IoT Based Multifunctional Smart Bin

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Abstract: **With the rapid increase in urbanization, the production of waste is increasing. Mostly the collection of waste happens at the wrong time, which is the foremost reason for the overflowing of the dustbin. Overflowing of the bin causes the spread of a foul smell. The early waste collection would add-on to the higher running cost and higher traffic clogging. Therefore, there is a need to improve waste management techniques. As the world is moving towards automated and smart techniques, there is a need to shift from traditional methods to smart waste management. It can be achieved by using technology and data to improvise the handling and collection of waste. This paper describes the ideology of automating the bin for opening and closing the lid and contributing to smart waste management by introducing IoT-based control and monitoring of the dustbin. IoT platforms like Blynk IoT and Thingspeak are used to achieve the objective.**

Index Terms: **Smart Waste management, Internet of Things (IoT), Blynk IoT, Thingspeak.**

I. INTRODUCTION

India being the second most populated country in the world, waste management is of great challenge. India generates 62 million tonnes of waste annually, which is estimated to be increased to 165 million tonnes by 2030.[1] Waste management is the biggest challenge to the authorities in developing countries, Waste leads to a great threat to the public health and environment if it is not stored and collected properly.[2] The filling status of the bin is imperceptible by the authorities responsible for emptying it felicitously, which causes the overflowing of the dustbin. Greenhouse gases like methane, carbon monoxide, ammonia, and low level of radiation are released from household municipal waste.[3] It not only contributes to the production of green gases effect but also causes the exploitation of the water bodies. Rainwater easily mixes with toxic substances and drenches into nearby water bodies,[4] which may also exploit the groundwater. The stray animals residing in urban areas of developing countries ingest the plastic waste from open dustbins causing health hazards.[5] Ruminal impaction, indigestion, recurrent tympany, and many other health hazards are caused in the ruminants due to the accumulation of plastic foreign into their rumen.[6]

The objective of an IoT-based smart dustbin is to provide access for continuous monitoring of the filling status of the bin to the concerned authorities responsible to empty it felicitously. Therefore, giving a wide berth to the spread of foul smells due to the overflowing of the dustbins. The following is achieved using an IoT platform, Thing- speak. Thingspeak is an IoT analytics platform that allows us to visualize and analyze the live data streams in the cloud, without developing web software or setting
up servers.[7]

To enhance the collection of waste promptly the concerned authorities are to be notified of the filling status of a dustbin, at least when it is about to fill. To achieve the following Blynk IoT application is used. Blynk provides an automated notification triggered by the user-defined condition. The notification could be sent as an in-application push notification, email, and SMS notification.[8] Hence these IoT-based platforms serve to attain continuous monitoring of the dustbins and notify the concerned authorities to empty the dustbin in time.

To avoid the dissipation of foul odor from the garbage in a dustbin, it is automated to open and close the lid on detecting humans approaching the dustbin. This will isolate waste inside the dustbin and pitch in to overcome the ingestion of plastic into the stray animals. There are a few more auxiliary features, which will be described later in this paper. The following features collectively contribute to smart waste management.

The approach presented constitutes various hardware components that include sensors, actuators, and controllers. The controllers are programmed using

Arduino Integrated Development Environment (IDE) software to actuate the hardware according to the requirements specified by the user, which depends on input received from sensors. Arduino IDE connects to Arduino hardware allowing us to upload the program written in the text editor present in it.[9] The simulation of the circuit is done in tinkercad, which will be discussed further in this paper. Tinkercad is a web application that facilitates electronic circuit simulation and 3D designing.[10]

II. HARDWARE SETUP

In this section, the hardware components required for the development of smart dust- bin and their working will be illustrated.

A. Hardware components:

Table 1. Hardware components required to build the product

Equipment Name	type
Arduino	UNO R3
NodeMCU	ESP8266(12E)
Ultrasonic Sensor	HC SR04
Servo motor	SG90S
LCD	16x2
Infrared Sensor (IR)	Passive
Buzzer	Piezo
Potentiometer	10 KΩ
Batteries 3200 mAh	AA type(rechargeable)

Arduino UNO is a microcontroller based on ATmega328P. It has 14 digital input/output (IO) pins, out of these 6 pins may provide a Pulse Width Modulated (PWM) output, 6 analog input pins, and a few peripheral devices that make it handy to use.[11] NodeMCU is an open-source IoT platform. ESP-12E version of NodeMCU is used where E stands for Enhanced.[12]

The ultrasonic sensor has a receiver and transmitter. A Trigger pulse for 10 µs is triggered from the IO port of Arduino as an input to trigger pin
of an ultrasonic sensor.

The ultrasonic sensor automatically sends eight 40KHz and the receiver detects whether there is a pulse received back at the echo pin of the ultrasonic sensor.

$$Distance = \frac{time * speed\ of\ sound}{2} \qquad (1)$$

The speed of the sound is 341 m/s in air. Distance is calculated using the formula equation (1).

SG90 servo motor serves as an actuator that provides a displacement from 0° to 180°. Input to the servo motor is a PWM signal, Which can generate a torque of 1.7 Kg- cm. LCD 16x2 implies a Liquid Crystal Display that has 16 columns and two rows so that it can display a total of 32 characters.[13] IR sensor has a transmitter and a receiver that detects obstacles. The working of the IR sensor is similar to that of the ultrasonic sensor, the emitter transmits infrared radiation into the surroundings and the receiver looks for that specific radiation to be received back. If the radiation is received it sends a high input to the microcontroller indicating the presence of an obstacle. A Piezo buzzer is an electronic device that is used to produce an alarm or tone. A potentiometer is a three-terminal variable resistor, which is used to control the contrast of the LCD used in the smart dustbin.

B. Circuit & schematic layout:

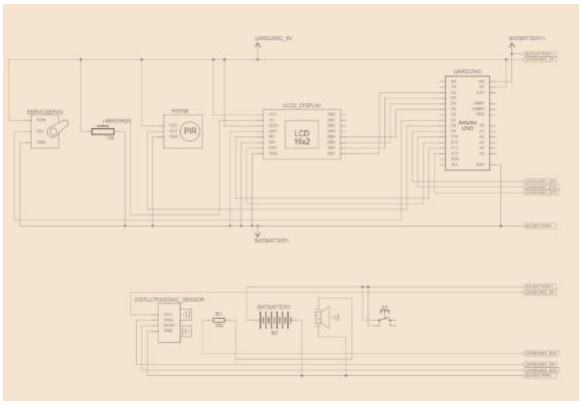

Fig. 1(a). Schematic layout of smart dustbin setup

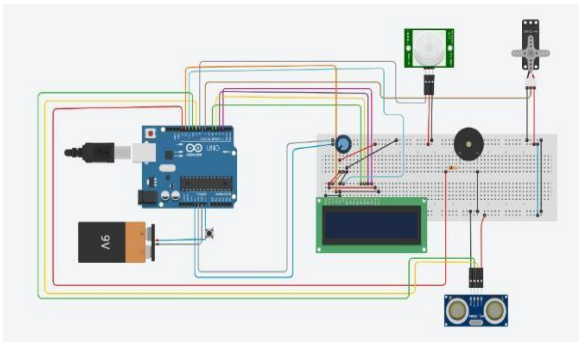

Fig. 1(b). Circuit diagram of smart dustbin setup

The schematic layout and circuit diagram shown in Fig. 1(a). and 1(b) mark out the connection of hardware components to the microcontroller. The digital IO pins of Arduino UNO are connected to the trigger and echo pins of the ultrasonic sensor, buzzer, IR sensor, and respective pins of LCD. The digital IO

pin 7 of Arduino UNO is connected to the servo motor since it can provide PWM signals to actuate it based on the requirement. IR sensor provides a digital input to Arduino through an IO pin that implicates obstacles specifically humans in the following case. The buzzer receives input from the controller and acts accordingly.

Fig. 2. Smart dustbin setup

The setup integrated with hardware components is shown in Fig. 2. A Handmade Circuit Board(HCB) with a modular arrangement is designed considering the effective placements of the sensors and actuators to obtain the output efficiently. An ultrasonic sensor is placed inside the bin, which provides distance as an input to the microcontroller. LCD is placed over the bin which provides visuals of the filling status of the dust- bin. Arduino UNO and NodeMCU are connected to each other using a serial communication port. A piezo buzzer is connected to the circuit, which generates a specific sound in a specified situation, which will be described later. The setup is powered using two AA-type rechargeable batteries each of 3200 mAh.

III. WORKING

The block architecture shown in Fig. 3. illustrates the working of all the hardware components collectively for the functioning of a smart dustbin. The input in terms of distance received from the ultrasonic sensor is processed by the Arduino UNO to obtain the filling status of the dustbin in terms of percentage and displayed over the LCD.

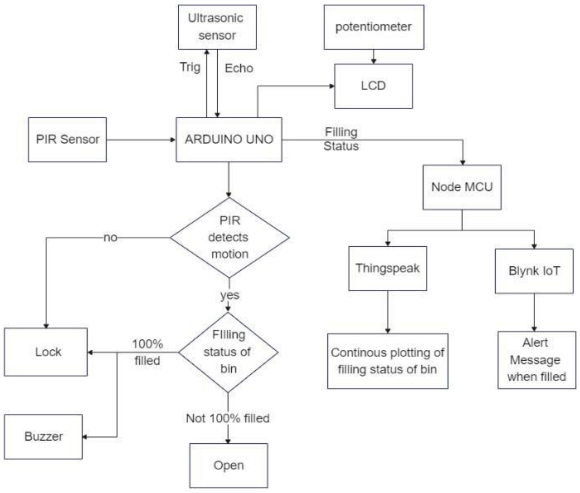

Fig. 3. Block architecture of smart dustbin setup

When the IR sensor detects the human it sends a digital input to the Arduino. Arduino checks if the dustbin is full or has space to accommodate waste, if it has space it sends the PWM input to the servo motor which opens the lid. If the dustbin is completely filled the servo locks at its position, and simultaneously the buzzer rings implicating that the dustbin is filled. It creates a mental dilemma for the person that may stop him from throwing the waste around the bin.

The filling status of the dustbin is continuously communicated to NodeMCU from Arduino through serial communication. NodeMCU Will push the respective data to thingspeak. When the filling percentage is more than 90%, a notification is sent to the concerned authorities to empty it, along with the location of the bin. The use of the buzzer will be limited since the dustbin would be emptied timely.

IV. EXPERIMENT AND RESULTS

In this section, the experimental approaches made and corresponding results obtained are presented.

A. TINKERCAD SIMULATION

Prior to the implementation of hardware and code compilation in the Arduino IDE application, the code required to obtain output and circuit was first simulated in the tinkercad web application. At the end of this phase, the possible errors and a list of required components were obtained as illustrated in the Fig. 4.

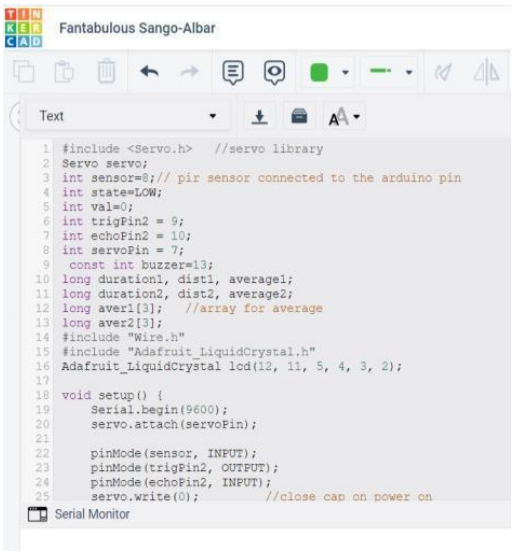

Fig. 4. Code simulation in Tinkercad web application

B. EVENTUAL OUTPUTS

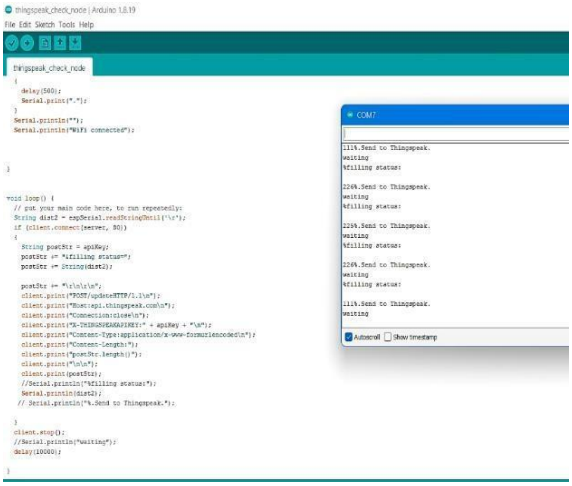

Fig. 5. Code simulation in Arduino IDE application

Fig. 5. shows the sketch containing the code, the decoding statements, and the output obtained over the serial monitor of the Arduino IDE application. The code is optimized to minimize the power consumption by the hardware components. The circuit simulated is then implemented over an HCB as shown in Fig. 2. Placement of the sensors and other hardware equipment was planned in correspondence to the requirement. The data obtained from the sensors were further processed by the microcontroller and the output is obtained.

Fig. 6(a). and Fig. 6(b) are the continuous data points obtained in the thingspeak. Fig. 6(a) was obtained during a short duration of an experimental period, whereas the curve in Fig. 6(b). was obtained for a long duration of the deployment period.

Fig. 6(a). The curve represents the filling status of the bin in the Thingspeak IoT platform for a few hours during the experimental period

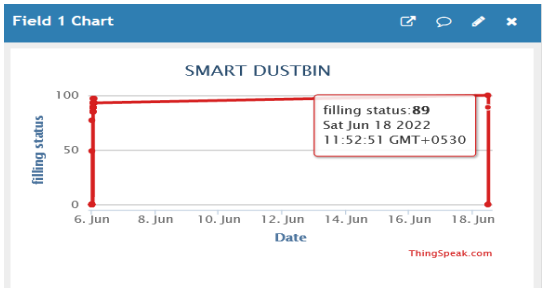

Fig. 6(b). The curve represents the filling status of the bin in the Thingspeak IoT platform over a few days

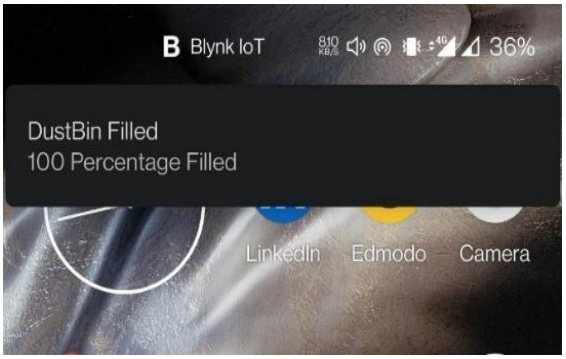

Fig. 7. Code simulation in Arduino IDE application

When the dustbin is filled, a notification is pushed to the concerned authority to empty the dustbin as shown in Fig. 7. The controller is programmed to trigger the notification every ten minutes to have a speedy response from the authorities.

V. CONCLUCION

The proposed system helps to keep the surroundings clean. It contributes to the initiatives like smart cities, smart campuses, smart urban waste management, and Swachh Bharat which is initiated by Mahatma Gandhi. The lid opening and closing is automatic, it can prevent diseases caused through contact, such as

COVID-19. Further, prevents the overflow of the bin, as the lid remains closed when it is completely filled. The buzzer acts as an add-on that prevents the overflow of garbage in a contingent manner.

VI. FUTURE SCOPE

- Build a web dashboard to create an easy interface for concerned authorities.
- Introduce machine learning for the distinction between wet and dry waste.
- Develop an E-SIM-based product to cut the dependency on Wi-Fi.

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