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Design and Implementation of an IoT-Enabled Smart Dustbin for Waste Administration: An Elucidation for Urban Sustainability

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ABSTRACT

The brisk augment in population has also led to rapid growth in the urbanization of modern cities, which in turn has resulted in increased garbage production, posing major challenges for garbage management. In this paper, we propose and implement the design of an IoT-based smart dustbin management system, which primarily aims at enhancing garbage administration and promote urban viability. Our proposed system shall incorporate advanced ultrasonic sensors and GSM system enables real time data distribution, to enhance the collection of garbage and efficient disposal processes. We utilize IR sensors to detect the motion of people coming to the garbage bin with trash, while the bin is at full status and block them from adding of more garbage in the trash bin via a buzzer. Through the GSM and peripheral sensors, fused with Arduino microcontroller, detection and real time feedback to the municipal authorities can ensure timely collection thus reducing human intercession. In addition, it adds up to the insight of garbage patterns, which can ensure enhanced resource allocation, planning and collection, improving overall waste management. This paper discusses the design, architecture, implementation and positive impact on the urban cities to obtain a decent level of sustainable living.

Keywords : Internet of Things, smart dustbin, Arduino-Uno, GSM.

I. Introduction

With the rapid growth of population, urbanization has increased dramatically. Urbanization has aided in the higher living standards of the general population but has also posed significant challenges, especially in the domain of waste management. The expansion of cities, and the population, has give unprecedented growth to the waste generation, exerting great pressure on municipal corporations for waste administration. The current methods of garbage collection and disposal is providing a failure in waste management, degrading the environment, and a continuous increase in the greenhouse gas emission. A

stern need to address these issues requires novel approaches through technological intervention.

The growth of Internet of Things (IoT) has been instrumental in the past years, proficient in reducing the gap between the customary garbage management methodology, and therefore achieving the contemporary urban sustainability. Through the usage of IoT, devices can now be integrated in the existing systems and the data can be streamlined to the management authorities in real time for allowing them to use their limited resources efficiently. The challenges in this regard have been explored in this paper, and to counter them, we have developed an IoT incorporated smart waste bin.

The solution includes an integration of several components, which will encompass sensors that can observe waste levels, which in turn communicate with components for transmission of data, and a podium for analysis. This provide for the real-time data collection and analysis, which in effect can provide for well-timed waste gathering. The solution will remove the inefficiencies observed in the conventional operational methodologies and provide for sustainability in an urban environment.

The paper is oriented towards an inclusive outline of the planning, design and implementation of an IoT-incorporated smart dustbin system. The organization of this paper is as follows: Section 2 looks into the similar researches, Section 3 represents the system design, Section 4 deals with the implementation and testing, and lastly Section 5 concludes our work.

II. LITERATURE SURVEY

Integrated Load sensors and IR proximity sensor, and a Radio Frequency transmitter, to build an electronic device known as “Smart Trash Bin” in [1]. The system included a GSM module, Load sensor, microcontroller, DC motor, LCD, Web camera, and power supply, to avoid the overflow of garbage in a residential area. [2] considered the “pay as you throw” weight based billing system for residential areas, thereby motivating the citizens to reduce their wastage. [3] Designed a system to collect data using ultrasonic sensor and to deliver data through the wireless mesh network. The system employed a duty cycle technique to reduce power consumption and to maximize operational time. In [4], the proposed system concentrated on eradicating the issue of ignorance of cleanliness which is spoiling our environment and then reduces it. The smart trash consists of two sensors namely IR and gas sensors. The IR sensor placed inside the trash to sense the level of trash and gas sensor will sense the toxic gases. Once the trash is filled, alarm rings.

In further studies, [5] employed a weight sensor, IR sensor and Wi-Fi module for transmission of data. The system assures the cleaning of dustbins soon when the garbage level reaches its maximum. If the dustbin is not cleaned within a specific period of time, the record is send to the higher authorities who can take appropriate action against the concerned contractor. This reduced the total trips of garbage collection vehicle and hence reduced the overall expenditure of the garbage collection. [6] Concentrated on image processing and GSM module for the automatic garbage collection and information gathering. The idea was that a camera will be placed at every garbage collection point along with the load cell sensor at the bottom of the garbage can. The camera takes continuous snapshot of the garbage can,. A threshold level is set which compares the output of the camera and load sensor. The comparison is done with the help of a microcontroller. After analysing the image, we get an idea about the level of garbage in the can and from the load cell sensor; we get to know about the weight of the garbage. Accordingly, information is processed and checks if threshold level is exceeded or not. The controller sends a message

with the help of a GSM module to Garbage collection centre, which takes the necessary steps to collect the garbage.

In [7], a sensor is placed under the dustbin. When the sensor signal reaches a final threshold value, a mail notification shall be sent to the authorities concerned. It also enables to monitor the density of the dustbin through internet on a Dashboard. A Graphical User Interface dashboard enables an authenticated person to check on the current condition of the Dustbin, and once found above the threshold value, the concerned person can send the collection vehicle to collect full garbage dustbins.

We observed that the present system were lacking certain aspects of efficient garbage collection, namely lack of information about the collecting time and area, lack of proper system of monitoring, tracking the trucks and trash bins that have been collected in the real time, lack of estimation of the amount of solid waste present inside the bin and the surrounding area due to scattering of waste, and the lack of response to urgent cases like truck accidents, break down and long time idling. Our proposed system will overcome the limitations posed by the current system and provide for a smart garbage collection mechanism to ensure environment cleanliness and sustainability.

III. Design and Architecture of the Proposed System

Our proposed system implements a Smart Bin system with IoT technology using Blink app. It will observe waste at real time, give the user the flexibility of accessing information on the fly, and provide respective alerts as per the requirements of the system. The working principal of the proposed system is displayed below with the help of a flow chart.

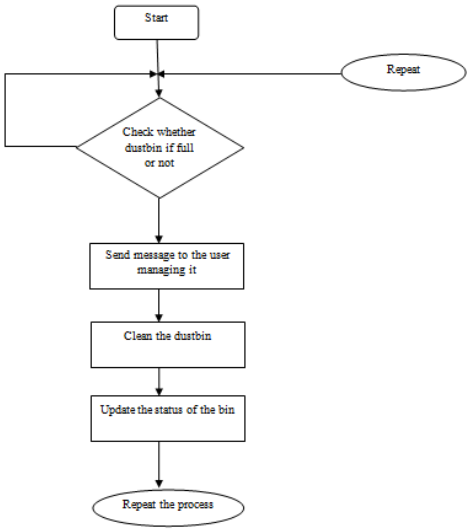

Figure 1: A flow chart depicting the working of our proposed system

The proposed system utilizes GSM technology as a backbone network for the flow of information between the system and the authorized user. For the purpose of our study, we have employed the services of a GSM 900 Modem. Load/ Level detector is handled via IR sensor. Four IR Sensors are employed to detect different levels of garbage in the dustbin which are placed in public areas. The output of these sensors is given to the microcontroller to send the message to the Control room via GSM. The threshold value can be defined using the GUI, to indicate different levels of the garbage in the can, accordingly which alerts can be generated and actions are decided. Initially, the threshold value of 5 cm has been established in the program code. The ESP82666A wi-fi adapter in employed which links Arduino to the webserver. The module is programmed in such a manner that once a threshold value is reached, the level buzzer gives alert sound regarding the same. These all processes are updated in IOT GECKO platform for monitoring purposes.

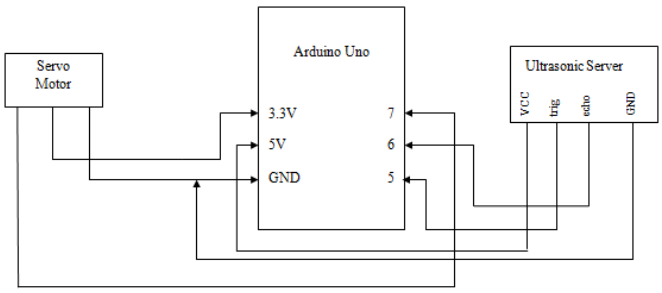

Figure 1: Block diagram of the Arduino Uno module

The system architecture for our work is displayed in the figure 3 below, which is essentially used to develop our hardware model of the smart bin using IoT. Figure 4 displays the Arudino Uno board utilized in our prototype.

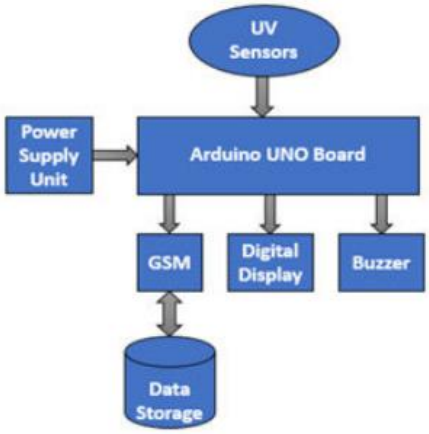

Figure 3: System architecture

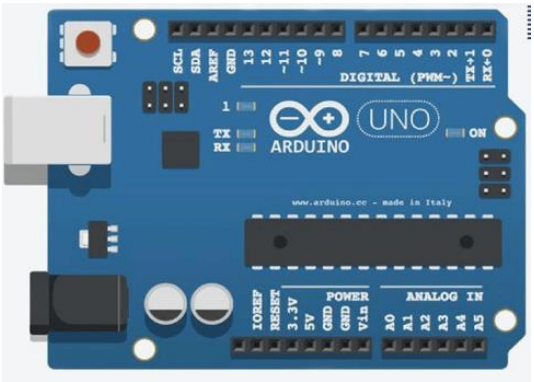

Figure 4: Arduino Uno Board

Our prototype has been built as follows: We utilized a dustbin, and placed the PIR sensor at the side of the dustbin. We have used cardboard as the lid of the waste bin, and a servo motor is attached on the lid. Another sensor is placed inside the bin which monitors the level of the garbage filled in the dustbin. The PIR sensor at the side, detects whether a person is coming towards the bin, and directs the servo motor to open the lid. The second sensor, which is placed inside the bin takes care of the notification part, programmed to send the message and alarms to the system as per the specification stated in the program.

The figure 5 shows the prototype been developed for our system.

The system has been thoroughly tested against various test cases. A list of the test cases against the prototype is listed as follows in Table 1:

TABLE 1

Test Cases

Test Case	Sensor/ Stage	Input	Expected Output	Obtained Output	Status P=Pass F=Fail
1	Smoke	Smoke	Smoke Detected	Expected	P
2	Ultrasonic	Content in the bin	Determines the distance	Expected	P
3	Inductive Proximity Sensor	Metal	Metal Detected	Expected	P
4	Inductive Proximity	Non Metal	Metal not detected	Expected	P

	Sensor				
5	Servo Motor	The output from Inductive Proximity Sensor	Required angle rotation	Expected	P
6	User Registration	Invalid email address	Entered email id is invalid	Expected	P
7	User Registration	Invalid email address	Proceed to the next step	Expected	P
8	User/ Admin Login	Incorrect user name / password	Display Username / password is incorrect	Expected	P
9	User/ Admin Login	Correct user name / password	Proceed to the respective privileged page	Expected	P

IV. CONCLUSION

IoT based smart bins can be utilized on a large scale to manage the city waste in an efficient manner in order to ensure healthy environment for our society. By utilizing such practices we can prevent the society from diseases born from unhygienic conditions. The phrase "Cleanliness is next to god and clean city is next to heaven" has been an inspiration for our work. Future work can include employment of Artificial Intelligence to further refine the management system in an efficient manner.

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