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Heterogeneous Trash Segregation Machine Using Internet of Things (IoT) - A Smart Waste Management Survey

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Intelligence solid waste bin is essential to develop an efficient and dynamic waste management system. The common litter bins placed by the municipal corporation are leading no. of health, environmental and social issues. This research presents the implementation and execution of an integrated sensing system and algorithm for solid waste trash bins to automate the waste management process. Various causes like improper dustbins placement in City Corporation and specifically, people are not aware enough to use dustbins in a proper way. Such major causes are leading serious problems like an unhygienic condition, air pollution, and unhealthy environment. Several sensing methods have been integrated and have combined their verdicts that offer the detection of bin condition and its parameter measurement. Research has been carried out by developing the software application for indicating dustbins status, shortest path method for collecting vehicles by integrating Radio-Frequency Identification (RFID), Global System for Mobile communications (GSM), Geographic Information Systems (GIS), trash collection and management in residential locality is the basic considerations referred to in smart cities. The concept of trash collection is quite tedious. For efficient trash collection, we use the concept of the Internet of Things (IoT) which acts as a backbone technology. With the increase in population, especially in the urban areas waste collection, categorization and disposal have become a major problem for government authorities. An IoT based waste collection framework is proposed to automate the solid waste identification, localization and collection process. The optimization algorithm is used as proposed evaluation criteria to achieve higher efficiency with the outcome of the efficient and intelligent sensing system to automate any solid waste bin management process and also the goal of making cities smarter, greener to provide the healthy and hygienic environment.

Keywords: *A Smart Solid Waste Collection, GIS, GSM, IR Sensor, IoT, RFID.*

1. INTRODUCTION

Waste management is the process of managing waste from its commencement to its eventual disposal. This includes dispensation of litters with monitoring and regulation. It also encloses the legal and regulatory framework that relates to waste management.

The solid waste is managed by the smart waste management system, which reduces the amount of time and energy required to provide waste management services. But with the rise of the Internet of Things (IoT), smart sensors and sensing-level technology have begun popping up in all kinds of places including trash receptacles. Solid waste management has to be thought-out in terms of making urban sprawl healthier. This paper portrayed the shortest path method for garbage collection by integrating RFID, Global System for Mobile communications (GSM) and Geographic Information Systems (GIS). Smart litter bin is designed whose fullness status will be laid out on a database for the corresponding person responsible for debris collection.

All these dominant factors are considered to check the abundance status of bins there by giving alert to the corporation to collect the litters by using a GSM system.

The analysis is done by reviewing the accuracy of the system in terms of cleaning garbage present outside the bins.

2. LID STATUS SENSING

Md.Abdulla Al Mamun et al.[9] considered the lid status sensing system (i.e.)implemented for tracking the initialization of waste loading and unloading event and perceiving the overflow status of the bin.

Accelerometer sensor datum is accumulated to provide the drift and its direction to identify the opening/closing of the lid. The magnetic proximity sensor reports whether the lid is closed properly or not by using a reed switch and the permanent magnet.

The switch can change its state and bias caused by the magnet when conductor attached in the lid enters into the magnetic field mounted on the upper edge of the bin.

The whole sensing system remains in sleeping mode and except the accelerometer, which remains in the inertial wake-up mode ensures the minimum consumption at idle state. When someone opens the lid of the bin, the accelerometer sensor sends interrupt message to wake-up the system.
After awakening, the following rules are used to perceive the bin status and measure the bin parameters.

Table1. Lid Status Sensing Rules

Rule	Bin parameter				Bin situation		Bin position	
	by	by	by	pl	Load	unload	open	closed
1	-	1	1	1	✓	-	✓	-
2	-	0	0	0	✓	-	-	✓
3	0/1	0/1	0/1	0/1	-	-	-	✓

Table 1 describes box, by, by – denotes acceleration towards x,y, z-Axis , pl- Proximity Sensor Value, this magnetic sensor reports whether the lid closed properly or not by using a reed switch and a permanent magnet. After measuring the bin operation situation and the following rules are used to detect whether the bin is overladed or not.

- If rule 1 satisfies and if the lid of the bin stays open for the time that exceeds a time threshold, then the system reports that the bin is overloaded.
- If rule 1 satisfies and if rule 2 satisfies before exceeding a time threshold, then the system reports that the bin is not overloaded.
- If rule 5 satisfies, then the system activates both the waste level sensing system and weight sensing system to measure the waste filling level and the weight of waste.
- If rule 4 satisfies, then the system activates only the weight sensing system to measure the weight of the waste.

3. WASTE FILLING LEVEL SENSING

Trushali et al. [13] proposed the Dynamic Solid Waste Collection and Management System based on Sensors, Elevator and GSM. This paper demonstrates the monitoring of bin fullness status by using sensors; the filling level sensing sensor is placed at the top of the litter bin whose fullness status will be laid out on a database for the corresponding person responsible for collection of debris, the rotating shaft and the elevator plays the main role in collecting the waste.

Gopal Krishna Shyam et al.[4] proposed the Smart Waste Management using IoT(Internet of Things), Here the level of trash in the waste bin is calculated for every two hours in weekdays and 1 hour during weekend; figuring out the rate at which litter bins are getting filled, this waste sensing is divided into three sensing parts; if the waste is fully filled then it must send the message to the corporation, if it is partially filled else not filled then no need to send vehicle to collect the trash. The algorithm of waste bin sensor is used to sense the trash level.
Sonar sensor is used to determine the waste level by measuring the distance from the top of the bin. The forecast of waste level for the future is based on historical data through Artificial Intelligence (AI) algorithm.

Keerthana.B et al. [6] proposed the Internet of Bins, the enactment of smart bins management using the sensor, microcontroller, and other modules. This system ensures emptying of litter bins appropriately when the garbage level reaches its maximum; Threshold limit is set that can monitor the level of the bin. When the threshold limit is set it gives an alarm when the litterbin gets fully filled. It provides a technique of collecting garbage in an optimized way. This paper mainly concentrates on threshold limit.

Dr.N.Sathish Kumar et al. [3] and Manoj Kumar Patra[8] establish the filling status by ultrasonic sensor which is interfaced with Arduino UNO to check the level of trash-filled in the litterbin after cleaning the dustbin; the driver confirms the task of emptying the garbage

with the aid of Radio Frequency Identification(RFID) tag. The computing technology used for the verification process. Automatic identification is done by using smart garbage system by providing identification of garbage filled in the litter bin there by, the whole process is upheld by the embedded module integrated with RFID and IoT facilitation.

Md.Abdulla Al Mamun et al.[9] describes the sensing of waste filling level inside a bin based on the measurement of the time of flight (i.e.) the complete return trip time, an ultrasonic pulse takes to transmit and receive its reflected echo between the sensor and the sensed material level. This paper replaces IR sensor by Ultrasonic sensor to increase the efficiency.
Junaid Shuja et al.[5] proposed a green internet of things, another emerging technology that facilitated data communication among multiple electronic devices without human and computer intervention. Green IoT is a set of procedures adopted by the IoT in the form of hardware or software efficiency techniques. Green computing aims to achieve energy efficiency through the concept of Green Radio Frequency Identification (GRFID).

4. WEIGHT SENSING

Md.Abdulla Al Mamun et al.[9], discussed the weight estimation of the waste inside a bin based on the principle of an electrical conductor whose resistance changes when its length changes due to stress are virtually proportionally to the applied strain. A Wheatstone bridge network is built by using at least four stain gauges with four separate resistors.

Waste inside the bin causes a variation in the value of one or more resistors due to the generated strain from a metallic member that changed with this variation in resistance (i.e.) proportional to the weight of the waste.

Trushali et al.[12] established the weight by using sensors. The weight sensor is placed at the bottom of a dustbin, wireless sensor networks play the role of conveying the status of respective dustbins. Wireless sensor network is newly emerging advanced and widely used technology in these days, many of the innovations have used these networks so as to achieve smart objectives of the respective system. ZigBee-Pro, GPRS is one of the types of the network where the information of a particular sensor placed for some desired application can be sensed remotely and makes the system user enable to proceed further.

Various papers have been proposed based on GIS, GPS technique to increase the accuracy and efficiency. The rotating mechanical shaft is placed at the bottom of litter bin and elevator assembly together collects the waste thrown outside and put it back in dustbin proper.

5. OPTIMAL PATH TO THE SMART BINS

Trushali et al.[13] establish the optimal vehicle routing algorithm, Smart litter bin is designed whose fullness status will be laid out on a database for the corresponding person responsible for the collection of debris. All these dominant factors are considered to check the abundance status of bins and focus on giving alert to the corporation to collect the litters by using a GSM system.

The optimal path algorithm shows the location of that particular bin in an optimal way, many models for shortest path algorithm has been investigated to manage routing cost. ZigBee-Pro which provides short range, low complexity, and low data speed, is replaced by GSM.

Gopal Kirshna Shyam et al.[4] establish the shortest path spanning tree algorithm used by server, the inputs given is the distance from waste bins to worker stations; output must be an optimized route between two points where the dustbins needs to be collected, the description must be considered as street network as a graph and segments as edges and joining points as vertices, calculate an accurate shortest travelling distance between two locations and distance from one to all litter bins to speed up the route optimization process.

Shashika Lokuliyana et al.[11] and Balazs Cs. Csaji et al.[2] establish the process of identifying the waste disposal areas, some are legally authorized, pre-defined waste demolition areas situated around the country as well as legally unauthorized litter clearance areas, a sensor network will be adopted in the authorized waste disposal area or locations and the sensor node will notify the relevant authorities of the accessibility of Waste to be collected. At last, a mobile application is developed with the capability of location area access. The user has the prospect to contribute to the environmental activities to the waste collection process by notifying the relevant authorities of an availability and overflow of waste in authorized or unauthorized locations.

Abhimanyu Singh et al.[1] establish the optimizing collection route with advanced routing software is a common approach to reduce travel cost; so the issues related to the waste collection could be divided into two major processes, the foremost is scheduling that is used to collect the waste from the bins and the second is routing, this follows the route to transport the waste. IoT based models can use real-time information from bins which can help in devising effective scheduling and optimizing routing of collection vehicles, this would help in completion of waste collection task with better efficiency, normally GPS based route optimization is used and also it is adopted in the United States and European countries, GPS systems are used to provide shortest routes. GIS is another optimization system for waste collection, the placement of bins and the collection routes are planned on a geographical map of the city.

Mahmuda Akhtar et al.[7] and Radek Fujidiak et al.[10] establish the optimal path by Travelling Salesman Problem(TSP) that is well known NP-hard combinational optimization problem, in directed graph the graph(G) contains vertices(V) and edges(E), where V is the set of vertexes/nodes and E is the edge set, accordance to the each edge; there is a non-negative number representing cost of the edge from node I to j, the objective of TSP is to find a route with minimum cost starting from initial node and coming back to the same node after visiting all vertices only once, the goal of using TSP is to find the effective way to collect litter with vehicles travelling least

distance. The author [10] proposed a Genetic Algorithm (GA) as a tool for garbage collection optimization process to deal with the problem of TSP.

Theodoros Vasileios Anagnostopoulos et al.[13] The author have illustrated the Top-k query which is based on dynamic scheduling for smart city garbage collection, the discovered Top-k Query to denote the number of filled bins which in turn to initiate the dynamic scheduling. The author [13] proposed adaptive large neighborhood search algorithm to regulate the cost-optimal path for the vehicle to clean the bin. The cripple of the model is that the dynamic scheduling is based upon k-value and cost of CPU overhead is high. The future work is that the dynamic model depends upon fuzzy demands.

6. RESULTS AND DISCUSSION

The system consists of sensors at various points of the dustbin. The sensing of its relevant points gets accomplished properly by these sensors, the analysis is done in some of the forms like accuracy of the system in terms of cleaning litters outside the system, this is done by the rotating mechanical shaft which is having cleaning brush at its bottom will play a major role in cleaning brush at the bottom of waste present outside the dustbin, by analysing this we get accuracy of 80% for the five iterations. Another form is by real-time alert message sending based on sensor data, the sensor is placed inside the litter bin so as to monitor the bin fullness when the sensor senses garbage level up to threshold then the system will automatically send the message to the respective authority. The Routing cost is managed by using dynamic scheduling method by optimal vehicle routing algorithm.

Some performance parameters are also assessed, length of the route is defined as the driving distance that is needed to flock together the selected litter bins for each of the days, next is time to cover the route which is expressed as the time taken to cover the length of the route, the final performance parameter is cost to collect and dispose of wastes that are associated with the garbage cleaning, it is evaluated based on daily, weekly and monthly basis. In the lid status sensing system, once the drift and its direction are detected based on acceleration, the cover condition and operative state are approximated to discern the bin is overloaded or not towards different sensor activation. During the loading operations, the bins position remains fixed, only the lid positions are changed. The output of the accelerometer shows variation in axes based on the lid positions, based on the data of acceleration and lid proximity gives the measurement of weight along with or without level value.

The particle swarm optimization (PSO) is a new concept, this paper [7] illustrate the heuristic approach to solve the traveling salesman combinatorial optimization problem by Ant Colony Algorithm (ACA). The route optimization is needed to consider different scenarios and constraints such as time window, vehicle maximum capacity, the percentage of the waste level. This shows a good optimization route for collecting waste by applying PSO; here only one spot is considered which is located in the middle of the bins. Route optimization is done using MATLAB, after the optimization process all the bins gives good reasonable routes but considering only 70% filling level of bins, the number of routes is decreased. The table 2 describes the methods, algorithm, merits, and remarks of the existing paper and shows the comparison to understand the concepts of the existing system to manage solid waste.

Table 2. Discussion on List of Methods and Algorithms of Waste Bin Management

METHOD	ALGORITHM	MERITS	REMARKS
Traditional method and dynamic on-demand solution	Optimization algorithm, Artificial Intelligent (AI), Shortest Path Spanning Tree Algorithm (SPST)	Travelling distance between two location is accurate and speed up the route optimization process	Demerits-As this uses traditional method, this become semi-static so problem of segregating different kinds of waste is not possible
Top-K query Dynamic Scheduling	Dynamic Scheduling Algorithm	More Accuracy is achieved than static scheduling	Demerits- cost of CPU overhead is high
Dynamic Scheduling Method	Optimal Vehicle Routing Algorithm	Routing Cost is Managed	Only 80% accuracy is achieved for five iteration
Dynamic Routing Protocol	Genetic Algorithm (GA)	Effective tool to deal with TSP of various implementation	optimization can be improved
Heuristic Approach	Ant Colony Algorithm (ACA)	Travelling Salesman Combinatorial optimization problem is solved.	Vehicle Routing Problem (VRP)

7. CONCLUSION

A Solid waste management is not maintained in a proper manner. Due to this, the environment gets affected; a lot of diseases are spread, the fertile soil becomes infertile which leads to water pollution. The existing system has major problem that there is no processing method for separating bio-degradable and non-biodegradable waste material, IR sensor is used for finding the overfilling of waste in the bin but during the dumping of the waste in the bin the IR sensor may provide false alarm signal, To overcome these problems, the heterogeneous waste collecting machine is proposed to household who dispose it properly. Proposed system not only gives benefits to the society but also motivates cleanliness of the environment. Furthermore, this system increases the responsibility of every citizen to make the surroundings clean and hygienic. In this system, the ultrasonic sensor is used to see the bin fullness.

The system provides more complexities and the flooding of the overflow of garbage by using ultrasonic sensor using GSM module. Filling level sensing module defines the process of considering the solid waste filling level by using ultrasonic sensor, this sensor produces the high-frequency sound waves and evaluates the echo which is received back by the sensor and intimation is done by GSM, an ultrasonic pulse takes to transmit and receive its reflected echo between the sensor and the sensed material level, the bin total capacity is calculated when the current weight is equal to total capacity and intimate corporation to pick up, weight estimation module is calculated by the load cell and it is a transducer that creates an electrical magnitude which is directly proportional to the force being measured and used to calculate the weight of bins.

One of the most significant aspects is Ultrasonic sensors sense the waste filling status by reflecting echo inside the dustbin and no false alarm is produced, so the exact status is sent to the corporation for the collection of litter bins. Hence the paper presents highly advanced and fully automated system to collect and manage waste efficiently.

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