certain waste is identified by the Machine Learning model using the Web camera.
   - The Motor Servo Rotates 90 degrees to open the lid for 5 seconds using the arm made using the 15-centimeter scale and shuts once after disposing of the garbage.
4. **Machine Learning Model:**
   - Once capturing the picture of the waste, the model uses it to classify the waste using the model ResNet –50 which is a deep convolutional neural network (CNN) architecture that uses residual blocks. These blocks allow the network to learn residual functions, which captures the difference between the input and the desired output.
   - The use of residual blocks in ResNet-50 allows for easier training of deeper networks while maintaining high accuracy. This model then gives the

output which is used to open the appropriate lid of the bin.

5. **Mobile Application:**
   - The User is required to sign up in the app and this credential is then used to log in to view the details of the waste disposed by the user and to generate the QR code which is required to dispose more waste and avail incentives for the disposed waste.

Algorithm:

1. The camera scans the QR code shown by the user that is generated in the app which contains the user's phone number.
2. The LCD displays the status of the dustbin of whether the dustbin is full or empty.
3. The Green LEDs glow if the dustbin is not full otherwise the Red LEDs glow.
4. The user shows the waste in front of the camera.
5. The Machine Learning model identifies the type of trash.
6. The Raspberry Pi opens the lid of the partition in the bin that is associated with the type of trash.
7. The user throws the trash in the bin.
8. The Raspberry Pi closes the lid of the bin.
9. The User is updated with his rewards in the firebase in the form of credits.

Flowchart:

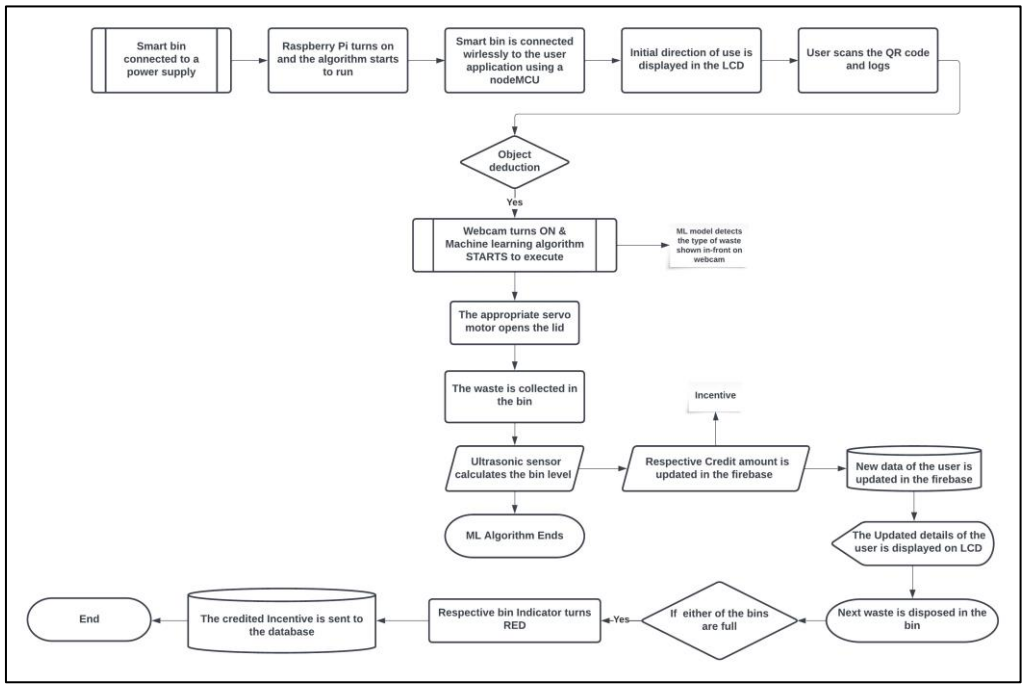

Figure 1: Flowchart of the system

4. Budget:

A detailed breakdown of the anticipated costs associated with the project.

Component Name	Quantity	Unit Cost (₹)
Raspberry Pi 4 Model B with 8GB RAM	1	₹ 9,549
Tower Pro MG995 Servo Motor	4	₹ 245 * 4
Ultrasonic Sensor Module HC-SR-04	4	₹ 105 * 4
Infrared Sensor Module	1	₹ 33
Red LED (3mm Diffused)	4	₹ 5 * 4
Green LED (3mm Diffused)	4	₹ 5 * 4
Generic 16 x 2 LCD Display	1	₹ 242
Bread board	2	₹ 115 * 2
Jumper wires	40 wires	₹ 295
Total Cost		₹ 10,682.00

5. Circuit Diagram:

Here is how the smart garbage management system circuit is designed:

1. Raspberry Pi 4B: This is the system's central processing unit and control hub. A gateway for data access and analysis, it handles data collection, communication with various components, and process data.
2. MG995 Servo motors: These motors control the movement of lids and compartments in garbage bins. They are attached to the bin lids, allowing the Raspberry Pi to control the servo motors to open and close the bins automatically.
3. The HC SR04 ultrasonic sensors placed on the lids, can be used to measure the distance between garbage items and the lid.
4. The Infrared sensor helps make sure the bins do not open by mistake or can give the system more information about when it's time to open the lids.
5. The 16x2 LCD display is a screen that can display useful information about the garbage system such as the level of garbage in the bins, directions, and can be used by people.
6. LED indicators are used as visual indicators to provide feedback on bin status (Bin full / empty).
7. The external power bridge regulates the power supply to the components, ensuring the system has a steady and reliable source of power.

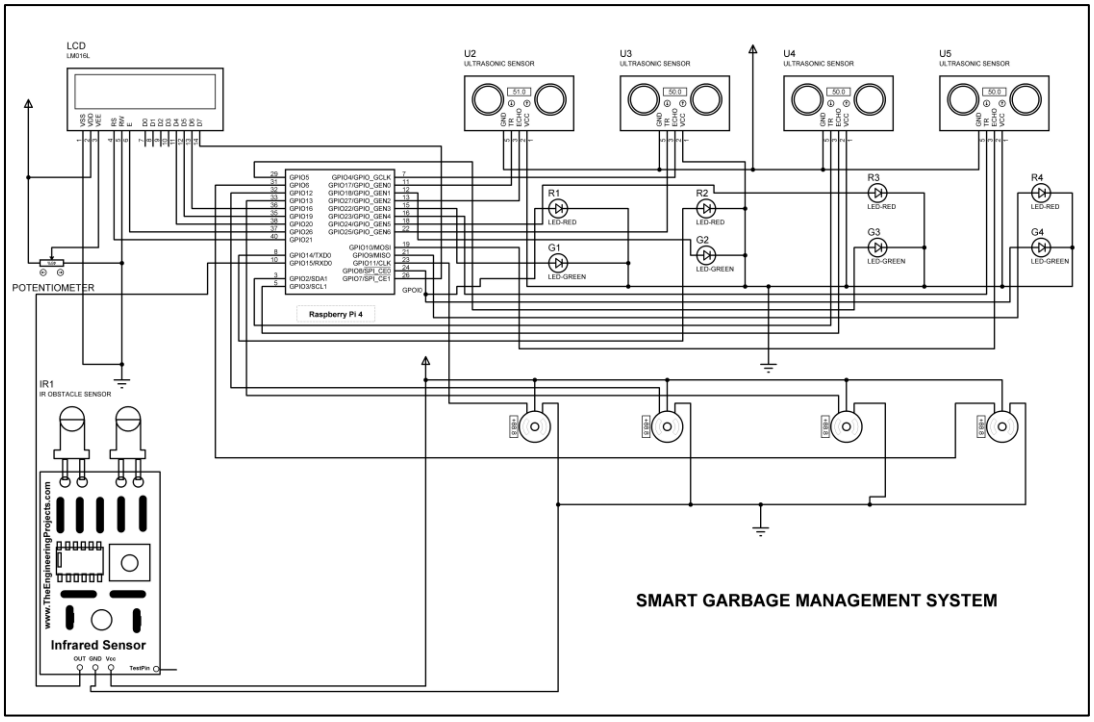

Figure 2: Circuit diagram

6. Simulation results / Discussion:

The distance measured by the ultrasonic sensor is printed in the display during the simulation of the integrated smart trash system to determine the correct distance between the waste and the bin lid.

```
SONIC DISTANCE 1 27.57948637008667

SONIC DISTANCE 2 27.75939702987671

SONIC DISTANCE 3 21.22945785522461

SONIC DISTANCE 4 28.838860988616943

SONIC DISTANCE 1 27.7634859085083

SONIC DISTANCE 2 27.338242530822754

SONIC DISTANCE 3 21.06999158859253

SONIC DISTANCE 4 28.73663902282715

SONIC DISTANCE 1 28.225529193878174

SONIC DISTANCE 2 27.7634859085083

SONIC DISTANCE 3 21.91638946533203

SONIC DISTANCE 4

Python 3.7.3 (/usr/bin/python3)
>>>
```

Figure 3: Ultrasonic sensor readings displayed in the console

The model utilizes the trash image it has just captured to identify the garbage using ResNet -50, a deep convolutional neural network (CNN) architecture that makes use of residual blocks.

The dataset needs to be split into four parts: paper, plastic, metal, and glass. As each epoch passes, the model gets trained on the training subset. Then, it assesses its performance and accuracy on the validation subset simultaneously.

Once the model predicts the type of waste shown in-front of the camera, the waste is printed in the console along with the user ID.

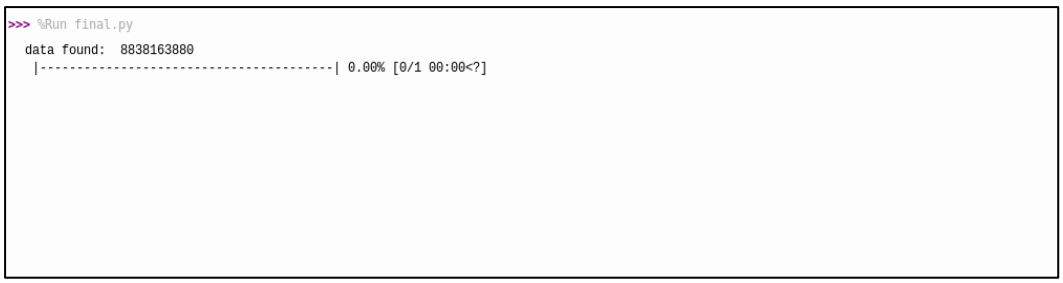

Figure 4: QR data found and ML model execution

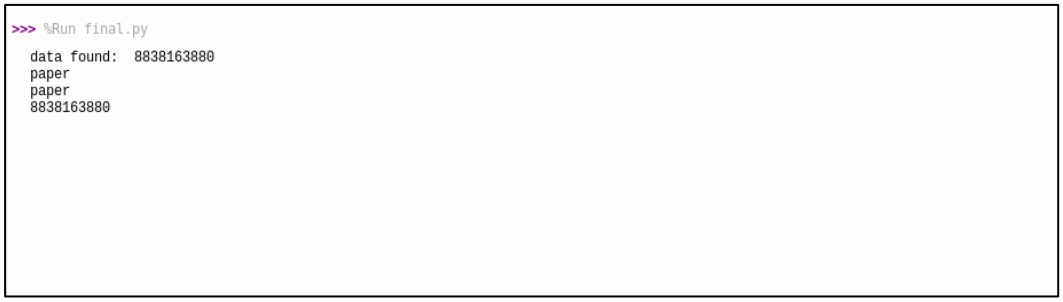

Figure 5: Machine learning model output

7. Implementation / Prototyping results:

A functional prototype of a smart dustbin, incorporated with Raspberry Pi microcontroller, servo motors, ultrasonic sensors, LCD display, LEDs is developed. The prototype can identify waste on its type and report the levels of bins and display in the screen placed.

We take the trained model and use it to perform predictions on the test set with around 3000 images to get the accurate predicted output.

The smart dustbin designed can achieve the following results:

- Predict the type of waste shown in-front of the camera.
- The appropriate bin lid opens with help of the servo motors.
- Ultrasonic measures the bin levels and LED lights turns on.
- The messages are displayed on the LCD Display.
- Incentive is updated in the user Application.

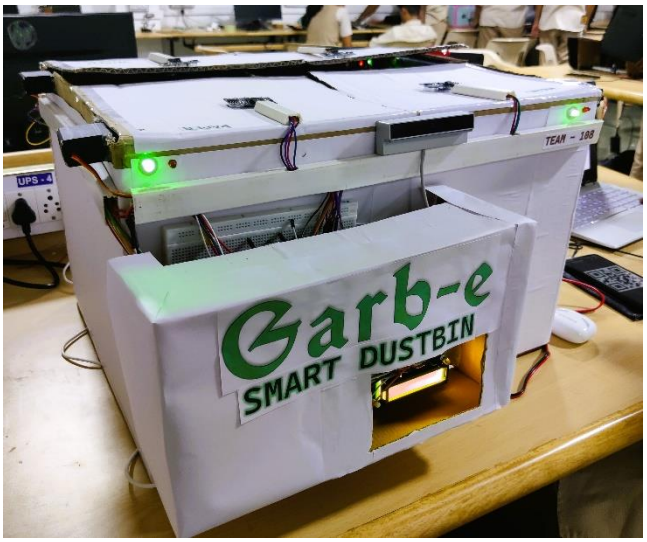

Figure 6: Front view of the smart bin

Figure 7: Top view of the smart bin

8. **Discussion & Conclusions**: The final prototype can classify the waste properly helping the user dispose of the waste and the appropriate incentive is credited to the user's account.

   The prototype that is been created might need the following improvements:

   - A GPS module might be connected so that the location of the bin can be determined and the appropriate authorities can collect the trash if it is full.
   - The model that was trained using waste photographs does not contain images that appear to be deviant from a certain category of trash but are within the same categories. If that type of garbage is exposed to the camera, the outcome might be misleading.