**B.Tech IoT Programming**

**Project Report**

**On**

**SMART GARBAGE MANAGEMENT SYSTEM**

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## 

## Abstract

The project is on making a smart waste management system by using two smart dustbins which have various sensors and communication modules. It will help in improving the process of collection of waste by ensuring its waste bins are full and informing immediately besides segregating it as wet and dry. Our Project provides two ultrasonic sensors that will check fill level of both bin that is Wet bin and dry bin,a LCD to display output, GSM module for message transmission, GPS for location, Servo motor for moving the lid, and also sensors of Moisture, which will predict the type of waste and additionally another ultrasonic sensor to detect garbage near Soil Moisture Sensor .

Results: The findings show that this system is able to manage the segregation efficiently with ultrasonic sensors detecting the waste and level of waste in the bin with 99.2% accuracy.

(Formula Used: Accuracy=(AverageDistanceRecorded/ActualDistance)\*100)

Some Important Key Words: IoT ,Ultrasonic Sensor,Soil Moisture Sensor, Servo Motor, Arduino

## 1.Introduction :

India generates 62 million tonnes (61,000,000 long tons; 68,000,000 short tons) of waste each year. About 43 million tonnes (70%) are collected, of which about 12 million tonnes are treated, and 31 million tonnes are dumped in landfill sites.With urbanization there is a significant increase in garbage produced.This is a cause for alarm and an alarming generation of waste. This creates a need for effective solutions that will effectively manage the handling of waste without causing environmental degradation and health hazards.[1]

This smart garbage management system project will overcome the challenges with the smart use of IoT technology. Such a smart dustbin will monitor not only fill levels but also communicate with the waste management system in real time. Such a proactive approach makes sure that wastes are collected and segregated on time and leads to a lot of recycling and obviously less overflow in landfills.

Using an Arduino microcontroller as a central processing unit, distance measurement will be achieved through ultrasonic sensors. The GSM module will send signals to the waste management authority, tracing location by GPS module, and humidity sensor will help differentiate between wet and dry waste. Through this mechanism, motorized lids could automatically open up based on the type of waste being sensed and easy disposal could be made. Also,LCD will display when to put garbage in along with warnings and closed status of Bin when they are full.

**Unique Functionality of the project :**

* We have tried to integrate 3 functionalities together that is,monitoring the bin level along with segregating the waste based on their moisture content and later alerting related authority through SMS using GSM module
* SMS notifications will be sent via GSM when the bin is filled above a certain capacity.
* Use of GPS for knowing the precise location of filled bins.
* Automated opening of lids of dry and wet compartments based on Moisture sensor inputs.

## 2.Related Work in Project :

Several studies have explored smart waste management systems utilizing IoT technologies. Below is a summary table of related works:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Author | Link of published work  (Research Paper/ Patent) | Year | Features | Model/ Sensors/ Used | Results | Drawback in their Project |
| Prakash Kanade  et al.[2] | [Link](https://ieeexplore.ieee.org/abstract/document/9418359) | 2021 | Focus on monitoring waste level and alerting when bin is full. | Ultrasonic Sensor, DC motor, Arduino uno,GSM,GPS | System can accurately read trash height levels using ultrasonic sensors, with application response times varying by network type (LTE being the fastest), and the warning system triggered at >60% or >80% trash level. | Neglected Segregation of dry and wet garbage.. |
| Shubham Srivastava et al.[3] | [Link](https://ijircst.org/DOC/40-iot-based-smart-waste-management-system-using-arduino.pdf) | 2024 | 1)Bins equipped with ultrasonic sensors, GSM, GPS, and similar technology for data collection  2) Data transmitted to a centralized database for storage and management and authorized persons have full access.  3)Authorized personnel are alerted about full bins and their specific locations. | Arduino Uno,Ultrasonic Sensor,LCD display,GSM and GPS | The given operation took place without major fault and did their work as intended. | Using just one bin will mixup the waste and there will be no scope of segregation. |
| Dr. Ihtiram Raza Khan et al.[4] | [Link](https://download.ssrn.com/21/08/09/ssrn_id3902056_code4099406.pdf?response-content-disposition=inline&X-Amz-Security-Token=IQoJb3JpZ2luX2VjEH8aCXVzLWVhc3QtMSJIMEYCIQDS%2FwXhwR3LxWtZ3RymJeCAZYJPNXQDHoDFNClVLOLw2QIhAML5LvMfFPfrDyCI0W3WMk%2FRVyjzJLXZVrnEOxhCR4F%2BKsYFCOj%2F%2F%2F%2F%2F%2F%2F%2F%2F%2FwEQBBoMMzA4NDc1MzAxMjU3IgxHbY2rSFix2viA4HoqmgWj3y98XZnOPBaAiIxf0B5TiBafAe0XBf%2FjQiHydu5NAR5rT80ve3VSOn8fjmB41AGqssV0UHYcOsAGh9C0JmsTgVAVBU%2B4wJ6G7MsJl3faYspLbOtoUxeZ266ywzbeoyn3gKnqWDEAUUgK20G1nhMJJA3Xx9aLFCz%2B13Z3xmw39QodwRzoqc3Thn3z9bkiWa%2F0rL0CVcXaefmj4RTc7EDRmREGcsWnlbEcls82aA4Ge%2FqZR2%2F1cUTHK4JIwvUI6r2Y3NMupYouQN76%2BwzEJfhwpSxlqu%2B4CibBrMBfE5B6U2g54YwSiRO4gFxBLB2w2KD6ULy0jxDqUMy5ERpHoV3%2BnvE6P59JAIrKhzna30DGIKn92KYcPn%2F0qqb8O3iufImHhWzt%2F3PQ1Sohl5cphK6WKK%2BMQM9UU1FcGVRzscQk0Q6Ru6PxkZs1k7vEUSkfWDeprNA9D%2BeQoFh8qwI9QnNPaIMtrOgeAXjiVDd9eSTCpF95%2BgCGugficEcJI5z0tL7rNcNr5r0dl0N%2BpB9V%2FDwCgq7Cu588X6LS%2Fz2FWBWsZvfDMZWp0OT3LUYkdxPVcXH4K7LO6XEox2ozag2XEXh8MnVH%2BJ7ETFaITjEBLfnWSV9GF08FyVTHk8QnCE0%2BquuMG0g238ZjRfce2xRkUZVmUedyNAvPnaYEXJLCH%2BXVNlv2d3nW72raYsSvIYFMlihnHsQ4y34rE%2BrHEWSRBmIrykF%2BpERxh1xOeawpZMWV6vi3W4PBVNsJo7QjOO3NZlyGqp7UUfSwk0fKgfTBYi5Y4f4BnmYRi9Or%2Fvf%2B4q9LSi%2BHNGidXQyA0JryioYxfL8fNwXDEglaBCDbyTj%2FzgtKEjBo0R6r2peKi1CtQe%2F1G1qZbUbdGl2eewsw%2FvXsuAY6sAHIrax95iP32Lc4yXuNH%2FE7a6gFYSfHOQ1hyoxbBl356o4WUbum%2FNjoB%2Flc1NKVKTu7H2vBUrOfTen2fmUY3n7poPsTVajfSQkFL8BmN7BOw4%2BygCJoOaDP7SklRvhN%2BtL%2BG%2FFjxh%2B64HEziGDMMBG%2FxxVs2ZFstWJM6xxxzuvFRMuT0gP3vLAYgU2E2iP9d4%2Bffj%2FXIXvLKOUAqK%2FoASvngt3SxgNYyJj8K3rW2uRylQ%3D%3D&X-Amz-Algorithm=AWS4-HMAC-SHA256&X-Amz-Date=20241025T073440Z&X-Amz-SignedHeaders=host&X-Amz-Expires=300&X-Amz-Credential=ASIAUPUUPRWE6AZGNZQW%2F20241025%2Fus-east-1%2Fs3%2Faws4_request&X-Amz-Signature=c688d190eb328750efc03ea22e9ed493d3ddd80c4a6b5e46ee8ec7735db56b0a&abstractId=3902056) | 2021 | Checks Level of Garbage in Bin and Send Alert messages to Municipal Corporation along with location using GPS and GSM. | Ultrasonic sensor,Arduino Uno R3, GPS,GSM,Buzzer | Limited Functionalities,no instruction to display on LCD. | No LCD to display warnings ,also segregation is ignored. |
| T Bhuvaneswari  et al.[5] | [Link](https://d1wqtxts1xzle7.cloudfront.net/96508914/14271-libre.pdf?1672290097=&response-content-disposition=inline%3B+filename%3DInternet_of_things_IoT_based_smart_garba.pdf&Expires=1729845043&Signature=Ssj3deFEF~PzkMfKN0WIPSc45d0MBWnoqdWuA3IKMzMnmq0ABGFHzdJaPKJFUNI~OliAZs2hlV0R4xubwEgYsSnD9x0yIHSic640asCFF-y~qQ1PQVyE~nFxDQ37AoUDcc9iZ~tULWpsu8i2UaPVFs518SOijG16HzXt2TaC~rLkPeDFwJShqKwFRzigABcAlOGjruJtQ0jyDzTLsdkCOtQcxMsVwYLLxQp1W1k7PbdKN5FLC4ycFiAOhncyF99wIFfpebIDGKTqId6Ue~cDhJEh66CpvKOm7Dy0PXGx6T3Hc8nTwAvlP-uNuKC3H7qvZADnefyZaVFCHnpe-ptuZQ__&Key-Pair-Id=APKAJLOHF5GGSLRBV4ZA) | 2020 | Monitoring Garbage level and Weight of garbage with help of ultrasonic sensor and weight sensor respectively.Collected data is constantly transmitted to a webpage through wifi where based on given data,garbage collection is scheduled. | Ultrasonic Sensor,  Weight Sensor  ,LCD screen,  Arduino  Microcontr  oller,Wifi Module & modem | 1) Reading of ultrasonic comes out as 94.25%  2)Load cell Reading comes out as 93.1 accurate. | No methods to put dry and wet wastes separately. |
| Rifatul Islam Rifat  et al.[6] | [Link](https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=9767993) | 2023 | 1.If the dustbin is full.  2.Message is sent to the municipal corporation | Arduino Mega  Motor driver (L298N),  Servo motor (SG90) ,  Ultrasonic sensor (HC-SR04), Sound sensor (LM393), IR sensors |  | \*\*No system to segregate dry and wet waste. Also no buzzer to alert the user to not to throw garbage. |
| Chinmay Kolhatkar  et al.[7] | [link](https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=8537245) | 2018 | The dustbin checks whether it is full and sends an e-mail to the concern authority to make arrangement to empty it. The users are provided with different instructions and status on LCD display. | LCD display, Ultrasonic Sensor, Proximity Sensor, Wi-Fi module (ESP8266) and Motor Driver (L293D) are interfaced with Arduino Uno board. | The proposed system has been operated as a pilot project in Andheri area of Mumbai for one day. The experiment showed that the average amount of food waste could be reduced by 33%. | No segregation of wet and dry waste.A |
| A Sivasangri  et al.[8] | [Link](https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=9418455) | 2021 | Using Ultrasonic sensor to detect levels and alerting via gsm and wifi Modules | Arduino UNO,GSM,GPS,Wifi module ESP8266,Ultrasonic sensorsHCSR04 | System can accurately read trash height levels using ultrasonic sensors. | Not able to segregate wet  and dry waste. |
| Shilan Abdullah Hassan et al.[9] | [Link](https://intelligentjo.com/images/Papers/smart%20waste%20management/Smart_Solid_Waste_Monitoring_and_Collect.pdf) | 2016 | Focuses on monitoring the fill levels in the dustbin and sending the alert to the waste collection vehicle when full. | Arduino mega2560, GSM/GPRS, SIM900, GLCD screen and Radio Frequency (RF) receiver | \*\*If the waste level in the bin is full or more than the half full level, a message will send to the vehicle to collect the waste from that bin.  \*\* If the waste level in the bin is empty, half full or less than the half full level. A message is not sent to the vehicle. | \*\*No system in place for segregation of wet and dry waste. |
| M srilatha  et al[10] | [Link](https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=9388438) | 2021 | collective data of levels inside database | NodeMCU,Ultrasonic Sensors | Real time database access to know the level of data | No segregation of result. |

**Drawbacks in these existing projects**

1. **No Segregation of Garbage:** Nearly all the above projects have not implemented segregation of waste and only focussed on level monitoring.
2. **No Buzzer to alert people:** Most of the above projects do not work with buzzer to alert nearby people in case bins are full.
3. **Partial Implementations of Functionalities:** Projects above have implemented functionalities in bits and pieces, that is, missing out on any one functionalities like some in buzzer, other in lcd or one bin only.

## 3.Project description

* It will be integrating many components and therefore make up an efficient solution for waste management.
* Ultrasonic Sensor: Mounted on the top of the can near the moisture sensor, measures the distance of garbage from the moisture sensor.
* Ultrasonic Sensor 2 & 3: Measures the level of garbage in both bins.
* Arduino Microcontroller: The brain of the system, which perceives the input from different sensors.
* GSM Module: will send only one SMS alert about bin full status along with the GPS location.
* GPS Module: This module offers real-time location to assist in route planning.
* Servo Motor: Opener dependent on sensor input, dry and wet waste.
* Moisture Sensor: Detects moisture levels to classify waste type.

**3.1 Algorithm for Smart Waste Management System**

**Inputs:**

* Ultrasonic Sensor Distances:  
   distance (for general trash detection)  
   level1 (wet bin level)  
   level2 (dry bin level)
* Soil Moisture Level:  
   SoilMoisture
* GPS Coordinates:  
   latitude  
   longitude

**Outputs**:

Bin status updates, trash detection notifications, warnings, and SMS alerts with location details.

**Algorithm**

1. **Initialize Components**

* Activate all components: ultrasonic sensors, servo motor, soil moisture sensor, GSM module, GPS module, and LCD display.
* Set the LCD backlight to green.
* Display 'System Init' on LCD.
* Send an SMS with message: 'System Initialized'.

2. **Main System Loop (runs every second)**

Sensor Reading and Display

* Read Soil Moisture Level:  
   SoilMoisture ← analog read from soilSensorPin

* Read Distances:  
   distance ← ultrasonic sensor reading (for trash detection)  
   level1 ← ultrasonic sensor reading (for wet bin level)  
   level2 ← ultrasonic sensor reading (for dry bin level)  
   Display Distances on LCD: show distance, level1, and level2

3.  **Check Bin Status**

* If level1 <= 30 and level2 <= 30  
   Display 'Both Bins Full' on LCD  
   Fetch latitude and longitude  
   Send SMS: 'Both bins full. Empty bins. Location: (latitude, longitude)
* Else if only level1 <= 30:  
   Display 'Wet Bin Full' on LCD  
   Fetch latitude and longitude  
   Send SMS: 'Wet bin full. Empty the bin. Location: (latitude, longitude)
* Else if only level2 <= 30:  
   Display 'Dry Bin Full' on LCD  
   Fetch latitude and longitude  
   Send SMS: 'Dry bin full. Empty the bin. Location: (latitude, longitude)
* Else:  
   Display 'Bins: Good to Go' on LCD

4.  **Trash Detection**

* If 0 < distance <= 30:
* If SoilMoisture < 500 and level2 > 30:  
   Display 'Trash Detected: Dry Garbage' on LCD  
   Move servo to open dry bin lid  
   Update level1, level2, and display updated status
* Else if SoilMoisture >= 500 and level1 > 30:  
   Display 'Trash Detected: Wet Garbage' on LCD  
   Move servo to open wet bin lid  
   Update level1, level2, and display updated status
* Else:  
   Display 'Closed' on LCD
* Else:  
   Return servo to default position  
   Display 'No Trash' on LCD

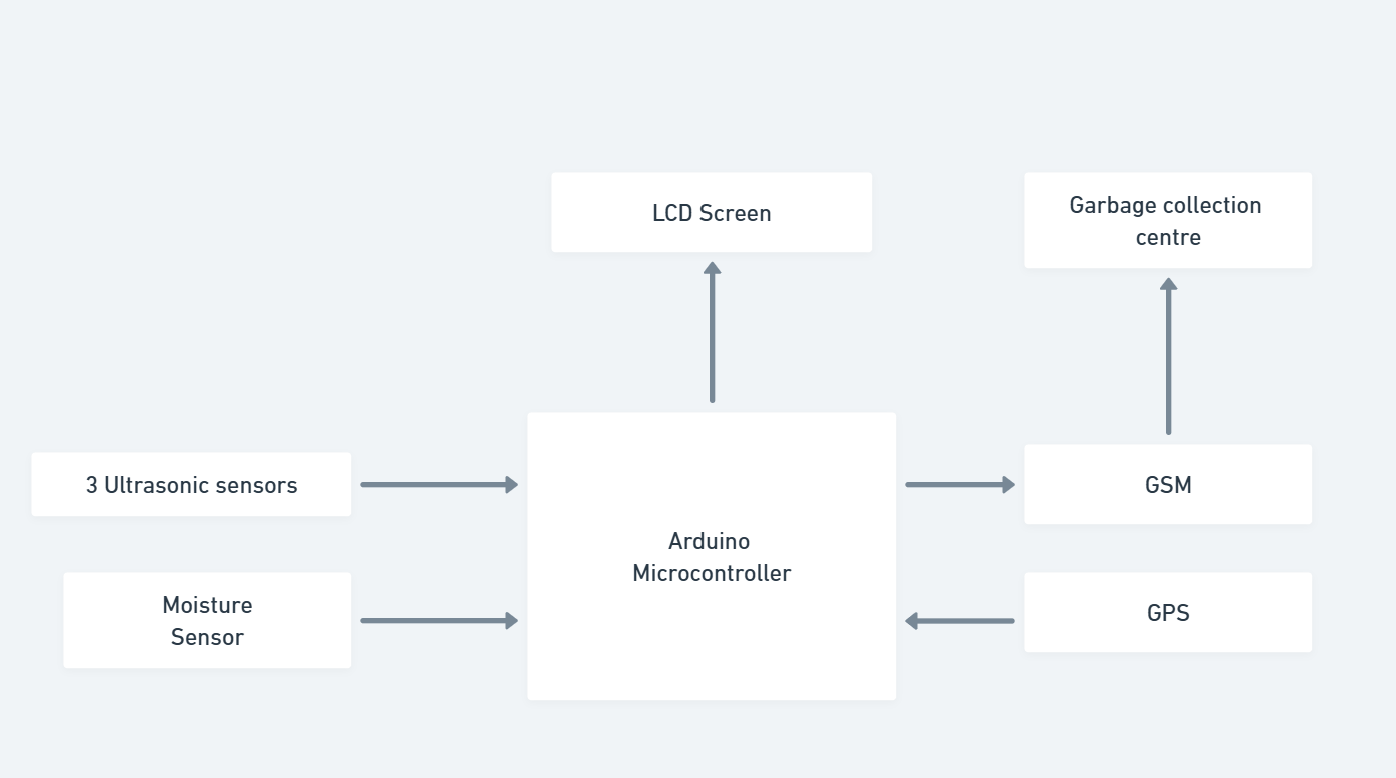
5. **Warning for Near-Full Bins**

* If 30 <= level1 <= 60 or 30 <= level2 <= 60:  
   Display 'Warning: Going to Full' on LCD  
   Buzzer on for few seconds
* If level1 < 30 or level2 < 30:  
   Sound buzzer continuously
* Else:  
   Turn off the buzzer

6. **Update GPS Data**

* Fetch and update latitude and longitude if available.
* End of Loop

**3.2 Conceptual Design Diagram**

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**Explain the diagram in steps-**

1. Ultrasonic Sensor Detects garbage near Moisture Sensor.

2. Moisture Sensor detects whether Garbage is dry or wet and sends it to Arduino.

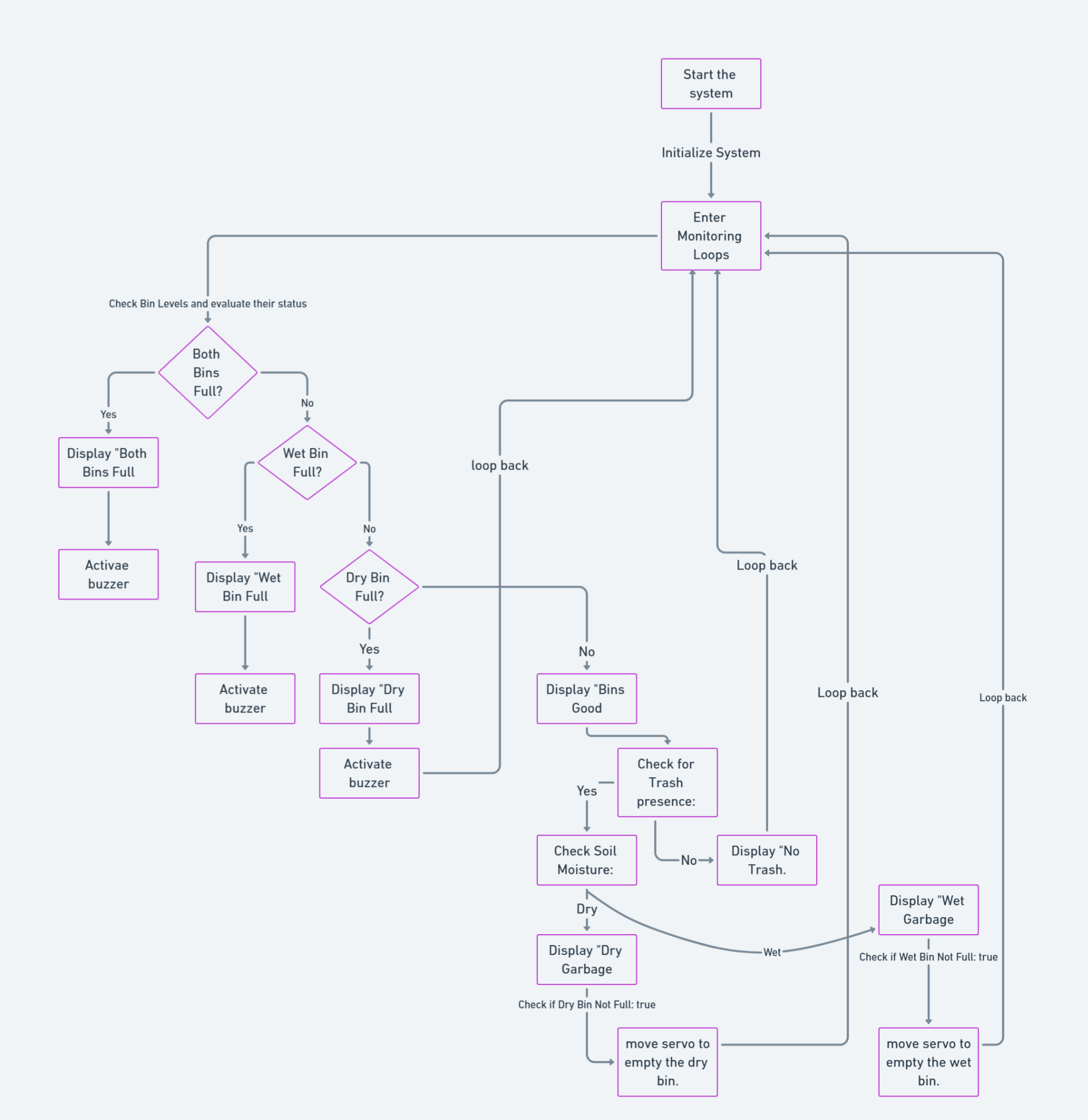
3.Based on data collected,Arduino sends a signal to Servo Motor to turn left or right.

4.Simultaneously both ultrasonic sensors will check the level of both levels and send it to the Arduino.

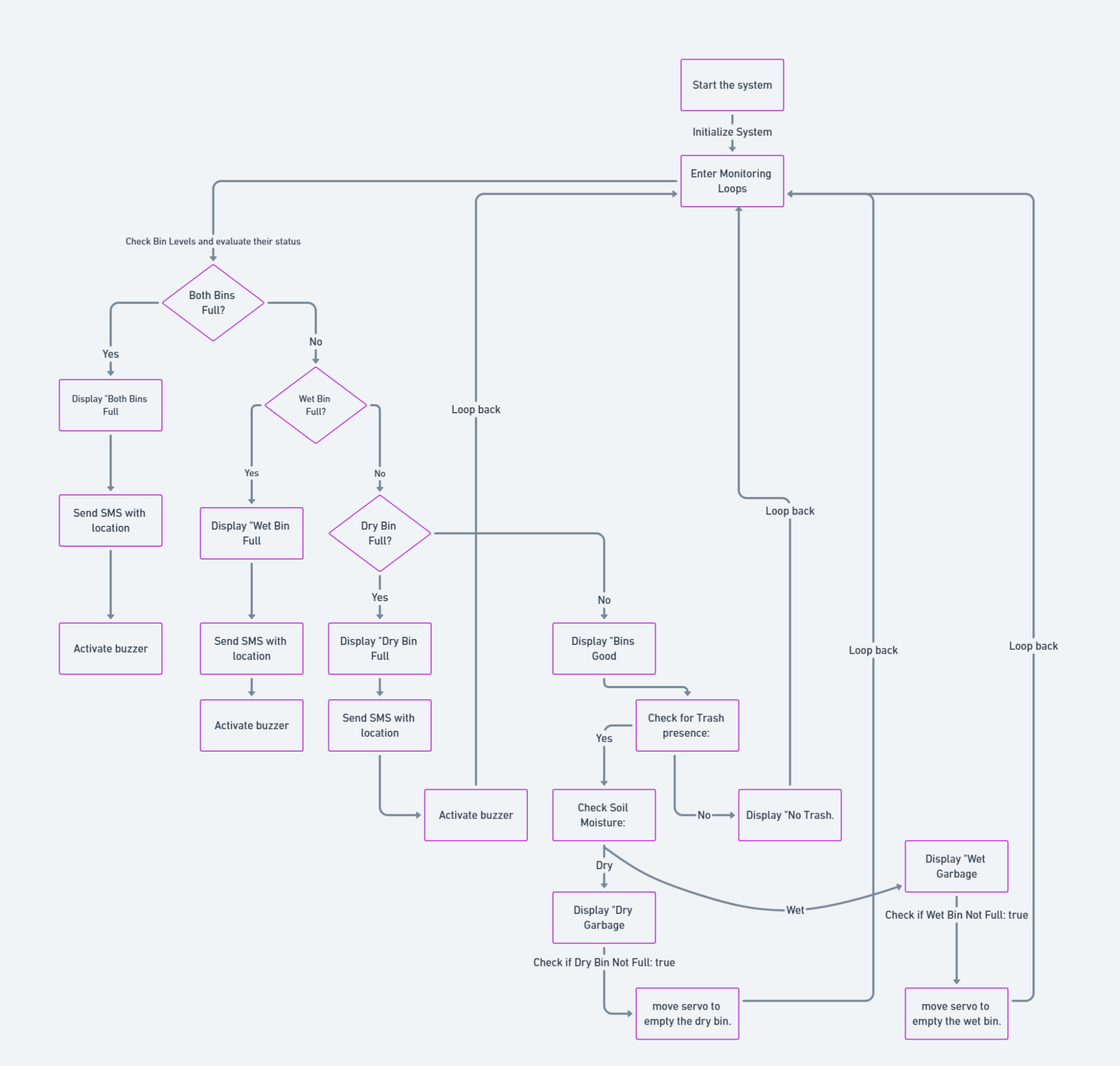
5.Based on data collected,the buzzer will operate.

6. When the bin is almost full,Arduino instructs GSM to send SMS to related authorities to collect the waste.

**Flowcharts**

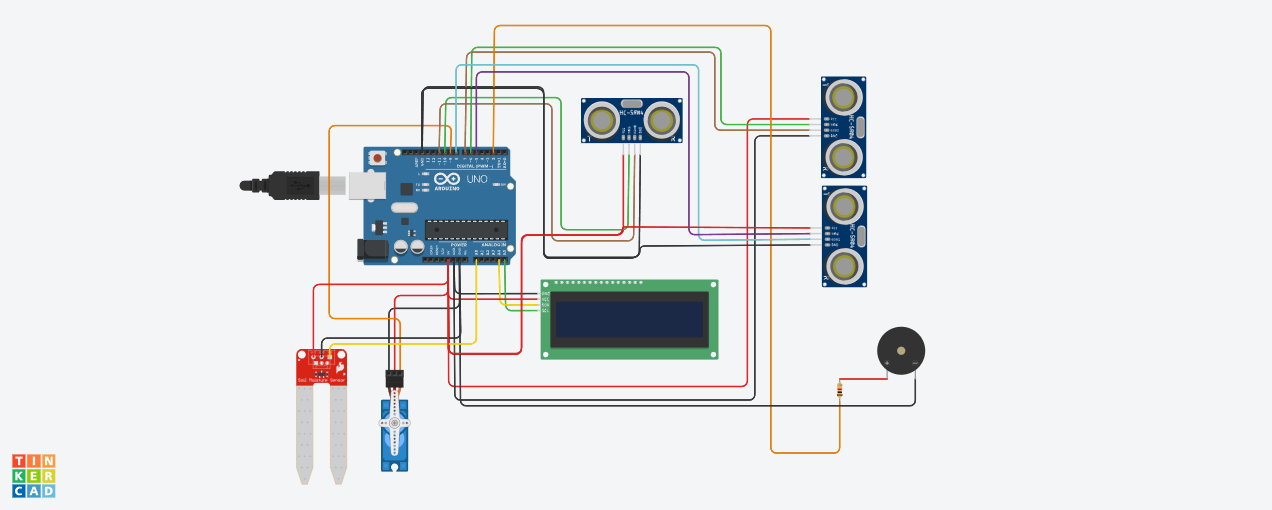
****

**Flowchart 1:(without GSM and GPS:- based on Tinkercad)**

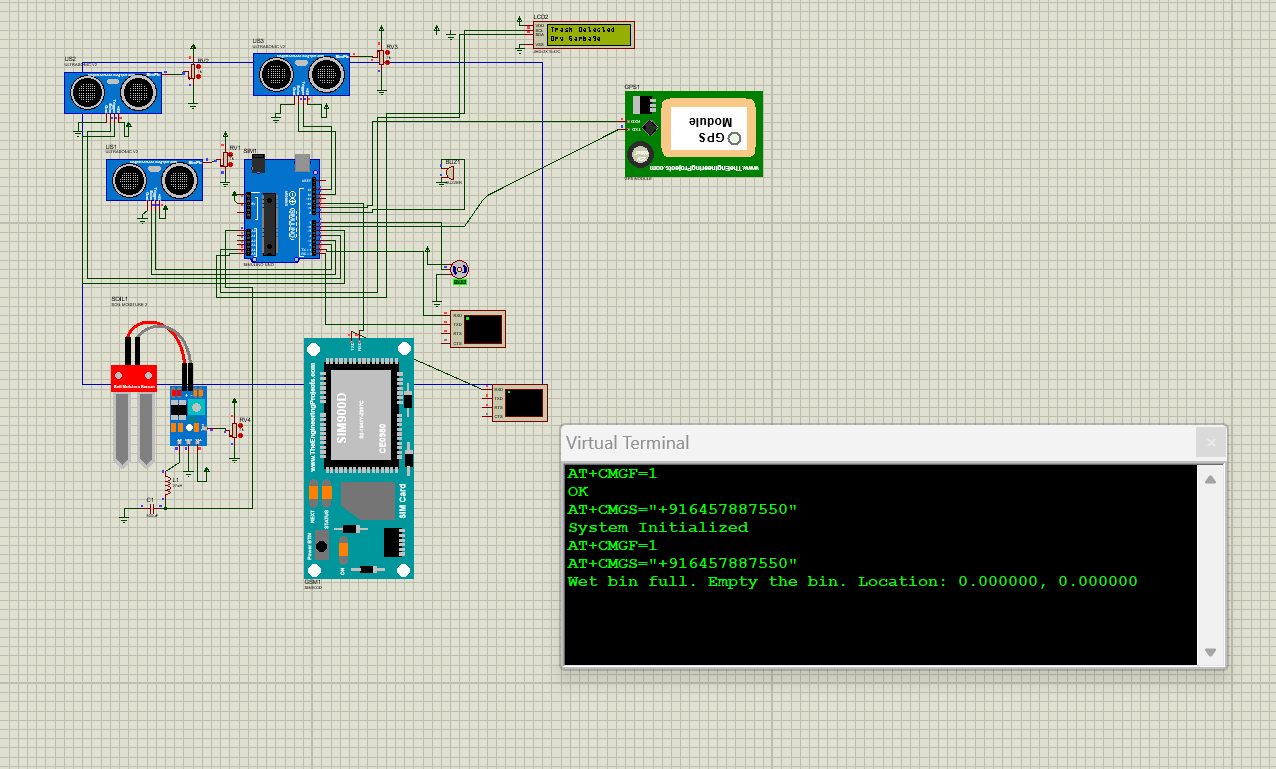
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**Flowchart 2:based on proteus(with GSM and GPS)**

**3.2 Working Example (Add Real time Photographs of the working project)**

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**Fig 1:Initial implementation(Without GSM and GPS)**

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**Fig 2: Final Implementation**

## 4.Experimental Setup

**4.1. Implementation Details**:

The below table summarizes the hardware and software components used in the project:

Table 1: Implementation Details

|  |  |
| --- | --- |
| **Component** | **Description** |
| Ultrasonic Sensor | Measures distance to determine fill level |
| Arduino | Central controller for processing data and instructions |
| GSM Module | Sends notifications when bin is full |
| GPS Module | Provides location data |
| Motor | Opens lids of one of two compartments based on input |
| Soil Moisture Sensor | Detects moisture content in the waste |
| Piezo Buzzer | Beeps on basis of signals |
| Tinkercad | An Online app used for simulation and designing 3D model |
| Proteus | Offline Software tool to simulate various circuits |

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## 5.Experimental Results

**Table: Experimental Results**

|  |  |
| --- | --- |
| **Parameter** | **Value** |
| **Fill Level Detection Time** | **< 3 second(Tinkercad)** |
| **Waste Segregation** | **\*Done based on Moisture sensor data** |
| **Ultrasonic Sensor Accuracy** | **99.23%** |

\*Observations are in cm.

\*1-Level of wet Garbage Bin(in cm)

2-Level of dry Garbage Bin(in cm)

3-Distance from the moisture sensor(in cm)

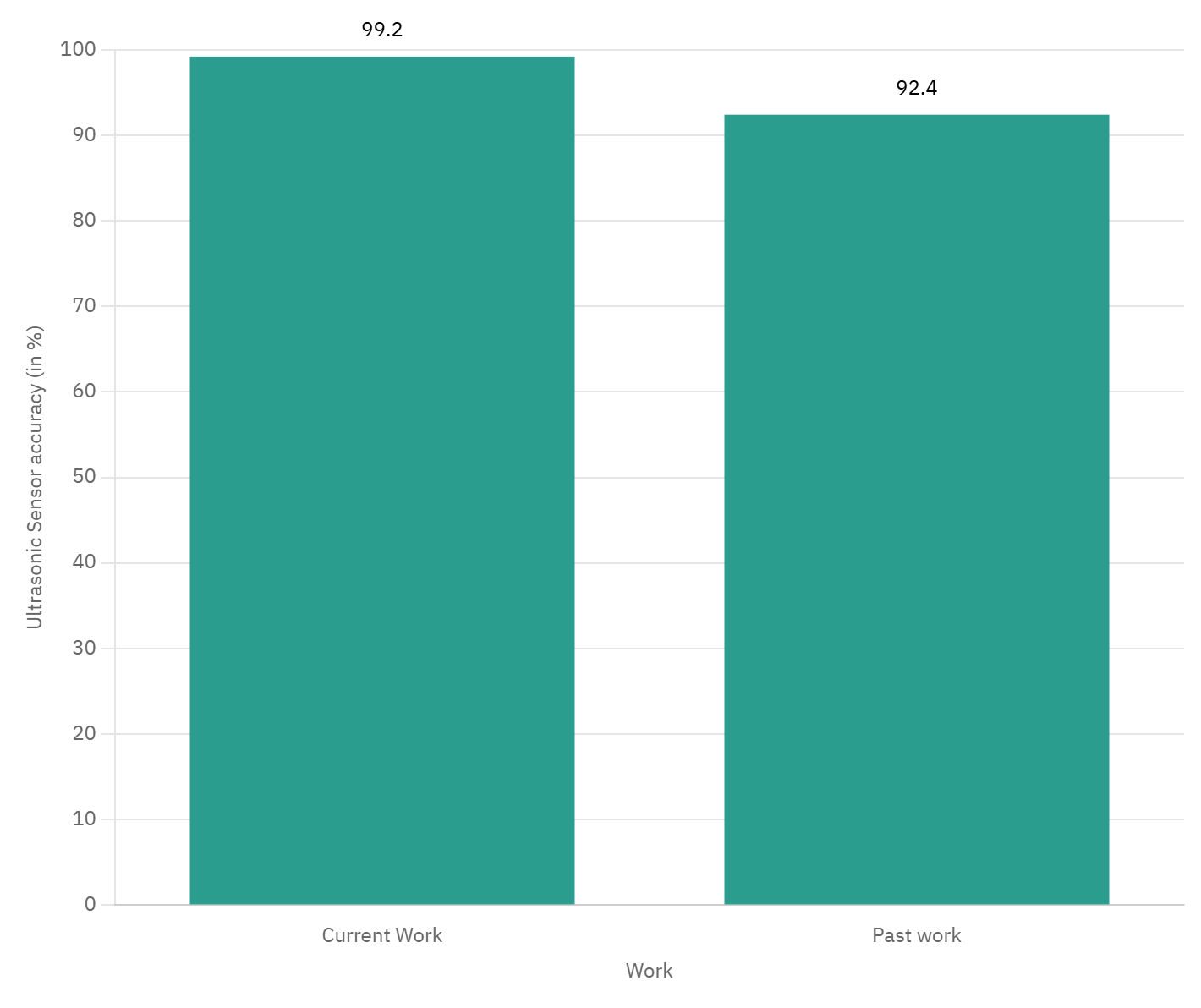
**Formula Used:**

***Accuracy=***(**AverageDistanceRecorded/ActualDistance**)\***100**

| **Sensor** | **Obs-1** | **Obs-2** | **Obs-3** | **Average**  **Distance**  **Recorded** | **Actual Distance** | **Accuracy(%age)** |
| --- | --- | --- | --- | --- | --- | --- |
| **1** | 79.8 | 79.99 | 79.8 | 79.86 | 80.2 | 99.5 |
| **2** | 45.72 | 45.72 | 45.78 | 45.78 | 45.9 | 99.7 |
| **3** | 24.16 | 24.73 | 24.61 | 24.61 | 24.9 | 98.8 |
|  |  |  |  |  |  |  |
| **1** | 121.51 | 122.37 | 122.18 | 122.02 | 122.7 | 99.4 |
| **2** | 78.67 | 78.63 | 78.67 | 78.65 | 78.9 | 99.7 |
| **3** | 32.04 | 31.28 | 32.22 | 31.96 | 32.1 | 99.6 |
|  |  |  |  |  |  |  |
| **1** | 207.57 | 207.6 | 207.6 | 207.59 | 208.4 | 99.6 |
| **2** | 117.8 | 117.8 | 117.99 | 117.86 | 119.8 | 98.4 |
| **3** | 75.43 | 75.43 | 74.67 | 75.17 | 76.4 | 98.4 |

Average accuracy of the ultrasonic sensors-***99.2%***

## **6.Comparison with existing work**

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**[5]** Data of Past Work

## 7. Conclusion and Future Work

The Smart Garbage Management System effectively solves the problem of sorting,monitoring the level of waste and tracking waste using modern IoT technology. With sensors like ultrasonic and moisture sensors, along with GSM and GPS modules, the system makes waste management more efficient. It automatically separates wet and dry waste and sends alerts when bins are nearly full, making it easier to manage garbage collection. The system works with a high accuracy rate of 99.2%.

:-However, there is still room to make it even better. In the future, we could add features to detect other types of waste, such as metal, by using metal detectors or integrating cameras to detect the type with AI. Also, we can integrate AI to help the system recognize more complicated types of waste. These improvements would make the system more useful and effective in dealing with waste management.

A mobile application can be developed for real time monitoring where the users and the waste management staff can receive instant notifications ,view the status of bins and track garbage collection.

Gas sensors can also be added for odor detection so that the system can be alerted of decomposing organic waste and hence it could be quickly disposed of.

Using real-time data from the bins,the routes for garbage collection can be optimized,ensuring trucks are sent to only those areas where the bins are full.

## References:

1. <https://www.trade.gov/market-intelligence/india-solid-waste-management>
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