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IoT Based Smart Garbage Management System

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ABSTRACT

The launch of the "Digital India Program" of the Government aims at transforming India into digital empowered society and knowledge economy and towards this IOT would play a very vital role. One of the key aspects of Smart City is Smart Garbage Management which involves monitoring Garbage in city towards removal appropriately and also disposing off. Now-a-days we are experiencing the problem of garbage which gets accumulated in cities and societies. There is no proper supervision from Corporation towards monitoring the activity of Garbage collection. Mostly whenever we see any vacant plot, people throw the garbage and as such no one is there to manage which obviously increases day by day leading to health issues, unclean city and also creating problems during rainy season

So, with the upcoming Internet of Things (IOT) Technology and digital India initiative, we are making a simple step towards developing an "IOT based Smart Garbage Management System" prototype which will help the people and the society and the country as whole in proper management of the garbage and time to time collection and deposition of the waste and garbage which will help in making a clean and smart city. In additional, statistical analysis would be performed towards predicting the rate of bin getting filled up towards getting cleaned for proper management. So towards this, the management system is developed for easy handling, supervision and monitoring of garbage in the societies and there is no need for the person to keep track of the garbage bins filled and no need to inform the Corporation

Keywords—Digital India, IoT, Smart City

1. INTRODUCTION

The launch of the "Digital India Program" of the Government aims at transforming India into digital empowered society and knowledge economy and towards this IOT would play a very vital role. One of the key aspect of Smart City is Smart Garbage Management which involves monitoring Garbage in city towards removal appropriately and also disposing off.

Now-a-days we are experiencing the problem of garbage which gets accumulated in cities and societies. There is no proper supervision from Corporation towards monitoring the activity of Garbage collection.

Lots of these Garbage collections are being let out as contract to private party but still there is no proper supervision towards cleaning the roads, collecting the garbage from bin in time and so.

Mostly whenever we see any vacant plot, people throw the garbage and as such no one is there to manage which obviously increases day by day leading to health issues, unclean city and also creating problems during rainy season.

Current Garbage Collection method by the Municipal Corporations is not good and up to the mark as they do not care about the cleanliness of the society. Current method employs large Garbage bins where the waste dumped by the users gets collected and increases daily. These bins are not regularly emptied by the authorities and as such repeated complaints need to be made to get the job done.

Currently Internet of Things (IoT) is expected to offer advanced connectivity of devices, systems, and services that goes beyond machine-to-machine (M2M) communication and covers a variety of protocols, domains, and applications. The interconnection of these embedded devices (including smart objects), is expected to usher in automation in nearly all fields, while also enable advanced applications like a smart grid, and expanding to areas such as smart cities.

So in this respect, research [1] has been carried out employing IoT Technology where Infrared or proximity sensor placed in estimating the level of bin and accordingly municipal authorities intimated via email or whatsapp. Research [2] also been carried out towards smart waste management system employing Infrared type wireless system interfaced with microcontroller where status of bin displayed to municipal authorities webpage. Lastly research [3] also been carried out by developing a low cost embedded device for multiple dustbins which help in locating the bin in the city and tracking the level of garbage bins as it reaches the threshold. This information is transmitted to the web based system of municipal authorities to access via internet from anywhere. The challenge in all these system is that the Infrared based sensor can only find the level of the bin as it reaches the threshold only when it is in close proximity. In addition there is no analysis on rate at which bin getting filled which is very important in managing the bin collection. The reason being in some area bin might get filled very soon in a day and in some area bin doesn't get filled so fast. So predicting the level of bin getting filled is an important measure for municipal authorities to plan the bin collection regularly

So with the upcoming of machine to machine communication and challenges in the current system, we here have developed an IoT based Smart Garbage Management System where Ultrasonic sensor employed which works based on sound waves in calculating the density of bin as compared to Infrared which can only find only if garbage in bin is kept very close to IR sensor. In here, level of threshold is set to 80% and

above based on bin depth for the indication of the dustbin getting filled and accordingly the alarm and the LED gets triggered. Secondly, the system is developed with threshold and this information is sent periodically to edge level processor which calculates the rate at which bin getting filled with date and time. This information updated on Webpage of municipal authorities for planning the bin collection rather than strict policy of once a day or so. This would result in dynamically planning of bin collection based on rate at which bin getting filled. The proposed system will help the people as well as the Municipal Corporation. The rest of paper organized as follows. Section 2 talks on Literature Survey pertaining to research work. Section 3 gives the detailed architecture of the proposed system with algorithmic details. Section 4 gives the implementation results and analysis. Section 5 is the conclusion and future work.

2. LITERATURE REVIEW

Before going into the details of our IoT based Smart Garbage Management system, we will review some of the existing system in vogue pertaining to Smart garbage System
In the traditional Garbage Management, the Municipal Corporations are assigned to place big dustbins in the society for the collection of the garbage and waste. Once the bin gets filled, bin gets cleaned by the garbage collector and bin collected are disposed somewhere appropriate. This system got no proper supervision from the corporation for cleaning the bin regularly which creates dirtiness on the streets and roads and spread diseases.
So accordingly some initiative have been proposed in developing IoT Technology for Garbage Management.

In one of the research [1], a sensor (Infrared sensor / proximity sensor) is placed under the dustbin. When the sensor signal reaches to the threshold value, a mail notification (like email, twitter, whatsapp message) will be sent to the respective Municipal / Government authority person. Density of the Dustbin also checked through a GUI (Graphical User Interface) so any of the authenticated people can check the present condition of the dustbin. This would enable the personnel to send the collection vehicle to collect the full garbage bin or dustbin.

In another research [2], the dustbins are interfaced with microcontroller based system having IR wireless systems along with central system showing current status of garbage, on mobile web browser with html page by Wi-Fi.
Lastly research [3] also been carried out for multiple dustbins located throughout the city or the campus which are provided with low cost embedded device that helps in tracking the level of the garbage bins and an unique ID will be provided for every dustbin in the city so that it is easy to identify which garbage bin is full. When the level reaches the threshold limit, the device will transmit the level along with the unique ID provided. These details can be accessed by the concerned authorities from their place with the help of Internet and an immediate action can be made to clean the dustbin

3.IoT BASED SMART GARBAGE MANAGEMENT SYSTEM

The existing Garbage Management system of Municipal authorities got no technological innovation and relies purely on human being towards collecting the bin regularly. The

collection of bin and getting cleaned are supervised by municipal authorities. But there is no record of bin being cleaned or not. Many a times the bin collector do not come regularly which results in garbage overflow and making streets and city unclean with foul smell.
So towards this some sort of technological innovation been developed as a prototype by employing IoT technology where Infrared sensor employed in detecting the level of garbage in the bin and accordingly intimate the municipal authorities by email or whatsapp. Also research done in developing low cost embedded system for tracking the level of the garbage bins and a unique ID will be provided for every dustbin in the city so that it is easy to identify which garbage bin is full.
In all these research, Infrared type sensor used which can only detect the level of bin based on threshold when garbage in direct line of sight with Infrared sensor. This is a bit of challenge in detecting the level of threshold in the bin. Also placement of sensor under the bin will give a wrong signal as bin is full due to line of sight. Also there is no system for predicting the rate at which garbage getting filled and cleaned from the bin for planning the garbage removal periodically rather than static policy.
So accordingly we here have developed an IoT Based Smart Garbage Management System where ultrasonic sensor attached to top of the Garbage Bin. These sensors would work on sound waves that would detect and monitor automatically the garbage in the bin and trigger alarm when the garbage gets filled in the bin. In addition the rate at which bin getting filled along with the date and time is computed based on the number of times the bin was filled during the day. This will give the analysis report to the municipal corporation towards planning in cleaning the bin which will be available to the Corp. as well as the public on the website for view. This system makes use of the hardware such as Ultrasonic sensor, Arduino Uno, LED, Alarm, and Raspberry pi3 Processor. The system design and architecture of an IoT based Smart Garbage Management system shown in Figure.1. Figures 2 to 5 give the Data Flow Diagram, Sequence Diagram, Activity Diagram and Use Case Diagram of the IoT Based System
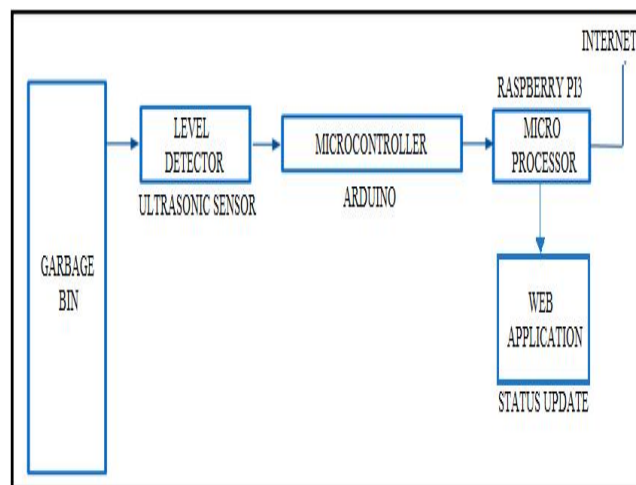

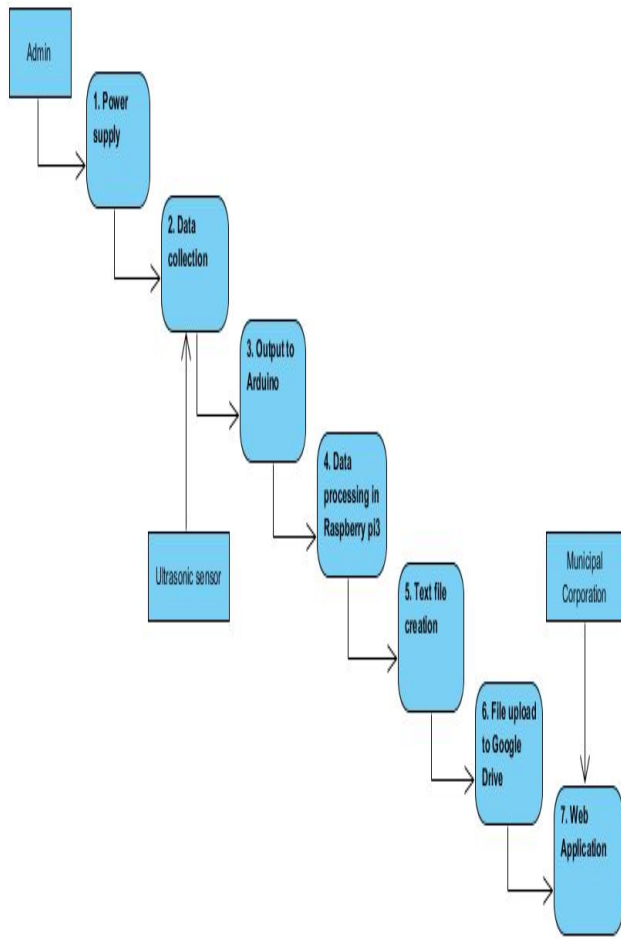**Figure 1**: IoT Based Smart Garbage Management System
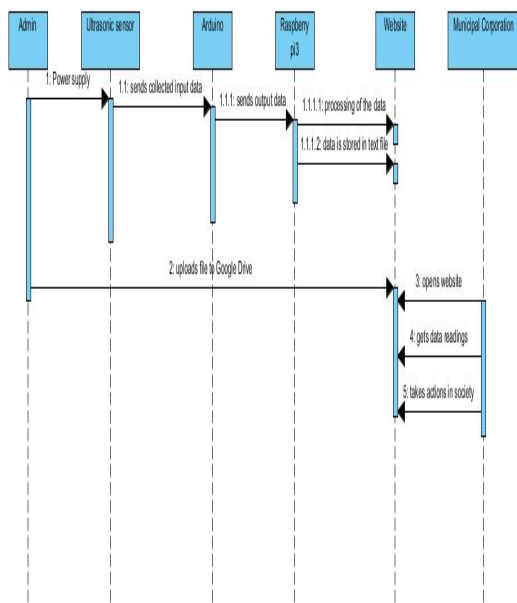
Figure 2: Data Flow Diagram

Figure 4: Activity Diagram

Figure 3: Sequence Diagram
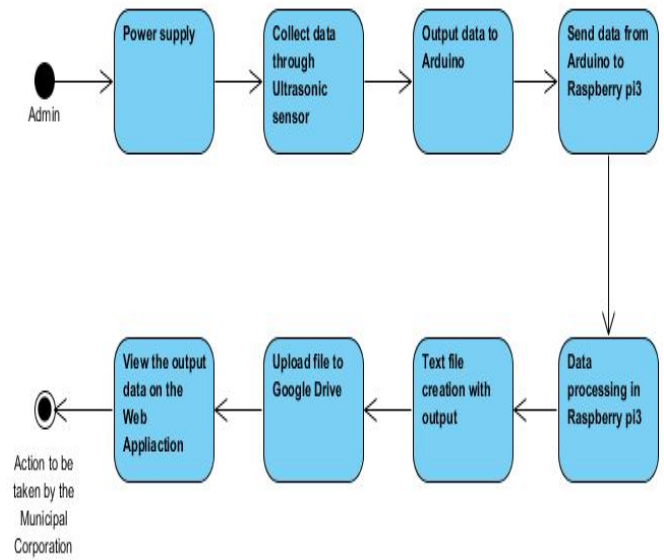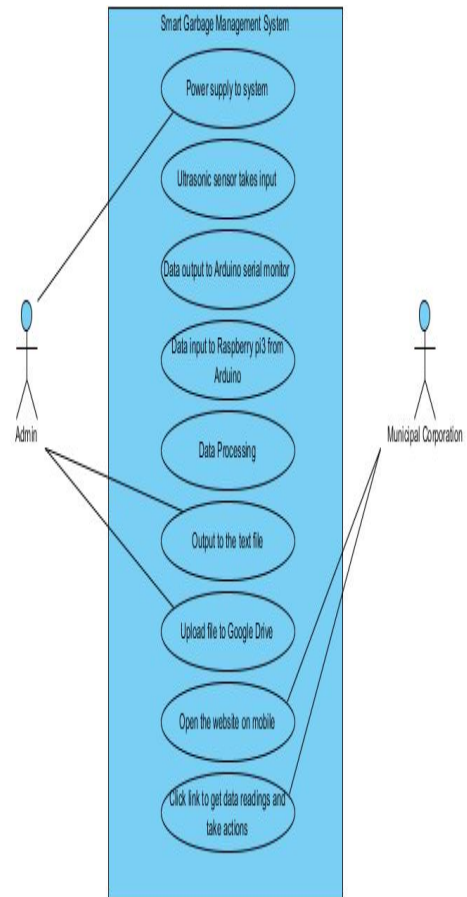
Figure 5: Use Case Diagram

3.1 Algorithm

The algorithm used for development of IoT Based smart garbage management system for calculating the bin level and also predicting the rate at which bin getting filled is given below:

- Depth of bin is collected from Ultrasonic sensor attached to bin.
- Check if the depth of bin reaches threshold which is 80%.
- Once threshold reached, alarm and LED is triggered till the bin is emptied.
- Information is sent to cloud with bin emptied along with date and time.
- Set Count = 5 as threshold and keep counting the number of times the bin is getting filled

4. IMPLEMENTATION RESULTS AND ANALYSIS

The complete hardware prototype of IoT based Smart Garbage monitoring system been developed by employing Arduino and Raspberry Pi3 as microcontroller and processing unit respectively. In addition Ultrasonic Sensor is fitted to every bin and same connected to Arduino microcontroller which would trigger the LED and Alarm once the bin reaches 80%. Also the Arduino unit is connected serially to Pi3 for communication of data for analysis towards predicting the rate at which bin getting filled. Figure 6 shows the complete prototype system developed. Figure 7 shows the Raspberry Pi3 processor connected to monitor screen.

Figure 7: Raspberry Pi3 Microprocessor

Figure 8 shows the Arduino IDE where ultrasonic sensor input processed towards threshold level of bin i.e 80%. Figure 9 is Processing IDE at Pi3 where data from Arduino Processed for analysis towards predicting the rate of bin getting filled. Figure 10 (a) and (b) shows the webpage of municipal authorities to view the status of bin. Figure 11 (a) and (b) shows the rate of bin getting filled with date and time.
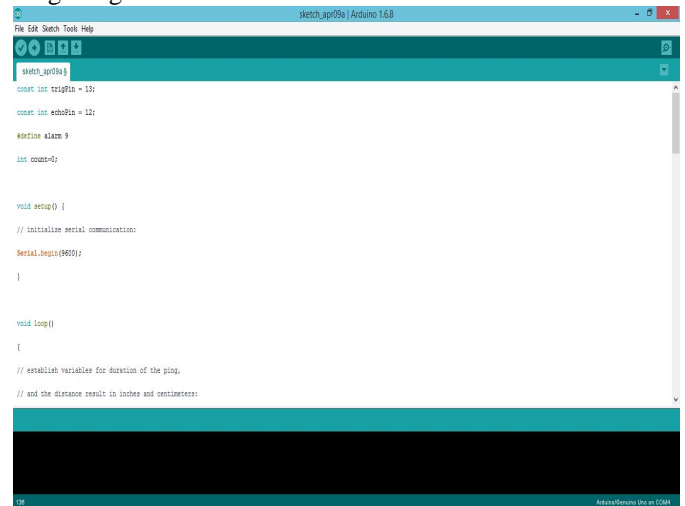

Figure 8: Arduino IDE
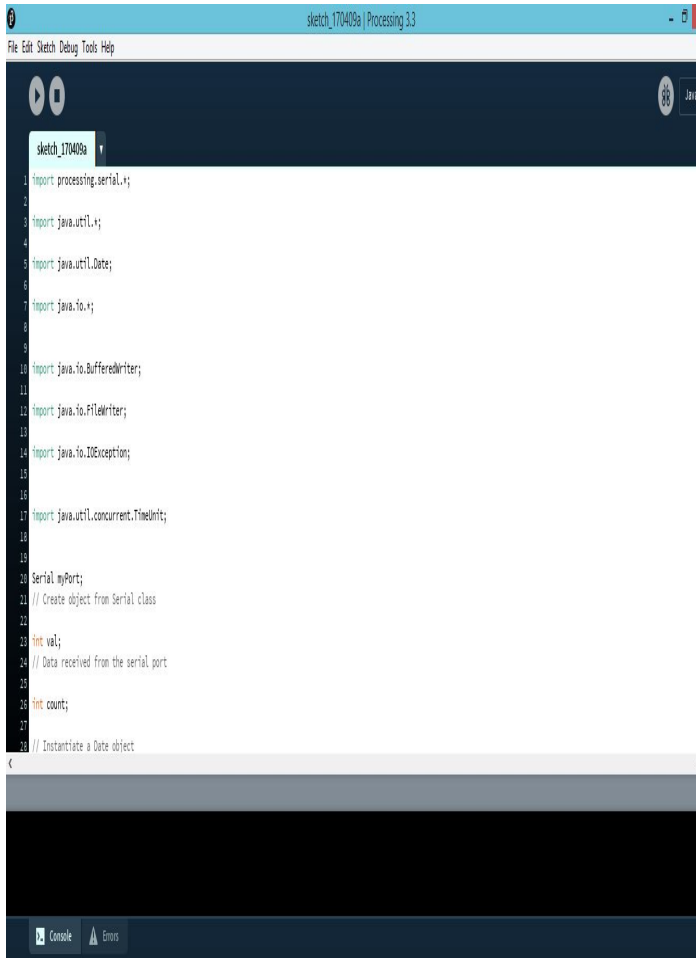

Figure 6: IoT Based Smart Garbage System

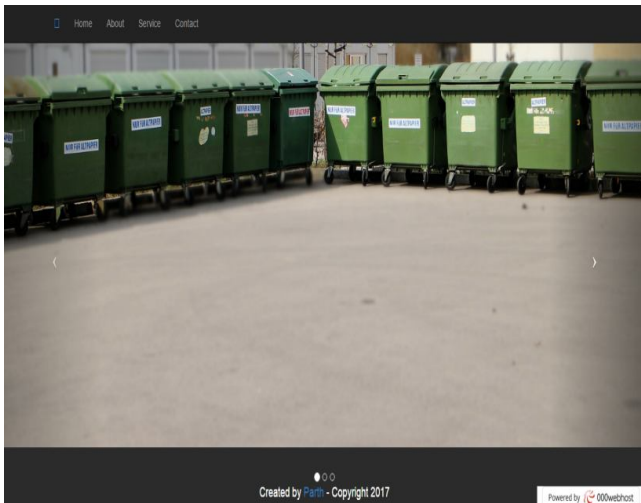**Figure 9**: Processing IDE

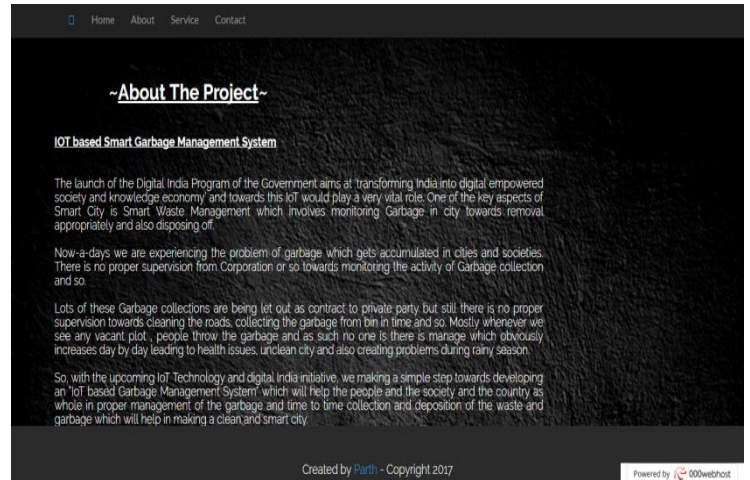**Figure 10(a)** : Municipal Webpage-1

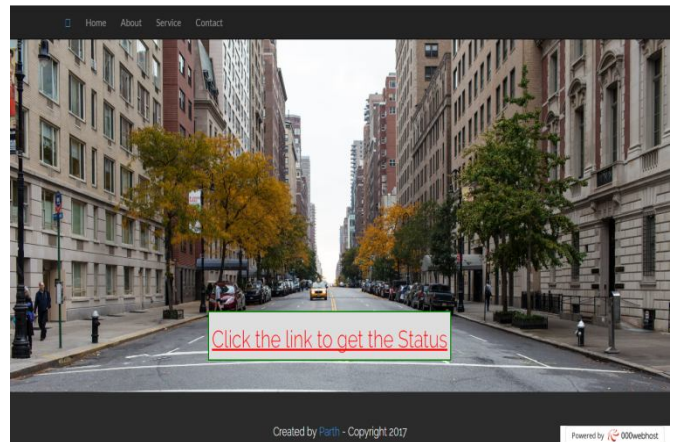**Figure 10(b)**: Municipal Webpage-2

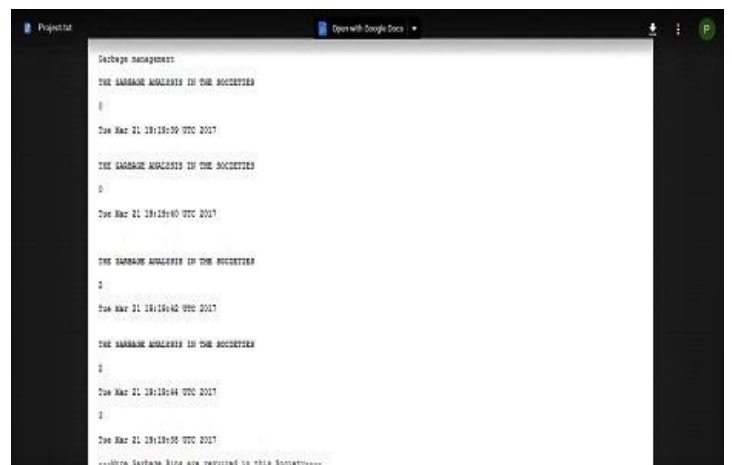
Figure 11(a) : Status Link

Figure 11 (b): Status of Bin

5. CONCLUSION AND FUTURE WORK

Garbage Management is very much important towards having clean and smart society. Traditional Garbage management employing human is not very effective with no proper supervision. Research has been done in employing IoT based technology in monitoring the status of bin towards collecting the garbage once threshold reached. There were certain drawbacks in the existing IoT based system which led to the development of IoT based Smart Garbage Management System employing ultrasonic sensors.

So accordingly IoT based Smart Garbage Management System been developed as a prototype where ultrasonic sensor fitted in bin for monitoring the depth of bin and accordingly once threshold reached alarm and LED triggered for cleaning the bin. This information updated in webpage of Cloud. In addition the rate at which bin getting filled is monitored for planning the bin collection dynamically. This information also updated with date, time and rate at which bin getting filled in webpage for municipal authorities for planning the bin collection. The project developed towards smart Garbage Management got lot of scope for future enhancement. One of the enhancement that can be though about is employing camera sensor for image processing of the cleanliness of the roads and penalizing persons not throwing the garbage properly in the bin. In addition the real time data of the analysis readings and survey on the cloud to be available on the website. Finally GSM module to send the notification to the truck driver of the municipal corporation for the dustbin filled and to be cleaned

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