Enhancing Periodic Storage Performance in IoT based Waste Management

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***Abstract*— Every day, Omnipresent gadgets are approaching agile and more akin. Due to rapid growth in internet of things, every object can now be purely recognized and made to interact with each other. Th strategy has been enforced for dustbins, to supervise garbage collection, portray diverse valuable intuition. Our procedure harnesses a self-same routeway to not only supervise junk cumulus and yet enhance it by practicing the concept of machine learning. The technique of unsupervised learning we draw on K- Means clustering, universally employed in data-mining and logical analysis. Our real device captivates dustbin content level with the help of ultrasonic sensor operation. The vital dataset attributes produced is examined by our k-means algorithm, to find the particular time intervals of the day, when a periodic clean-off is required, such that the dustbins are free from the junk, for maximum attainable quantity time. The design or algorithm displays the emplacement, where additional dustbins to be ensconced, for further enhancement. It can be done by, perusing a single cluster idiomatically and parsing out particulars, which are the stern most away from its nearest centroid, and dustbin related numerous particulars.**

Keywords— Data-Mining; Junk Disposal; K-means clustering (centroid based); Telegram; Thing Speak (IoT Platform).

I. INTRODUCTION

The accessibility of readily available hardware and software resources has scintillated an accelerated buzz in developers, innovators, and researchers, to test and build with IoT platform. It has brought revolution in our day to day life making it convenient as automation can be acquainted with almost anything in our life. With the help of automation, all that exists is growing and getting " smarter." Similarly, dustbins can be developed more smartly. As we know smart bins are more convenient in preserving the city extra clean, this aid to increase attraction and tourism towards the city, waste collection reduces congestion and traffic disruption, resulting in a cleaner and safer street. Dustbins that inform to clean immediately, when it is full, this type of dustbins can decimate the issue of overflowing junk, which are giving rise to harmful insects.

It makes surroundings to appear clean and beautiful and smell better, by creating eco- friendly environment. Our project overcomes the problems which are occurring in normal dustbins such as odour problems, set up cost, maximum usage of junk collection trucks and inability to adopt the changes related to circumstances.

With the use of IoT, a garbage monitoring system is developed and achieved. An efficient way of storing data for analysis is by using cloud computing (Thing Speak). To access the internet, it can get connected to available Wi-Fi. The content level of dustbins is detected by the sensors and updated via telegram application. By using Thing Speak, every dustbin data can be stored and configured. Messages sent via telegram informs the junk level to the dustbin's headquarters or BBMP control office, and through the cloud, dustbin fill and clean time is stored and the frequency of getting filled or cleaned.

To enhance the overall cleaning efficiency, learning, and analysis of factual data provides a way to solve it. We aim to inform headquarters or BBMP control about the dustbin is full or empty, and notify the times it was cleaned and filled up. With this data, frequency of clean-ups is optimized by machine learning and also recommends where additional dustbins should be ensconced. As a result, a single garbage collector is not allowed to get filled repeatedly. Hence the number of clean-ups can be optimized**.** Furthermore, in such positions, a new waste collector is installed. Hence due to optimization, data produced discover that it had an admiring effect.

By knowing each dustbin fill time, an algorithm known as K Means clustering is applied. Based on the number of routine clean-ups that an administrator of establishment requires; the value of K can be changed. The instances of each regular clean-up, are given by centroid of the clusters. For the same particular bin, if an idiomatic cluster consists of numerous data items or the cluster items are too exiguous, it keeps track of the dustbin causing the abnormality. Then, the Installation of a new junk collector recommended, only If the same noted junk collector keeps causing deviation. Due to the clusters formed, additional dustbin installation should have admiring effect. Eventually collection gets optimized.

II. RELATED WORKS

In [1], The fundamental aim of this system is to develop an agile junk collector using IoT protocols. The current junk collector status display was seen by interfacing the ultrasonic sensor, LCD and the Espresso chip that is a node MCU ESP8266 platform, which gets linked with the accessible WIFI network, gives notifications through email and updates the user system, this system uses the Arduino programming in the device. This Arduino UNO board has an interface of a proximity sensor, ultrasonic sensor, LCD, motor driver, node MCU ESP8266.

In [2], This paper describes the efficient collection of waste in terms of truck fuel and cost. This system is IoT based, which gives information regarding poisonous gases that are releasing from the junk collectors and also the fill time status of a dustbin. This system also aims to optimize the collection of waste, like the shortest way for vehicles to reach bins. It uses sensors like GSM/GPRS to analyze the junk collectors, in this system, each dustbin is interlinked and calculation of time, monitoring of bins and transmission of vehicles are made from the base station.

In [3], The proposed model describes waste management using solar panels append to junk collectors. Solar smart dustbins consist of two bin appended in the same place, one junk collector is to gather junks, in which waste may be broken down into methane, carbon dioxide, and some other molecules and may produce toxic gasses, utilize of another junk collector is to gather normal wastes like bottles, papers and some of the cities will partition these dustbins as dry waste and wet waste. This project uses solar energy for charging the 12v battery through a solar panel, which eventually helps GSM modules. These junk collectors create problems in operating systems, during unpleasant weather conditions.

In [4], This system aims to automatically open and close of a dustbin bonnet if there is any appearance near to its vicinity range. At the front side of the dustbin, the system uses two IR sensors to detect an obstacle, so it works automatically close and open of bonnet using a servo mechanism. Usually, this form of junk collectors uses two bins, the specialty of these junk collector is not to allow putting garbage in a 2nd bin unless 1st bin is brimming and once 1st bin is full, it won't open until we make that empty, this helps to reduce the overflow of a dustbin. 12V battery, Arduino UNO, ultrasonic sensors are used to control the whole working performance and to detect the garbage level in the junk collector. It also uses the GSM module to send messages to the concerned department once the level of garbage in the junk collector reaches full.

In [5], This paper tells us about another way of building smart dustbin and monitoring its status by user-built android application. This model is an IoT Based, which needs sensors to know the level of junk in the bins and also adopts the GSM/GPRS system to inform the user if the dustbin is full, microcontroller acts as a link between sensors and module GSM/GPRS for the proper functioning of the system. This system uses LED as an indicator to signal. The output indications are made visible on the LCD screen if the signal of LED is green, then DUSTBIN- EMPTY is displayed on the LCD screen and DUSTBIN- FULL is displayed, if the LED glow RED. These texts are written according to the user's understanding and displayed on LCD.

III. METHDOLOGY

A. Block Diagram

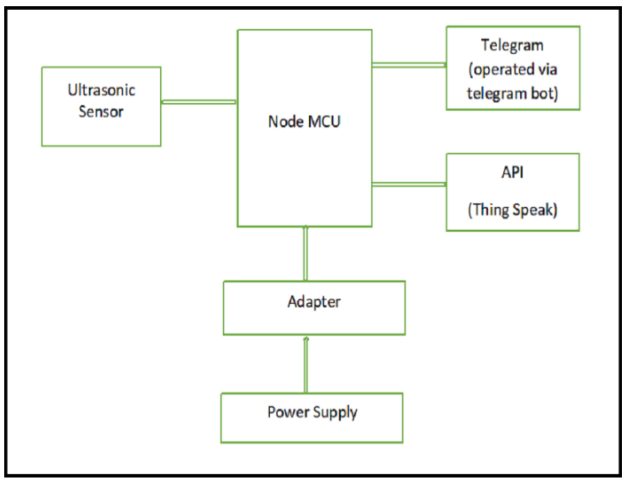

Fig. 1. Proposed outline of the module.

In the above block diagram, shows of interfacing of various hardware peripherals. Adaptor acts as an external power supply here, both ESP8266 and Ultrasonic sensor get power through the adaptor. Here Node MCU gets connected to the available WIFI network, with the interface GPS Module, which provides the location of each dustbin, and the quantity of a dustbin is updated through messages via Telegram and also gets updated in the cloud (Thing Speak). If the junk level outstrips a cusp of the total limit of the junk, it apprises the linked servers, through a networked application program called telegram and also updated in the cloud ("Thing Speak") built for this design. Our Thing Speak channel also stores associated information like content level, clean-up time, date, time entry, and location, to name a few.

B. Hardware Components

TABLE I.

Serial no	Components	Specifications
1	Ultrasonic Sensor	HC- SR04
2	Microcontroller WIFI	NodeMCU ESP8266
3	Adaptor	5V

HC-SR04 Ultrasonic Sensor

Fig. 2. HC SR04

Ultrasonic sensors are mostly and widely used in detection, in industrial operations to encounter shield tracks, sporadic in metals, composites, plastics, ceramics, and for water level detection. Since ultrasonic sensors use sound as a medium instead of light for detection, the laws of physics are used, which mark the propagation of sound waves through

solid materials. It measures the distance from the nearest impenetrable object, yielding a range of measurements of around 2cms-400cms. On detection of reflected wave Echo pin is enabled.

$$S= (v*t/2) *100$$

S gives the length measured from the impenetrable body that reflects the sound wave from collision point.

v is the speed of sound in the medium, considering it as 340m/s.

t is the time required by reflected wave to be reversely

detected by the sensor after colliding with an opaque object.

Speed of sound:

$$v=240 \text{ m/s.}$$

v= velocity of sound.

Time= distance/speed

$$t= s/v= 10/0.034=294 \text{ micro/s}$$

Distance:

$$S= t*0.034/2 \text{ (in cms)}$$

Microcontroller

Node MCU is an economical free source.

ESP8266 gets linked with the accessible Wi-Fi network and gives notification through telegram and updates it in Thing Speak. By using the K Means clustering algorithm along with data gathered from sensors, it decides whether the dustbin is filled up or not. Its main elementary objective is to send messages through telegram each time when the sensor finds that there are objects under 4cmsaway.

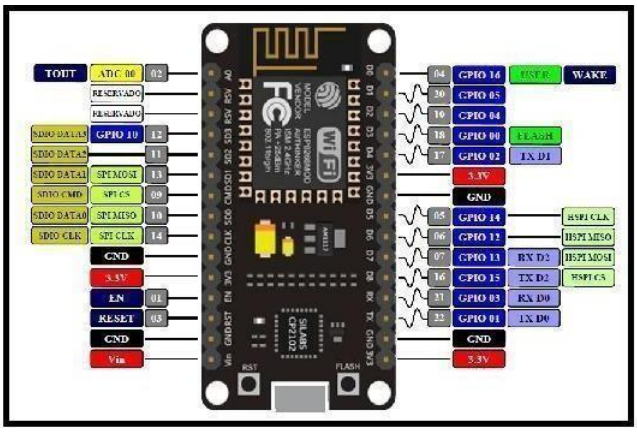

Fig. 3. NodeMCU ESP8266 Pin diagram

Adaptor

An AC/DC converter or AC/DC adaptor is used as an external power supply, analogous to an AC plug. Hence, the adaptor is used as an external power supply for our microcontroller (NodeMCU ESP8266), through which supply also given to IV sensors and GPS modules.

Fig. 4. Adaptor

C. Software Tools

Thing Speak

Nodejs Style Network API;

For network applications, event-driven API is used, which aids developers, researchers, enthusiasts for writing and testing different code in a Nodejs style. Which in turn enhance and accelerates the process development of IOT operation. By using a free and open- source IoT application and API known as Thing Speak, used to store and fetch data from stuff with the use of HTTP and MQTT protocol through the Internet or LAN. Thing Speak facilitates the development of applications such as sensor logging, tracking location and social network of things with every time status update. Due to the integrated support of MATLAB with Thing Speak, live data streams can be easily analyzed and visualized, and also allows to aggregate live data is easy.

Telegram

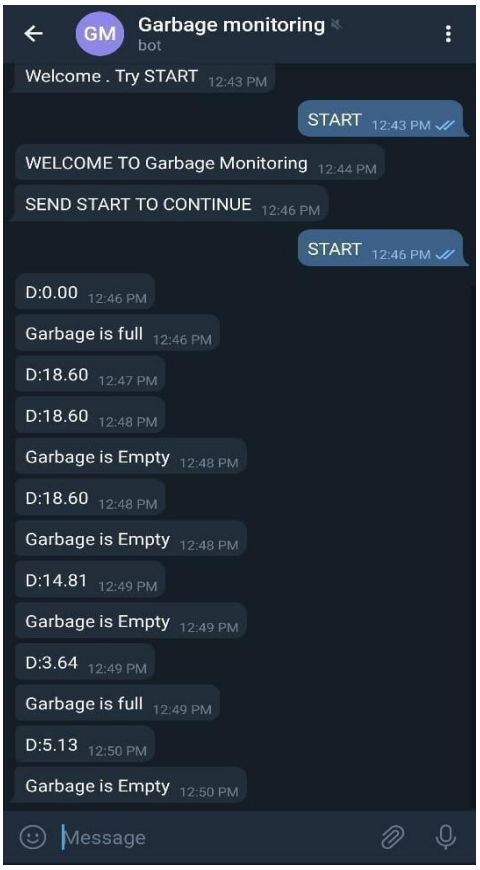

Fig. 5. Screen Shot of Bot Telegram

Telegram is an instant messaging and cloud-based voice over IP service. In our project, we make use of Telegram bot named "garbage-monitoring-system", to receive the updates and status of the particular dustbin. Inline Bots are operated by programs known as telegram accounts, which can be used from any chat screen. To activate an inline bot, the user needs to type a bot name along with the query, which then offers its content for the request.

D. Interface

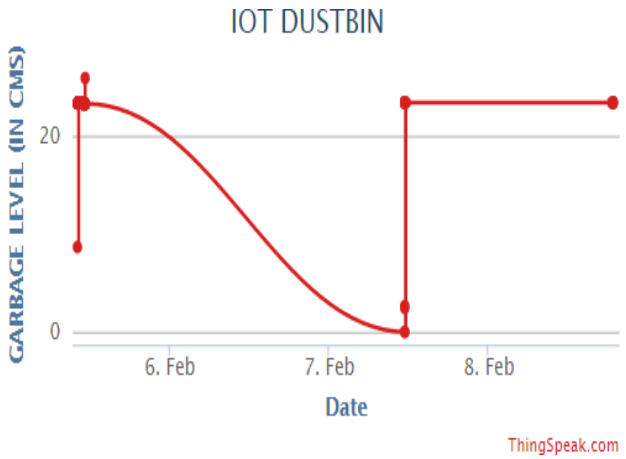

Fig. 6. Garbage Data Analytics

Fig. 7. Location of Dustbin

On clicking, bin icons manager gets to know the following garbage monitor attributes:

- The If dustbin content level if full, LED turns red.
- Periodicity of Dustbin getting filled and last cleaned, by giving its average frequency of the number of routine clean-ups.
- At what time dustbin previously was filled.
- At what time dustbin previously was emptied.
- Complete analysis of different dustbins content level.

Fig 6. Shows the complete analysis, where the Y-axis shows the content level of dustbin in CMS and the X-axis shows the time and date of particular.

E. K-Means

An approach of vector quantization popularly known as K means clustering derived from signal processing, used indata mining for cluster analysis, where segregation of the observations into K Clusters, in which each consideration resides to the mean value of a forthcoming cluster prototype, by figuring out the distance between each combination of observations chosen.

A Euclidean measure function used in our application is as stated below: -

$$d_{\text{Euclidean}}(x, y) = \sqrt[2]{\sum_{z=1}^{n}(x_z - y_z)^2}$$

TABLE II.

ATTRIBUTE	DESCRIPTION
Dustbin_no	Primary Key
Locality	Location of dustbin
Junk_percent	Level of junk in dustbin
Longitude	Longitude Location of bin
Latitude	Latitude location of bin
Content_fill_time	Full time of the dustbin
Content_clean_time	Clean time of the dustbin

F. Optimizing periodic clean-ups and Dustbin placement

Our target is to determine the routine clean-ups required to the implanted area of the junk collector. So that maximum time of the day, the area under the establishment of dustbin stays as free as possible. Hence, we employ the K Means clustering algorithm to limit the number of clean-ups occurring in a day. On depending on the K value as given by management or BBMP, it clusters the collected data on the fill time feature into K clusters. Hence several routine clean- ups for the day are found by cluster centroids so that junk collectors stay free as possible for the entire day. Additionally, we examine the optimizing time by computing range and standard deviation.

Also, we find multiple data items by using a clustering algorithm to the same dustbin by altering the place of the same junk collector at a certain distance to check whether data items generated are either too far away from the centroid. If there are numerous data items related to the identical junk collector in a peculiar cluster, then it points the regularity of getting dustbin filled is too high, for which the algorithm recommends placing an additional junk collector near to the prior dustbins. The data sets generated shows the positive effect of installing a newjunk collector.

IV. RESULTS AND DISCUSSION

A. Standard Deviation

Standard deviation (SD) is a quantity that measures the extent of change or diffusion of data value sets. On low SD, the values tend to close to mean value of set while a high SD indicates a greater deviation extent.

Hence here it indicates a difference in cluster data and centroid, with use of formula given below:

$$S.D\ (S_y) = \sqrt{\frac{\sum_{m=1}^{n}(y_m - \bar{y})^2}{x}}$$

B. RANGE

In statistics, the set of data range is the disparity between the largest and smallest values in the data set.

$$Range = Y_{max} - Y_{min}$$

In our application, the range should tend towards a minimum for the feasibility of the application.

C. Levels of Result

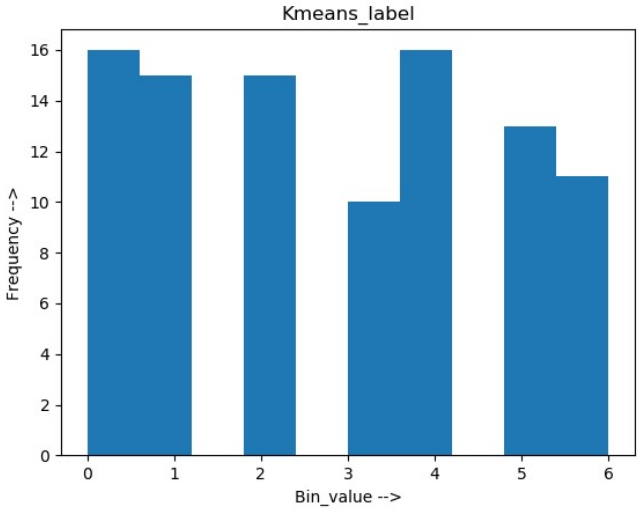

Fig. 8. K-means label

Above figure shows the histogram of K-means labels. After collecting raw data by identifying each dustbin particularly with Dustbin_no and finally obtaining zoo data of all the dustbins placed at locations shown below.

Table III.

Location	*Total Dustbins*
Hostel premises	2(Bin1, Bin2)
Playground	2((Bin3, Bin4)
Café corner	2(Bin5, Bin 6)

After a congregation of 21 days of data and the number of routine cleanups were derived from the zoo data gathered. Then Algorithm suggested placement of new dustbin at the location where the dustbin was getting filled up soon and an immediate clean-up is required.

As data collected is enormous, hence we apply PCA (principal component analysis) to filter noise in the datasets. The following figure shows the principal component analysis of data sets,

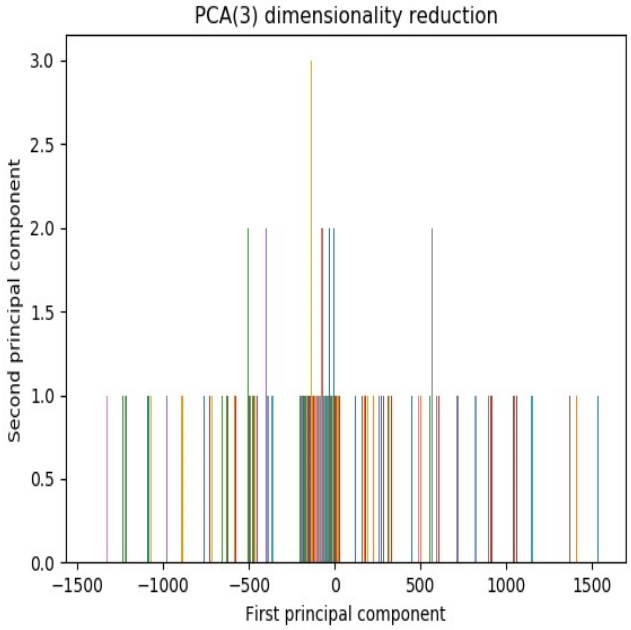

Fig. 9. PCA Dimensionality reduction

After applying PCA the data set is fed into algorithm for clustering which provides the below result.

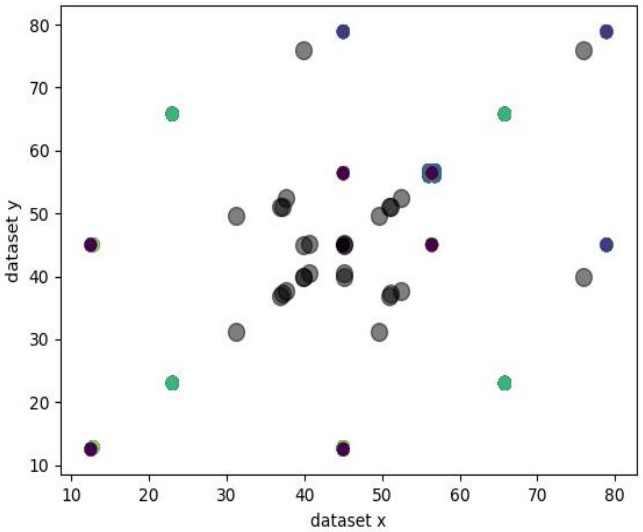

Fig. 10. Formed Clusters after 21 days on applying PCA

The clusters formed for the original data set without considering the attribute reduction method we obtain the following clusters.

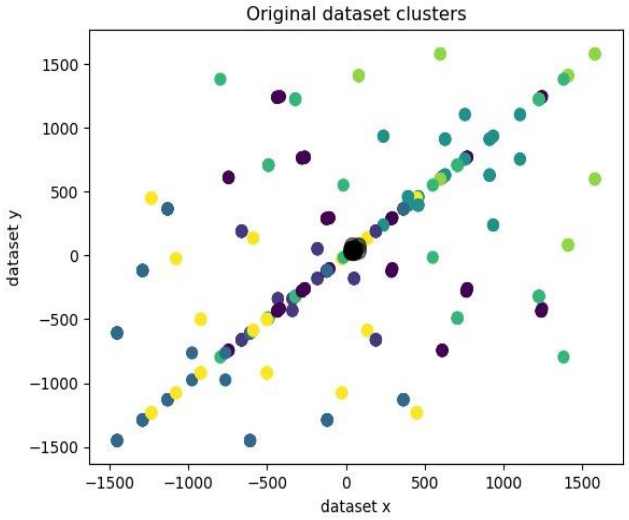

Fig. 11. Original data clusters

After the congregation of 21 days of data and on data analysis, we choose K value as 7 with 96 distinct iterations on PCA (principal component analysis) analysis we get cluster data with centroids and following results obtained.

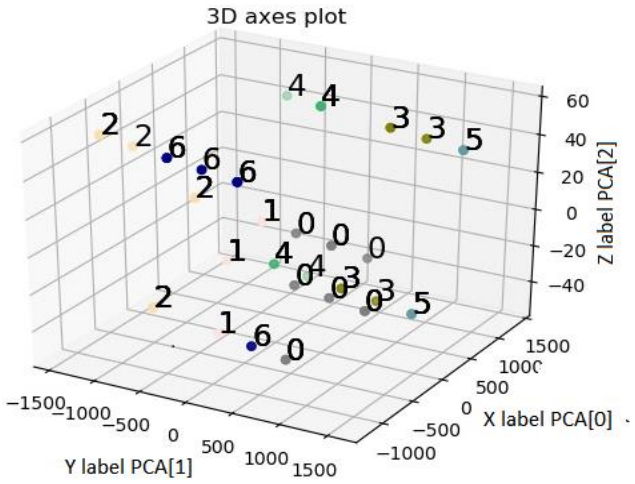

Fig. 12. 3D Axes plot of formed clusters

Formed clusters data fed to PCA for dimensionality reduction and hence we obtain the noiseless 3D axes plot of clustered data with centroid co-ordinates, further which then gives the dustbin placement location by algorithm suggestion.

Heatmap: -

We are generating co-relation heatmap by SNS (visualizing dataset structure) in order to output console which is further required for generating correlation data.

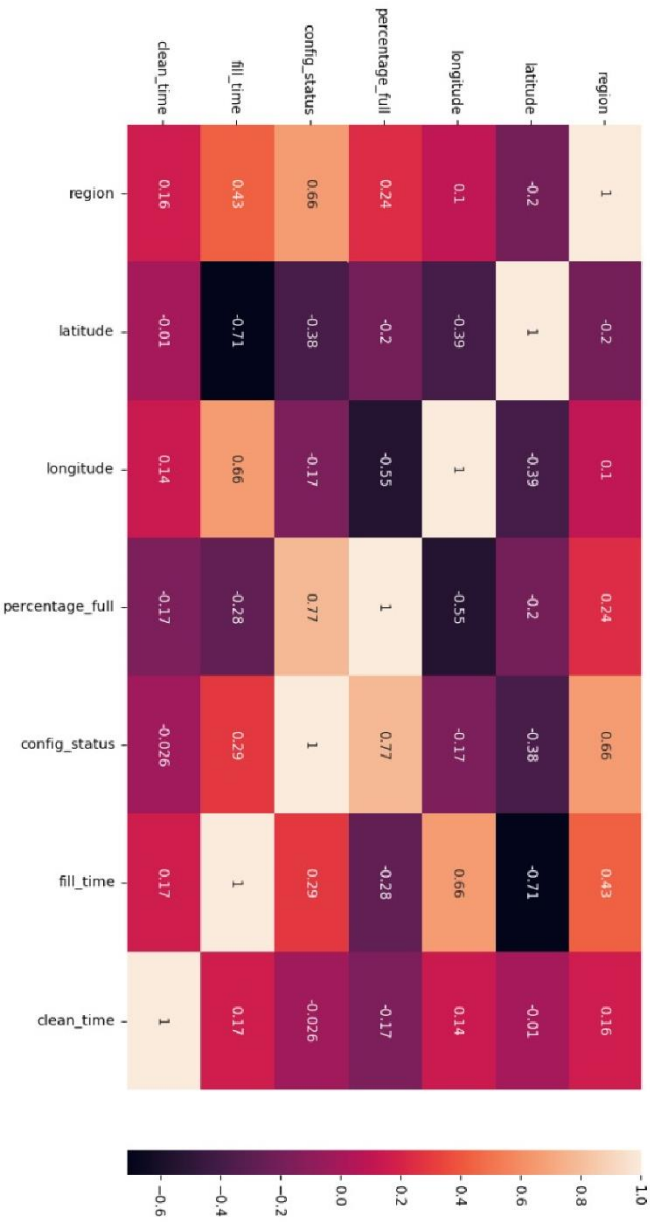

Fig. 13. Heatmap of dataset

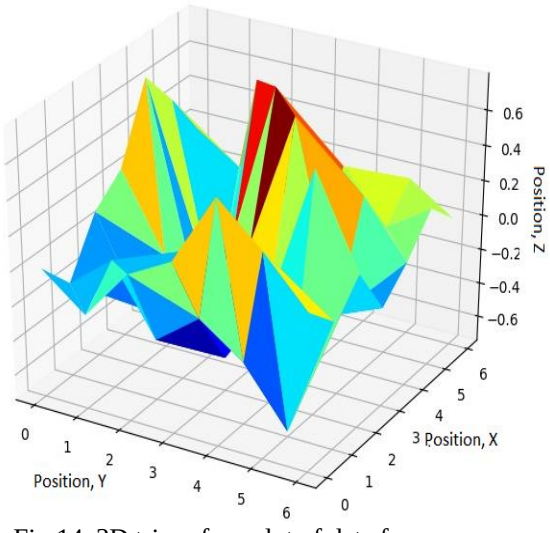

Fig 14. 3D tri-surface plot of data frame

We generate the co-relation data from wide range of dataset, by generating co-ordinates with corresponding co-relation values. By flattening data frame values and by converting list of tuples in to tri-variate data frame.

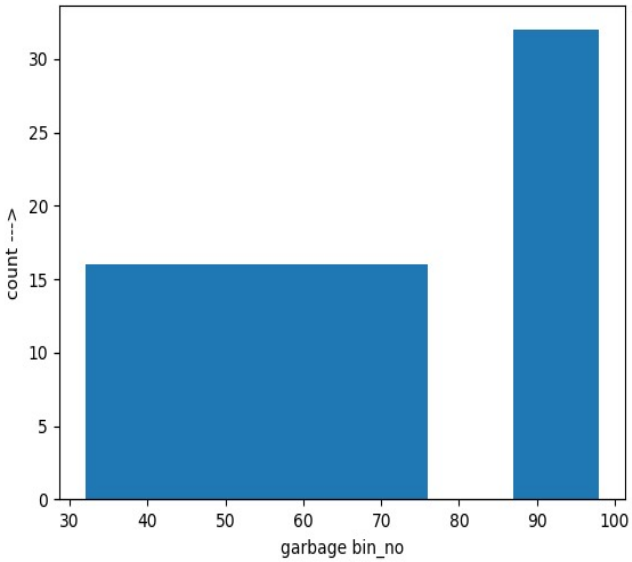

Fig. 15. Percentage configuration of Dustbin

The results regarding clean-ups were:

Table IV.

Dustbin_no	*Average cleaned time before dustbin is full (in minutes)*
Dustbin_1	00:41:44
Dustbin_2	00:45:24
Dustbin_3	00:31:48
Dustbin_4	00:32:33
Dustbin_5	00:24:21
Dustbin_6	00:25:24

On the complete analysis of data, we observe that Dustin number 6 nothing but the Dustin near the Café corner is getting filled soon and hence new dustbin allocation is suggested at 78.9(latitude) 45.60(longitude), in order to prevent dustbin getting filled up soon.

Hence on enhancing the storage efficiency, further new dustbin installation has caused positive effect on our scheme.

On an average the standard deviation of different centroid clusters is given by

Table V.

Cluster_no	*Standard deviation (in Hours)*
1	0.558983
2	0.634636
3	0.574383
4	0.481259
5	0.510172
6	0.702365
7	0.428684

On an average the standard deviation is now 0.555783 hours (33 minutes 22 seconds), this analysis shows that dustbins are getting cleaned every 33 minutes 22 seconds before getting filled completely. Which requires 4 routine clean-ups daily which is further enhanced on new dustbin placement.

On an additional bin placement, we concluded that it had a positive effect as the data range was increased on an average and there is reduction in standard deviation by 0.12757 hours (7 minutes 40 seconds), and hence our optimization turned out to have some admiring effect.

Similarly, in order to enhance dustbin placement and by considering the cost limit, we found that this scheme has enormous effect on choosing large geographical area under consideration for employing the project, as large as area under consideration so high is the enhancement and cost effective, for setting up junk collectors.

V. Conclusion

Finally, on experimenting and after the analysis of data generated, the number of routine clean-ups can be enhanced. The number of optimum clean-ups varies as on with different placement of dustbins and on particular days of times. The number of routine clean-ups derived varies from 5 to 6 times on optimization. If this were carried out in large fields like city or Industry, by limiting the number of clean-ups, as the number of clean-ups increases it turns out to be infeasible. Taking the standard deviation and routine clean-ups measure, average SD value gives the time duration dustbin was left without cleaning even after getting filled.

Hence in short distances, it proved to be not feasible, hence implementation in wide areas may bring out the feasible number of clean-ups and thus enhancing efficiency.

Hence, in future considering 'region' as an attribute for clustering the dustbin placement can be modified and new dustbin installation place can be found as on increasing the geographical area the number of routine clean-ups can be optimized and make sure dustbin is free as possible for the complete day. Hence, the BBMP board/administration can analyze the cost with the benefits of planting additional dustbins at required locations.

As we have a large-scale data collection, due to which big datasets are produced with high level of non-linearity, hence machine learning concept of K-Means clustering is efficient for big data sets. Which gives improved efficiency and speed as on training model day by day, by considering the required attributes and neglecting not required attributes. For which we use PCA (dimensionality reduction) for our datasets which is not possible in CNN, most commonly applied to analyzing visual imagery (Image clustering). Hence model training becomes difficult and future outcome predictions may not be up to mark in CNN for our unsupervised learning, but K-means clustering algorithm has efficient outcome, fast, flexible, when centroids are recomputed the cluster changes and finally it has better computational cost and less complex.

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