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AN INTELLIGENT ENVIRNMENT MONITORING SYSTEM USING DECISION TREE MODEL

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Abstract

We are living in 21st century and the world is progressing day by day. For progress the environment should be healthy to seek healthy life. With this progress, we are facing some issues. One of the major issue which is ubiquitous problem, it's about hygiene. In olden times we had to regularly check bins ourselves and empty filled, spill over and stinking bins. These conditions mess up the environment and spread different kind of diseases. Which infect different age groups of people. Garbage monitoring system is required to keep the environment clean and mitigate waste. The paper intends to build an intelligent smart dustbin through which we can do monitoring of trash by using sensors and provide the details about different factor present in trash such as garbage level in trash, germs productions (which are harmful for health), gasses (which causes stinking and germs production), humidity level in trash. In this research we proposed an effective smart bin solution integrated with decision tree model using Rapid miner. This system ensures the proper garbage monitoring and keeps the environment clean. The system shows the accuracy level of 89.47%.

Index Terms- garbage pile, IOT, machine learning, decision tree, sensor and smart

1. INTRODUCTION

The key role of smart dust bin is to prevent garbage pile for long period of time, provide clean environment and preventing the wide spread of diseases. Overflow of garbage causes unhygienic environment, it means that which is the ideal breading environment

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for bacteria which causes infections and diseases. The primary concern of smart dustbin is to maintain the level of cleanliness.

The rapid development of population recently, cause more waste dumping. The waste bins are overfilled, as we see, and all the waste spills out. It creates harmful smell around the surrounding this leads in spreading some dangerous infections. But in summer dustbins becomes a bacterial hotspot. If it left unemptied for a fortnight, the growing level of harmful germs or bacteria can multiply by 600% [1]. Bad garbage monitoring system can result unhygienic environment. It has bad effect on human life and health. So, an appropriate waste monitoring system is essential. For this we deal with smart dustbin by checking its status and accordingly taking the decision for improvement in existing system [2].

So, continuous dustbin monitoring for garbage management can result in a better smart dustbin response. Some type of waste disposal that can be [3].

1. Liquid waste: it can be both in households and industries. It can include wash water, organic liquid, waste detergents, dirty water and rain water.
2. Solid Rubbish waste: classified as Plastic waste: Many of the plastic waste can be recycle but it cannot be bio-degradable, paper / card waste, tins and metals. It is various types that found throughout in home. It can be recycled, ceramics and glass. It is also recycled.
3. Hazardous waste: This involves all flammable, hazardous, acidic and reactive waste forms of garbage. It can harm or pollute the surroundings so it can dispose properly.
4. Organic waste: Its common household waste such as garden waste, food waste, rotten meat and manure. It is biodegradables waste.

The waste consumption rate for all type of waste is not same in all areas. It’s depend on the people consumption pattern. It’s also differ across income level. High income level areas generate more dry waste and middle income level areas generate more food and green waste [4]. But in proposed system we consider Organic waste, solid waste and hazardous waste.

A good breeding ground for flies is the garbage field. The flies are then able to transmit the disease and infect several individuals. Malaria is a mosquito-enhanced illness. The protozoa plasmodium is caused by it. It is a very common illness in which mosquitoes breed very rapidly. Reproducing of mosquitoes and houseflies happen basically in waste bin which is an important reason for different illnesses Enteric fever, Food poisoning, Gastroenteritis. It is found out from the essential overview done in different cities in Assam that the trash collection causes of 41% air pollution [5]. The air pollution prompts different respiratory issues like COPD, asthma and so on [6]. There are around 235 million individuals’ presently experiencing asthma for which foul smell is additionally an essential reason. Practically 90% Chronic Obstructive Pulmonary Disease (COPD) happen in middle and low wage areas, caused by foul smelling. In 2005 more than 3 million individuals died due to COPD. Inappropriate administration of trash is recognized as one

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of the significant reasons for 22 infections in human and origin of unexpected passing each year [7]. Overflow garbage bin additionally causes migraine, queasy sensation and increment in the feeling of anxiety.

Waste generation rate increasing day by day. The garbage generation rate depends on two factor one is population and second its consumption rate [8]. According to EPMC (Engineering Planning and Management Consultant) study “Data collection of national study on privatization of solid waste in 8 cities of Pakistan” conducted during 1996, these towns grow 3.67% to 7.42%. These towns generating high amount of solid waste with respect to population growth. The normal household size of these towns differs from 6.7 person to 7.3 person. The EPMC analysis also found that waste generation ranges from 0.283 kg per capita per day to 0.613 kg per capita per day or from 1.896 kg per house per day to 4.29 kg per capita per house per day for all the towns selected [9].

Discussion of earlier studies found that several variables are associated with the smart dustbin management, where environment factors, population growth rate and its consumption pattern which are most critical [10]. Therefore, a comprehensive smart dustbin management solution must consider most noticeable elements, as revealed in following Fig. 1, as humidity and temperature, germs, gasses, garbage level in waste bins. These factors can impact smart bin management in given ways.

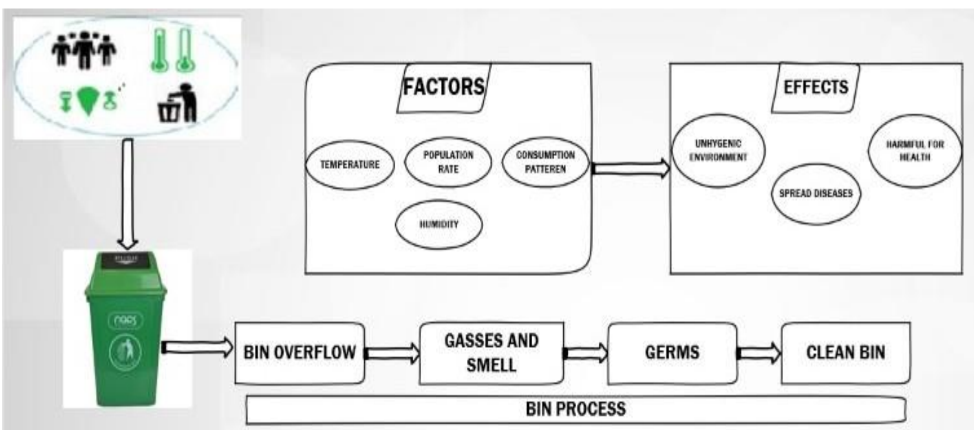

Fig 1: Factor Role of Dustbin Process

1. Humidity and temperature associated with the dustbin moisture level, if humidity and temperature level raises to high, bacteria need warmth and moisture to grow, it may cause different bacteria production that effect human health.
2. Gasses and germs also associated with dustbin, if Organic garbage present in bin for a time period, it produces harmful gasses, germs and bad smell. On the other hand, Hazardous garbage can cause fire in bins which leaves dangerous and unhealthy effect on human life such flammable gases and gasses that produced bad smell include Hydrosulfide gas, ammonia gas and natural gas (methane) etc.

Although previous research showed effect of garbage level, weight and location of filled bin on smart dustbin which provided a base for garbage management system, but we

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defined two stimuli provided to design an efficient garbage monitoring system with inclusive prior studies as shown in Table 1.

Table1: Features of Earlier Obtainable Garbage Management Techniques

Work Year	Technology Used	Work done
[11] 2016	LPC2148 and IR sensor is used. Weight sensor is also being used. For communication purpose Wi-Fi module is used.	This system avoids the corruption due to the use of weight sensor. Reduce expenditure value concerning to the garbage vehicles.
[12] 2016	Arduino Software with the help of Microcontroller 8051 is used. And also used ARM7.	Data is identified wirelessly; sensor continuously monitor the level of trash.
[13] 2016	For the communication purpose GSM, ZigBee module is used. ARM dual core processor is used for monitor purpose and various sensors are used like IR Sensor.	This paper gives the solution related to the time and garbage vehicles management
[14] 2017	Iterative Dichotomiser 3 and travelling salesman problem algorithm is used for decision making.	Give information about garbage level in bin and inform about shortest path of filled bins.
[15] 2017	Based on PIC Microcontroller and GPRS modem, and also used compress.	This system increases the garbage tank capacity by compressing the garbage and formed sheet.
[16] 2018	GSM 900 is used. Minimal no smart bins are used instead of no of plenty dustbin placed in inappropriate manner.	Using a smart dustbin, no. of benefits can be achieved such as durability, affordability etc.
[20] 2019	The ultrasonic sensor, IR sensor and moisture sensor is used to get info about garbage in bin. Raspberry Pi is used as core controller. Wi-Fi system and camera is also used for garbage management.	It effectively actualized for the isolation of waste into dry and wet garbage.
[23] 2020	Alarm system based on Arduino sensors connected through LED lights.	LED lights shows the message to dispose of the dustbin.
[24] 2021	The system used is integrated with ESP32 module by usage of network web to collect the data. To analyze the more waste about certain food ARIMA model is used with the help of machine learning.	Waste management is carried out in college hostel to make environment healthy and germs free for living.

In this paper, we projected a smart dustbin built in arrangement with multi sensors to get data using the microcontroller Arduino and then integrated it for analysis with Rapid Minor. Experiments showed that the device reads and records current data values that can be further properly classified in Rapid Miner by decision tree. The proposed scheme offers a good solution to the three main issues listed.

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The proposed system discussed; three major concerns addressed are below.

1. The proposed solution monitors the feasibility of the device by interacting with several data elements at one, as the humidity and temperature, gases, bin waste level and germs production.
2. Four sensors are used by our proposed approach: a humidity and temperature sensor, BARDOT sensor, a gas and ultrasonic sensor to get current data efficiently.
3. Proposed system uses a decision tree Model based intelligent approach to determine the existing system viability for smart dustbin by checking humidity & temperature, gasses, germs production and garbage level.

This study is organized in following sections: the section 2 deliberates the algorithms, techniques and obtainable methods for smart dustbin management using sensors to provide Smart dustbin solutions; Section 3 defines the proposed system architecture and explains the design of proposed system components, i.e., Decision tree. Section 4 provides details of implementation and the decision tree through the development of experiment design in a rapid manner. Section 5 explained the outcomes and the discussions to demonstrate the implementation tests with the results of the presented system, and at the end section 6 define the future work and conclusion of the research presented.

2. RELATED WORK

A huge research work has been completed in the domain of smart garbage management system. Many researchers have studied various factors relevant to the smart dustbin. e.g., get location of filled bin, inform about shortest path for bin collection, level of garbage in bin, inform about flammable gasses in bin. Previous studies on smart dustbin solutions concentrate on keeping the environment healthy and minimum resources utilization factors [11-16, 20, 23, 24] have been presented, but, the learning based investigation for smart dustbin not covered by previous research, as given in Table 2.

In this project [12] several dustbins are fixed all over the campus which are interface with IR sensor (to detect garbage level in bin), RF modules with micro controller. Enabled Internet connection via LAN modem cable. Cloud process and analyze the data, it displays the status of garbage bin on web browser.

In this system [15] Compressing machine is used for smart garbage monitoring system, which starts its working when tank is full. It compresses the garbage and forms its sheets. The project based on IR sensor, PIC micro-Controller and GPRS module. Collected data from garbage tank and sheet collection tank are uploaded on web browser through GPRS.

In this project [8] to clean the city researcher used different component to implement garbage monitoring system use Arduino board platform. Garbage bin is equipped with waterproof sensor which detects the dustbin level and its comparison done with the depth

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of dustbin and also detect the liquefied waste. It also interfaced with GSM modem and ESP8266 Wi-Fi module.

In this paper [17,18] author used ultrasonic sensor, micro controller and Wi-Fi/Bluetooth module to ensure the cleaning of dustbin. It also makes use of GPS in android application to alter the nearest employees. Optimization of route can save resources; it can do by application of advance analytical algorithms such as Frequent Pattern mining and Time service production.

In this project [19] author implement the garbage monitoring system using PIR sensor, microcontroller, ultrasonic sensor, GSM (Global system for mobile communication), GPS (global positioning system), and Wi-Fi module. It also used a rain sensor servo meter, in the case of rain falling the lid will be closed, otherwise the lid will remain open.

The ultrasonic sensor, IR sensor and moisture sensor is used to get info about garbage in bin. It effectively actualized for the isolation of waste into dry and wet garbage. Raspberry Pi is used as core controller. Wi-Fi system and camera is also used for garbage management [20].

The garbage monitoring System [21] based on IOT in which the system was based on ESP8266 as Wi-Fi module and Arduino Uno board. It also used bread board and ultrasonic sensor to measure the distance. This system contributes in resource optimization, clean and safe environment from all disease.

In this paper [22] an IOT based smart system for garbage management in urban areas act to keep the city healthy and clean, an innovative system helps. This system used the ATMega16 micro Controller, Ultrasonic sensor and SIM 800(GPRS/GSM) modules, to show the working devices status on 16*2LCD powered by a 12VDC adopter via 7805 regular IC.

In waste management system [23] smart intelligent alarm system is very important. They have used waste alert system which indicates the level of dustbin in public and in homes. Alarm system based on Arduino sensors connected through LED lights which shows the message to dispose of the garbage in dustbin.

This paper [24] presents waste management in college hostel to make environment healthy and germs free for living. The system used is integrated with ESP32 module by usage of network web to collect the data. To analyze the more waste about certain food ARIMA model is used with the help of machine learning. To implement the system Arduino microcontroller sensors integrated with pic microcontroller is used.

For smart garbage disposal [25] to detect the level of bin different sensors are attached. These sensors send the data to corporation office by using IOT integrated with tag of RFID (Radio Frequency Identification). When they receive all the information about the garbage overflow, they send their vehicle to make sure that dustbin is unfilled on time.

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3. METHODS AND MATERIALS

The design of presented smart dustbin is described with algorithms and techniques in this section.

3.1 Smart Dustbin Architecture

Proposed smart dustbin is equipped with the capacity to intelligently classify the level of the bin, gasses and germs produced in bin and environmental factors like humidity and temperature. For efficient sensing of different above mentioned elements proposed intelligent approach manages the effective use of sensors.

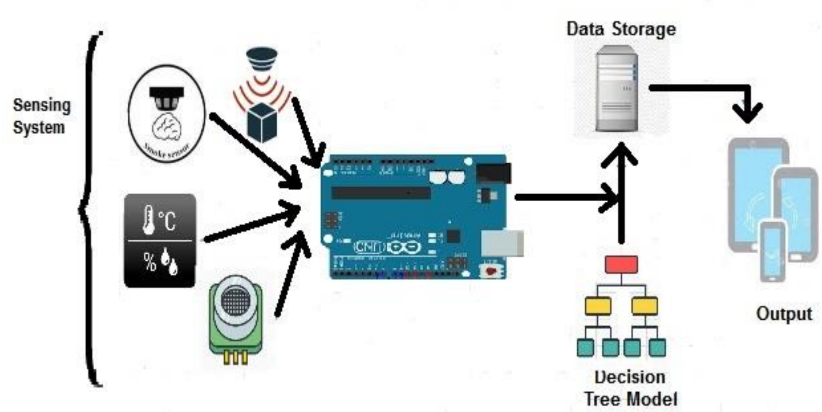

Fig 2: Architecture of Smart Dustbin

The planned system accurately monitors the garbage. The planned system is split in two main elements, as the sensor-based data collection element and decision tree. Architecture includes the data analysis model, display performance on the mobile app, as shown in Fig. 2.

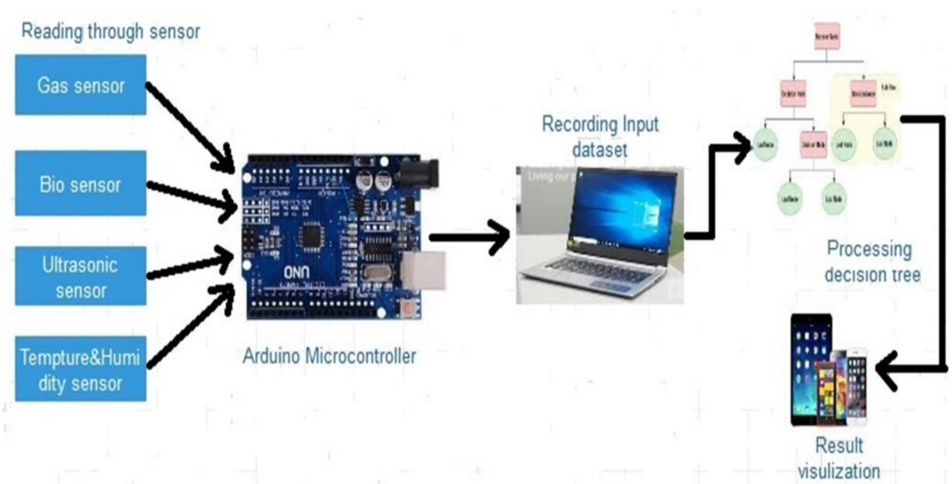

Fig. 3: Smart Dustbin: Integration Design of Hardware Components

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Fig. 3 illustrates the detail function of the proposed smart bin breaks up in several phases.

1. System-based data collection using Arduino Sensors
2. In-system data recording
3. Analysis of data by decision tree Model
4. Showing the dustbin obtain class using the Android App

In designing the hardware components of smart dustbin, different sensors like gas sensor, bio sensor, ultrasonic sensor, temperature and humidity sensor were used to collect the data. Then this data is taken as input and recorded as datasets. These datasets are analyzed by using decision tree models. At the end android app is used to show the visual results of dustbin.

3.1.1 General Remarks on Figures

Sensor based data collection is first step in proposed approach as illustrated by Figure 3. For this purpose, humidity and temperature sensor, Ultrasonic sensor, gas sensor and Bio sensor are used. Data collection tasks involving system devices, microcontrollers, and all hardware devices such as sensors, were performed by the proposed system. Figure 3 explains the process collection of data, sensor operation and data storage in a system for more evaluation.

3.1.2 Decision Tree Model

We used the Decision Tree in proposed system for the classification of current environment in order to build an effective system of dustbin monitoring. Although several other machine-leaning algorithms, such as NN, KNN, SVM, etc., that solve classification problems, we choose a decision tree for other approaches for a given reason.

1. It can use nominal attributes, while many common algorithms for machine learning cannot. But, the numeric attributes in ID3 need to be changed to nominal. In addition, there is an evolved C4.5 versions that can handle nominal data.
2. The algorithms of the decision tree are strong; they have long training time.
3. It tends to fall over-fitting.

Decision tree named as ID3 algorithm in1975 is based off the Concept Learning System (CLS). ID3 is an algorithm for classification that constructs decision tree by using the collection of training instances. The future samples identified by resulted tree. The internal node is a decision node, denoted by rectangle and class name is at the leaf node of decision tree, denoted by oval. The decision node is an attribute test, with any branch being a possible value of the attribute (to another decision tree). ID3 use Entropy and Information gain to assist it to make a decision which attribute is most dominant attribute and goes into the decision node.

Iterative Dichotomization 3(ID3) is an iterative process. Dichotomization means the division into two parts or items that are entirely opposite. Algorithm divide most dominant attribute into two groups iteratively and others to construct a tree. After this, entropy and

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data gain of each attribute are computed. The most dominant attribute can be based on this measure. And the most dominant attribute goes into as decision node. Similarly, among other attributes, entropy and information gain is measured again and finds the next dominating attribute. This procedure is come to an end after reaching a decision for that branch.

In this proposed method, we evaluated the suggested ID3 decision tree after data collection. It follows the algorithm steps given to work.

1. Calculate Classification Entropy of the target data set.

$$Entropy(S) = \sum_{i=1}^{c} -p_i log_2\, p_i \quad (1)$$

2. Calculate Information Gain using classification attribute.

$$Gain(S, A) = Entropy(S) - \sum_{v \in Values(A)} \frac{|S_v|}{|S|} Entropy(S_v) \quad (2)$$

Where v represents the value of A. |Sv| is the instance subset of S, where the value v is taken by A, and |S| is the number of instances.

3. Decision node is selected by choosing largest information gain attribute.

A branch needs further splitting which have more than 0 entropy. A branch with 0 entropy is a leaf node. It runs reclusively on the leaf branches, until all data is classified.

4. IMPLEMENTATION

In Rapid Minor, the smart dustbin was implemented. The system was implemented in combination with four sensors for reading data using an Arduino UNO controller. The data sensed by mean of sensors via the microcontroller then forwarded to decision tree. The following part explains the description of the hardware used and the implementation of the Smart dustbin.

4.1 Used Hardware

We are developing inexpensive systems in our proposed approach. We design a system of given components to read values in observation of environmental aspects i.e., germs, gasses, temperature of humidity, bin level, Arduino UNO.

1. MQ2 Gas Sensor
2. Ultrasonic Sensor
3. DHT11 Humidity and Temperature Sensor
4. The BARDOT Sensor

Figure 4 shows an Arduino that is an open-source programming company that designs and manufactures microcontroller packs for intelligent objects and programmed devices that control and identify in real world. It is ATmega328 based controller board with 14 pins for output and input.

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Figure 4: Arduino-Uno Microcontroller

The 14 of 6 pins for analog input and 6 for PWM output pins. It also has a 16MHZ resonator, USB connection for power, reset button, power jack and In-Circuit System programming (ISCP) header. It can easily connect with computer using USB cable. Gas sensor is shown in Figure 5, it used to detect the variation in harmful gases and gasses which produced bad smell in order to keep the bin safe, keep enjoinment clean and avoid/caution any unexpected threats.

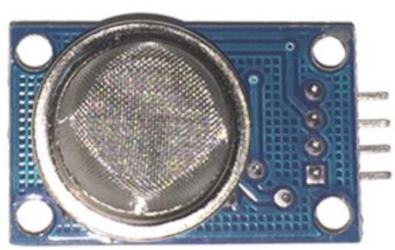

Figure 5: MQ135 Gasses Sensor

MQ-135 semiconductor is used to sense various bad smelly gasses and burnable gases such as it detects NH3, NOx, mathen, alcohol, Benzene, smoke, CO2, etc. It is low cost and easy to use. It has both digital and analog pins.

1. Specifications:
2. The Operating Voltage is +5Voltage
3. The Analog output is from 0V to 5V (Voltage).
4. And Digital Output is 0V or 5V (TTL Logic)
5. Preheat time is twenty seconds
6. High sensitivity and Fast response
7. Using the potentiometer, the digital output pin can be varied.

The Ultrasonic sensors shown in figure 6, are used for bin level detection and also measure the distance of object from itself with high accuracy. It emits ultrasonic waves and if the object gets in its way, it will be reflected back to the sensor.

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Figure 6: Ultrasonic Sensor

It then calculates echo time to return to the sensor and uses the sound speed in the medium to determine the difference of distance with target object. Its ultrasound wave frequency in air is 40 KHz. DHT-11 is used as humidity and temperature sensor using a single wire digital interface shown in figure 7. Its low cost. It is easily integrated with 8-bit microcontroller.

Figure 7: Humidity and Temperature Sensor

Specifications:

1. Voltage Supply +5V
2. Its temperature range is from 0 to 50 °C with error of ± 2 °C
3. Its Humidity range is from 20% to 90% RH with ± 5% RH error
4. The Digital Interface

BARDOT associate multi-pathogen selective medium, Salmonella, Listeria, and E-coli to analyze the light scattering sensor usage for the simultaneous discovery of the three foodborne microorganisms in a test. The result show that in 29-40 hours, BARDOT combined with SELA can effectively test for the presence of three significant microbes concurrently.

4.2 Implementation of Decision Tree in Rapid Minor

After data collection, data analysis performed via the implementation of the proposed Rapid miner decision tree.

4.2.1 Training Dataset Design

Proposed system is implemented with decision tree, for this pre-labeled data set for training is required. We designed a training dataset for 129 total elements in our proposed method, as shown in Table 3.

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Table 3: Dataset Design

Location	Instance	Class
Kitchen/Room → 129	21	Alright
	52	Clean
	56	Immediately Clean

The complete portrayal of utilized training dataset cases of each variable given. For this we consider different conditions and prepared dataset as shown in Table 4.

Table 4: Used training dataset

Bin Level (%)	Temperature (degree)	Humidity (%)	Gases (ppm)	Germs (LOD)	Label
0	6	23	0	0	Alright
9	9	25	0.01	1	Alright
10	11	24	0.02	1.06	Alright
11	10	50	0.03	1.02	Alright
19	12	23	0.04	1.01	Alright
20	13	19	0.05	1.07	Alright
24	14	30	0.06	1.03	Alright
25	15	66	0.07	1.08	Alright
29	15	66	0.08	1.06	Alright
30	17	37	0.09	1.09	Alright
34	18	49	0.1	1.07	Clean
35	20	54	0.2	1.1	Clean
39	21	30	0.3	1.08	Clean
40	22	37	0.4	1.12	Clean
44	23	46	0.5	1.09	Clean
45	24	47	0.6	1.13	Clean
47	24	34	0.7	1.11	Clean
50	25	47	0.8	1.14	Clean
72	30	47	0.05	1.17	clean
73	35	55	0.06	1.18	Clean
75	31	77	0.07	1.2	Clean
78	39	60	0.08	1.2	Clean
81	34	50	0.09	1.24	Immediately Clean
82	40	81	0.1	1.24	Immediately Clean
85	42	83	0	1.25	Immediately Clean

4.2.2 Designing Decision Tree

We implemented decision tree in Rapid miner using Repository (managed data and process), and operator panel.

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Following steps are followed to design a novel decision tree model in rapid miner:

1. Import Training dataset Target dataset
2. Open operator panel and add process in repository.
3. Add operators in process work page to build decision tree model such as
4. Add set Role operator to the work page and set the parameter used. In parameter set attribute name' and 'target role' as 'label'
5. Add split operator and set partition parameter ratio.
6. Add decision tree operator and in parameter 'criterion' select as 'information gain'.
7. Add apply model operator
8. Add performance operator and in parameter, check accuracy and classification from available check list.
9. Start execution of process

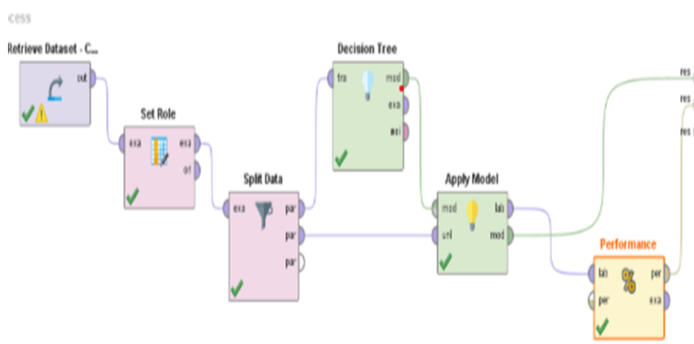

Figure 9: Preparing Decision Tree Model

Figure 9 shows the preparation of decision tree model. All the processes are connected to each other.

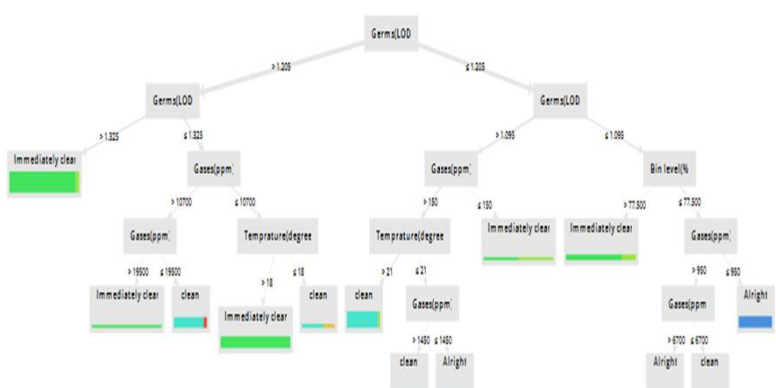

Figure 10: Trained Decision Tree Model

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In figure 10 the complete trained decision tree model is displayed. Decision tree predict the assessment by the 'label role', now this case the "Decision Label" element is prediction (Alright/ clean/ immediately clean). As the root node the Information Gain select the Germs attribute. Highest value of germs is classified as immediately clean.

5. RESULTS AND DISCUSSION

The smart dustbin is an intelligent system based on the model of a decision tree that has the ability to make true decisions. A new concept is the use of intelligent approach for sensor-based smart dustbins. The implementation details and architecture of proposed system are given in the previous section. We use four kinds of sensors (germs sensor, humidity and temperature, ultrasonic and Gas Sensor), to test the performance of proposed system in testing field. In this section, all the findings obtained from this experiment are discussed thoroughly.

Table 4: Levels of Temperature

Temperature/°C	Class
<20°C	Low
20°C-25°C	Normal
25°C-29°C	High
29°C-45°C	Very High

The sensor is used to obtain input data and sent to the device, the results are displayed in an Android app. It is completely automated system. The 4 sensors are used to receive three types of sensor data and the calculated output is handled by decision tree Model by the support of categorization tables represented as follows. The four classes (very high, high, normal, low) for different degrees of temperature identified by DHT11humidity and temperature sensor as given in table 4.

Table 5: Levels of Humidity

Humidity (%)	Class
0%-20%	Dry
21%-50%	Normal
51%-100%	Wet

Table 5 shows various levels of humidity that have three classes (dry, normal, wet) identified by DHT11humidity and temperature sensor.

Table 6: Gasses Levels

Gasses(ppm)	Class
<1000	Lighter
1000-5000	Normal
5000-15000	High
<15000	Very High

Table 6 demonstrates four classes (lighter, normal, high, very high) for the several levels of mathen, hydrosulfide, and ammonia gasses identified byMQ-135 gas sensor.

Table 7: Germs Levels

Germs(LOD)	Class
<1..16	Low
1.16-1.27	Control
>1.27	High

Table 7 demonstrates 3 classes including Low, control and high for the several levels of listeria, E-coli, shigella and salmonella germs production identified by the BARDOT sensor.

Table 8: Bin Levels

Bin-level (%)	Class
0-29%	Low
30%-54%	Medium
54%-79%	High
80%-100%	Very High

Table 8 shows various levels of Bin that have four classes (Low, medium, High, Very High) detected by the Ultrasonic sensor. The following graph analysis relationship between different attributes of the system. Graph represent the visualizing and analyzing of training dataset.

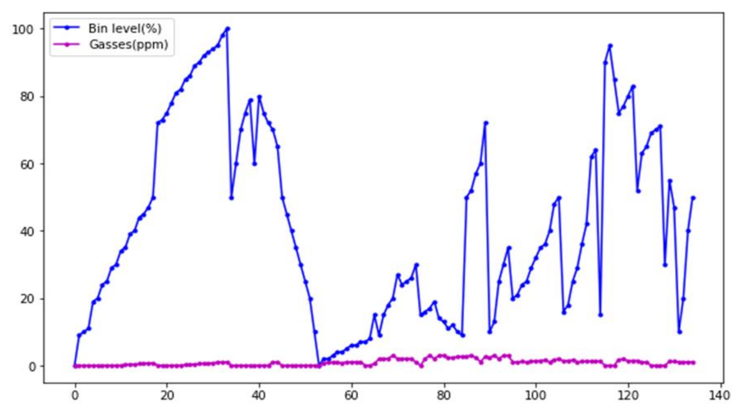

Fig. 11: Analysis of Garbage Level and Gasses in Bin

The above graph is the pictorial representation of bin level and gasses. The blue line represents the bin level and purple line indicates gasses in dustbin. It also represents sometimes gasses production does not depend on the level of the garbage but the type of garbage because some types produce more gasses which are more harmful and hazardous for health.

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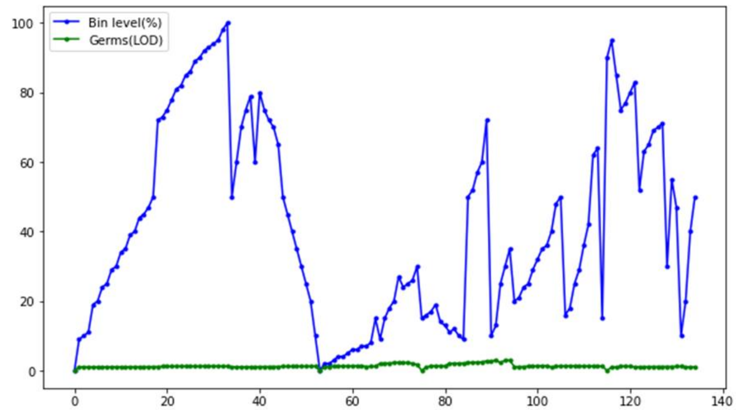

Fig. 12: Analysis of Bin Level and Germs in Bin

The above graph is the pictorial representation of bin level and germs. The blue line represents the bin level and green line indicates germs in dustbin. Bin level increases or decreases, the quantity germs remain almost same.

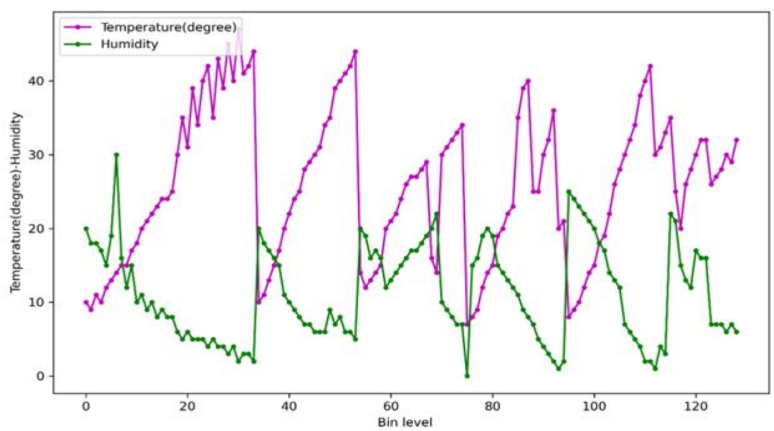

Fig. 13: Analysis of Garbage Level with Temperature

The above Fig. 13 shows temperature and humidity in bin. The purple lines show temperature and green line represents the humidity, if temperature increases humidity decreases, they go vice versa. Following graph shows both the worst and best case, increase and decrease in temperature.

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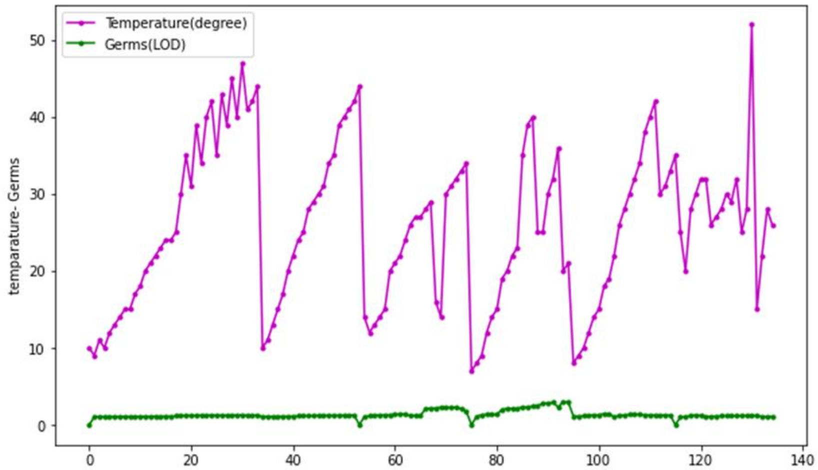

Fig. 14: Analysis of Temperature and Germs in Bin

Fig. 14 shows the analysis of temperature and germs in bin. It is shown through graph in which purple line shows temperature and green shows germs. Temperature increases or decreases the rate of germs almost remains the same.

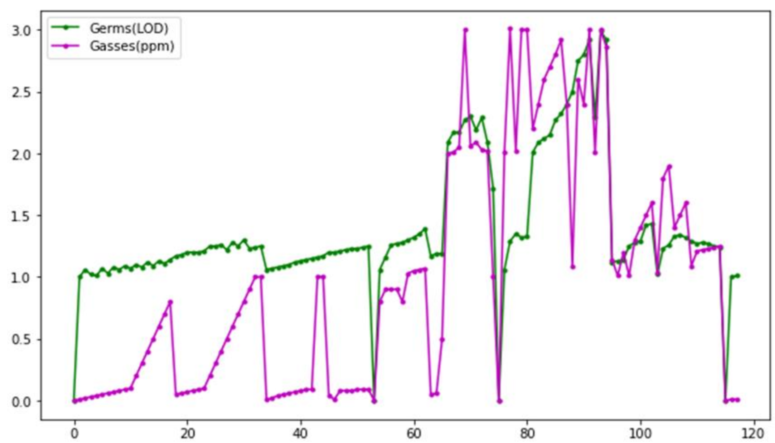

Fig. 15: Analysis of Germs and Gasses in Bin

The above Fig. 15 shows a graph in which there is analysis of germs and gasses produced in bin. Germs and gasses both depend on one another. Increase and decrease both depend on different type of gasses and germs.

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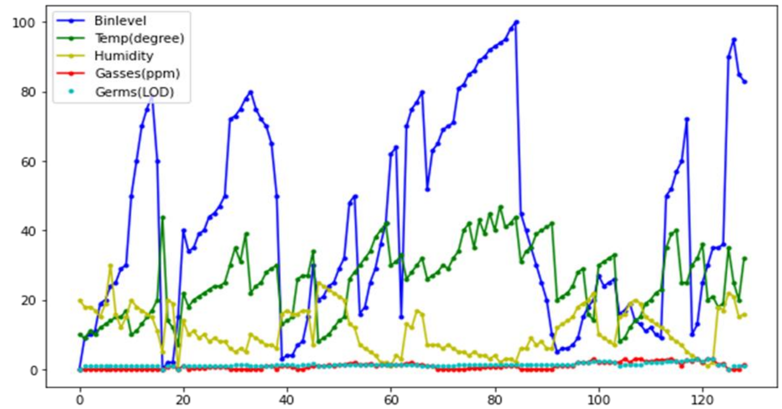

Fig. 16: Analysis of all Items in Bin

Fig. 16 shows a graph of analysis between all the items in bin. It shows bin level, temperature, humidity, gasses and germs produced in bin. Basically, bin level is the cause of all the production of stinky gasses and germs which are harmful and hazardous for health and pollution.

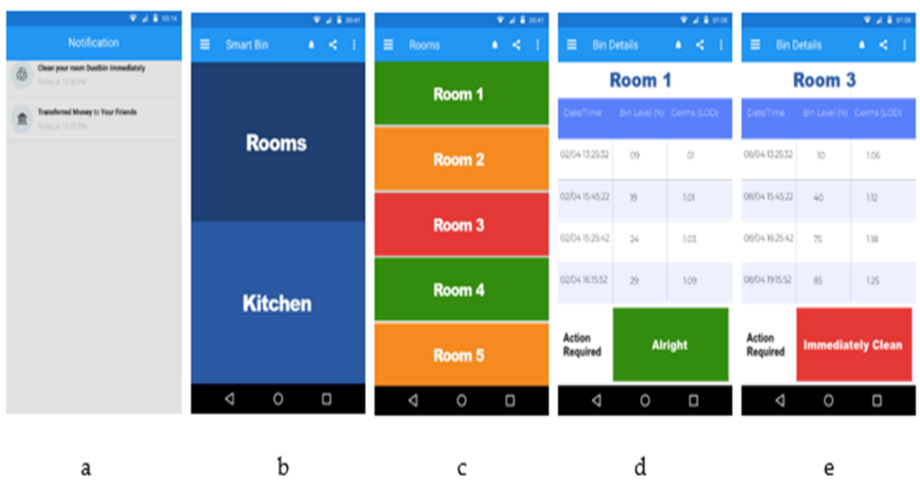

Fig. 17: Mobile application interface

Fig. 17(a) shows the notification received by user to empty the dustbin of room 3. The data is sent to the mobile application in real time to the user. This data is updated on mobile application continuously to provide the user with real time information which will notify the user to clean the dustbin of the specific room/kitchen. As it is seen that once the user gets notification on his mobile, he will be able to quickly detect that which dustbin he has to clear on urgent basis. Three colors green, orange and red are use in application that will provide the visual presentation of the status. The green color is the safest level and red indicates the high level of germs, temperature and humidity etc.

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5.1 Performance of Decision Tree Model

To conclude decision tree model's accuracy, the test is performed by using Confusion matrix as shown in the Fig 18.

accuracy: 89.47%

	true Alright	true clean	true Immediately cl...	true claen	true Claen	true clean	class precision
pred. Alright	6	0	0	0	0	0	100.00%
pred. clean	0	11	0	1	0	1	84.62%
pred. Immediately c...	0	2	17	0	0	0	89.47%
pred. claen	0	0	0	0	0	0	0.00%
pred. Claen	0	0	0	0	0	0	0.00%
pred. clean	0	0	0	0	0	0	0.00%
class recall	100.00%	84.62%	100.00%	0.00%	0.00%	0.00%	

Fig. 18: Confusion Metrics

The calculation of classification error is 10.53% and accuracy is 89.47%. Class precision is 100% which is highest. The used data are representative enough (varies) so the resulting accuracy was good.

6. CONCLUSION

The current research purpose to ensure cleanliness and keep the environment which is healthier for living. We can constantly check the garbage level in trash which is placed in our kitchen or room while using this system. We can also check gasses produced in bin, germs production that are danger for health and humidity level in trash. If dustbin meet any of this problem, it can notify us. Then we can quickly take immediate action to evacuate it. You can also check trash status on their mobiles. This proposed system can be used as standard by the people who are keen to take one step more for improve the cleanliness in their houses. Level of garbage in bin is checked by Ultrasonic sensor, MQ-135 sensor is used for check gasses, Bacterial Rapid Detection using Optical Scattering Technology (BARDOT) is used to note germs production, humidity and temperature sensor (DHT-11) is used. We programmed Arduino Controller to record Temperature, humidity, gasses, germs and record sensed data in Excel sheet. The next element of proposed model use of decision tree trained model of Rapid miner which take designed standard training dataset to trained decision tree. We implemented proposed smart dustbin monitoring solution for kitchen or room, results indicating that presented model predict 89.47% accuracy rate.

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