This full-text paper was peer-reviewed and accepted to be presented at the IEEE WiSPNET 2017 conference.

Smart Bin: An Intelligent Waste Alert and Prediction System Using Machine Learning Approach

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***Abstract*—This work is about creating a smart waste-bin that alerts the authorities to gather the waste which has been piling up in the bins. It guides the garbage-trucks to collect the garbage only from those areas where the bin is critically filled. The 'machine-learning' concept has been used to gather information about the waste generation habits in that region and hence predict the amount of waste that will be generated in the near future. Apart from that, the analysis of the continuous data is also done that has been sent over the cloud in the form of graphs. The email alert and the text message have also been sent automatically to the concerned authorities once the level of waste in the dustbin crosses the threshold as set by the authorities. This would save time and money of the authorities considerably. This would also reduce air pollution in the area and prevent spreading of diseases caused by unpicked waste.**

***Index Terms*—Arduino, Raspberry Pi, Azure, Machine Learning.**

I. Introduction

According to the reports of United Nations, by 2025 there would be an increase in the world population by 20% making the population mark reach up to 8 billion [1]. Such a steep increase in population will increase demand and consumption of commodities, thereby increasing the generation of waste at a similar rate. Considering our current methods of waste management in the cities, the authorities are unequipped with the technologies needed for such a large scale waste management system.

The municipal authorities maintain dustbins at various places in the entire city. It is their duty to check and clear the waste kept in the dustbins at regular intervals. But many a times they turn up late or go empty handed as there may not be enough waste in the dustbin. In case they are late, there may be some chances of the degradation of the waste. It would lead to the growth of bacteria and viruses. The accumulated garbage would then create air pollution and cause respiratory problems like COPD, asthma, etc. It is estimated that 90% of the people suffering from Chronic Obstructive Pulmonary Disease are due to the foul smell created by garbage and about 235 million suffer from asthma from the same foul smell of the unpicked garbage [2]. So the question arises that how we can inform the municipal corporation that it's time to empty out the waste bins, without human interference. It must also be remembered that 75–80% of the solid waste management budget of the authorities is spent on collection and transfer of the waste [3]. In big cities it is wasteful, time consuming and expensive approach to physically check each and every bin. This approach doesn't suits todays modern technological era where everything is getting automated and more systematic and efficient [4]. Therefore, can anything be done to avoid the unnecessary garbage truck trips to every waste-bin?

The answer to the above question is yes, a technological solution can be incorporated to make the garbage collection system more efficient in the coming future. Before that first let us look at some of the recent methods adopted to solve the issue. Some of the neighborhoods of Delhi, Goa have decided to use WhatsApp to inform the authorities about the waste-bin status. Also, an app called Apna Patna has been launched by the Patna authorities to lodge complaint about the cleanliness in their area. All these efforts taken by the people are admirable but there seems to be lacking a broader outlook to the problem. Our country is growing both in terms of population and economy and our cities are expanding too [5]. It is estimated that by 2050 vast amount of population (70%) will be moving to cities [6]. Hence, we propose a solution to the above problem which could be implemented on a large scale due to its simplicity in design and novelty in approach.

The proposed system monitors the real time waste generation pattern using basic ultrasonic and IR sensors and microcontrollers. It also alerts the authorities in case the dustbin is full by sending a mail and SMS using Raspberry Pi and it also predicts the amount of waste generated in future using Machine Learning approach by taking data on cloud using Arduino and Ethernet Shield Board.

The motivation behind this work is discussed in Section I. The methodology and implementation procedures involving various steps are discussed in Sections II and III. The results are discussed in Section IV and the conclusions drawn from this project work is explained in Section V.

II. Methodology

A. Working of Proposed System

The block diagram of the proposed waste management system is shown in Fig. 1. The ultrasonic and IR sensors are installed in the dustbin which senses the level of waste in it. Once a threshold is crossed, the data is sent to Raspberry Pi

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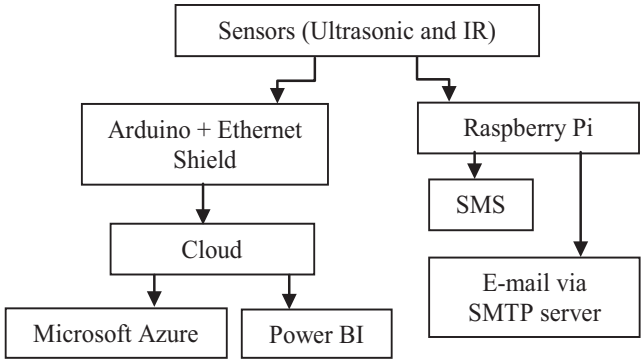

Fig. 1. The block diagram for proposed system.

which sends an alert via SMS and E-mail. Also, the data is sent to Arduino in parallel to Raspberry Pi. This data is then sent to the cloud via Ethernet shield. The data is then further sent to Microsoft Azure platform and Power Bi platform for training the data set, real time monitoring of waste and future prediction of the waste generation pattern in the given area. A Google Calendar event and mobile alert system has also been provided using IFTTT approach.

B. Components Required

1) Software:

- Arduino IDE: An environment for Arduino to write sketches.
- Raspbian: A Debian based computer operating system for Raspberry Pi.
- Microsoft Windows AZURE platform: It is a cloud computing platform which enables the user to communicate to IoT devices. It features various tools which are easier to use than other platforms [4].
- Power BI: It is an interactive visualization tool.
- Microsoft Azure Machine Learning Studio.
- IFTTT: "If This Then That" approach.

2) Hardware Requirements:

- Arduino UNO.
- Ethernet Shield: It is used to connect to Azure platform.
- Raspberry Pi with Wi-Fi module: Raspberry Pi is a single board computer which runs on Linux based operating system and is best suited for IoT based devices [7]. It can also act as a web server [8].
- Ultrasonic sensor.
- IR Sensor.
- 16×2 LCD.
- Waste bin.
- Router.

III. Implementation

Step-1: We will get the real-time sensor data (IR and Ultrasonic) and upload it on the SQL database on Azure. Thus, we got the real-time data on the cloud. Fig. 2 shows the database created.

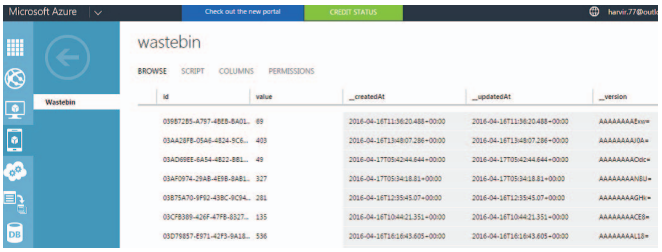

Fig. 2. The database created on SQL database.

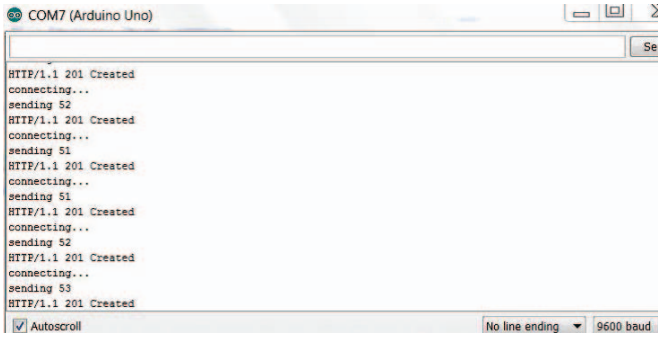

Fig. 3. The data being sent to the cloud.

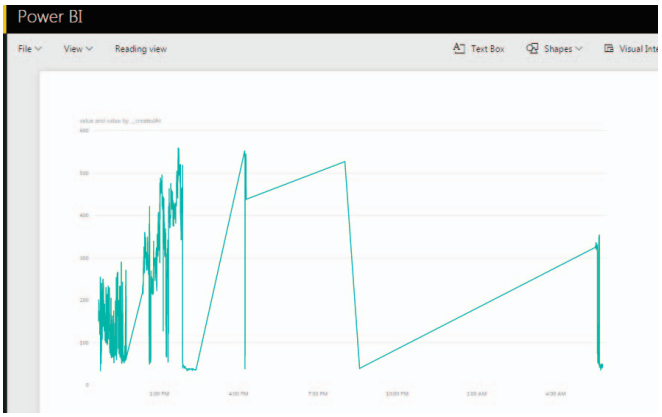

Fig. 4. The analysis of the garbage levels in the smart-bin.

Fig. 3 shows the serial monitor window of the Arduino showing the sensor data being sent on to the cloud.

Step-2: Now, we will be visualizing and analyzing this cloud-data using **Power BI**. We used the line-graph to analyze the rise and fall of the garbage levels in the smart-bin. Fig. 4 shows the analysis in the form of line chart.

Step-3: We have data on the cloud now and we can see the patterns of rise and fall, we'll now use this data to predict how much waste will be generated in the future time. But for that, we need to filter out only the necessary parameters that actually contribute towards the waste generation.

To accomplish this, we used the **Microsoft Azure Machine Learning Studio** [9]. There we created the flow chart, linked the modules and then finally ran the evaluation. Based on the results which include parameters like coefficient of

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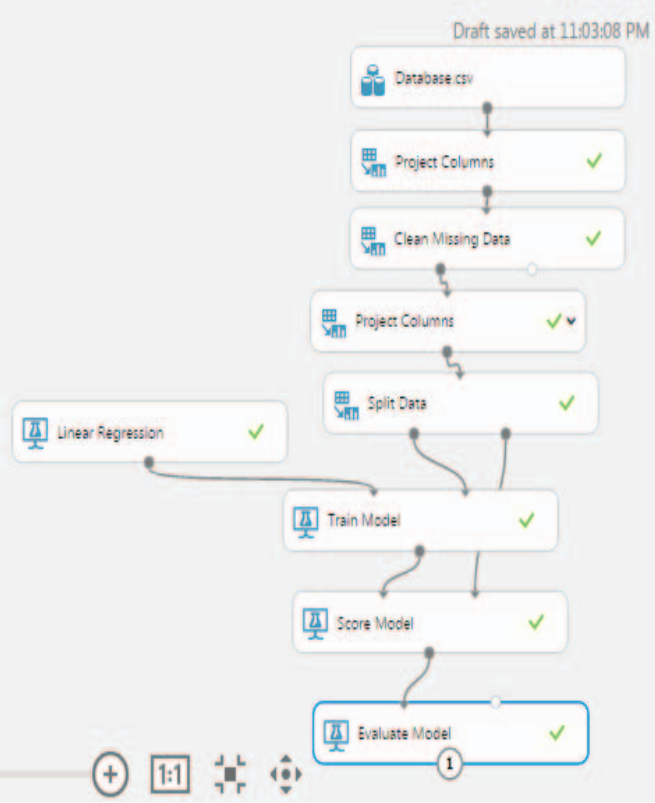

Fig. 5. The machine learning algorithm.

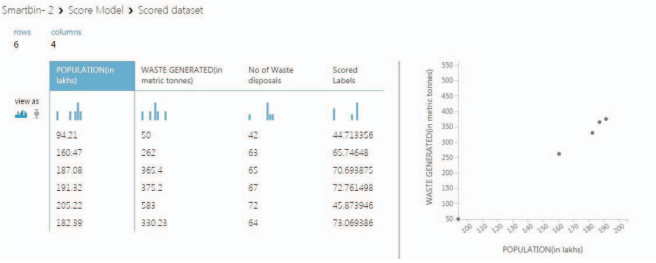

Fig. 6. The graph showing the expected rise in waste production.

determination, the roots mean square error etc. we decide which parameter is the best factor.

The flowchart of the algorithm that we created in the **Microsoft Azure Machine Learning Studio** is shown in Fig. 5.

Fig. 6 shows the expected rise in the waste based on population growth in that region in the form of scatter plot.

Step-4: Now we set-up the **web-service of the Machine Learning Algorithm** we created and make a predictive experiment to find out the waste levels in some future time.

Fig. 7 shows the result of the experiment we conducted wherein we passed only the parameters like population, GDP and No. of waste disposals and hence automatically calculate the waste that will be generated in future.

Step-5: Sending alerts to the authorities every time the smart bin gets filled. To accomplish this task, we used Raspberry Pi that checks the waste-levels in the smart bin using Ultrasonic

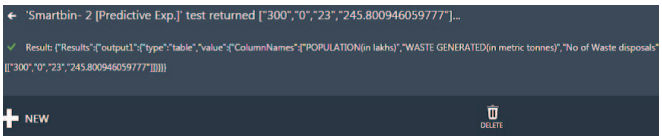

Fig. 7. The expected waste generated prediction result.

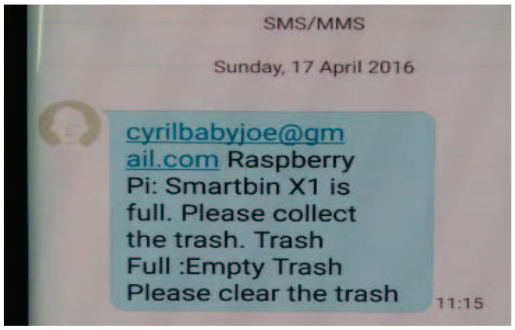

Fig. 8. The alert SMS received.

Fig. 9. The alert E-mail received.

Fig. 10. The Google calendar event.

Sensor. Using **SMTP server**, a mail is sent to the concerned authorities once the threshold is crossed.

Next, using **IFTTT** (**IF This Then That**), we provide mobile and Google calendar alerts.

Figs. 8 and 9 shown below are the alert messages that are automatically sent to the authorities once the bin is full and Fig. 10 shows the google calendar event.

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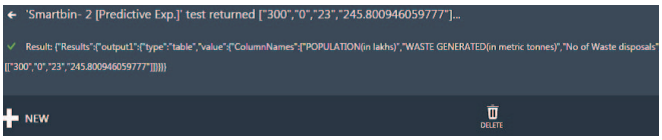

Fig. 11. The prediction result.

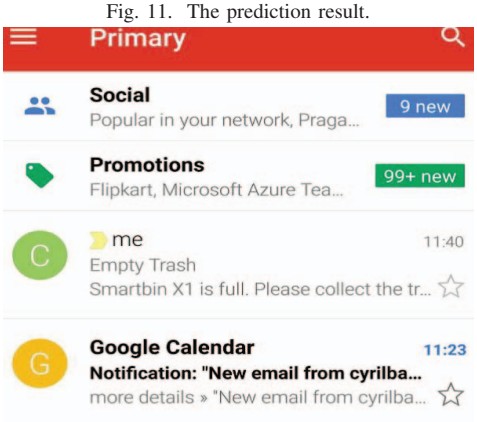

Fig. 12. Gmail applications with received mail.

Fig. 13. IFTTT implementation.

IV. Results

Fig. 11 shows the real time prediction of the future waste generation. Fig. 12 shows the Gmail Application with a received mail requesting to empty the waste bin and Fig. 13 shows the IFTTT implementation. All these would help the waste management authorities to get updated about the waste patterns in a given area so that they may take necessary steps on time to collect the waste from the given region.

V. Conclusion

The proposed system successfully demonstrates its capability of real time monitoring of the waste generation patterns in a city. The alert messages are also sent to the responsible authorities to pick up the waste in case the bin is full.This will save both money and time spent by the authorities in manually tracking all the dustbins. The prediction of the amount of waste generated in future is also done accurately using a simple linear regression model for a city. This prediction model could be useful in deciding the budget allotted for the collection and transfer of waste in a given area by the authorities. It would ultimately lead to a cleaner environment which would be pollution and disease free. Further, if implemented on a large scale it would be a good initiative under the "Swachh Bharat Campaign" of our Honorable Prime Minister.

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