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Smart Waste Management using IoT

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***Abstract*: The main problem in cities today is the condition of the areas around the big dustbins in the cities. The dustbins in some areas get filled too quickly and then people start throwing garbage around the area which then becomes the reason for bad odour, spread of diseases due to breeding of mosquitoes etc., All these problems can be solved with this idea plus it will also save numerous resources. In this paper we have described the idea of a smart dustbin which will inform the garbage collector that the dustbin is full and pickup is to be done in a particular area using an Android App. The dustbin will have ultrasonic sensor attached to ESP8266 NodeMCU which will send data of dustbin level to android app through Wi-Fi and the status of dustbin will be displayed on the city map using colour location pointer where red pointer will represent filled dustbin and green will display an empty dustbin. The pickup record will be created using the scanner in the app by scanning the barcode of the dustbin in a particular area.**

***Keywords*: ESP8266 NodeMCU, Smart Dustbin, Sensors, User, Barcode Scanner, Google Map API, IoT**

1. Introduction

In a developing country like India the waste management of the garbage produced by a population of 1.32 billion is a bigger issue which doesn't get much attention, or investment as it seems a trivial thing to worry about. But when you look at the condition of areas around garbage dustbins which seem to overflow all the time we realise that there needs to be a solution on this so that the problems- bad odour, spread of diseases, and improper disposal of plastic which further leads clogging of drains and natural calamities like flood happen which then becomes a reason for huge loss of public property.

Our paper here proposes a module created out of Ultrasonic Sensor [2] and ESP8266 NodeMCU which will sense the distance of the garbage from the top of the garbage bin and will inform the garbage collector using an android app with map of the city and location pointer to all the dustbins all over the city. The module will be such that it can be installed to any dustbin all you need to take care of is the angle of sensor as it should point to the centre of the dustbin. Unlike other prototype in market the user doesn't need to buy the dustbin itself which becomes an unnecessary expense as dustbins are already there all over the city and nobody would replace the already existing dustbins with those prototype. And mostly these prototype have closed leads which people are not used to, open dustbins are much easier to access. Second point is that every smart city is soon going to become connected through Wi-Fi throughout the city so having these modules installed on dustbin we can make use of this Wi-Fi network instead of using a separate GSM module, Arduino UNO, Raspberry Pi, Wi-Fi dongle, etc. which is very costly and installing such expensive hardware on each dustbin is not feasible.

2. System design and app

The fig. 1 shows use case diagram of actual working of the scenario. In this use case diagram there is single actor as user and Android application is used for letting user know status of bins. Then application will interact with database to store the record of pickups. ESP8266 interacts with sensors and sends the distance of garbage from the brim of the dustbin continuously to the app further it is displayed visually on map.

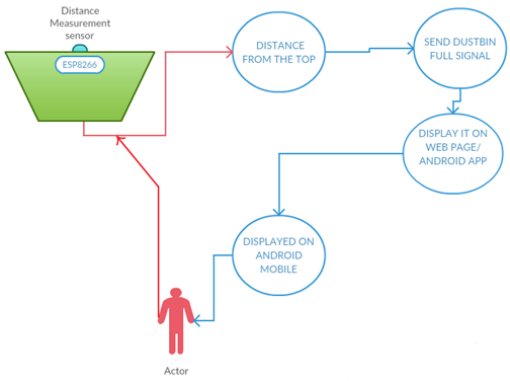


Fig. 1. Garbage Collector

A. Sensors and ESP8266 NodeMCU

Dustbin needs to be installed with one or two sensors as per required precision. Those sensors will be attached to ESP8266 NodeMCU [8]. ESP8266 need 5V power supply and to send the sensor data to android app we need to get the ESP8266 module into Wi-Fi zone. The sensor and the ESP8266 will be covered in a casing which will be either welded to the dustbin itself to keep the module safe and also it will be installed in such a way that water won't enter into the casing near the microprocessor.

The above fig. 2 displays a simple prototype of a casing which is used to cover the sensor, an actual covering made of metal will be more sophisticated and durable.

There were numerous options other than ESP8266 but looking at the application and cost criteria using ESP8266 NodeMCU was our best option.

Fig. 2. Casing Model

Table 1
Hardware Comparison

	ESP8266	Arduino	Raspberry Pi
Cost in Rupees	250-350	250-2000	2000-2800
Wi-Fi	In-built	Needs shield or ESP8266	USB dongle
Programming	C++/Lua	C++	Python/Java/C++
Storage	Built-in	Built-in	SD card
I/O	10 GPIO/ 1 ADC	13GPIO/16ADC	17 GPIO

In the table 1 we have compared numerous factor which will give us a better perspective of reasons why we switched form Raspberry Pi to Arduino and Arduino to ESP8266.

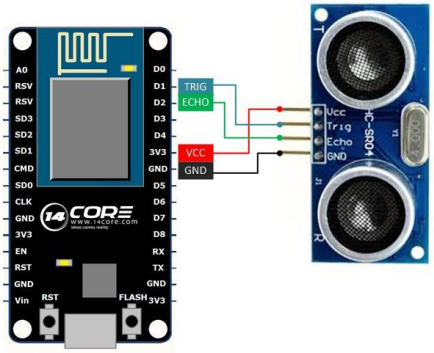


Fig. 3. Connections

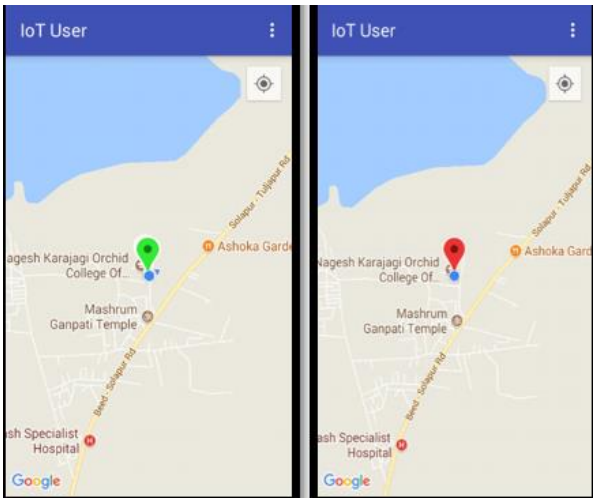
The connections are pretty easy, where the ESP8266 will be connected to the ultrasonic sensor [4] mounted on a breadboard. The ESP8266 will need 5v+ supply from a simple adapter which we see being used as mobile charger. The casing will be covering the sensor part and will be welded to the dustbin itself. It will be completely sealed so that water or dust doesn't settle on the sensor. The only part that will be open is ultrasonic transmitter and Receiver.

B. App

There will be two apps one for User who is going for pickup, another for Admin who needs to see the data in database [1].

1) User

It will perform two functions, on clicking button one it will open scanner module, using the camera on the android device user will scan the barcode on the dustbin and make an entry of the pickup. The Smart Waste Management system needs user to have an Android device to register the entry of pickup of waste from a particular area. The second part is the map when dustbin is empty the location pointer of the dustbin on map will be green. As soon as it reaches a threshold level of almost filled the pointer will turn red. This will be the most important Module in the app. All the dustbins and their live status will be visible on a single map. There will be no pickup rounds in the area where no garbage is collected, which will save time, resources and manpower. Area which need pickups will be decided by the change in the colour of the location pointer making the pickup faster and efficient.



(a) When dustbin is emptied (b) When dustbin is Full

Fig. 4. Dustbin status

2) Admin

Admin app will perform three function,

1) It will have a barcode generation module for administrator. Whenever new dustbin is to be installed the admin will create a new barcode of a particular area and take screenshot of the barcode, print it and paste it on the dustbin.
2) It will show all the records of pickup on a single page making it easy to see the latest pickup and the first pickup at the same time.
3) When the Admin will click on Report he will be directed to a calender to pick a date from any month, the counter of pickups from that month will be displayed in the form of bar graph according to the location.

The Fig. 5, display the app menu, and Fig. 6 displays the pickup log.

Fig. 5. Admin menu

Fig. 6. Pickup log

Fig. 7. Admin menu (Report)

Fig. 8. Calendar activity

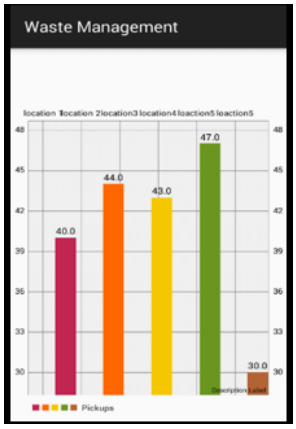


Fig. 9. Bar graph report

The report generation will give admin visual representation of data which will help him in creating schedules for pickups. This will also be useful in creating patterns for future references which will give us information about collection of garbage in a particular area and which area will need more pickups and how much expenditure will happen on resources.

3. Technology used

A. *ThingSpeak*

ThingSpeak [10] is an IoT analytics platform service that allows you to aggregate, visualize and analyze live data streams in the cloud. ThingSpeak provides instant visualizations of data posted by your devices to ThingSpeak. Using ThingSpeak library in the code of ultrasonic sensor [12] we can easily send the data to our custom android app.

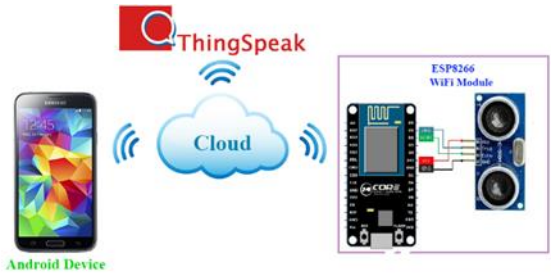


Fig. 10. Functioning of ThingSpeak

With the ability to execute MATLAB code in ThingSpeak you can perform online analysis and processing of the data as it comes in. ThingSpeak is often used for prototyping and proof of concept IoT systems that require analytics.

B. *Firebase*

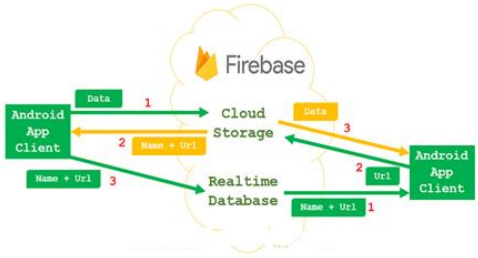


Fig. 11. Functioning of Firebase

[9] Firebase is a mobile and web app development platform that provides developers with a plethora of tools and services to help them develop high-quality apps, grow their user base, and earn more profit.

It was developed by Firebase, Inc. in 2011, then acquired by Google in 2014.

1) *Real time database*

Firebase provides a real time database and backend as a service. The service provides application developers an API that allows application data to be synchronized across clients and stored on Firebase's cloud. The REST API uses the Server-Sent Events protocol, which is an API for creating HTTP

connections for receiving push notifications from a server. Developers using the real time database can secure their data by using the company's server-side-enforced security rules.

4. Advantages

Today our country is at a point where cleanliness is being taken as a serious problem. Our Prime Minister of India, Sri Narendra Modiji has introduced the thought of creating one hundred smart cities in India. “Swachh Bharath Abhiyan” was initiated as part of this mission to make India clean. Dustbin is a fundamental part of the cleanliness mission. Adding intelligence to our dustbins will solve most of our problems and the smart-bin has a lot of advantages. The product which is designed to make every dustbin smart will be affordable and the other benefits from its implementation will be huge.

The main goal is to keep the city clean and garbage bins well maintained, but the value that this app and product provides is much more than just cleanliness. As all the dustbins are visible and also every single person now will know which dustbin is to be emptied, they will go only to that particular dustbin instead of wasting there going through the whole city which leads to wastage of fuel, time, resources and Manpower.

The cost of the sensor and circuit board is not more than 500 rupees, which will be more cheap if ordered in bulk. So the maintenance is easy. Casing for the sensor will be one time thing, so once installed it won’t be necessary to change it all the time.

The Stakeholder using this will easily cover the expenses which he will have to bear for the installation after he starts saving a lot of resources due to smart dustbins. Further using the reports generated from the database the stakeholder is given a pattern which will give him a brief idea of the area where pickups happen more often or dustbins get filled quickly. This will allow him to focus his resources where they are really necessary making a win-win situation for the people in the city and for the stakeholder himself.

5. Practical challenges

Before the deployment of Smart bins there are some limitations which are needed to be discussed.

The ESP8266 Wi-Fi module attached to the sensor node has a range of 20 meters so the Wi-Fi zone created needs to be pretty wide. The sensor we will be using will have a range of measurement between 2cm to 400cm, more than 400cm is possible but we lose the accuracy factor. But we don’t need accuracy when dustbin is almost empty.

The ESP8266 will need +5v power. While installation we need to find the nearest power supply point, get the wire from there to the dustbin, and mostly the wires will go below the ground for safety purposes. Or else we can simply use a battery backup in the dustbin itself but that will again increase the cost of module on dustbin and there is always fear of the battery being stolen.

Every time the employee will need to carefully detach the supply wire from module to pick up the dustbin and empty it into the truck. But there is no need to worry, as soon as the supply is plugged in it will start working normally with any booting or execution statement needed.

1) Angle of the sensor

To receive correct data from dustbin its important that we set the angle of the sensor right. The angle accuracy of sensor goes from 15°-30°. Tilt angle while mounting the sensor on dustbin should also be precise, so that it faces the middle part of the dustbin where maximum garbage is collected.

The maximum range of the sensor is about 3 meters for an accurate reading, we cannot implement the module to a dustbin whose depth crosses the threshold of accurate reading. There is also a possibility that to cover the whole dustbin we may need to implement two sensors. That will increase the cost of module by some extent.

In the fig. 12, we see the angle of dustbin which is set for the dustbin which we see all over the city set by Municipal Corporation.

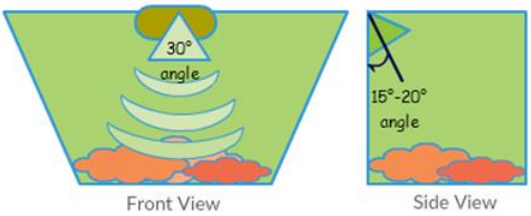


Fig. 12. Angle of Sensor

Front view shows the actual range of coverage of the sensor and where maximum garbage will fall, and side view shows the angle of sensor from the surface of the dustbin at the brim of container which is placed on that angle so that it faces the middle part of the dustbin.

6. Conclusion

This application is developed for flexible implementation of Smart Waste Management System on any kind of container using ESP8266 NodeMCU processor and IOT. This will make task of Garbage collection more efficient and reliable. Since the future is completely going to be full of devices connected to internet, implementing this product will be very easy and affordable as cost of maintaining a Wi-Fi network all over the city will soon be possible. Considering the increasing health problems and awareness among public an application like this will be a step towards a clean environment and saving of resources.

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