Smart Cities: Waste Minimization, Remanufacturing, Reuse, Recycling Based on IoT

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***Abstract*--As the population of world is increasing day by day, the environment should be clean and hygienic for our better life leads.Due to rapid growth in the population automatically demands better infrastructure and more facilities. Employment and attaining balance in economy is an important concern for a nation having such rapid increase in its population, which finally results into evolution of new urban areas and cities. A smart city is created upon various particular components and strong waste administration is one of these crucial viewpoints. In this case, waste minimization or waste management is one of the primary problems that the world faces irrespective of the case of developed or developing country.In most of the cities the overflowed garbage bins are creating an obnoxious smell as well as pollution and making an unhygienic environment which is causing different types of diseases. To overcome these situations efficient systems are getting developed based on internet of things (IoT). In this paper, we inspire and propose an IoT using waste minimization system for Smart Cities. The main purpose of project is to develop the system which uses the information collected from sensors to manage the collected waste as well as also discuss waste minimization by remanufacturing, reusing, Recycling.**

Keywords--Internet of Things (IoT), Smart cities, Smart waste bin; Solid waste management, Sensors, Waste Minimization.

I. INTRODUCTION

Waste minimization or waste management is a name given to a waste collection system, including its disposal or recycling.This term is attributed to waste material that is produced through a human activity which must be handled to avoid its adverse effect for health and for the environment. Most often, waste is managed to reuse available resources. The management of waste in metropolitan or smart cities and rural areas is the general responsibility of a municipality, while waste produced by industries is their responsibility and managed by them. Internet of Things (IoT) has a main role as a key facilitator of the integration of various application solutions and communication technologies which is a new and promising technology, which has the potential to globally change human life in a positive way, thanks to its diverse connectivity.Things (Embedded devices) that are connected to Internet and sometimes these devices can be controlled from the internet is commonly called as Internet of Things. IoT provides exchange and linkage between low energy devices and interactions through the Internet. Many applications around the world have been implementing different operations, based on the background of IoT, to offer novel services for smart cities and optimize energetic efficiency. One important application is that IoT technology has become a practical and efficient tool to build smart cities. In the recent years, there was a rapid growth in population which leads to more waste disposal. So, proper waste management system is necessary to avoid spreading some deadly diseases. The basic project idea is to design a smart waste detection system which would automatically notify the officials about the current status of various garbage bins in the city, would have real-time monitoring capabilities.The main purpose of project is to develop the system which uses the information collected from sensors to manage the collected waste as well as also discuss waste minimization by remanufacturing, reusing, Recycling. To overcome wastes it can be done using the sensors and notify the controlling the authority in the control room through wireless communication. The system uses a less operational time cleaning the garbage in the city, which can make the city a smart city. This is easily achievable due to the GPS employed and the GUI application built in the mobile phones. Waste minimization is important because it helps protect the environment and it makes good business sense. In fact, businesses can simultaneously manage both business and environmental objectives by focusing on waste minimization. For example, companies have discovered that waste minimization:

Types and Methods of Waste Disposal:

The garbage generated by various segments of society can be classified according to its composition and destination. This classification is fundamental because it facilitates the selective collection, the recycling, and the definition of the most appropriate goal. These solid wastes discarded by urban municipalities represent a highly heterogeneous volume of matter, as well as a more homogeneous load of industrial and hospital waste. Currently as elective collection is the basis for proper waste management and the primary method adopted around the world when the goal is recycling. The different types of considered waste are described as follows:

- *Organic Waste* - It is the garbage derived from organic waste. They are generated mainly in residences, restaurants, and commercial establishments that work with food. They must be separated from other types of waste since they are mostly destined to municipal landfills.

- *Recyclable Waste* - It is all the waste that can be used in the process of transformation to other elements or in the manufacture of raw materials. It is generated in residences, companies, and industries, and must be separated so that the selective collection teams gather and then deliver to final processing in cooperatives and recycling companies.

- *Industrial Waste*-They are the residues, mainly solid, originating in the process of production at industries. It is

usually composed by leftovers of raw materials destined for recycling or reuse in the industrial process.

- *Hospital Waste* - It is the waste originated in hospitals and medical clinics and can present contamination and transmit diseases to people that come into contact with it. It should be treated according to established standards, with all possible care. This type of waste is intended for companies specializing in the treatment of such waste, where it is usually incinerated.

- *Commercial Waste* - It is the one produced by commercial establishments, such as clothing stores, toys, and appliances. This waste is almost entirely for recycling.

- *Green Waste* - It is the material that results, mainly, from the pruning of trees, branches, trunks, barks, and leaves that fall in the streets. Because it is organic matter, it could be used for composting and production of organic fertilizer.

- *Electronic Waste* - This is the waste generated by the disposal of consumer electronics products that no longer work or have become obsolete. For disposal, there are appropriate places, such as companies and cooperatives that operate in the area of recycling. They send this waste in a way that does not cause damage to the environment.

- *Nuclear Waste* - It is the one that is generated, mainly, by nuclear plants. It is a highly dangerous waste because it is a radioactive element and should be treated according to strict safety standards.

II. SOLID WASTE MINIMIZATION USING IOT

The Integrated Solid Waste Management (ISWM) is mainlyrelated to 3R (Reduce, Reuse and Recycle) Approach whichmainly focus on the minimization of the solid waste generatedfrom different sources and implementation of waste processingplants by involving the stakeholders. The hierarchy consists of Reduction of wasteat source itself, Recycling, Composting, and Waste to Energyconversion and at last it prefers Sanitary Land filling.

In another way several published papers cover different aspects of IoT technology for waste management solutions. For example, in Reference, the authors present a solution that, through intelligent monitoring, allows the planning of garbage collection. It is possible to operate applications from different domains of information and communication to bring a great ease of implementation. From that one of the solution is a monitoring phase where the level of waste inside the compartments are constantly measured and stored. The authors address a dynamic waste management model through a set of infrastructure services for Smart cities based on IoT with the use of sensors or in another way by recycling of waste that can be reused. The sensor (For example, Ultrasonic sensor and Gas sensor) used here works by sensing means to capture specific and relevant data from objects on a network and send them to a database so that they can be analyzed and serve as the basis for decision making in a particular service. Many IoT solutions associate sensors with single board computers (SBCs) that are devices (for example, Arduino Yun, Raspberry PI, Beagle Bone Black) which connect to application software in a central management to provide information that clients need. A municipal waste management system for domestic use is presented that focuses on the application of biological and physicochemical methodologies that can eliminate or significantly reduce the stage of waste collection.

Internet of Things (IoT) is a technology that is transforming slowly for the city administration. The cities will generate a waste at an alarming rate, so waste must be collected in s smarter way in easily manageable time in real time. The waste disposal mechanism should have more efforts in collecting the waste by selecting the optimal path. The methods done earlier were collecting the waste with smart bin in the place and plan an optimal trip which is not considered. The proposed work using IoT technology does the management of waste with the management of trip in the cities. The cost and time are reduced with optimized path for waste gathering. Thus, the planned effective results for same. In current times, garbage disposal has become a giant cause for concern in the world. A huge amount of waste that is produced is inclined by means catch have an opposing consequence on the environment. The communal technique of removal of the waste is by unexpected and unrestrained open selling at the low-lying sites. This technique is harmful to human fitness, plant and animal life. In India, duster pickers play a crucial role within the utilization of urban solid waste. The amount of the waste generated be situated completed if it's recycled fully. We area unit implementing a wise ash-bin that may be a low cost, simple to use resolution for a segregation system at households, in order that it will be sent directly for procedure. It is calculated to sort the recycle into degradable waste and bio-degradable waste. It will also to inform the concerned person when the bins are full through IoT.

III. LITERATURE SURVEY

The smart dustbins with the internet of things are used in a scrap and public area. This could beused for waste reduction. This could be a continuous finished downside at universal in addition as communal level IoT primarily based good Garbage Detection System. It's a complicated domain of technology during which all your information is keep on the database with real time fast access to information furthermore as its data processing primarily based Waste Management associate application to sensible town. Devices are connected to the network for the transfer of knowledge and to communicate with other devices with a given UID, to reduce the interaction from person to person or with a person and a laptop overview for Solid Waste Bin watching and assortment System. Solid waste is associate degree enhancing issue that impact thanks to apace of accelerating urbanization and economic development witnessed by the quantity of municipal hard waste operative Waste collection with Unswerving Path Semi-Static and Dynamic Routing. Sensible cities square measure subsequent step in human habitation aiming at economic integration with property setting. Future web and IoT alter little devices to be established inside the backbone of the human society in world objects just like the waste bins Intellectual System for Valorizing Hard Inner-city Waste. From Associate in nursing environmental position is imperative to seek out effective education solutions for voters to actively participate in exercise the waste created to considerably cut back the ecological footprint and therefore the scarce of natural resources Robust Waste assortment exploiting value potency of IoT potentiality in good Cities. These cities can incorporate heap parts in their backbone infrastructure therefore sanctioning innovative services Protected trendy aid System based on net of Things and Secret Sharing of IoT aid knowledge it's the rising technology nowadays Smart town policies an abstraction approach. The third a part of the paper includes recommendations for the event of sensible cities supported the combined conclusions of the previous components Smart

Garbage observance System. Garbage could contain the unwanted material left over from town, Public space, Society, College, home etc. This project is said to the "Smart City" and supported "Internet of Things" (IoT). So, for sensible modus vivendi, cleanliness is required, and cleanliness is starting with Garbage Bin.

IV. SCOPE OF THE WORK

The Smart Bin is the process of predicting the waste filling percentage and detecting the nasty smell and level of filling the machine learning is the part where the prediction takes place. The Model is trained according to the level of dustbin and filling period. So that when it detects the level of waste it will predict when the bin will be filled. Then the status of the dustbin will be mailed to the municipality. The Ultrasonic sensor will find the depth of the waste filled and the Gas sensor is attached so that it will detect the gas of contaminated wastes. The Gas has certain limits above that limit will be the contaminated smell so it will indicate the model about the gas then mail will be sent. The municipality will handle the disposal method and the main objective is it will save the time and Fuel of dump truck. It optimizes the work of the routine. We can also overcome it by following methods like, by remanufacturing, reusing, recycling the solid wastes.

V. BLOCK DIAGRAM OF MONITORING SYSTEM

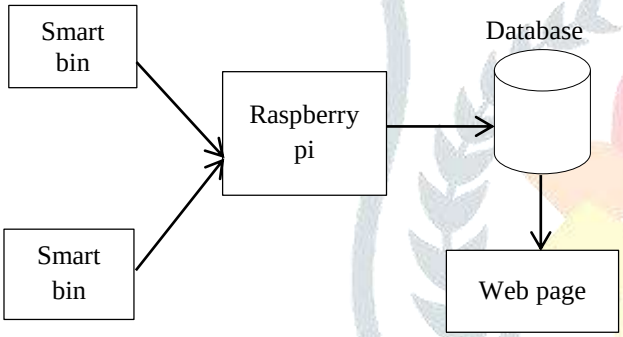

Fig 1: Block diagram of monitoring system

VI. SMART BINS IN USE

Smart dust bins are used today to reduce abundance of waste with the IoT and they provide the smart solutions to the smart bins. These smart bins are useful to keep dry and wet garbage on an individual basis in order that completely different processes composting, recycling, burning shall be applied to completely different forms of garbage. Some of the drawbacks of using these smart bins are:

- It won't give the immediate updates.
- It won't detect the gas.
- Public don't know the status of Garbage level.

VII. MONITORING SYSTEM FOR WASTE

Build a model for associate automatic open trash barrel which will mechanically open the lid once it detects the folks that wish to throw out their trash. It can also notice the extent of the trash that within the trash barrel. If the trash barrel is jam-packed with trash at the sure level, the lid won't open even once their area unit folks that wish to throw out their trash. Dustbins area unit supplied with a device that helps in trailing the extent and weight of the rubbish bins and a singular ID are provided for each trash barrel in the city therefore it's straightforward to identify that garbage bin is full so as to avoid the decaying smell round the bin harm-less chemical mechanical device is employed which can sprinkle the chemical as presentlybecause the smell sensors find the decaying smell. So, this will be done by implementing IoT based mostly waste management victimization sensible bin, this implementation of sensible trash collection bin victimizations. This method assures to send mail notification and standing on dashboard of dustbins once the rubbish level reaches its most. Some of the benefits of using these types of bins are:

- Addition of gas sensor senses the Bad smell.
- Less time and fuel consumption as the trucks go only to the filled containers.
- Public can complaint.

VIII. HARDWARE USED IN OF WASTE MANAGEMENT SYSTEM

IOT are connected to the web and controlled by the user through the internet and can also be called as web of things. The IoT is used with the hardware components to collect the data like the sensor that senses and gives the data to the IoT devices. Some of the hardware components used is described below.

Ultrasonic Sensors:

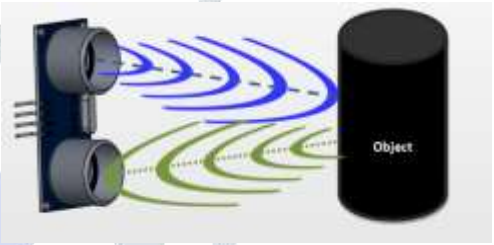

Fig 2: Ultrasonic Sensor

Ultrasonic sensor is a device that measures the distance of a target object by emitting ultrasonic sound waves, and converts the reflected sound into an electrical signal. The period taken for sound wave production and active use is also calculated. Each waste bin is attached with a ultrasonic sensor which detects the waste level of the bin. The ultrasonic sensor measures the level of the waste by sending a sound wave at a specific frequency and listens the reflected sound wave that is bounced back. It calculates the time taken by the wave for traveling and reflecting back, and measures the distance at which obstacle is present. The implementation of this ultrasonic sensor in the waste bins prevents the overflow the waste and also an alert is sent to collecting authority.

Analog to Digital Convertor:

Fig 5: Analog to Digital Convertor

The device which converts the analog signal to digital signal commonly known as analog to digital converter i.e. ADC converter.Here analog quantities are converted into digital form so that a digital device can process it.(ADCs) allow micro-processor controlled circuits, Arduino, Raspberry Pi, and other such digital logic circuits to communicate with the

real world.In the real world, analogue signals have continuously changing values which come from various sources and sensors which can measure sound, light, temperature or movement, and many digital systems interact with their environment by measuring the analogue signals from such transducers.

Raspberry Pi:

Fig 3: Raspberry Pi

Raspberry is a low-cost microcontroller designed to work with the sensors and other software that can be programmed on it. The program can be done on this using python. It is a low cost, credit-card sizedcomputer that plugs into a computer monitor or TV, and uses a standard keyboard and mouse.

Gas Sensor:

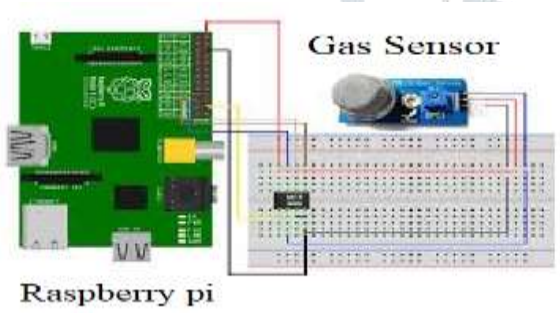

Fig 4: Gas Sensor

A gas detector is a device that detects the presence of gases in an area, usually a part of security system. This type of equipment is used to detect a gas leak or other emissions and can interface with a control system. This sensor will observe the leak for different emission. It may be useful to avoid harmful to organic life like human and animals.

Jumper Wires:

Fig 6: Jumper Wires

Jumper wires are simply wires that have connector pins at each end, allowing them to be used to connect two points to each other without soldering. Jumper wires are typically used with breadboards and other prototyping tools in order to make it easy to change a circuit as needed.

IX. MODULES IMPLEMENTATION

a) Data Collection through sensor:

Data will be collected by certain sensors implemented. The Ultrasonic sensor will be used to collect the depth and percentage filled by bin. Gas sensor is used to collect the data of the gas present in the bin. The Data's are collected to build the efficient model. Then also it is collected for predicting and process smart bin project.

b) Data Analytics using KNN Classifier:

Data Analytics exploitation KNN Classifier KNN is used for equally classification and regression issues. This means that the new purpose is allotted a price supported however closely it resembles the points within the coaching set. The values are plotted and similarly according to the model trained. The Data's from the sensor is given as the Input after the model created. Then KNN model predicts the output for the given values KNN regression has higher accuracy probability by considering other Algorithm.

The three different algorithms are implemented for the prediction process. The algorithms are namely Linear Regression, Logistic Regression and K Nearest Neighbors algorithms. After implementation of algorithm the model it is tested for accuracy. The all the 3 algorithms produced different accuracy rate. The algorithm having higher accuracy is used for the prediction process. The algorithm that gets more accuracy is the KNN algorithm than the linear and logistic regression algorithms. The model is implemented by the following modules.

- Hardware Implementation
- Data Collection from Sensors
- Model Building
- Accuracy
- Prediction and Information Sharing

A. Module Description:

1. Hardware Implementation

Hardware is constructed by connecting Raspberry pi and Internet supportable port. Connecting the Ultrasonic sensor and Gas sensor in Pin configuration and getting values from the sensors will be implemented. Connecting the Bin and sensors are done for collecting the data from the bin.

2. Data Collection from Sensor

The Data's are collected from Sensor's for providing the data to create the machine learning model. The Model should be trained on the collected values then only it can predict the days related to the sensors for that process data are collected form the sensors.

3. Model Building

The Model Building is the process of creating the machine learning model. In machine learning model the input data are the data's collected from the sensor and input is given to the model. It will be fitted for the model to train and predict.

4. Accuracy

The accuracy can be found by applying the test values. Then the model will predict the values according to the training. The predicted values and original values will be compared, and the

accuracy can be found. Accuracy rate will be compared among the algorithms implemented and we can get the more Accurate model.

B. Working Principle

The ultrasonic sensor senses the garbage in the dustbin and find it is full or not by sensing the data. The gas sensor inside the dustbin will sense the gas and sends message if the dustbin is not cleaned for a long time.

Algorithm Garbage full

1) Start
2) Repeat the steps below
3) Check if the dustbin is full
4) If yes send the message to control room
5) Send the cleaning vehicle
6) Updates the status of the dustbin
7) End

Algorithm anonymous gas

1) Start
2) Repeat the steps below
3) Check if the gas is high
4) If yes send the alert message to garbage collection.
5) Send the garbage vehicle as soon as possible
6) Updates the status of the dustbin
7) End

C. Application of the work:

- Saves money through avoided disposal and raw materials purchase costs.
- Reduces regulatory burdens and compliance costs.
- Waste Level detection inside the garbage bins.
- Builds better community relations.
- System can be accessed anytime and from anywhere.
- Minimizes short and long term liability.
- Creates safer working conditions for employees.
- Protects human health and the environment.
- Demonstrates environmental leadership.
- Improves competitiveness through greater efficiencies and deceased overhead costs.
- This system has no individual use, but can be used by acity, state or a country.
- Improves Environment quality-Fewer smells-Cleanercities.
- The information will be updated every 5 minutes.
- Reduce human efforts.
- Enhancement of a smart city vision.

X. EXPERIMENTAL RESULT

The proposed system is more user-friendly and it can be successfully implemented. This system consists of Raspberry Pi which acts as a central system and ultrasonic sensor which is used to detect the amount of garbage in garbage bin. The collected data is sent to the web server which in-turn displays results in the android phone developed. The sensors are connected to the dustbin as shown in figure which is overall IoT System.

Fig 7: Waste monitoring dustbin based on IoT system

The raspberry pi is programmed to show if the message as dustbin full by using the data collected to the sensors shown below. Will shows the massage alert in the android phone shown in figure 8.

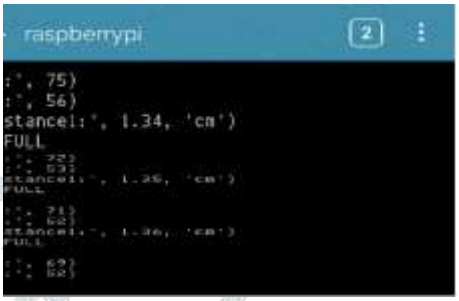

Fig 8: Bin full Message

The gas sensor senses the anonymous gas in the dustbin and send the data to the raspberry pi which is programmed using the python programming and display the message as high gas as shown in figure 9.

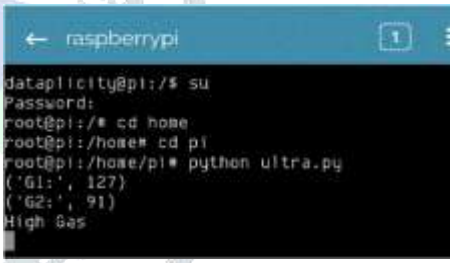

Fig. 9: Gas High Message

X1. CONCLUSION

To achieve the transformation of traditional cities into smart cities, waste management becomes a criticalelement in achieving sustainability, efficiency in public spending, improving urban mobility, and preserving natural resources. Recent literature has been revised to investigate variant characteristics and aspects of intelligent waste management systems using the Internet of Things. Since the deployment of IoT infrastructures can enable many opportunities, first, the main search motives were identified, and some useful applications on the topic of waste management were described. Through a detailed literature view, solutions to identified problems were described, considering data detection, analysis, and processing of collected data, and obtaining the final result for an efficient handling solution for solid waste. Using IoT, it is possible to minimize various types of wastes, monitoring the level of garbage deposited, which promotes citizenship and avoids significant problems resulting from the accumulation of garbage outside waste collectors.

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