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RESEARCH ARTICLE

# Smart Dustbin using IOT

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## Abstract

Living in a technological world that is upgrading day by day, there is one major problem that should be dealt with. Garbage, which is the issue preventing us from developing into a sanitary, clean, and healthy society. In our daily lives, we frequently encounter trash cans that are overflowing with junk. Neither our environment nor our growth benefit from situations like this. Due to the abundance of flies and mosquitoes that breed on the garbage, this issue significantly negatively impacts health. As a result, this project is designed to prevent the trashcan from becoming overfilled by giving it the ability to alert itself when it needs to be cleaned. The smart trash bin system in this project is built on a microcontroller and has ultrasonic sensors on each of the two trash cans to display the garbage's current status on an LCD screen and a smartphone.

**Keywords**: Smart dustbin, Dijkstra's algorithm, LCD, wireless fidelity, global positioning system.

## Introduction

Smart cities refer to a smart lifestyle with continuous monitoring and control of the actions around humans.

With the enormous increase in population rate there is a vital need for waste management. Due to dustbin overload, countless people die each year from environmental diseases like cholera, diarrhea, malaria, and typhoid. Solid waste management is evolving into a global issue due to rapid population increase, city government dysfunction, a lack of public awareness, and inadequate money for programmes. Smart trash cans use the integration of both ultrasonic and infrared sensors to detect the level of waste and determine a human's presence. The Internet of Things (IoT) is a concept through which the objects under observation are continuously monitored and controlled using wired or wirelesscommunication in another device. This scheme comprises an ESP8266 Wi-Fi router, a LCD display, and an Arduino to send data. A website is also created so that the user watching it can see the dustbins' current state in real time. This web page also aids with the stored information regardingthe status of the bins and the frequency at which a dustbin is filled. Data logs can be analyzed and suitable correction measures can be taken.

A customized buzzer that is set to flash whenever the waste level exceeds the predetermined limit is included into the website. Thus, by notifying the public about the rubbish levels via a website, this technique contributes to keeping the city clean.

The shortest path between the dustbins is calculated in a manner to minimize time and fuel consumption. Dijkstra's algorithm calculates the shortest path from one dustbin to the nearest dustbin. A MATLAB simulation using fiftynodes was programmed to identify the shortest route from a current node to the nearest node where the nodes represent the dustbins and the location of the nodes are provided using the x-y coordinates. The simulation output includes the shortest path and the distance between the two nodes.

### *Problem Definition*

The World Health Organization (WHO) claims that a significant sanitation-related issue is urban solid waste disposal. According to recent study projections, cities produce 1.3 billion tons of solid trash annually; by 2025, this number is predicted to increase to 2.2 billion tons. This is primarily the result of inadequate solid waste collection and disposal. This may also lead to an increase in the number of insects and rodents that spread disease. Other urban

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features like overcrowding can make these dangers worse. Garbage collecting truck drivers are unable to identify all the locations of the trash cans leading to overloading of the missed garbage bins over a time period. Also, the drivers lack awareness regarding the shortest path to the garbage bins, increasing fuel consumption and collection time. This problem can be addressed by detecting the waste of the dustbins and proving the location of the filled dustbins to the user through a web page also the shortest route can be identified through Dijkstra'salgorithm.

### *Objective*

The objective of this project is to facilitate the automatic opening and closing of the garbage bins whenever motion within range is detected and also to monitor the level of garbage filled in the bins using the ultrasonic sensors and update the status to the web page created, through Internet of Things (IoT) so as to provide awareness regarding the waste level in real-time to the garbage truck driver. The locations of the filled dustbins are also provided to the truck drivers through the web page. A simulation depicting the identification of the shortest path to the dustbins using Dijkstra's algorithm is done using MATLAB. In real-time conditions, the dustbins are connected using Global Positioning System (GPS) and can be continuously monitored using the web page created. Ultrasonic sensors detect the volume of waste in the dustbins, and those that are overfilled are taken into account when calculating the quickest route. Once the filled dustbins are identified, Dijkstra's algorithm code is executed to choose the minimum distance path from the current to the nearest node. The dustbins are represented as nodes in the program, the location and the distance between them can be identified using the Global Positioning System.

### *Project Scope*

The proposed method is for utilizing the sensorseffectively to detect human intervention and waste level and provide an effective means of transferring the information to the user through IoT and also offer the shortest path to the filled garbage bins by implementing Dijkstra's algorithm, this system can not only allow the truck driver and officials but also the residents to check for the overflow. Thus, it provides awareness regarding the level of waste and the frequency at which the waste is being collected.

### *Literature Survey*

Several works have been published for prototype development of smart dustbins. The major attributes include sensors and methodology adopted, technology used and algorithms implemented.

Sensors are vital for receiving the input signals such as level of waste collected, human movement, and amount of the waste collected. Ultrasonic sensors have been used in (Wijaya et al., 2017; Patel et al., 2019; Soh et al., 2019) for detection of trash level inside the bin. However, the above prototypes do not include the dustbin's automatic opening and closing facility. Rohit et al. (2018) proposed a prototype that incorporates an automatic opening and closing function using an IR sensor also the system includes two dustbins where the second dustbin is operationalonly after the first dustbin reaches its maximum limit. Alert systems were also provided (Sreejith et al., 2019; Alsayaydeh et al., 2019; Anilkumar et al., 2019; Sharma & Singh, 2018). An alert message is raised when the waste level reaches its maximum capacity and additional sensors for rain waterdetection was also provided (Sreejith et al., 2019).

In the paper by Alsayaydeh et al. (2019), the alarm is raised in two stages the first alarm is raised as a warning and the next indicates that the dustbin is full. Additional sensors such as gas sensors for odor detection, Bluetooth module and weight sensors, have also been included (Anilkumar et al., 2019; Johnson & Shyni, 2019). The smart dustbin identifies a human using an IR sensor (Anilkumar et al., 2019). If a human is detected thelid of the dustbin will automatically open and if the person goes away from the bin the lid of the dustbin will closeautomatically using a stepper motor action. The proposed wastebin by Johnson & Shyni (2019) is made to monitor the level of trash in the bin, the weight of the trash collected and the presence of CO2 in the trash. LCD displays are used to provide the current status of waste in the dustbin. However, no long-range communication alert system (Sharma & Singh, 2018).

IoT and wireless communication plays a major role for smart dustbins. Technologies such as IoT, GSM/GPRS and GPS have been used to achieve real time information sharing. Simulation tools, mobile applications and cloud platforms have been utilized to develop the prototype models. Android applications have been developed for user interface (Kumar et al., 2017; Anitha et al., 2018; Soh et al., 2019; Kariapper et al., 2019). Arduino have been widely used as the processing platform (Anitha et al., 2018; Soh et al., 2019; Sharma & Singh, 2018) and also ATmega has been used processor by Anilkumar et al. (2019) and Kaushik & Yadav (2017).

To achieve real-time operations GSM and GPRS have been used for location tracking of the dustbins (Kumar et al., 2017; Rohit et al., 2018).In a paper by Kariapper et al. (2019), GPS and the shortest path algorithm are used fortracking applications. Simulation tools such as Network Simulator 2 (NS2) was used by Anitha et al. (2018) and Ionic3 was used for mobile app development by Sharma & Singh (2018). Ubidots cloud platform has been used for data storage by Soh et al. (2019).

In real time scenarios dust bins are distributed widely in various locations in a city hence it becomes difficult for the trash car driver to locate the dustbin. For effective location tracking various shortest path algorithms have been used. Anitha et al. (2018) used the LEACH algorithm for location detection. Dijkstra's algorithm has been commonly used (Kariapper et al., 2019; Kaushik & Yadav, 2017; Xiao & Lu, 2010. Kariapper et al. (2019) and Kaushik & Yadav (2017) employed Dijkstra's algorithm for real time tracking of the location of the dustbins using GPStracking devices.

Xiao & Lu (2010) presented a modified Dijkstra's algorithm for optimal tracking operation. Heuristic algorithms have been employed to solve the tracking problem by Johnson & Shyni (2019). Sinha et al. (2015) presented a detailed survey of algorithms and provided a comparative analysis. The algorithms presented include Nearest Neighbour, Genetic algorithm, Ant colony, Integrated NearestNeighbour Algorithm and Genetic Algorithm, Floyd Warshall and Dijkstra's algorithm.

### *Proposed Technique*

The project titled "Smart dustbin using IoT" is implemented to provide a clean environment that involvesfeatures such as automatic opening and closing as well as detection of waste level in the dustbins. A block diagram is asimple diagram used to represent a system's principle parts or functions by blocks. The blocks are connectedby lines that show the relationship between the blocks. In thischapter, the block diagram of the proposed technique is also being discussed.

The techniques incorporated include automatically opening and closing the dustbin lids and continuously detecting waste levels in the dustbin. The level of waste is recorded in Thing Speak cloud platform and notified when the dustbin gets almost filled. The shortest path to find the location of the filleddustbins is calculated using Dijkstra's algorithm.

Figure 1 represents the overall block diagram of the project. The waste which is thrown in the dustbin is denoted as the object to be sensed. The infrared sensor senses the movement of humans and automatically opens the dustbin lid. The ultrasonic sensor senses the level of waste thrown in the dustbin continuously. The programs to facilitate the working of sensors, servo motor, uploading of data in ThingSpeak cloud, and finding the shortest path are coded in the Arduino Uno. When a human is detected, the signal from the infrared sensor makes the servo motor to open and close the dustbin lid automatically. The level detected by the ultrasonic sensor is uploaded in the ThingSpeak cloud environment to make the data available anytime, anywhere. The shortest path to find the location of filled dustbin is calculated using Dijkstra's algorithm and displayed on the ThingSpeak homepage. The data could be monitored using any smart device.

### *Algorithm*

The nearest pathways between the necessary nodes in a graph which could, for instance, represent a network of roads are found using Dijkstra's algorithm. Edger W. Dijkstra, a computer scientist, created it in 1956. The original Dijkstra algorithm identified the shortest route between two specified nodes. The algorithm determines the fastest way between a source node and every other node in the graph for a given source node. By entering the node address in the application, it can also be used to determine the shortest routes from one source node to one destination node. The illustration of the Dijkstra algorithm is explained through an example. Consider a graph having 5 nodes each with different costs between the nodes.

From the graph the adjacency matrix is formed by assuming the distance between the nodes to be infinity and theknown distances to be zero. The previous vector is also assumed to be zero.

### *Software*

Arduino UNO collects the data from the IR sensor and ultrasonic sensor. The results collected by the Arduino UNO are fed to the ThingSpeak cloud along with the dustbin's location displayed on the ThingSpeak window. Channels can be created to display various results. Here the position of the dustbin i.e., whetherthe dustbin is closed or not is displayed through an indicator.If the dustbin is opened the indication on the ThingSpeak window changes to green. The level of the dustbin is displayedon another channel by displaying some value. Figure 3. shows the results displayed on the ThingSpeak window.

The simulation tool used is MATLAB. The simulation isdone to find the shortest distance between the filled dustbinsby using Dijkstra's algorithm assuming there are

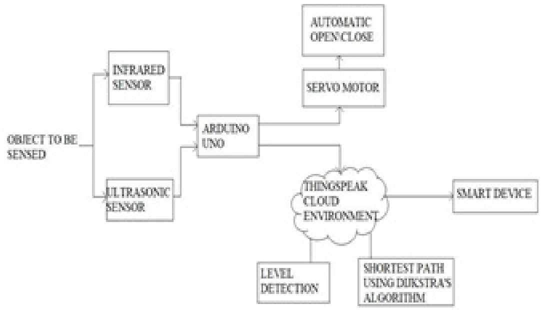


**Figure 1:** Block diagram

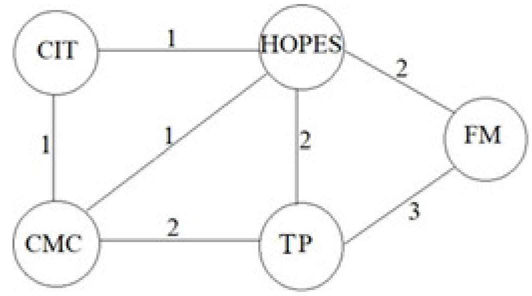


**Figure 2:** Graph considered for Dijkstra Algorithm

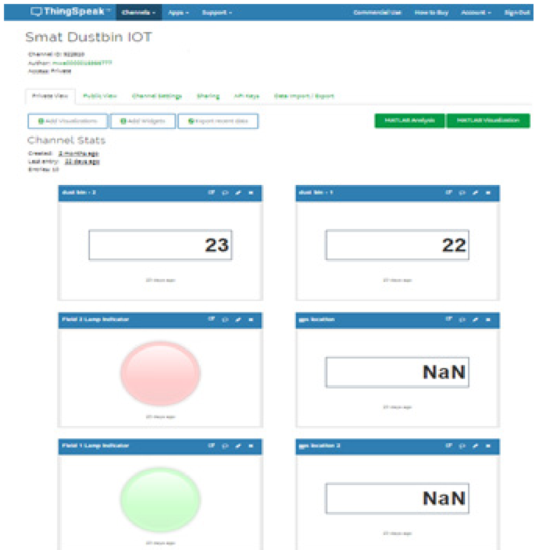


**Figure 3:** Thing speak window

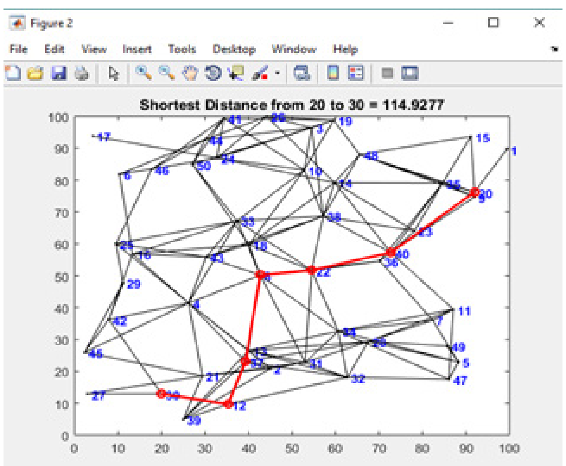


**Figure 4:** Simulation Output

50 nodes. The algorithm in real time application helps the truck driver find the nearest filled dustbin, reducing fuel consumption and saving time.

The simulation is done by assuming 50 nodes. For real time application, the position of the dustbin should be knownto find the shortest distance. In the simulation, the location ofthe nodes is randomly assumed since a random function is usedin the MATLAB code. It can also be manually given by giving the location of the nodes assuming it to be a three-dimensional plane.

The nodes that are represented in the simulation are the location of the dustbins. So, when the location is fed as information in the Arduino UNO, it will perform the code and display the shortest way between each node. The location can be manually given or automatically detected by location detectors like GPS/GSM.

Dijkstra's algorithm is implemented using a real time cost matrix. The example considered here demonstrates the process of finding the shortest path between the source nodeand all other nodes. The user will be able to identify the pathto be traveled with minimum distance. Implementing Dijkstra's algorithm using the MATLAB simulation tool helps implement it in real time.

### *Hardware*

The hardware components used and their purposes are listedbelow:

- The main purpose of an infrared sensor is to detect motion by emitting infrared radiation hence it is used for human detection.
- The ultrasonic sensor measures distance by emitting ultrasonic sound waves, thus it is chosen to measure the level of waste inside the dustbins.
- For automatic opening and closing of dustbin lids servo motors are used because they can rotate with greater precision.
- The Arduino UNO controller was chosen for its easy programming environment.
- The Wi-Fi module is chosen for making the data available in the cloud environment.
- All the components used are of 5V rating hence a step-down transformer 230V/5V is used to feed the power supply board.

### *Circuit Diagram*

Figure 5. gives the overall circuit diagram of the project. The 230V AC supply is stepped down to 5V to supply the Arduino UNO, servo motor, Wi-Fi module and LCD display. The LCD is connected with the Arduino which displays human detection along with the level of the dustbin. The Wi-Fi module is connected with the Arduino and provides the data to be available in the ThingSpeak cloud homepage. The sensors are connected to the Arduino board for performing opening, closing, and level detection. The 6V battery is used to supply power to the servo motor for automatically opening and closing the dustbins.

### *Hardware Setup*

Figure 6. shows the hardware model of the project. The IR sensor detects human intervention and provides opening

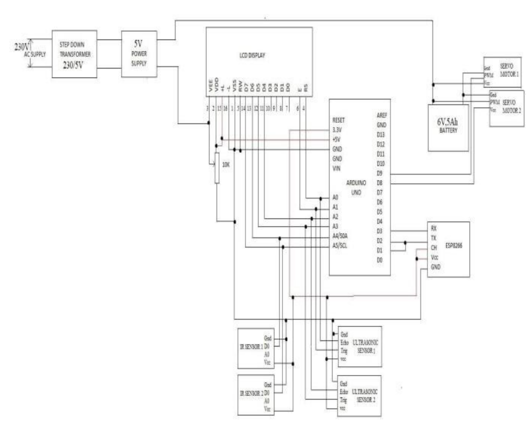

**Figure 5:** Circuit Diagram

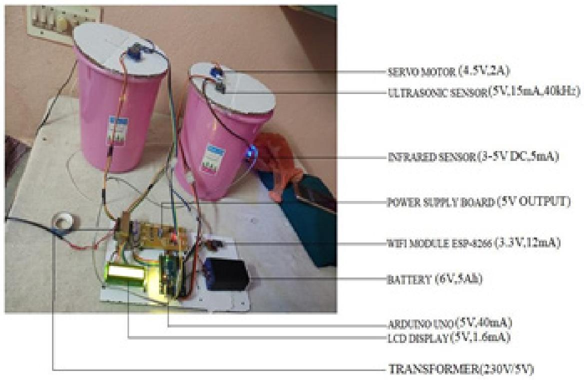


**Figure 6:** Hardware setup


**Figure 7:** Human detection


**Figure 8:** Level indication

andclosing of the dust bin. The ultrasonic sensor monitors the wastelevel continuously and uploads it to the ThingSpeak cloud page. The sensors' working and data uploading are done with Arduino UNO on the basis of the code uploaded in it and the Wi-Fi module, respectively. The results arealso displayed in LCD display. Since all the components usedin this setup are of 5V rating, a step-down transformer is utilized to supply the power. The power supply board consists of capacitors and regulators that rectify the ripplesand provide a steady 5V DC. A separate battery is providedto supply the servo motors to reduce the complexity of connections.

When the supply is given, the 230V AC supply is stepped down to 5V to give supply to the Arduino board. A servo motor automatically opens The dustbin's cover when the IR sensor triggers any disturbance. The ultrasonic sensor is positioned inside the trash can to gauge how full it is. Figure 7. shows the signal for human detection so that it can open the dustbin's lid automatically. Figure 8. shows the level of dustbins filled by displaying it on the LCD display.

The project's ideology is to provide a clean environment and prevent the overflow of waste. This concept was put into practice by automatically opening and closing the trash cover with IR sensors based on human detection and level detection with ultrasonic sensors. This setupcan also be implemented in real time with components of higher ratings. The smart device can be given to the truck drivers so that they can pick the waste once filled.

## Conclusion

When the garbage level reaches its peak, this project's construction of a smart trash can using IoT as hardware ensures that the trash can will be cleaned as soon as possible. This system employs IR and ultrasonic sensors to detect the amount of rubbish in the trash can and to automatically close and open the trash can. Implementing Dijkstra's algorithm in simulation helpsfind the shortest distance among the filled dustbins. The smart dustbin using IoT system makes garbage collectionmore efficient, less time consuming and reduces fuel consumption for truck drivers. Any of the smart cities can use this trash can models. The deployment of a trash collecting and monitoring system for the collection of waste from the city can be well-directed for collection.

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