Astute Recycle Bin Management Conglomerate with Brisk Air Vintage Monitoring Regime

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Abstract- *For the clean nation to work, our country initially needs to take care of its waste disposal issues. Internet of Things (IoT) can play an important role in order to keep metropolitan area greener, invulnerable and most effectual manner. In smart cities, the waste disposal technological solutions can be accomplished by making different collaborators work together. Despite, continuously frame working such solutions on an open standard based communications program is a challenge. Internet of Things (IoT) is a concept that can connect various physical objects to the Internet with the help of sensors and other wireless technologies. This paper presents a waste accumulation management and air pollution monitoring solution based on providing intelligence to recycle bin by utilizing an IoT prototype with sensors that can read, collect and transmit the huge volume of information over the Internet. In order to manage the waste collection dynamically and efficiently, the accumulated data is given into a spatiotemporal context and processed by graph theory optimization algorithms. This paper mainly focuses on the monitoring system and forecasting module. The conclusion of this paper could give a chance to be effectively advantageous to disturbing provisions clinched alongside areas for high air pollution levels.*

Keywords- Air Quality Monitoring, Internet-of-Things, Machine Learning Algorithms, Sensors and Smart Waste Management.

I. INTRODUCTION

Worldwide interest in Smart Cities has aggrandized, encouraged by the need to find effective remedies to the major challenges foreseen for the next years [1]. The garbage management is becoming a global problem due to rapid population growth, disorganization of city governments, lack of public awareness and limited funding for programs. With the generation of the populace, the scenario of cleanliness with respect to waste management has become crucial. In order to overcome this issue, necessary care should be taken by corresponding authorities and should figure out the strategy can be taken after. Later investigations have demonstrated considerable proofs that purposes of presentation with climatic pollutants need a strong link to unfriendly illnesses including asthma and lung inflammation. Acknowledging the significance of air quality with respect to human lives, the World Health Organization (WHO) created rules to lessen the production of various air pollutants, such as ground-level ozone (O_3), nitrogen dioxide (NO_2) and sulfur dioxide (SO_2) [14] and securing public health. 70 percent of the world populace will be urban and most urban development will happen in undeveloped countries by 2050. Necessary steps need to be taken for improving the quality of life and requires extensive development of infrastructures related to social, economic, physical and institutional fields.

This paper deliberates a smart mechanism for improving the management of wastes and monitoring the air pollution in urban areas. Waste and Air Quality Management is a method of collection, transport, processing, managing and monitoring of waste materials and air quality such as O_3, NO_2 and SO_2. The proposed framework establishes a foundation of Geographic Information Systems (GIS), applied graph theory on graph optimization and machine learning. It comprises a youth based prototype with sensors measuring the waste volume in trash cans with the capability of sending information to the internet via a wireless link. This data is used to optimize the management and strategies of waste collection logistics In case of air quality monitoring; three machine learning (ML) algorithms are investigated. These ML algorithms are support vector machines (SVM), model trees (M5P) and Artificial Neutral Network (ANN). Furthermore, for time series data modeling multivariate is utilized. These algorithms prepare models that are recognized similarly as nonlinear estimators, with good predictive and generalization abilities, which are successfully applied in various fields. The acquired output indicates that most ML algorithm's forecasting performance is improved when multivariate modeling is utilized. The main objective of this system to be implemented is to supersede the tedious existing system which will aid city to become a Smart Metropolitan area.

II. RELATED WORK

The Recycle bin management and air monitoring system play an important role in urban areas. The waste management in metropolitan has to be produced and meticulously implemented. Many research works are done tremendously on this topic, some of these are given below.

In [1] system uses a low-cost air-quality monitoring system that is furnished with a variety of gaseous and meteorological sensors. The modules are responsible for storing the data and converting the data into useful information, forecasting the pollutants based on historical information and finally presenting the acquired information through different channels, such as mobile application, Web portal and short message service.

In [2] paper present a waste collection management solution based on providing intelligence to waste bins, using an IoT prototype with sensors. It can read, collect and transmit the huge volume of data over the Internet.

According to [3], the main intention is to study the implementation of the smart garbage management system using IR sensor, microcontroller and Wi-Fi module. It merely provides the brief idea about the cleaning of dustbin when the garbage level reaches its extremity.

Another strategy for recycle bin management is introduced Smart Recycle Bin [4] as follows. This paper mainly concentrates on the review of an adequate increased rate of resource consumption and waste production and thereby providing a scenario to encourage the policymaker to recycle and reuse of raw material rather than polluting the land.

In [5] an advanced Decision Support System (DSS) for adequate waste collection in Smart Cities is suggested. The system consolidates a data sharing model between truck drivers in real-time in order to perform waste collection and dynamic route optimization. The waste gathering framework target to give high caliber of administration to the residents of a Smart City.

The proposed system in [6] illustrates the detection of wastage with the assistance of Sensor systems and imparted to the authorized control room through GSM system. The microcontroller is utilized to associate with the sensor framework with GSM system. The garbage from the different selected locations is monitored the desired information using the GUI. This will deal with the waste accumulation productively.

The authors in [7] have built a framework in which a Camera will be set at each garbage collection point alongside load cell sensor at the base of the waste can. The camera will take ceaseless previews of the waste can. After examining the image a thought regarding the level of garbage in the can and from the load cell sensor, weight of garbage is known. This is convenient to utilize however economically not solid.

III. PROPOSED WORK

In this paper, the proposed work is the air monitoring system along with the smart Recycle-bin management. The data obtained through the sensors is transmitted over the Internet to a server for data collection, communication, storage and processing mechanism. Based on the waste bins picked from different locations, the device used to monitor the daily selection of waste bins and also multi-gas sensing (MGS) attached to the waste bin for sensing the quality of the gasses present in the environment. Each day, the navigational device provided to the workers receives the updated optimized routes. The noteworthy characteristic of this framework is that it is designed to update from the last encounter. Furthermore, it decides the daily waste level status and also predicts the future state with respect to factors like traffic congestion in an area where the waste bins are placed, cost-efficiency balance and other factors that are difficult for humans to observe and analyze. In view of this authentic data, those rates toward which waste bins get filled are easily investigated. The figure1 shows the system architecture with a brief components' idea given below.

A) Sensors

With the help of sonar, the waste level can be measured from the top of the recycle bin to the waste accumulated. In this prototype for a typical waste bin, the sonar should be of measurement from 2cm to 400cm with 3mm accuracy e.g., Ultrasonic Ranging Module (HC-SR04). It is vital to optimize the battery utilization to accomplishing greater lifespan of the device. Gathering and forwarding of data might be carried out once or twice in a day.

B) Controller

The microcontroller exercised in this scheme is ATmega328 is an 8-bit exalted achievement microcontroller of Atmel's Mega AVR clan. Atmega32 can function on a supreme frequency of 16MHz. Atmega32 is bottomed on refined RISC (Reduced Instruction Set Computing) framework with 131 vigorous commands. ATmega32 has 2 KB programmable flash memory, static RAM of 2 KB and EEPROM of I KB. The operating Voltage is 5V and power

consumption 40 to 50 mA. The microcontroller is adequate for gathering information from sensors and sending them to the Internet through a network interface. The choice of microcontroller depended on the required processing, memory, less power consumption and lower cost.

C) Multi-Gas Sensing Devices

MGS devices comprise four gas sensors, data logging, communication and controlling boards. The gas sensors can be either electrochemical or metal-oxide semiconductor sensing technology. The devices are then exposed to a sample of the ambient air every 15 minutes where every sensor generates an electrical analog signal proportional to the amount of the gas exists in that sample. The electrical signals are then fed to the analog inputs of the controlling board and converted into digital values that are mapped to the concentrations of the monitored gases. The precision of the sensors is ±10% and resolution is within 20 ppb. The values would afterward store in the data logging board and transmitted wirelessly using GPRS protocol to the central platform through the GPRS modem. The device is also equipped with temperature, relative humidity and wind speed and direction sensors. Lastly, these devices aided to power toward solar energy system composed of a solar panel, a battery and a charging controller. Every 15 minutes the battery voltage level is sent along with the data.

D) Network Interface:

The information gathered is sent to a remote server by means of a remote connection by utilizing WiFi. The CC3000 module is self-contained wireless network processors which lessen the usage of Internet connectivity and furnishes an incredible coupling with the microcontroller used. The CC3000 Shield with on-board Antenna and gives an ideal solution for embedded applications using any low-cost and low power MCU.

E) Battery:

It is essential to optimize the battery usage to expand the life expectancy of the devices. Sensing and data forwarding rates and wireless technology have a strong influence on energy consumption. In this specific case, data are collected and forwarded once in a day. The estimated device battery life is no less than two or three years considering the used technologies and conditions.

F) Database:

The information gathered by the sensor and the truck is stored by using a MySql database.

G) Artificial Intelligence (AI):

Historical data through an artificial intelligence algorithm will determine the forecast of waste levels for the future and determine accordingly for the selecting of a waste bin in daily bases.

H) Optimization algorithms:

Once the identification of waste bin has been done, route optimization algorithms calculate the best route to follow. In this work, the routes are optimized for the driving distance, such as to minimize driving time based on historical data on traffic congestion.

I) Information adaptation and forwarding:

The collectors receive information from the destination path in an understandable format as a KML file by using visualization devices.

J) Data collection:

For a better selection of routes, GPS location might a chance to help and determine the traffic flow on the distinctive lanes. The Artificial Intelligence and Optimization Algorithm modules gather this information to learn and improve the selections and routes.

K) Visualization for end-user:

The end users receive the path via mobile phones, potentially installed with cameras, to facilitate the driver to effectively follow the path.

Algorithms

Shortest Path Spanning Tree (SPST) [8]: This algorithm program is employed to figure the shortest distance between two points in the area (for example, two trashcans), combined with GIS data of the streets within the city. The street network can be represented as a graph where street segments are edges and the joining points are vertexes. Subsequently, it is conceivable to figure a realistic short driving distance between points by applying SPST. The distances are essential as an input for the route optimization process. For viable reasons, it is convenient to re-compute the distance from all-to-all trash cans to accelerate the route optimization process.

Genetic Algorithms (GA): Collection routes are basically traveling cycles which comprise of a set of trash cans and cause a combinatorial surge problem. The objective of this optimization is to minimize the driving distance; the problem is well known as The Traveling Salesman Problem and closely related to The Minimum Linear Arrangement Problem which is NP-hard [9]. In order to carry out the high number of route optimization experiments, GA provides the relatively fast near-optimal solutions.

K-means [10]: Clustering is likewise an NP-hard problem, particularly complex to tackle while including hard clustering size limitations. Nonetheless, the investigations completed in this work don't have such limitations and K-means gives a simple and quick answer for the clustering issues to be understood.

ML APPROACH

The ML algorithms used for building the forecasting models based on the future steps to be predicted and multivariate modeling is utilized. ML includes computational methods that enhance the execution of mechanizing the obtained information from experience [11]. Machines learn from complex data to have the capacity to take care of issues, answer questions and be more insightful. One of the assignments that profoundly include learning is forecasting, in which the forecasting model is worked through preparing for data that is generally nonlinear on account of air quality [12]. Therefore, an approach based on linear modeling is not reasonable for such information [13].

In particular, the precisely predict concentrations of O_3, NO_2 and SO_2 are considered due to most harmful gases [14]. Before utilizing the nonlinear modeling strategies, all gases are verified for the nonlinear structure of the data. Here, Brocke-Decherte-Scheinkman (BDS) method is utilized [15]. The BDS statistic is processed and the null hypothesis of linearity is rejected at the 5% critical level, thereby the non linearity in the data is checked.

Multivariate Modeling: In order to predict the target gas future values, various features are consolidated including:

i. Temporal features such as, the hour of the day and the day of the week as they are indicative of traffic volume which directly increases pollutants in the air.
ii. Meteorological features such as temperature, humidity and wind speed. These measures have played roles in the formation of specific pollutants, for example, O_3.
iii. Measured gases collected from the similar sensor since some gases are by-products of other gases' interactions such as SO_2 results from an interaction of H_2S and O_2 [16].

In order to build ML-based forecasting models, there exists a plenty of algorithms which acts differently to the given data. Some of the most effective models are SVM, ANN and M5P.

SVM is a regulated learning strategy that can be utilized for taking care of classification and regression problems. SVM regression mainly aims to discover an approximation to a nonlinear function that connects the input data into higher dimensional space.

ANN is a network of nodes associated with input layer, hidden layer(s) and output layer. In a feed-forward neural network, input data are applied to the nodes in the input layer and afterward, it is engendered through the network passing by hidden layer nodes after that to the output layer [17]. The estimation of each hidden node is computed as the activation function of total weighted input of that node [18]. To train the network, ANN utilizes a back-propagation algorithm. In this phase, the output of the network is contrasted to the actual correct output and an error is computed. This error is propagated from the output back to the hidden and input layer and changing the weights of each connection in the network layers. To minimize the error, the procedure again repeated.

M5P is a model tree algorithm which has the combination of trees and regression models. It has the structure of a tree with linear regression models at the leaves. These regression models are linear multivariate regression equations that can be resolved to discover the predicted values [19]. M5P coordinates the key advantages of trees and regression equations. Trees are generally significantly bigger and more intricate than the regression equations, but they are more accurate. In many cases, trees are cumbersome and difficult to translate into account of its vast size. That is the reason model trees combine the exactness of trees and effortlessness of regression models [20].

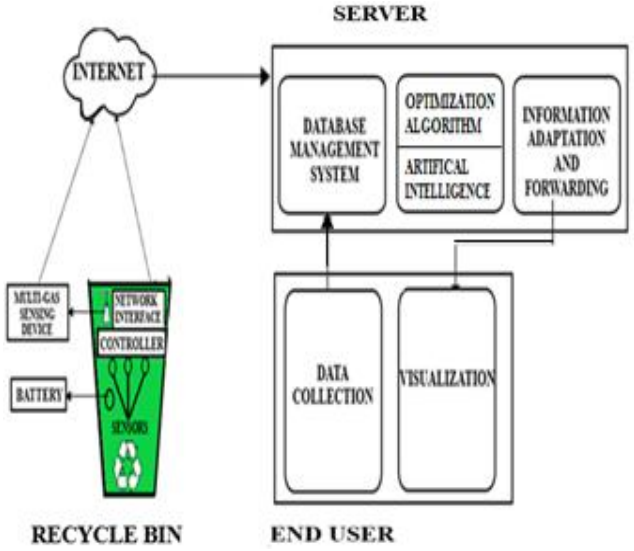

Fig 1: System overview of Smart Recycle Bin Management and Air Monitoring System

IV. CONCLUSION

Air quality and waste disposal is an important problem that directly affects the human environment. This paper presents a practical Smart City use case of an intelligent waste collection and air monitoring cyber-physical system. The system is based on an Internet of Things sensing prototype which measures the waste level of trash cans and air quality data are collected wirelessly from monitoring motes that are equipped with an array of gaseous and meteorological sensors. For storage and processing, this data send over the Internet to a server. Based on this data, an optimization process allows creating the most efficient collection routes and these are forwarded to the workers and also used in forecasting concentration values of pollutants using the intelligent machine to machine platform. The platform uses ML-based algorithms to build the forecasting models by learning from the collected data. Using multivariate modeling approach enhances the prediction accuracy and reduces error because of the dependency between target gases and other features included such as temperature, a day of the week and H_2S.

This work can be extended by considering data changes over time for real-time forecasting. This can be achieved by building online models that adapt automatically to changes in the environment. Also, more data can be included to increase data seasonality. In the future, the natural step to take is to test how the use of historical data analysis can improve the efficiency and collection costs of dynamic strategies.

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