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Web Service Interface for Smart Waste Management using Android Device (IoT)

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Abstract - *The population is growing day by day, the environment should must be clean and hygienic. In most of the cities the overflowed waste bins are creating an unhygienic environment. This will further lead to arise of different types of unwanted diseases and will demote the standard of living. To overcome these situations an efficient smart waste management method has to be developed. This project proposes an idea of monitoring waste bins at different places. The level of garbage is continuously monitored by ultrasonic sensor. System also uses the garbage compression mechanism. Based on the inputs from the level sensors, microcontroller decides which vehicles should go to pick up the garbage. These processes are controlled via android application and web application. The system ensures cleanliness and hygienic environment.*

Keywords: Ultrasonic Sensor, Arduino UNO, GPS Network, Android Application.

1. INTRODUCTION:

Waste management system (WMS) is an important environmental health service and an integral part of basic urban services. Our Primitive ancestors used to safely collect and dispose the solid waste. The challenges of the WMS are growing with rapid urbanization in the developing world. A traditional WMS consists of trucks, bin and landfill. Due to the growing issue of landfill disposal, many researches are investigating waste diversion through an integrated WMS. The solid waste planner, monitor and management require comprehensive, reliable data and information on solid waste. However, the solid waste database in Malaysia is limited to manage the data by individual local authorities or waste contractors. In order to deal with this great demand on data management, advanced information technologies such as IoT, GPS must be utilized. [4]

The collection process can be improved if there is system that can monitor the truck and bin in real time. The situation and status and the trucks data can be optimized using advanced waste management and monitoring system. The view of waste being discarded around the bin destroy the view of big cities, overflowed bin is a serious problem and need close monitoring. Motivation to develop real time system is to tackle all these problems. Figure 1.1 shows the architecture of solid waste monitoring and management system. [7]

The process of making things automatic is increasing day by day so that user can monitor or control anything easily. Automation reduce the human work burden. It is the cost effective solution against manual working. Considering garbage management as a major problem. [1]

The correct waste management is must for the society as well as in city or anywhere in the world. Strong waste which is one of the sources and reasons for ecological contamination has been characterized under resource conservation and recovery act as any strong, semi-strong fluid or contained vaporous materials disposed of from modern, business, mining or rural operations and from

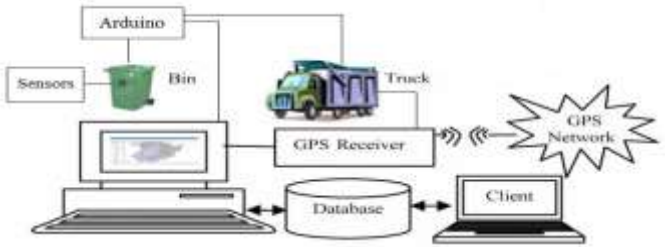

Figure 1.1: Architecture of solid waste monitoring and management system

group exercises. Keeping in mind the end goal to shield human well-being and the earth from the potential risks of postponed squander transfer and natural contamination. An efficiently administered and controlled treatment of these squanders is must. [1]

The natural contamination which underlines residential decline comprising of degradable substances squander, leaves, dead creatures and non-degradable ones like, plastics, bottles, nylon, therapeutic and healing centers squanders, produced in families, clinics, enterprises and business focuses. The route toward making things customized is being Man handled in all the noteworthy fields of life. Impacting things customized reduces to inconvenience on the general population. The cost and effort used as a piece of physically controlled things is significantly higher than the robotized systems. Considering the truth, that the issue of gainful waste organization is one of the huge issues of the propelled conditions, there is a most extraordinary need to address this issue. [3][5]

Today waste is a problem on which huge sums of money is spent each year for its collection and segregation process. India particularly generates approximately 133760 tons of MSW per day, of which approximately 91152 tones is collected, and a huge sum of money is spent on collection. World waste production is expected to be approximately 27 billion tons per year by 2050, one-third of which might come from Asia, with major contributions from China and India. In urban areas of India, Waste generation might be 0.7 kg per person per day in 2025, approximately four to six times higher than in 1999. [4]

Environmental pollution is often due to the Municipal Solid Leftovers(MSL). A Proper maintenance becomes necessary for an efficient and effective removal of the generated MSL. The main issue in the waste management is that the garbage bin at public places gets overflowed in advance before the commencement of the next cleaning process. [9]

In present scenario of digital world everything in our surroundings have been equipped with modern technology and internet to ease our work and gain more efficiency. But the systems existing today for waste management are the same as they were before in most of the countries. [13]

Currently, for collection of waste in some countries, we have door to door collection systems that require a lot of efforts and money. A waste collector has to visit everybody's place, knocking the doors, and has to wait till each resident brings the waste to them. Moreover, residents have to be available in-order to get their waste collected at that particular time which brings in a major disadvantage of this system. Also in some countries, systems do exist in which waste is collected from the trash bins of each colony, but this system also brings a disadvantage that many a times dustbins are overfilled and waste isn't collected from it. This also makes dustbins, a place facilitating bacterial growth, feeding animals and a breeding place for insects. Also at times it happens that dustbin collection is done in prior resulting in waste of fuel and increasing costs of waste collection. So, at each step a lot of fuel and money is invested unnecessary for the process. [17]

1.2 Internet of Things (IoT)

The real and the virtual worlds are growing speedily and closely to form the IoT. IoT is connect to the embedded devices seamlessly, it is possible without any human intervention using standard and interoperable communication protocols. Practically this work shows, how IoT integrates with data access networks, It identifies Geographic Information system, combinatorial optimization, and IoT can contribute to improve cities management systems. The proposed work presents a collection of garbage is the solution based on providing intelligence to garbage cans, by using an IoT prototype embedded with sensors, which can read, get information, and transmit trash volume data over the Internet. This data put into a spatio-temporal context and processed by graph theory optimization algorithms can be used to dynamically and efficiently manage waste collection strategies. The things is a person, place, or any object that is considered relevant to the interaction between a user and an application. It consists of an IoT based prototype with sensors measuring the waste volume in trashcans or containers, with the capability of transmitting information to the Internet via a wireless .This data is used to optimize the management and strategies of garbage collection logistics. The IoT might be an interesting issue in the industry yet it's not another idea. [3]

Moreover, the development IoT and their applications have been acquiring relevance in Smart City solutions. In a nutshell, data gathered by sensors can be sent to remote servers where it is stored, processed and used for tracking, monitoring and ultimately making intelligent decisions for infrastructure or service management. When the deployment and use of sensors becomes massive, the data collected together with its processing and storage can be directly linked to server. Server opens new business models and data in this context is known as the new gold. In addition, Open Data is considered a promoter of server technologies such as IoT, and consequently the integration of both as part of cyber Web Service Interface For Smart Waste Management Using Android Device (IoT) physical systems enhances the potential of a large spectrum of innovative Smart City solutions. The proposed system would know when things required replacing, repairing or reviewing, and whether they were fresh or past their best. [8][9]

Every sensor will screen a particular condition, for example, area, vibration, movement and temperature. In IoT, these sensors will interface with each other and to frameworks that can comprehend or show data from the sensor's information sustains. These sensors will give new data to an organization's frameworks and to individuals. IoT-empowered articles will share data about their condition and the encompassing condition with individuals, programming frameworks and different machines. This data can be partaken continuously or gathered and shared at characterized interim. Going ahead, everything will have a computerized personality and network, which implies you, can recognize, track and speak with objects as shown in figure 1.2. IoT information varies from conventional figuring. The information can be little in estimate and continuous in transmission. The quantities of gadgets or hubs that are associating with the system are additionally more prominent in IoT than in conventional PC registering. Machine-to Machine correspondences and knowledge drawn from the gadgets and the system will enable organizations to robotize certain fundamental errands without relying upon focal or cloud based applications and administrations. [19]

Figure 1.2: Collection of Garbage System

2.1 Problem Definition

In environmental issues now a days the major concern is solid waste management. This is mostly true to urban areas where population is rapidly increasing and amount of waste generated is mounting like never before. Current worldwide population is 6.8 billion and it is estimated that almost 50% of this population lives in urban areas. Urbanization and industrialization leads to modernization of lifestyles and behavior which affects waste composition from mainly organic to synthetic material that last longer such as plastics and other packaging material. E-waste that hardly existed before was generated as much as 20-50 metric tons a year. The management of waste becomes difficult and the facilities provided could not cope with the increasing demand and needs. Therefore, best approach is needed to be implemented immediately while considering environmental, social and economic aspect. The drivers of sustainable waste management were clarified which include human, economic, institutional and environment aspect. The study suggests that each driving group considered in local context as managing solid waste for a particular society may differ from the others.

Limitations of existing Systems:

- Major Concern for growing population on Urban Area.
- Urbanization and industrialization including lifestyle is major cause.
- The management of waste becomes complex and unmanageable.
- Best approach need to be implemented immediately.
- Localization of method needs to be opted.

Problem Statement:

"To design and implement an automatic garbage handling and monitoring system"

2.2 Objective

- To monitor level of garbage and to compress dry garbage as per the need.
- To decide a path vehicle should follow to pick up the garbage.
- To display tracking of vehicle on the webpage as well as on the dashboard.
- To design a visual indicator system showing the status of bin.
- To implement a system to accurately manage the garbage from the city.

3. METHODOLOGY

3.1 Block Diagram

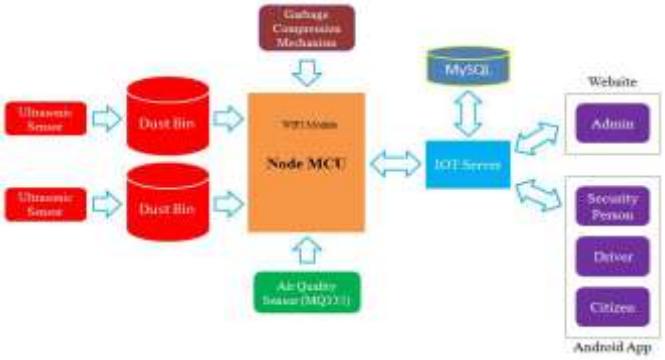

Figure 3.1: Block Diagram of Proposed System

This proposed system contains Ultrasonic Sensor, Air Quality Sensor and Garbage Compression Mechanism. It also consists of Node MCU. Data is collected by the server from 3 different places as shown in figure 4.1. The ultrasonic sensor is for detecting level of garbage in bin. The actuator is used for pressing garbage in downward direction and it has following two conditions. If the garbage is dry then it will press garbage or actuator will be ON and if the garbage is wet then motor will be OFF. If garbage has bad odour then the motor will not press garbage. Parameters measured by sensors like ultrasonic sensor will be updated at server. Smart waste bins located in several areas of city are connected to Internet, this system is equipped with sensors which collects the data about level of collected waste in waste bin. The sensors placed at smart waste bin sends this information to central web portal using WIFI module. If this waste bin is filled up to its threshold value then the message is displayed on web portal and the responsible authority take proper action and it will show all the information on to the smart waste bin Application on the users android mobile phone.

3.2 Modules

1. Smart bin module

- Level detector consists of ultrasonic sensor which is used to detect the level of the garbage in the smart bin.
- The output of level detector is given to Node MCU.
- If the smart bin is filled up to the highest level, then output of ultrasonic sensor receiver becomes actively low.

2. IOT Module

- This output is given to Arduino to send the message to the admin module via IOT module.

3. Admin module

All the activities are manage by Admin module. Like,

- Scheduling
- Routing
- Update status
- Send Notification

4. Driver module

- Receive notification
- Clean bin
- Send notification

3.3 System Requirements

3.3.1 Hardware Requirements

- **Processor**: Intel Core I3 or Higher
- **RAM**: 4 GB or Higher
- **Hard Disk**: 100 GB (min)
- **Microcontroller**: Node MCU
- **Sensors**: Ultrasonic Sensor, Air Quality Sensor
- **Actuator**

3.3.2 Software Requirements

1. **Operating System**: Microsoft Windows 7 and Above
2. **Programming Language**: HTML, JAVA, Embedded C
3. **IDE**: Netbeans, Android Studio, Arduino IDE
4. **Database**: MySQL

3.4 Applications

Applications of this system are**:**

- Real time data and analysis.
- Garbage compression mechanism.
- Smart Bin live dashboard.
- Collection operations become more efficient and smarter.
- It will stop overflowing of dustbins along roadsides and locality.
- Provides garbage management and monitoring.
- Aims for creating clean as well as green environment.
- Route algorithm will smartly find out the shortest route.
- Less amount of fuel consumed by vehicles can save a large amount of money.
- Automation system, reducing cost and man-power.
- System will be helpful in industry, city, corporation for waste management or everywhere needs to manage garbage or waste.

3.5 Algorithm

3.5.1 K-Means Algorithm

K-means algorithm is used for implementation the pothole detection system. The procedure has a simple and easy way to classify a data set through a certain number of clusters (assume k clusters)by fixed priority. The main purpose is to define k centers, one for each clusters. These centers should be placed smartly because different location causes different result. So, the best way is to place them as much as possible far away from each other. The further step is to take Point to point belonging to a given data set and associate it to the nearest center. When no point is remaining, the first step is completed and an early group age is done. At this point I need to re-calculate k new centroids as barycenter of the clusters resulting from the previous step. After I have these k new centroids, a new binding has should be done between the same data set points and the nearest new center. A loop has been generated. Now k centers change their location step by step until no more changes are done or in other words centers do not move any more.

- **Input**: K- the number of clusters
- **D**: A data set containing n objects
- **Output**: A set of k clusters

Steps 1: Randomly select k data objects from dataset D as initial cluster center.

Steps 2: Repeat.

Steps 3: Calculate distance between each data object di (1 <= i <= n) and all k cluster center cj (1 <= j <= k) and assign data object di to the nearest cluster.

Steps 4: For each cluster j (1 <= j <= k), recalculate the cluster center.

Steps 5: Until no changing in the center of clusters.

The computational complexity of the algorithm is O (nkt)

Where,

n: the total number of objects

k: the number of clusters

t: the number of iterations

4.6 Process Flow

S = fI;P;Og

S = System

I = Input

P = Process

O = Output

_ I = I0, I1, I2

I0 = Bin details

I1 = Admin details

I2 = Driver details

_ P = P0, P1, P2, P3

P0 = Receive message from bin to admin

P1 = Schedule and Route

P2 = Send message to the driver

P3 = Receive message from admin

_ O = O1, O1, O2

O0 = Schedule which first bin clean

O1 = Route to which bin is close to garbage collector truck

O2 = Clean bin

3.6 Tools and Technologies Used

3.6.1 Tools

- **JDK**
- **Netbeans**
- **MySQL Query Browser**
- **Android Studio**
- **Arduino IDE**

3.6.2 Technology

- **HTML**
- **JAVA**
- **MySQL**
- **Embedded C**

4. RESULTS

The project "Web Service Interface For Smart Waste Management Using Android Device (IoT)" ensures cleanliness and hygienic environment. The most significant cleanliness campaign run by the Government of India is "Swachh Bharat Abhiyan",which has motivated me to choose this topic related to smart city.

The project proposed an idea of monitoring garbage bins at different places, making the system automatic that will reduce the working burden on human. Automation is also the cost effective solution against manual working.

Considering in view of waste and garbage management in any area or city is a major problem. Overflowed garbage bins create an unhygienic environment. Giving rise to unwanted diseases and degrade the standard of living. An efficient smart garbage management are needed to overcome these types of situations.

The implemented system for monitoring the garbage level uses the garbage compression mechanism, based on the inputs from the sensors, microcontrollers decides which vehicles should go to pick up the garbage. These whole processes are controlled via android application and web application.

Fig.4.1 shows the complete structure of hardware of proposed system. The system includes hardware module such as dustbins, Node MCU, Ultrasonic Sensors (HC-SR04), Air Quality Sensors, Actuator, Relay, PC, Power Supply, Hardware connection and Project Module. The results of this system are seen on PC and personal mobile.

Figure 4.1: Project Hardware Module

The results of sensors displayed on the PC in the Arduino IDE. There are three different ultrasonic sensors which are placed in three different dustbins which are located in three different places. Fig.4.2 shows the screenshot of h/w values i.e. reading of ultrasonic sensors, air quality sensor and actuator in Arduino IDE s/w. This screenshot displays in the Arduino IDE software in which these readings represent the sensors values and Node MCU receives these sensors value and send to the server. And at the same time, continuously observes the same results on Web Server of the PC.

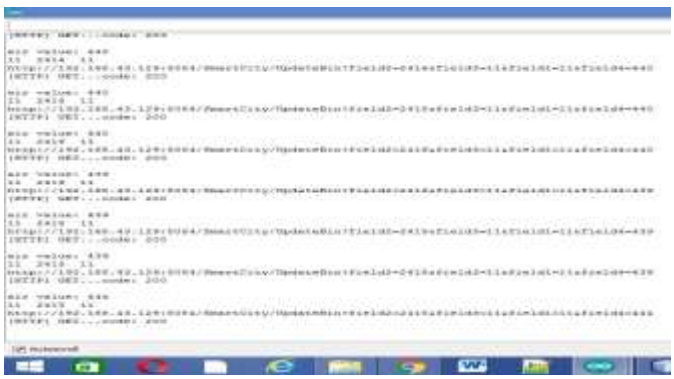

Figure 4.2: Hardware status in Arduino IDE

The output sections of the implemented system with various conditions are shown as below. Fig.4.3 shows the screenshot of admin login page of the system. Username and password for login the page is must. After successfully connection of hardware and software, the system runs and shows the login page on PC.

Figure 4.3: User Login Page

The admin home page contains dashboard, dustbin location map, dustbin information tab, driver information tab, vehicle information tab, assign vehicle information tab, and logout tab. Fig.4.4 shows the screenshot of admin home page. In this page, the map shows the dustbin location as well as status of bins. The two green colors indicate the empty bins and a single yellow color indicates partially filled bins.

Figure 4.4: Home Page, Dashboard and Location of bins

When we click on Bin tab, we checks the Bin information means status of bins. If status shows 0 means bin is empty. If it shows 1 means partially filled and if it shows 2 means bin is fully filled and in map it shows in red color. It denotes that bin is completely filled and alerts the admin for collecting the garbage from such container. Fig.4.5 shows the screenshot of dustbin information such as ID, Location, Longitude, Latitude, Status, Edit and Delete. These all dustbin operations are performed by admin.

Figure 4.5: Dust Bin Information

Fig.4.6 shows the screenshot of Driver Information Page. Admin edit like add or delete the details of driver.

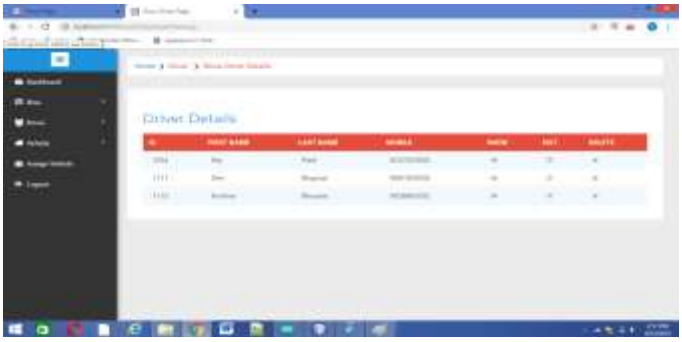

Figure 4.6: Driver Information

Fig.4.7 shows the screenshot of Vehicle Information Page, Vehicle type, Edit and Delete menu and all the operations performed by the admin.

Figure 4.7: Vehicle Information

Figure 4.8: Assigned Vehicle to Driver

Above Fig.4.8 shows the screenshot of Assigned Vehicle to Driver Page, availability of the vehicle in that particular area and send the message to the driver to pick the garbage from that particular location.

After assigning the vehicle, driver open the smart city app on android mobile from where he checks his destination of picking the garbage. Fig.4.9 shows screenshot of Android Driver Login Page.

Figure 4.9: Android Driver Login Page

After login, driver clicks on view bins and get the location of bins. After collecting garbage to update the bin status, so that bin's status becomes 0 in the webpage and it will be shown in green color which means bin is empty. There is also another tab for logout for drivers. Fig.4.10 shows screenshot of Android Driver Home Page.

Figure 4.10: Android Driver Home Page

There is one more android app for citizens and housekeeping supervisors of the society from where they check the status of bins and location of bins. Fig. 4.11 shows the screenshot of status of bins.

Figure 4.11: Dust bin status

5. CONCLUSIONS & FUTURE SCOPE

5.1 Conclusions

A smart waste management system is a step towards the automation of waste detection in nature and overcome the manual collection. The currently employing method in which concerned municipal employee has to look for the filled waste bins manually across different spots in an area for checking regularly whether the waste bin is filled or not. This approach is complex and time consuming. The implemented automated system of waste management will reduce the human effort and consequently the cost of the whole process and ensures cleanliness and hygienic environment.

5.2 Future Scope

- In future, instead of person in the vehicle we can make use of a line follower robot which does not require a man power to move the vehicle.
- A path follower robot is able to follow line marked on contrasting background usually black line on a white surface or white line on a black surface.
- Line follower robot technology vehicle moves to the particular trash bin area based on the information sent from the LoRa Gateway. So this makes the system more reliable.
- In future, some additional features can be added to this system to crush and recycling plastics and other materials automatically.

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