Smart Waste Management System

Abstract

Waste management has turned out to be one of the prime issues over the last few years leading to various other consequences and malfunctions in the society. Even though municipal corporations and authorities around the world have employed workers to clean and empty out garbage cans of their localities every once in few days, there are days when the garbage overflows lead to spillage of waste which attracts flies and spreads other diseases within the locality. Furthermore, in most of the cases the garbage cans are left unclean or are just washed with water which often leaves a lot of moisture content in the garbage can resulting in the growth of microbes and bacteria. In order to address this issue, we have proposed and elaborated on a smart waste management system which is automated and works using Arduino board and a set of necessary sensors. Furthermore, we have also proposed an additional feature of automated sanitation to the smart waste management system which would make use of a sprinkler mechanism to sanitize the entire garbage can using solvents which are volatile and would dissolve the dirt present in the dustbin easily and evaporate.

Keywords: automation, waste management, Arduino, ultrasonic sensor, sanitation, garbage spills, GSM module

1. Introduction

With rapid evolution in the technological industry, automation and autonomous systems have turned out to be one of the prime solutions for majority of the problems in a plethora of domains including health, finance, transportation, education, sports, etc. Smart waste management is one of the key components when it comes to smart cities and smart and sustainable cities have been the goal for many of the developed and developing countries across the globe. With all these in mind, an appropriate model for the smart waste management has been proposed in this paper. Smart waste management is essential in any type of area, be it a village, town or a city in order to maintain clean and neat surroundings and as well as the public health over there. In many of the cases though the municipal authorities and the corporations are doing well with their duty, they may not get notified whenever the dustbins are full or the garbage is overflowing. This particular problem is being addressed in this paper. There are many ways to address this problem, this paper proposes a

model in which an SMS is sent to the respective municipal authority or office whenever a garbage can is full so that they can come and empty it. Apart from this SMS notification system, an additional feature of automated sanitation is proposed which makes use of a sprinkler mechanism to sanitize the garbage can each time it is emptied. For this, a suitable solvent which is volatile and is capable of dissolving the dirt present in the dustbin. This helps in overcoming the foul smell or the wetness caused by the traditional way of cleaning the dustbin with water which sometimes leads to the remaining of excess water in the bin.

2. Literature Survey

As discussed earlier, smart waste management is very crucial in any area and can be done in different ways. A smart alert system for garbage clearance by giving an alert signal to the municipal web server for instant removal of waste with proper verification based on level of garbage filling is proposes in [1]. After cleaning the dustbin, the driver confirms the task of emptying the garbage with the aid of RFID Tag. In [2], an alarm system based on Arduino is proposed which conveys the information through LED blinking for disposal of the waste material of the dustbin. Smart waste management can also be achieved by automatic separation of the wet and dry waste. One such model is proposed in [3] where automatic separation of waste takes place with the help of sensors. It can separate the wet and dry waste with help of moisture sensor. The moisture sensor will check whether the waste is wet or dry and then it will send the response to the arm. And then arm will lift the garbage in the responded section of the dustbin. By this method the wet and dry garbage is separated using the new technology. Apart from notifying the respective authorities regarding the overflow of garbage, the people using the dustbins should also be notified. This Smart Dustbin Utility System in [4] using IoT implements an IOT based dustbin management system which regularly checks the garbage level, calculates the filled percentage and if filled totally, directs the person in front to move towards the nearest dustbin which is not filled. Once the system detects the bin is completely filled, it also quickly sends alerts in intervals of time to empty it. According to another model proposed in [5], alarm will turn ON if the dustbin is exposed to fire and the pesticides will be sprayed if there's excessive moisture content inside the bin. The proposed system in [6] guides the garbage-trucks to collect the garbage only from those areas where the bin is critically filled. The ‘machine-learning’ concept has been used to gather information about the waste generation habits in that region and hence predict the amount of waste

that will be generated in the near future. Apart from that, the analysis of the continuous data is also done that has been sent over the cloud in the form of graphs. It uses the "If this then that" approach for the algorithm using linear regression model. In [7], a smart dustbin is built on Arduino Uno board and is interfaced with GSM, GPRS and sensors. The sensors are used to check the threshold level of the dustbin. The threshold levels are already set. If the garbage hits the mentioned threshold level, continuous alert is sent to the respective authority until the garbage is recovered and the externally fixed LED is changed into red color. Once, the garbage from the bin cleared the LED changes to green color. This alert system is triggered by the sensors to the GSM modem. A time limit (say 24 hours) is given to respective authority, where if he/she fails the duty, the alert to the higher authority is sent. By this facility, the higher authority will be able to take action on the irresponsible workers. An IoT-based trash checking system utilizing Arduino or Raspberry pi board and an open IoT stage is presented is shown in [8]. The proposed framework includes an Arduino microcontroller, ultrasonic sensor, Wi-Fi module and a heap battery.

3. Requirements Specification

The main components used for this system and their workings are mentioned below:

Ultrasonic Sensor: The HC-SR04 ultrasonic sensor (Fig. 1) uses SONAR to determine the distance of an object just like the bats do. It offers excellent non-contact range detection with high accuracy and stable readings in an easy-to-use package from 2 cm to 400 cm or 1” to 13 feet.

Fig. 1 Ultrasonic Sensor

Arduino Uno: Arduino Uno (Fig. 2) is a microcontroller board developed by Arduino.cc and based on Atmega328 Microcontroller. Microcontrollers are used in embedded projects and are normally act as a brain in electronic devices. Arduino UNO is a very valuable addition in electronics that consists of a USB interface, 14 digital I/O pins, 6 analog pins and an Atmega328 microcontroller.

It also supports serial communication using Tx and Rx pins. This acts as the heart and brain of the badge by connecting the different other sub components in the device.

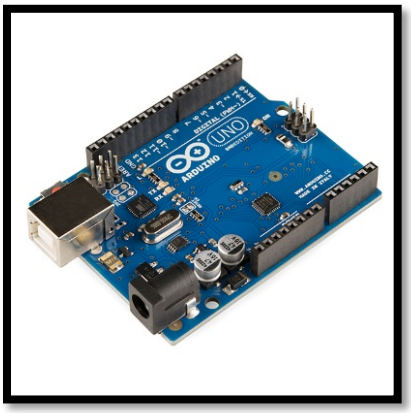

Fig. 2 Arduino Microcontroller

Jumper Wires (Male to Male/Male to Female): A jumper wire (Fig. 3) is an electrical wire, or group of them in a cable, with a connector or pin at each end, which is normally used to interconnect the components of a breadboard or other prototype or test circuit, internally or with other equipment or components, without soldering. These wires are essential to connect the different components of the device to that of the Arduino board.

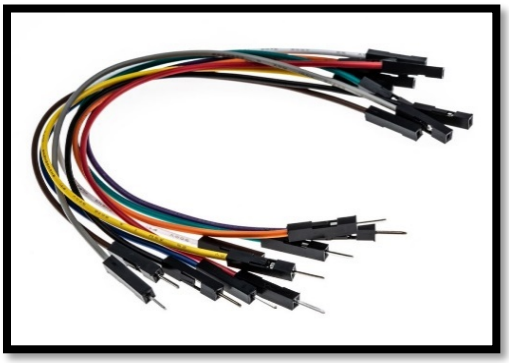

Fig. 3 Jumper Wires

USB Cable: All instructions and programming codes which need to be embedded and executed by the Arduino board can be fed in from the computer to the microprocessor using the USB cable (Fig. 4) without any hassles.

Fig. 4 USB Cable

GSM Module: A GSM (Global System for Mobile Communication) modem (Fig. 5) or GSM module is a hardware device that uses GSM mobile telephone technology to provide a data link to a remote network. From the view of the mobile phone network, they are essentially identical to an ordinary mobile phone, including the need for a SIM to identify themselves to the network.

Fig. 5 GSM Module

LM2596 Buck Converter: AC-DC Buck Converter Step Down Module LM2596 Power Supply (Fig. 6) is a step-down(buck) switching regulator, capable of driving a 3-A load with excellent line and load regulation. These devices are available in fixed output voltages of 3.3 V, 5 V, 12 V, and an adjustable output version. LM2596 series operates at a switching frequency of 150kHz, thus allowing smaller sized filter components than what would be required with lower frequency switching regulators.

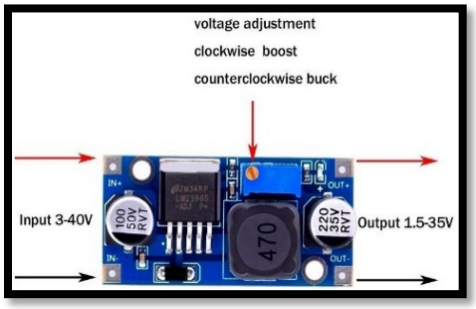

Fig. 6 LM2596 Buck Converter

4. System Design and Implementation

The proposed smart waste management system is an automated system which makes use of an Arduino board to control the sensors and process all the gathered data. The other major components of the system include ultrasonic sensor, GSM module, LM259 Buck Converter, jumper wires and

USB cable. The ultrasonic sensor will be used to measure the distance of the empty area in the garbage can, If the garbage is filled above the threshold value, then the GSM module will be used to send a notification via message to the concerned authorities so that they can clean the dustbins accordingly.

The architecture of the basic detection mechanism of the system involves an interconnection of various sensors and required microcontrollers and power supplies. The power supply is used to to power up the buck converter – LM2596D. The supplied power is regulated and reduced to a range which can be sufficiently used for the functioning of the GSM Module – SIM800L. The GSM module, is thus connected to the buck converter and further the RX/TX pins of the module is connected to the Arduino board. The 'trig' and 'echo' pins of the ultrasonic sensor is used to receive and emit ultrasonic waves and is connected to the necessary digital pins of the Arduino board. Fig. 7 shows the circuitry involved for curating the system involved in detecting the amount of garbage level in the dustbin.

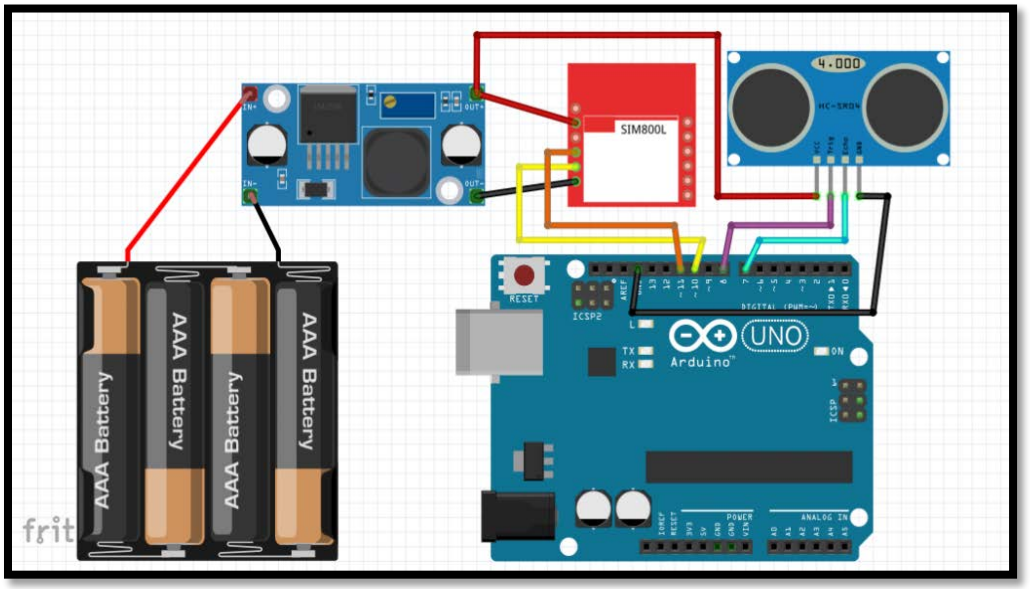

Fig. 7 TinkerCad Circuit for Detection of Level of Garbage in the Dustbin

In order to analyze and comprehend the simulation of the ultrasonic sensor in depth, a simulation of the sensor with a suitable code was also implemented using a software called TinkerCad (Fig. 8). On running the code, the simulation can be visualized and necessary code tweaks can be made

to improve or optimize the code further before direct implementation. Due to the absence of other components like GSM module and buck converter, their simulations were not possible.

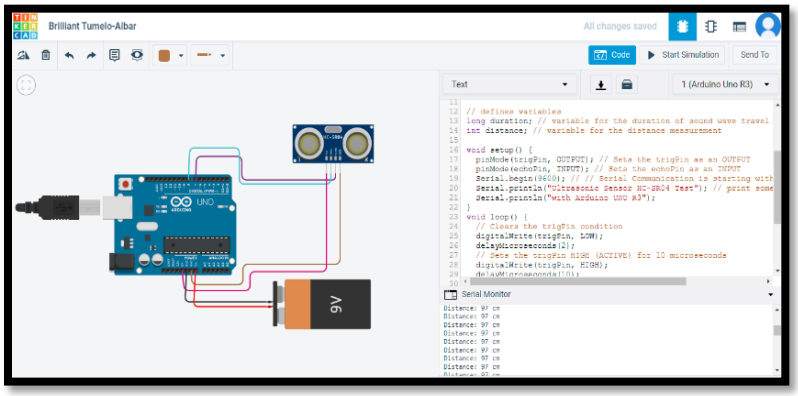

Fig. 8 TinkerCad simulation of Ultrasonic Sensor

In order to introduce a novel feature and solve the issue of cleansing the garbage can after the waste has been removed for hygienic reasons, the proposed system has another additional functional module attached to it. This module consists of ultrasonic sensor, servo motor Arduino board and a breadboard along with jumper wires. The servo motor is used to generate torque and velocity using the voltage and current supplied to it. Servo motors come in different sizes based on which the torque generated varies. To facilitate the working of the sanitation module of our project, MG995 servo motor has been used as it provides higher torque. The main purpose of this module is to ensure that once the cleaner takes the garbage from the can, they can place their hand close to the ultrasonic sensor. When this hand movement is detected by the module, it will operate the servo motor to rotate by ninety degrees causing the strong cleansing solvent to be sprayed across the dustbin. This sanitation feature will ensure that the cleaner need not physically clean the can while exposing himself to the unhygienic environment and at the same time ensures that the garbage can is not left moist as the solvent used is a volatile and strong cleansing liquid.

In order to simulate the working of the servo motor, the circuit and the setup was created in the TinkerCad environment (Fig. 9). On executing the Arduino code in the simulation environment, it was observed that when the distance from the ultrasonic sensor crossed the threshold value, the servo motor rotates by ninety degrees indicating that the spraying mechanism of the sanitation solvent was activated for further cleansing.

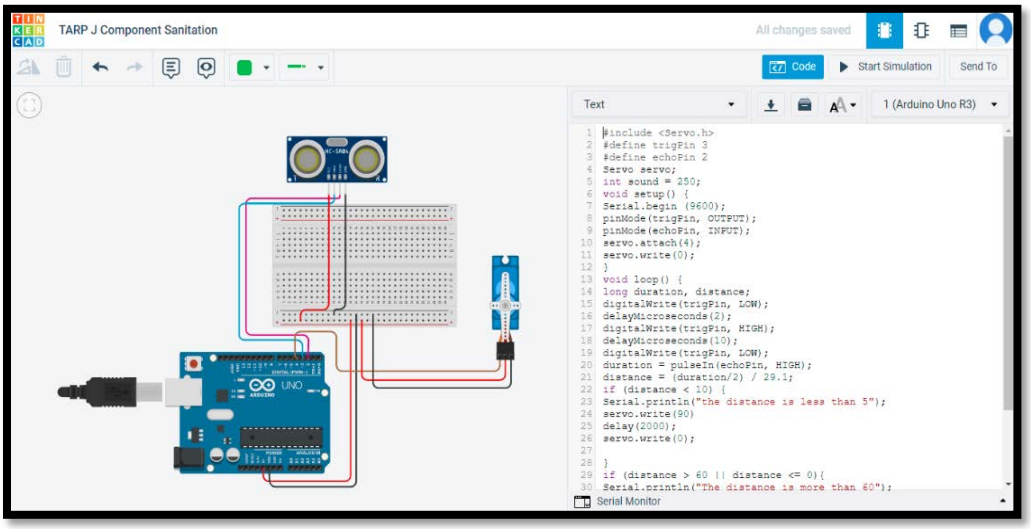

Fig. 9 TinkerCad Simulation of Sanitation Feature of Smart Waste Management

5. Results and Discussion

As observed in the circuit design of the proposed system, there will be two main modules attached to every garbage an. The first module is responsible for intimating the authorities regarding when to clean the garbage cans and is commensurate to the amount of trash in the can. While the second module is responsible for ensuring that the garbage can remains clean and free from dirt by automatic sanitation using suitable sanitation solvents. The detailed work flow of the modules one and two are shown below. As shown in Fig. 10 once the data is received from the ultrasonic sensor regarding the amount of distance left for the garbage to fill the can, it checks if it passes the threshold value which is set. If the condition is fulfilled, it then activates the GSM module which would then send an SMS to the concerned municipal corporation for cleaning the garbage can.

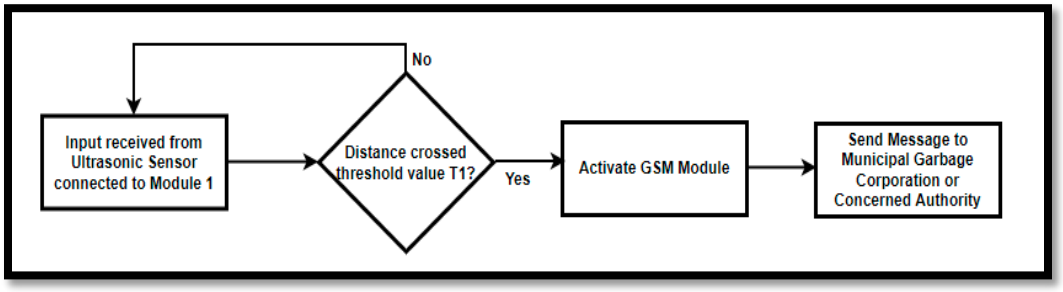

Fig. 10 Flow Diagram for Garbage Level Detection

Once the garbage can is cleaned by the concerned authority, they can activate the sanitation module by keeping their hand close to the ultrasonic sensor of module 2 as shown in Fig. 11. Once the

sensor detects the movement of hand, it then activates the servo motor which in turn activates the spraying mechanism of the cleansing solvent which would spray it and cover the garbage to its maximum reach.

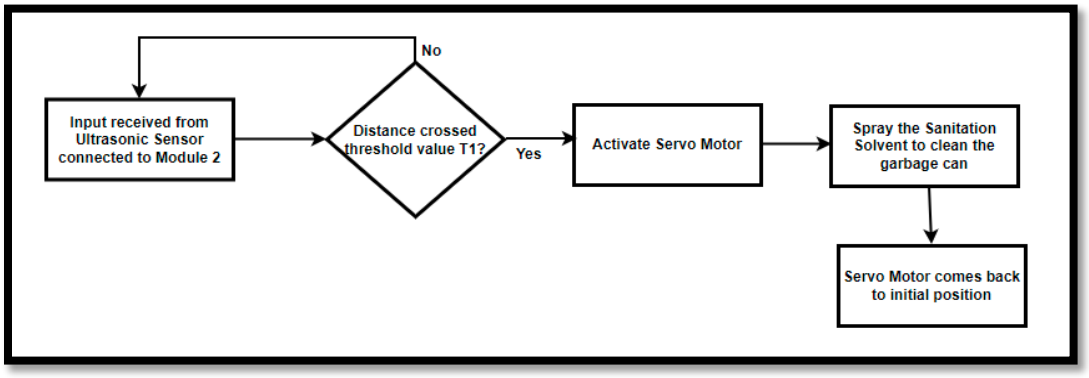

Fig. 11 Flow Diagram for Sanitation Feature of Smart Waste Management

The performance and implementation of the proposed model can be contrasted with some of the existing techniques in terms of the sanitation feature available in the existing works. Most of the works explored and surveyed in the literature review have a pretty decent accuracy but most of them used IR sensors or moisture sensor to detect the garbage threshold levels and the amount of moisture content in it.

Fig. 12 Implementation of Smart Waste Management System

As observed in Fig. 12, the figure on the left-hand side shows the physical implementation of the model proposed in this paper which contains both the modules – garbage level threshold detection and the sanitation modules. As soon as the ultrasonic sensor placed inside the garbage can detects

that the trash is likely to overflow, it sends a notification to the registered mobile device via text message. The screenshot of the received text message is shown on the right-hand side of the above figure.

6. Conclusion and Future Work

The proposed model of smart waste management not just provides the detection if the dustbin is filled or not but also comes with a novel part involving the sanitation of the dustbin. This kind of smart waste management can lead to a healthier life and environment as seen. This smart management can be enhanced in future in different ways. The proposed model is for one dustbin but it can be upgraded to connecting several dustbins and do the smart waste management system. This when implemented and used in villages or cities can improve the cleanliness and maintain a safer environment. Not just in the streets of cities this can also be used in our own homes to give us an alarm when the dustbin is full and as soon as we remove the waste the dustbin will be sanitized thus making the work easier for us.

7. REFERENCES

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APPENDIX

Arduino Code for Detecting Garbage Threshold

```
#include<SoftwareSerial.h>
#define trigPin 8
#define echoPin 7
SoftwareSerial mySerial(10, 11);
int normalDistance=3;
boolean triggered = false;
long duration, distance;
void setup()
{
mySerial.begin(9600);
Serial.begin (9600);
delay(100);
pinMode(trigPin, OUTPUT);
```

```
pinMode(echoPin, INPUT);
long duration, distance;
while (millis() < 5000)
{
digitalWrite(trigPin, LOW);
delayMicroseconds(2);
digitalWrite(trigPin, HIGH);
delayMicroseconds(10);
digitalWrite(trigPin, LOW);
duration = pulseIn(echoPin, HIGH);
distance= duration*0.034/2;
Serial.print("Distance: ");
Serial.println(distance);
} }
void loop()
{
digitalWrite(trigPin, LOW);
delayMicroseconds(2);
digitalWrite(trigPin, HIGH);
delayMicroseconds(10);
digitalWrite(trigPin, LOW);
duration = pulseIn(echoPin, HIGH);
distance= duration*0.034/2;
Serial.print("Distance: ");
Serial.println(distance);
if (distance < normalDistance)
{
triggered = true;
Serial.println("Message Sent!");
delay(1000);
}
```

```
else
{
triggered = false;
}
if (triggered)
{
delay(250);
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=\"+919497087143\"\r");
// Replace x with mobile number
delay(1000);
mySerial.println("I am SMS from GSM Module");
// The SMS text you want to send delay(100);
mySerial.println((char)26);
// ASCII code of CTRL+Z
delay(1000);
} }
```

Arduino Code for Sanitation Facility

```
#include <Servo.h>
#define trigPin 3
#define echoPin 2
Servo servo;
int sound = 250;
void setup() {
Serial.begin (9600);
pinMode(trigPin, OUTPUT);
pinMode(echoPin, INPUT);
```

```
servo.attach(4);
servo.write(0);
}
void loop() {
long duration, distance;
digitalWrite(trigPin, LOW);
delayMicroseconds(2);
digitalWrite(trigPin, HIGH);
delayMicroseconds(10);
digitalWrite(trigPin, LOW);
duration = pulseIn(echoPin, HIGH);
distance = (duration/2) / 29.1;
if (distance < 10) {
Serial.println("the distance is less than 5");
servo.write(56);
delay(2000);

servo.write(0);
}
if (distance > 60 || distance <= 0){
Serial.println("The distance is more than 60");
}
else {
Serial.print(distance);
Serial.println(" cm");
}
delay(500);
}
```