Development of an Automated Smart Waste Collection System Using IoT

Jithin Sunny

Abstract

This paper presents a cost-effective and intelligent way of collecting waste in Smart Offices and Cities. India faces major environmental challenge associated with waste collection and disposal. Current outdated techniques followed in India cannot cope up with the large volumes of waste generated by an expo-nentially increasing population, and this has a major impact on the environment and public health. Waste management is a primary problem among developing and developed countries. The key issue is that the garbage bins get overflowed much before the next cleaning process. This project proposes a smart alert + clearing system for garbage clearance in Offices / Hospitals and Smart Cities by giving an alert signal to the janitor's mobile for instant cleaning of dustbin with proper verification based on level of garbage in the bin and also navigating autonomously to the dumping yard. It also monitors the garbage collected from every place and gives us an accurate data which can further be used for analysis and detecting trends/patterns.

Keywords: Arduino, Blynk, Internet of Things, NodeMCU, Real Time Analytics, Smart Bin, Smart Cities, Smart Office, Waste Management.

I. Introduction

The increase in the quantity of garbage being produced is unavoidable to a certain extent as the demands of the population have increased. But it is vital to come up with a solution to this problem before it goes out of hand. The harmful effects of garbage caused by improper waste management systems of present use are known to everyone. Many diseases like hepatitis, cholera, dysentery, typhoid, malaria and dengue among others have now become a part of our lives. And hence, we are in dire need of a system that can bring in some relief on this issue.

The other problem with the current system is that most of the bins remain uncovered, transforming into breeding grounds for insects. We can also find animals digging for food in the heaps of garbage that's overflowing. This is dangerous for the animals. In the end, improper waste management causes air, water and soil pollution [1]. To fight an issue this serious, we must start from the scratch. This project aims at making the dustbins smart with numerous functionalities added to them which can be used both indoors and outdoors.

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We focus on turning an ordinary dustbin into an automated garbage collection and management system to make our lives easier and healthier. This collaboration of technology with intelligence can introduce an intelligent waste management technique. The major problem is that the bins are not cleaned on time which causes the overflow of garbage and the foul smell around it. The Smart Bin aims in notifying the people in charge of cleaning the bins when it's almost full.

The concept of smart waste management is implementable in offices where waste production is high but the effort put to control it is relatively very low. Normal office consists of 10-15 bins on each floor with 2-3 workers who are in charge of cleaning it.

This Smart Bin can easily replace 10-15 bins. Only one person is enough to clean the bin because of its smart features where in it notifies the person in charge of cleaning and also moves autonomously to dump the waste. This is a smart way to give this daily work a break by using technology to innovate. At companies, dustbins can be cleared as and when they get filled without the need for any human supervision.

The rest of the paper includes the following sections. Literature Survey in section II, Components in section III, Working in section IV, Software and Analysis in section V, IoT in section VI, Advantages in section VII, Conclusion and References in sections VIII and IX.

II. Literature Survey

There is rigorous research going on all over the world to tackle the issue of growing quantities of garbage and their effective management. Internet of Things is rapidly changing how we used to manage waste. Smart garbage bin has been a Smart City initiative. The author in [2] uses a GSM module to transfer the data read by the IR sensors based on the amount of garbage present in the bin. It triggers a message if the quantity of waste in the bin crosses 70%.

As a solution to the overflow of garbage, [3] defines IoT based solution with ultrasonic sensors, adding moisture sensor and flame sensors to integrate more functionalities. An SMS is sent to the concerned authority. [4] focuses on efficient disposal of domestic garbage in rural areas. Realtime monitoring of garbage followed in [5] helps authorities spend less on resources yet stay informed of the status. Author in [6] discusses about an easy way to clear garbage with minimum human monitoring using RGB indicators and the whole alert system being connected by WiFi. As most dustbins can be seen fallen at times, [7] talks about integrating a tilt sensor to keep a track of the orientation of the bins. It also integrates an efficient and easy garbage clearance system for use by the authorities. Additional functionalities such as automatic opening of the dustbin cover [8] can be integrated to ensure minimum contact with the garbage bin. This paper focuses on giving a complete solution to garbage overflow issue, the garbage clearance issue and the hygiene factors surrounding them.

III. Components

Table 1: List of Hardware Components

Components	Specifications
Microcontroller	Arduino Mega 2560
Ultrasonic Sensor	HC-SR04
Wifi Module	ESP8266
Bluetooth Module	HC-05
Motor Driving IC	L293D
RF Encoder & Decoder	434 MHZ Wireless Communication Board
Voltage Regulator	7805
Motor	150 RPM BO Motors
Battery	Lithium Polymer 12V, 1500 mAh
Servo Motor	MG995 – Metal Gear Servo Motor
IR Sensor	-
RFID Reader	MFRC-522
LEDs	-

IV. Working

The Smart Bin is powered by 12v LithiumPolymer battery. The Smart Bin has 2 modes:

1. Manual Control Mode
2. Automatic Mode

In the manual control mode, the user controls the Smart Bin using his/her mobile phone via Bluetooth / Wi-Fi. The user will have to completely guide the Smart Bin by giving it directions through the phone. Once the bin reaches the user, only a wave is required to open the bin's lid. The lid is opened using a servo motor. The user gets 15 seconds to dump the waste into the bin and once the waste is dumped it automatically closes. After closing the user will have to guide the bin back to its initial position so that the next user can access it easily.

In automatic mode, the user needs to connect to the Smart Bin via Bluetooth / Wi-Fi and then request the bin to come near you. The bin uses IR sensors with a guided path (dark coloured path, preferable black, the same principle used in a line following bot) to reach near the user.

The Smart Bin uses Ultrasonic Sound Sensor HC- SR04 to calculate the volume (V) of the waste in- side the bin using the formula in (1):

$$V=(d-d_C)*(\pi*r^2) \quad \text{.....(1)}$$

Where,
d=actual depth of the bin, d_C=current depth, r=radius of the bin and glows the LEDs accordingly. If the bin is 0-25%, 25-75% and 75- 100% full it glows LEDs of green, yellow and red

colour respectively.

The microcontroller is used to calculate the time period of the sound wave to travel back to the sensor. Then, the calculated time can be computed through the following equation into the distance(cm) unit.

D = {(t*v)/2}*100 .....(2)

In (2), we have 'D' as the distance in cm measured by the ultrasonic sensor, 't' is the time taken by the sound wave to echo back to the receiver in seconds, 'v' is the velocity of sound wave. Thus, this equation is computed by the micro controller, and we can get the distance of any waste material present in the bin.

Once the bin is 90% full it sends a mobile noti- fication as well as an email to the person in-charge of cleaning the Smart Bin via ESP8266 module using Blynk application. It also sends a trigger signal to the slave bin which follows the path and reaches near the main bin. Once the slave bin reaches the main bin it [master bin] moves out to the dumping place to be cleaned following the guide line with the help of IR sensors.

V. Software and Analysis

Every Smart Bin is embedded with Ultrasonic Sound Sensor HC-SR04 which constantly mea- sures the volume of waste inside the bin using the equation - (1). The real-time measurement of the volume of waste is calculated and is sent to the Blynk Application's server from where the data is retrieved on to the phones and plotted in a graph to show real-time status of the volume of waste inside the bin. Every time before disposing the waste, it sends the total volume of waste collected to the Blynk server which helps in keeping a track of the waste collected on each floor of the office. Another software called Arduino Bluetooth Controller is used to manually control the Smart Bin within the visibility range. The data stored can be analysed further to know the approximate time at which the Smart Bins get filled.

This analysis will help authorities stay prepared for times when there might be too much garbage. We can also find the right path for the trucks to take.

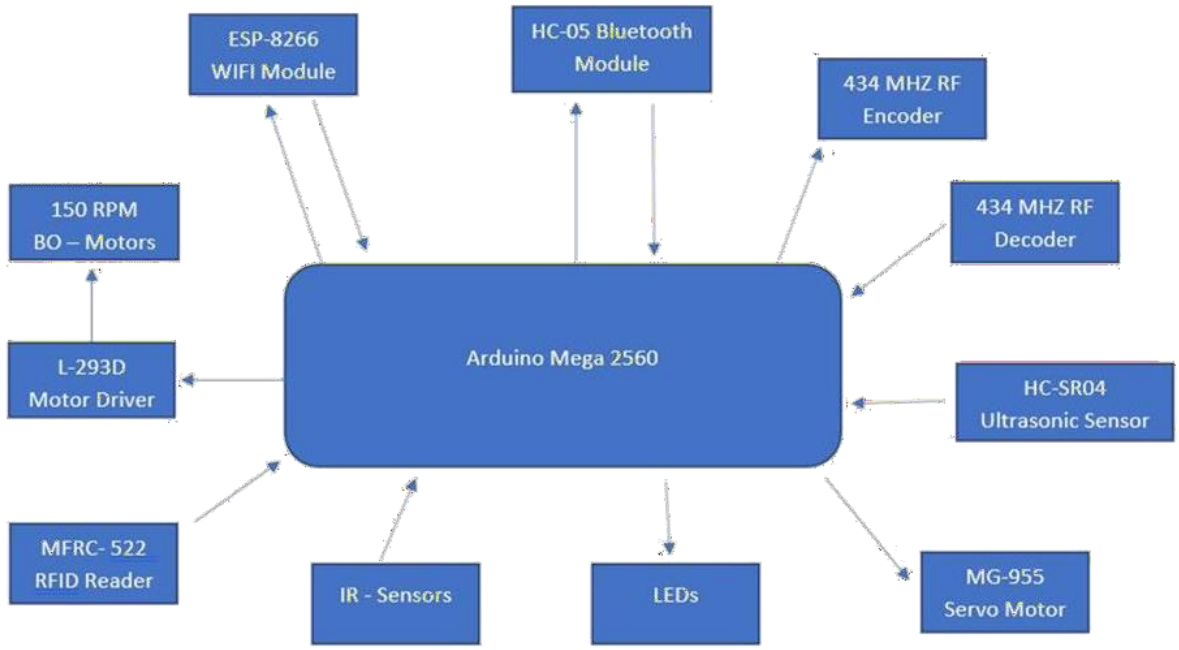

Figure 1: Block Diagram of the hardware

VI. Internet of Things

Every Smart Bin has a unique number and it sends out data [volume of waste collected] every 10 minutes to the Blynk server which can be fur-ther analyzed to gain lot of insights. Once a master bin is full it triggers a signal to the slave bin via Bluetooth/Wi-Fi. The slave bin on receiving the trigger signal moves towards the position where the master bin is and replaces the master bin. Once the slave bin reaches, the master bin makes its way towards the dumping location. Now the slave bin acts as a master bin and the whole cycle repeats again. This system of inter-linking of Smart Bins to collect waste brings out the true sense of Internet of Things.

VII. Advantages

One of the most notable advantages of smart bin is that it prevents the over-flow of waste. Relevant signals are sent to the user according to the amount of waste in the bin. Smart bins keep the users notified of every activity taking place in it. The real time interface keeps the user informed about the level of waste in a smart bin at a given time and gives out different signals according to the level of waste.

The healthiest part about smart bin is that the user need not come in contact with the bin or the waste. Smart bin has 'self-dumping' capacity that enables it to empty the waste by itself. This safeguards the health of the user as the self-dumping capacity cuts out most of the chances of germs entering the user's system. Hence, smart bin is completely healthy and safe.

Smart bin can also reduce manual labour to a very considerable level. The usual requirement of at least two to three men to clean a whole floor of an apartment or a corporate office can be replaced by just a single smart bin working all by itself.

Smart bin is autonomous and also can be controlled with mobile. The user can control smart bin by a mere touch on a phone; however, smart bin has the capacity to function on itself while it is not under the functioning of the user. Hence, the user need not always worry about the working of the smart bin as it is autonomous.

Also, the smart lighting system is an added feather to the cap. A smart bin lights up by itself whenever it senses a passer-by. This enables the passer to clearly locate the bin and dispose the waste.

The most appreciated as well as interesting feature is that the smart bins work in pairs. When one smart bin is nearly full, it sends out information to its pair and goes to dump the waste while the pair takes up its position and waits to fill it-self to hand on its position to the first bin, and his process goes on.

In this efficient era where a man's physical work is reduced to an unimaginable level, Smart Bin also focuses on reducing the effort of the user. When it is needed for the user to dispose any waste, the smart bin comes to him (based on the notification sent to it). This significantly reduces the user's work!

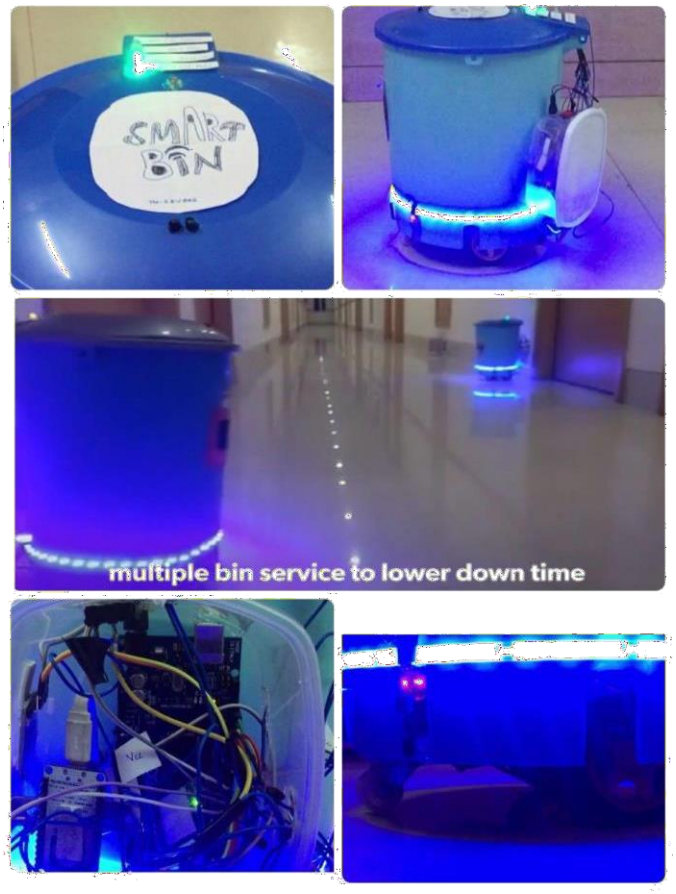

Figure 2: View of Smart Bin from different sides.

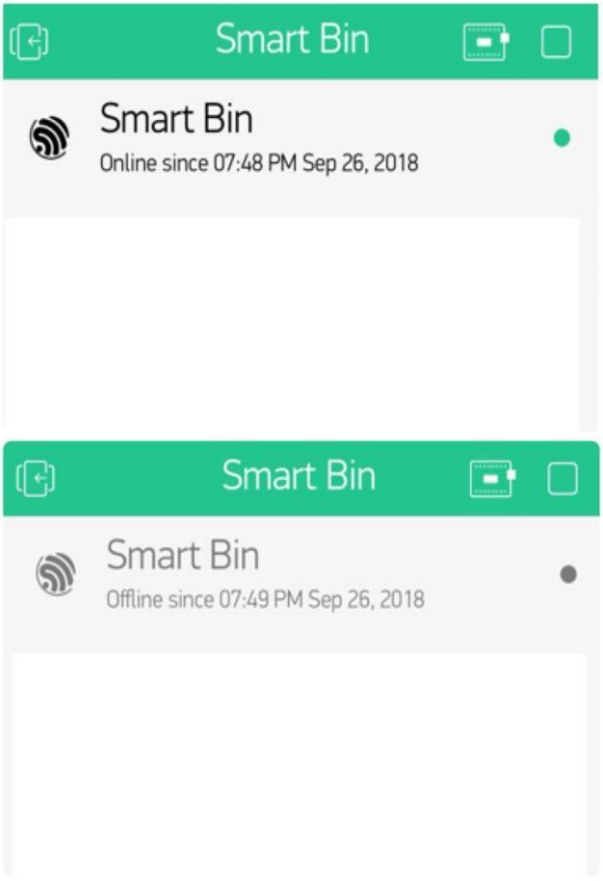

Figure 3: Status of the Smart Bin as shown on themobile application.

VIII. Conclusion

The Smart Bin presented in this paper gave a good accuracy of about 98%. It was successful in alerting the users about the filling of the dustbin.

Integrating Microsoft's Cortana with Smart Bin using Raspberry Pi to suite its name "Smart Bin" was also successful. Using/integrating such technologies into the Smart Bin will enhance its features and make it smarter in the coming years.

Smart bins have been created keeping smart cities initiatives in mind. The dream of clean and neat environment can be brought out by Smart Bins. Huge amount of focus is given to further the improvement of these bins. Smart Bins can be made smarter by enabling special facial recognition techniques. In the future, smart bins might be able to recognize as well as interact with people. It can also be enabled with the power of memory that can be used to remember a person's name and associate the name withhis/her face.

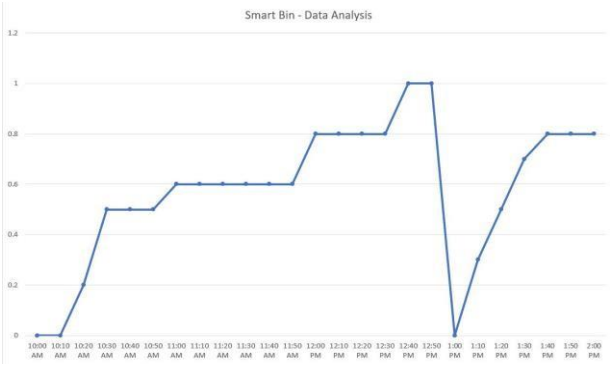

Figure 4: Data collected from the Smart Bin every 10 minutes.

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X. Author biography

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