Department of Computer Science & Engineering

SOUTHEAST UNIVERSITY

CSE4000: Research Methodology

IOT based Smart Waste Management System & Waste Collection Solution using Machine Learning

A dissertation submitted to the Southeast University in partial fulfillment of the requirements for the degree of B. Sc. in Computer Science & Engineering

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Letter of Transmittal

October 22, 2020

The Chairman

Department of Computer Science & Engineering

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Banani, Dhaka.

Through: Supervisor, Ishan Arefin Hossain

Subject: Submission of Research Report

Dear Sir,

With due respect, we have researched on IOT based Smart Waste Management System & Waste Collection Solution using Machine Learning under the course, Research Methodology. we are going to implement an IoT based Smart Waste Management system . Actually, this is a project based research and we are trying to give here a theoretical model that we already applied.

So, we try our best to complete this research. we have given our best efforts to complete the research. we are requesting for your kind approval of this report. Hope you may admire our tough work and excuse the minor mistakes.

Thank you.

Sincerely yours,

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Certificate

This is to certify that the research title IOT based Smart Waste Management System & Waste Collection Solution using Machine Learning has been submitted to the respected member of the board of examiner of the faculty of Science and Engineering in partial fulfillment of the requirements for the degree of Bachelor of Science in CSE. Science and Engineering by the following student and has been accepted. This report has been carried out under our guidance.

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Abstract

IOT and machine learning based waste management system for Green smart society are aimed to make management of waste from the every corner of the society more efficient using the most technology. This paper discuses the collection and find shortest path to dispose waste in the smart way. For that purpose KNN machine learning algorithm are using for prediction and Dijkstra algorithm are used for shortest path. Real-time tracking of these criteria can be done utilizing suitable sensing units attached to the Internet utilizing a Wi-Fi connection. Main aim of this waste management system is to make a user friendly platform where municipal can find accurate view and take proper action for quick waste management.

Acknowledgements

At First, We want to acknowledge and most grateful to Almighty God, the most merci-full blessing us with patience and tenacity of mind to complete the Research paper which is the requirements for the degree successfully.

We would like to thank Md. Ishan Arefin Hossain sir who is our research supervisor giving us the opportunity to work under him and gave us a clear understanding about our research topic. Without their unbelievable support, it would be quite hard to complete this Research.

Contents

Chapter 1

Introduction

Arising quality of life and high rates of resource consumption patterns have had a unintended and negative impact on the urban environment generation of wastes far beyond the handling capacities of urban governments and agencies. Cities are now grappling with the problems of high volumes of waste, the costs involved, the disposal technologies and methodologies and the impact of wastes on the local and global environment.

So smart waste management system can create a great solution for this enormous problem.

1.1 About project

Smart waste management solutions use sensors placed in waste receptacles to measure fill levels and to notify city collection services when bins are ready to be emptied.

Over time historical data collected by sensors can be used to identify fill patterns, optimize driver routes and schedules, and reduce operational costs. The cost of these sensors is steadily decreasing.

Making IOT waste bins more feasible to implement and more attractive to city waste municipal.

1.2 Purpose

The main purpose of the entire waste management system is to create smart waste bin which build by several kind of sensors. Sensors are providing the reliable data from different kind of positions. After receiving the data we using it for predict the waste amount for a particular area and find the shortest path for quick dispose.

1.3 Statement of the Hypothesis

Bin is fraughting up quickly in city area. There is very little land space for gather the waste . We want to find the amount of waste can gather a particular day as well as finding the quickest way of decomposing the waste.

If there is an overflowing chance arise and change in temperature from the sun the solid waste products should decompose faster.

1.4 Limitation

Mainly in that management procedure have a lot of limitations like

**Maintain is not always cost-effective

**Practices are not done uniformly

**Sensors failure cause data interruption

**Weak internet signal create lack data flow over iot platform

chapter 2

Review of Related Literature

In Bangladesh 22.4 million tonnes million tonne of waste is generated yearly in the country as a result of 5.6 million tonne of plastic waste, 0.17 million tonne of biomedical waste, 7.90 million tonne of hazardous waste generation and 2.5 million metric tons e-waste. The Center for Environmental and Geographic Information Services (CEGIS) has surveyed the implementation of solid waste management (SWM) in different cities based on the collection, segregation and processing of the waste. Segregation of the waste into hazardous and nonhazardous waste has become a necessity and reusing of the nonhazardous waste remains as a critical element for the ranking of the cities. The segregation of waste is to be executed into 3 streams, wet (biodegradable),dry (plastic, Paper, metal, wood, etc.) and domestic hazardous wastes (diapers, napkins, empty containers of cleaning agents,mosquito repellents, etc.) and handover segregated wastes to authorized rag-pickers or waste collectors or local bodies. In the traditional approach, a number of trucks from the municipal authority are sent to the waste bins to collect the municipal waste (MW). The wastes are loaded in the truck and then transported and transferred to the per-specified locality. However the group of the people involved in collecting and transporting the wastes are usually not responsible enough to make the job well done. Very often the wastes are not collected from each and every waste bin properly due to driver’s attitude and lethargy .In this regard review of existing work on smart waste management system is useful for carrying out further research.

Chapter 3

Design of the Study

Analyzing the waste data from various kind of sensors and applying the KNN machine learning algorithm for predict the amount of can gather. After that applying Dijkstra algorithm to find the quick shortest path for smooth release of vast amount of waste.

3.1 Design and Procedures

Microcontroller: There were several micro-controllers available but we have picked the Arduino Uno is an open-source microcontroller board based on the Microchip ATmega328P microcontroller and developed by Arduino.cc. The board is equipped with sets of digital and analog input/output pins that may be interfaced to various expansion boards and other circuits.

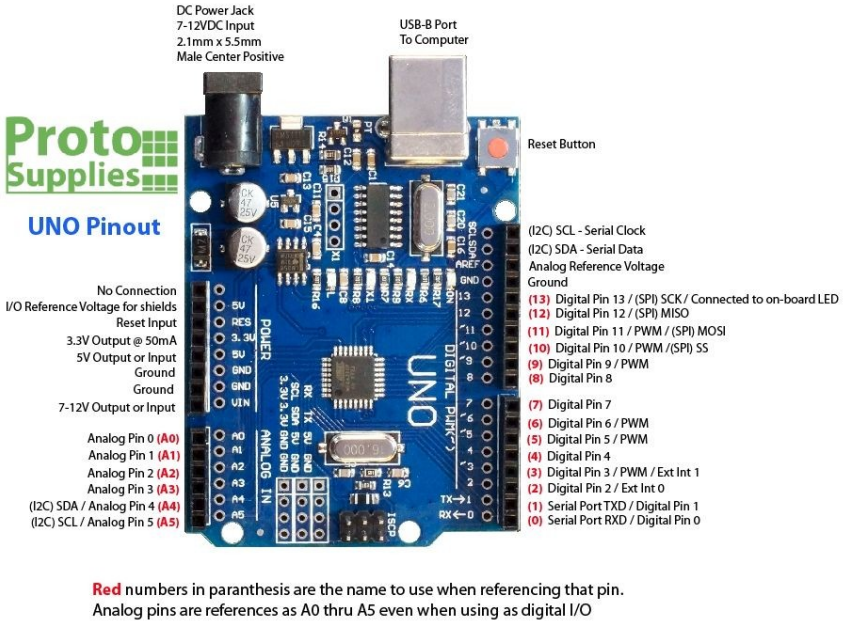

Figure-1:Arduino Uno

Wi-Fi Module: Here using ESP8266 Wi-Fi module for data transmit to platform. The ESP8266 is a low-cost Wi-Fi microchip, with a full TCP/IP stack and micro controller capability, produced by Espressif Systems in Shanghai, China. This small module allows micro controllers to connect to a Wi-Fi network and make simple TCP/IP connections using Hayes-style commands.

Figure-2: ESP8266 Wi-fi Module

Sensors:

Ultrasonic sensor HC-SR04:-

The HC-SR04 ultrasonic sensor uses SONAR to determine the distance of an object just like the bats do. It offers excellent non-contact range detection with high accuracy and stable readings in an easy-to-use package from 2 cm to 400 cm.

Vcc- Connects to 5V of positive voltage for power
Trig- A pulse is sent here for the sensor to go into ranging mode for object detection
Echo- The echo sends a signal back if an object has been detected or not. If a signal is returned, an object has been detected. If not, no object has been detected.
GND- Completes electrical pathway of the power.

Figure-3:Ultrasonic sensor

MQ4 Gas Sensor:-

MQ series sensors use a small heater inside with an electro-chemical sensor in order to measure different kind of gases combinations. Producer says that MQ4 sensor can sense methane / natural gas easily with a range sensitivity from 300 to 10000ppm , costs are very low, and can be easily plugged with Arduino boards.

Figure-4:MQ4 Gas Sensor

Load Cell HX711:-

HX711 module is a Load Cell Amplifier breakout board for the HX711 IC that allows you to easily read load cells to measure weight. It is a specially designed for the high precision electronic scale design, with two analog input channel, the internal integration of 128 times the programmable gain amplifier.

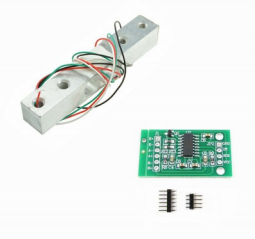

Figure-5:Load Cell HX711

3.2 Circuit Design

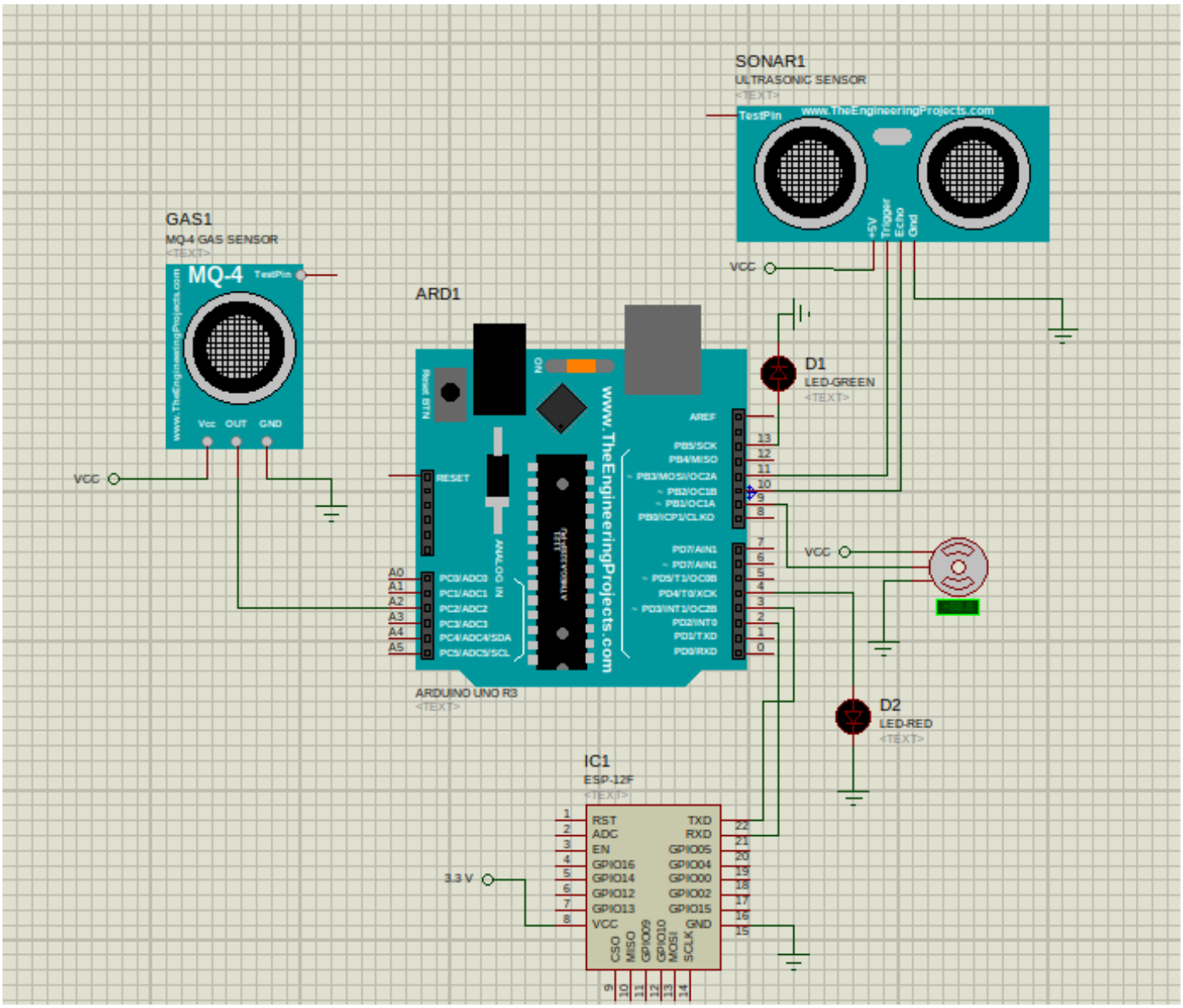

Figure-6:Circuit Diagram

3.3 Sources Of Data

We were trying to collect the accurate data from municipal. But they do not have any particular day to day data for a certain area. So for that reason we were made a train data set for our work purpose. So we were make an excel data sheet and by that sheet created a CSV format file.

1	Day	Bin_ID	Weight	Main_station
2	1	Bashabo-001	116.033	FULL
3	2	Bashabo-002	150.004	HALF
4	3	Bashabo-003	180.055	HALF
5	4	Bashabo-001	116.009	FULL
6	5	Bashabo-002	130.756	FULL
7	6	Bashabo-003	220.854	HALF
8	7	Bashabo-001	205.009	FULL
9	1	Bashabo-002	115.478	HALF
10	2	Bashabo-003	187.493	HALF
11	3	Bashabo-001	197.873	FULL
12	4	Bashabo-002	201.873	FULL
13	5	Bashabo-003	104.622	HALF
14	6	Bashabo-001	229.109	HALF
15	7	Bashabo-002	212.873	FULL
16	1	Bashabo-003	121.253	HALF
17	2	Bashabo-001	147.146	FULL
18	3	Bashabo-002	156.743	HALF
19	4	Bashabo-003	187.333	FULL
20	5	Bashabo-001	135.078	HALF
21	6	Bashabo-002	218.089	HALF
22	7	Bashabo-003	210.564	FULL
23	1	Bashabo-001	118.956	HALF
24	2	Bashabo-002	174.467	FULL
25	3	Bashabo-003	211.894	HALF
26	4	Bashabo-001	135.399	FULL
27	5	Bashabo-002	177.389	HALF
28	6	Bashabo-003	193.089	FULL
29	7	Bashabo-001	218.984	HALF
30	1	Bashabo-002	151.769	FULL

Figure-7:Train dataset

3.4 Methodology

The main purpose of the entire waste management system was to build a smart waste bin which surrounding by several kind of sensors. The sensors were used for a particular measurement. Like ultrasonic sensor use for distance measurement. By that we were found the bin was full or not. MQ4 Gas Sensor were use for sensing the (Methane [CH4] is a colorless) gas existing limit.

The next one was Load Cell HX711 sensor. It was measuring the amount of waste this bin was producing. Sensors were providing the reliable data from different kind of positions. After receiving the data we were using it for predict the waste amount for a particular area by using KNN machine learning algorithm. Since this algorithm required no training before making predictions, new data could be add seamlessly. Also there were only two parameters required to implement KNN(the value of k and the distance). Finally we were find the shortest path by using Dijkstra for quick transport of fulled area waste.

For the whole procedure we were using Thing-speak which is an iot platform for analyzing the data and cloud storage. It was showing the data graphs per channel wise. For data transmit with iot platform we used ESP8266 Wi-Fi module. This module was a connection bridge between the main station and the platform.

At last we were sending the result via e-mail to municipal. For that we were used IFTTT. Its a Collections groups together applets for different platforms. Like here it was connecting between Thing-speak server and e-mail server.

3.5 Statistical Treatment

In the classification setting the K-nearest neighbor algorithm essentially boils down to forming a majority vote between the K most similar instances to a given “unseen” observation. Similarity is defined according to a distance metric between two data points. A popular choice is the Euclidean distance given by

$$d(x, x') = \sqrt{(x_1 - x'_1)^2 + \ldots + (x_n - x'_n)^2}$$

but other measures can be more suitable for a given setting and include the Manhattan, Chebyshev and Hamming distance.

More formally, given a positive integer K, an unseen observation x

and a similarity metric d.

KNN classifier performs the following two steps:

- It runs through the whole dataset computing d between x and each training observation. We’ll call the K points in the
- Note that K is usually odd to prevent tie situations.

- It then estimates the conditional probability for each class, that is, the fraction of points in with that given class label. (Note I(x) is the indicator function which evaluates to 1 when the argument x is true and 0 otherwise

$$P(y = j|X = x) = \frac{1}{K} \sum_{i \in A} I(y^{(i)} = j)$$

Chapter 4

Analysis Of Data

Here describe the patterns observed in the data. Use tables and figures to help clarify the material when possible.

4.1 Algorithm

4.1.1 Smart Bin Algorithm:-

```
 void setup() {

Serial.begin(9600);
  esp8266.begin(115200);//for wifi module
  sendCommand("AT",5,"OK");//for wifi module command communication
  sendCommand("AT+CWMODE=1",5,"OK");//for wifi module connection
   sendCommand("AT+CWJAP=\""+ AP +"\",\""+ PASS +"\"",20,"OK");//own device wifi name and password
}
```

```
int UltrasonicSensorValue(){
   // if Ul_sensor value less than 14 cm and Greater than 4 cm then green led is on otherwise off
  // if Ul_sensor value less than 4 cm then red led is on otherwise off
  // if Ul_sensor value less than 4 cm then servo motor rotate 0 to 180 degree
}
int GasSensorValue(){
  //if gas_sensor value Greater than 400 then red led is on and servo motor rotate 0 t0 180 degree otherwise off
}
int LoadcellValue(){
  // if loadcell value cross the thresshold value when green led on otherwise off
}
void loop() {
   UltrasonicSeonsorValue();
   GasSensorValue();
   LoadcellValue();
   //now code to send thingspeak platform by wifi module
   void data_transfer(){
    //esp code and thingspeak field id number
   }

}
```

4.1.2 Knn Prediction Algorithm:-

1. Load the training and test data
2. Choose the value of K // here k = 3
3. For each point in test data:
   - find the Euclidean distance to all training data points
   - store the Euclidean distances in a list and sort it
   - choose the first k points
   - assign a class to the test point based on the majority of classes present in the chosen points
4. End

4.2 Figure

Smart bin:-

Figure-8:Whole Smart Bin

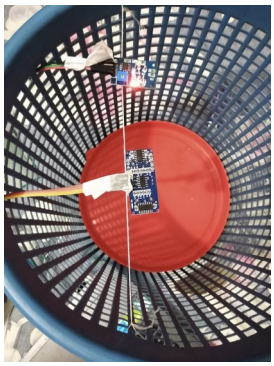

Figure-9:Ultrasonic and gas sensor when Bin is empty

Figure-10:Load Cell Inside the Bin

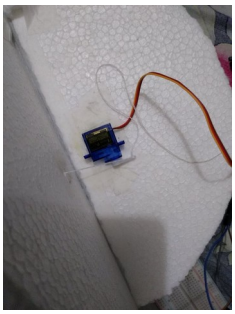

Figure-11:Servo Motor using in the door

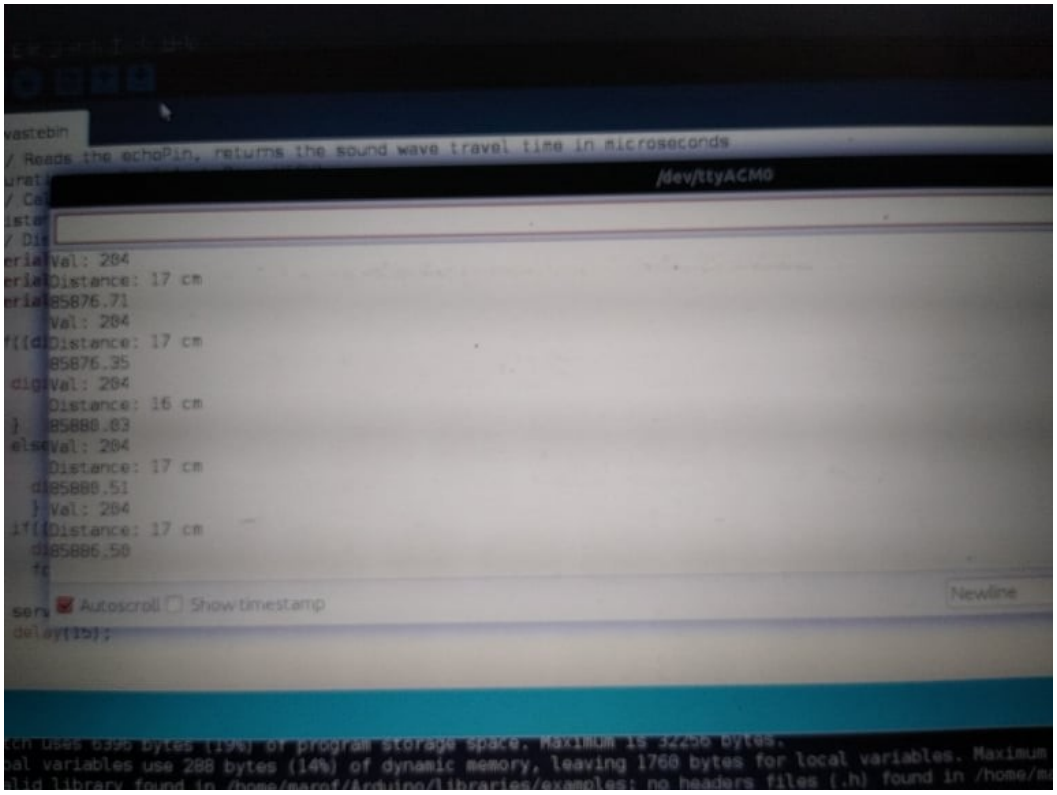

Figure-12:Sensors Output

Thing-speak figure:-

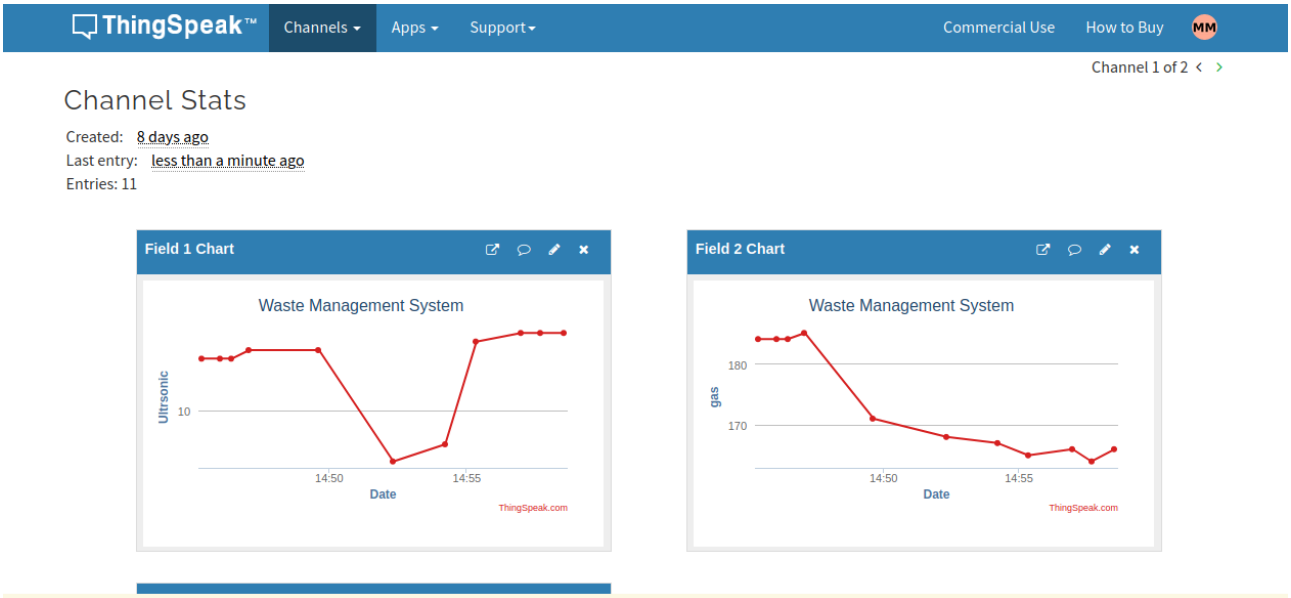

Figure-13: Ultrasonic sensor and Gas sensor data flow

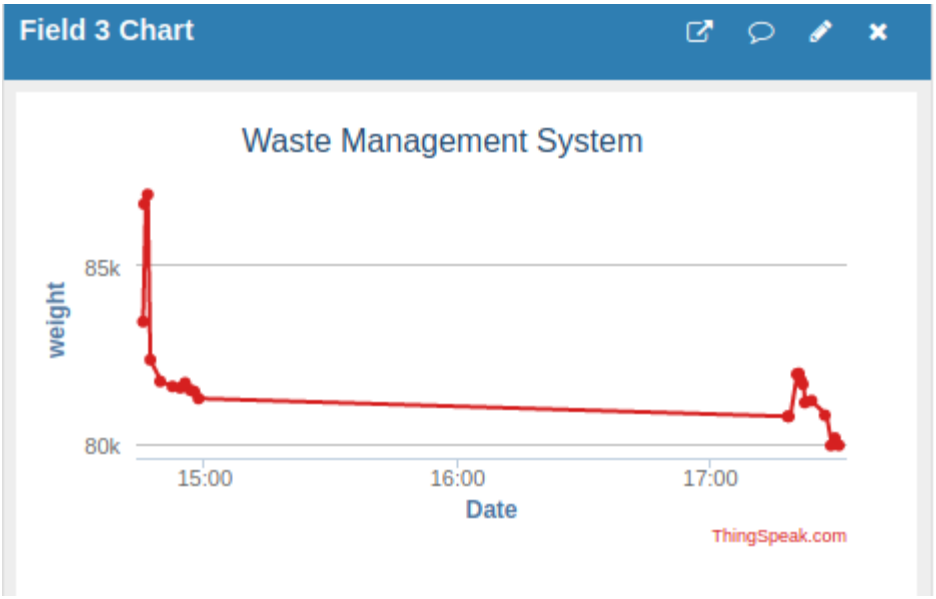

Figure-14:Weight sensor data flow

Figure 1 and 2 shows the result of arduino to Thing-Speak data transmission result by using WIFI module.

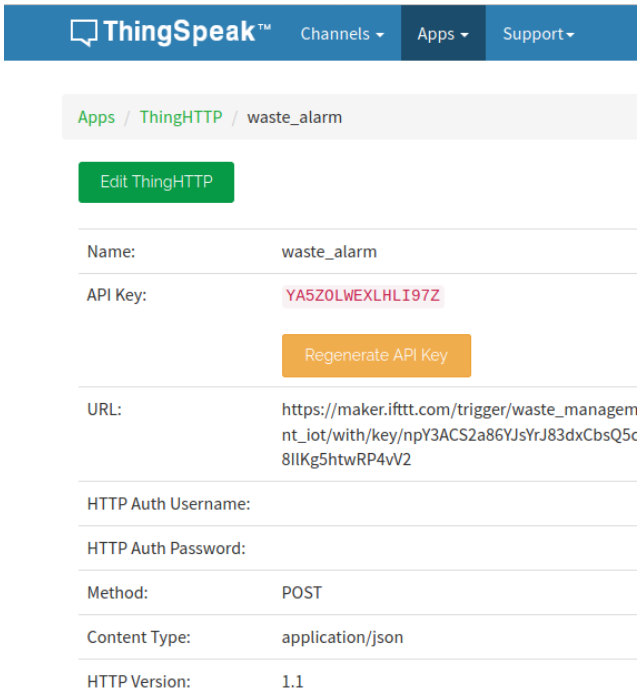

Figure-15:Thing-Speak HTTP server

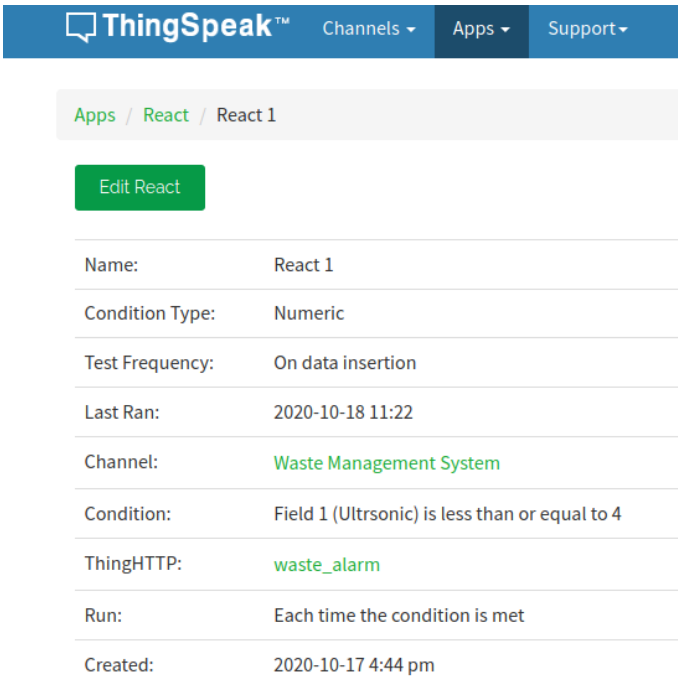

Figure-16:Final Statement

Figure 3 and 4 shows the final procedure of e-mail notification. If the bin is full text will send otherwise no work will do by that server.

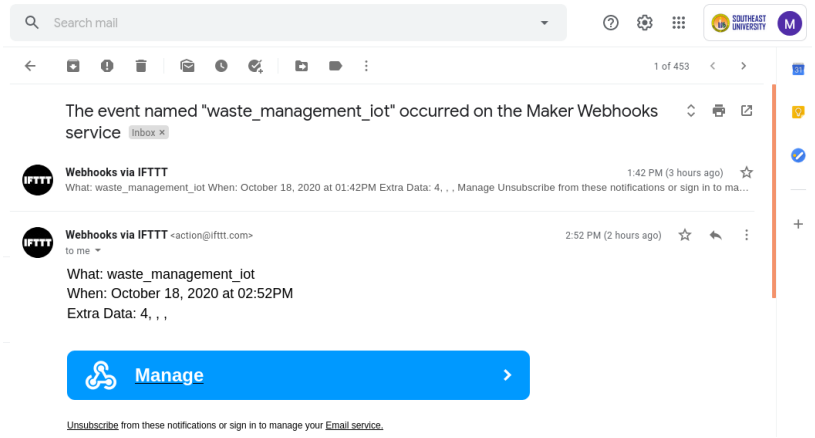

Figure-17: E-mail output from this IFTTT

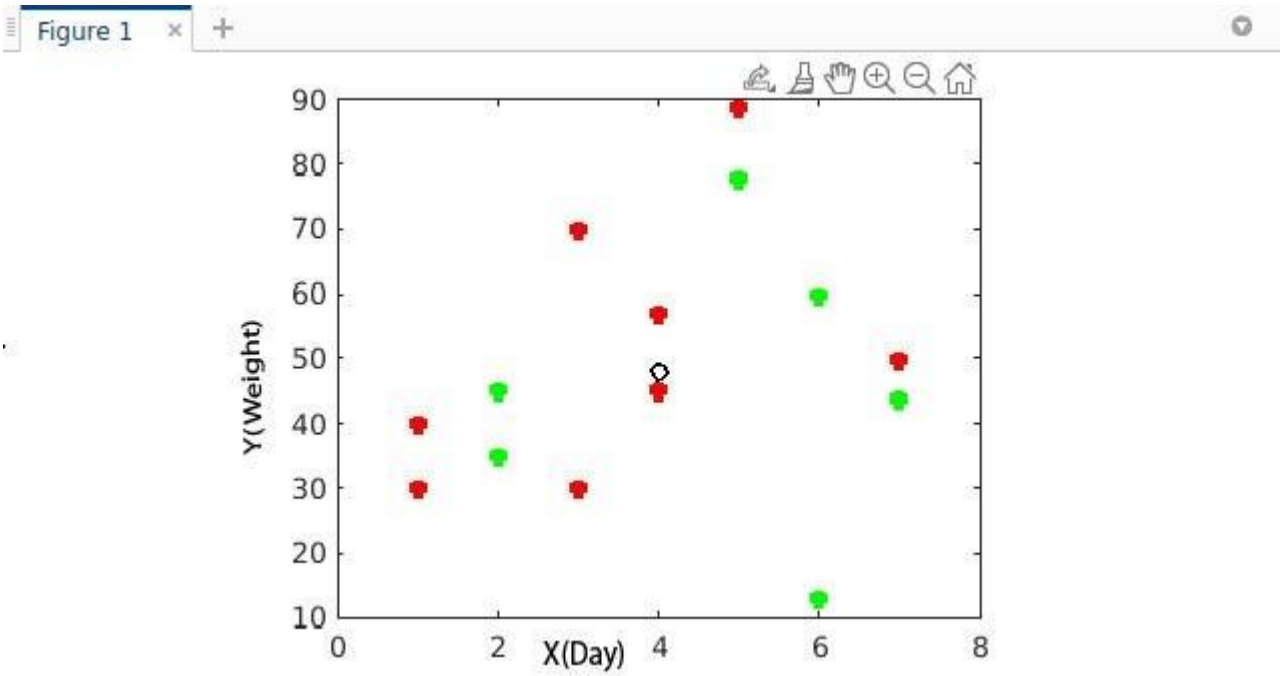

Figure-18: KNN Graphical View

Figure 18 shows graphical view of KNN prediction. Here the X axis represent the value of day and Y axis represent the value of weight. There are three different marks like-Red,Green,Black. Red marks are indicating the bin is Full,Green marks are indicating the bin is Not Full and Black mark is using for the threshold value for KNN prediction purpose.

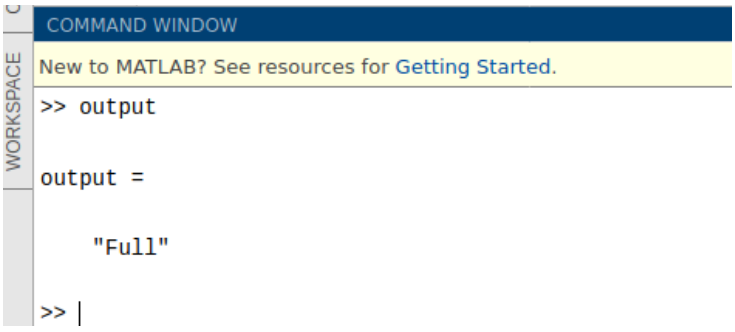

Figure-19:KNN Output

Figure 18 and 19 show the KNN graphical view and output for the prediction result of the main station(particular area) Full or not.

4.3 Collection

When municipal were getting the e-mail they need to quickest way for collected the waste. So here we were using the Dijkstra algorithm for finding the shortest path. Using the Dijkstra algorithm, it is possible to determine the shortest distance (or the least effort / lowest cost) between a start node and any other node in a graph/area. The idea of the algorithm is to continuously calculate the shortest distance beginning from a starting point and to exclude longer distances when making an update. It consists of the following steps:

1. Initialization of all nodes with distance "infinite"; initialization of the starting node with 0
2. Marking of the distance of the starting node as permanent, all other distances as temporarily.
3. Setting of starting node as active.
4. Calculation of the temporary distances of all neighbor nodes of the active node by summing up its distance with the weights of the edges.
5. If such a calculated distance of a node is smaller as the current one, update the distance and set the current node as antecessor. This step is also called update and is Dijkstra's central idea.
6. Setting of the node with the minimal temporary distance as active. Mark its distance as permanent.
7. Repeating of steps 4 to 7 until there aren't any nodes left with a permanent distance which neighbors still have temporary distances.

Chapter 5

Conclusion

The objective of this research is to make the society as a smart green society which is environmentally sound and healthy. This model continuously monitors the level of waste in the biodegradable and non biodegradable compartment of the dustbin and also the concentration of poisonous gases. This model uses machine learning technique (KNN) to prediction of waste amount and find smooth ways to pass through disposable waste by Dijkstra. We also tried to follow the holistic design principle so that the interface of the system is simple. During the course of this assignment we have gone through many obstacles which made us tore search and though increased our knowledge. we are very well clear with all these concepts and fundamentals which will be going to help us in the future.

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