Project Report

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Smart Waste Management System for Metropolitan Cities

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ABSTRACT

Traditional waste management system operates based on daily schedule which is highly inefficient and costly. The existing recycle bin has also proved its ineffectiveness in the public as people do not recycle their waste properly. With the development of Internet of Things (IoT) and Artificial Intelligence (AI), the traditional waste management system can be replaced with smart sensors embedded into the system to perform real time monitoring and allow for better waste management. The aim of this research is to develop a smart waste management system using LoRa communication protocol and TensorFlow based deep learning model. LoRa sends the sensor data and Tensor flow performs real time object detection and classification. The bin consists of several compartments to segregate the waste including metal, plastic, paper, and general waste compartment which are controlled by the servo motors. Object detection and waste classification is done in TensorFlow framework with pre-trained object detection model. This object detection model is trained with images of waste to generate a frozen inference graph used for object detection which is done through a camera connected to the Raspberry Pi 3 Model B+ as the main processing unit. Ultrasonic sensor is embedded into each waste compartment to monitor the filling level of the waste. GPS module is integrated to monitor the location and real time of the bin. LoRa communication protocol is used to transmit data about the location, real time and filling level of the bin. RFID module is embedded for the purpose of waste management personnel identification. In this project an automated system is provided for segregating types of wastes as biodegradable, non-biodegradable and metallic wastes. A mechanical setup can be used for separating wastes into separate containers where sensors are used for separating the wastes. In this process, the colour sensor detects the type of waste according to the RGB colour scale. The sensing range is from 0-1024 in digital value and 0-5 volts in Analog value. If the detected value is from 0 to 500 then the particular waste is detected as bio-degradable waste and if it is from 500 to 1024 then the detected waste is termed as Non-

biodegradable wastes and then that detected waste is putted into that particular container. The metal wastes are detected with the help of metal sensor these sensors create an EM field for detection of the waste. These containers are embedded with ultrasonic sensors at the top, the ultrasonic sensor is used for measure the level of waste. This makes it possible to measure the amount of waste in the containers if the containers attain a certain level, an alert message containing the location of the dustbin is sent to the garbage collector if the garbage is collected and the bin is emptied an acknowledgement is sent to the municipality corporation if not a complaint is filed against the garbage collector. This proposed system will give an enhanced waste management system for segregating and managing the wastes.

INTRODUCTION

Waste management is one of the major alarming threat all over the world. Poorly managed waste leads to contamination of the oceans. Clogging drains and transmitting of new diseases. The current systems cannot cope up with the current volumes of wastes generated by the increasing urban population. The world generates about 2.01 billion tons of municipal solid waste annually, with at least 33 percent of that extremely conservatively not managed in an environmentally safe manner. Worldwide, waste generated per person per day averages 0.74 kilogram but ranges widely, from 0.11 to 4.54 kilograms. That too in the developing countries like India due to the rapid urbanization and industrialization the waste generated increases day by day. According to the recent data from MNRE Report, India is generating exponentially about 145 million tons of waste per year and further it is expected to reach approximately 260 to 300 million tons per day in the year 2047.The wastes are best at when it is recycled and treated. This waste has to be managed effectively and efficiently in order to have healthy environment to have a safer environment. The major problems affecting the solid waste management are unscientific treatment, improper collection of waste, and ethical problems. This in turn leads to hazards situations like environmental degradation, water pollution, soil pollution, and air pollution. In this project we have proposed a model for proper collection and segregation the wastes are segregated into Bio-degradable, Non-biodegradable, e-wastes with the help of colour sensors and the metal wastes are detected using the metal sensor. After the detection of

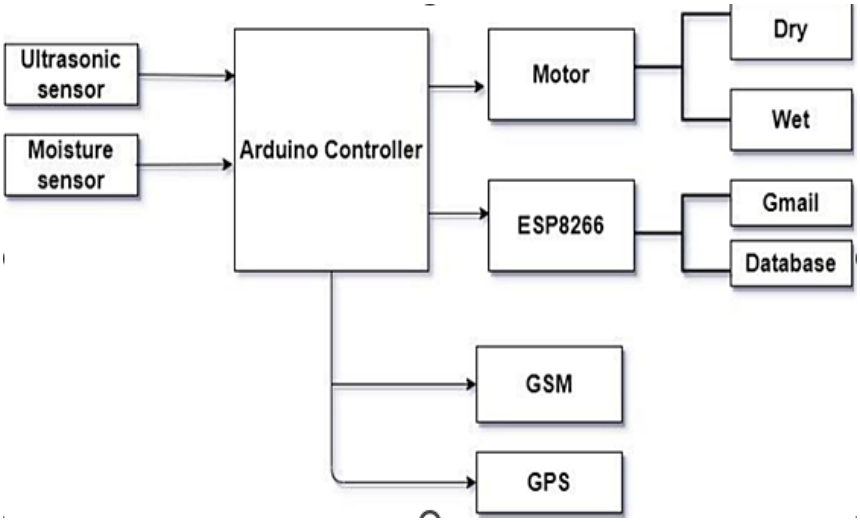
the type of waste the detected waste is put into the particular dustbins, these dustbins are embedded with the ultrasonic sensors which are used to measure the level of the dustbin ,if the dustbin attains a certain level an alert message containing the location of the dustbin is sent to the garbage collector if the garbage is collected and the bin is emptied an acknowledgement is sent to the municipality corporation if not an complaint is filed against the garbage collector. Internet of things (IoT) is a communication paradigm that envisions a future paradigm where everyday life objects will be equipped with a microcontroller and some form of communication protocol. One well-known product of IoT is the smart city, which can be defined as a city with smart technology, smart people, and smart collaboration. IoT shall transparently and seamlessly incorporate a large number of heterogeneous end systems while providing open access to select subsets of data for the development of a plethora of digital services . One major topic within the smart city is smart waste management. When it comes to waste management systems, the communication distance between the waste collection Center and the waste collection point is a major factor in determining the system's effectiveness. However, available communication technology such as LoRa and SigFox, which operate on a low power, wide-area network (LPWAN) are able to cater to the long-distance communication needed by the waste management system while sacrificing on the rate of data transmission. Studies in the field of wireless communication in IoT have also been accelerating. Conversely, communication technology such as Bluetooth, WI-Fi, and Zigbee offer better data transmission rates, but these are limited by their data transmission ranges. Waste management is a costly operation as it takes up a great deal of resources and labour. Efforts have been taken by the authorities to improve waste management systems by setting up the recyclable bin and launching the 3Rs campaign (recycle, reuse and reduce). A study on public awareness of recycling activities in Kota Bharu, Kelantan Malaysia shows that only 31.8% of the total of 384 participants were involved in recycling. This shows both that the initiatives taken previously were not effective and that a smart waste management system needs to be developed to replace the existing infrastructures. Advances in the field of IoT have made it possible to improve the existing waste management system. Sensors implementation in the waste bin together with IoT connectivity allow for real-time monitoring, which is absent in the existing waste management system. Data such as filling

level, temperature, humidity, and any necessary data can be collected from the sensors. These data can then be transferred to the cloud for storage and processing. The processed data can then be used to study and access the limitation of the existing waste management system and therefore improve the system's efficiency as a whole. IoT application in the waste bin is one step towards a smart city. In addition, deep learning has provided state-of-the-art solutions for comprehensively understanding human behaviours. With the development of deep learning and image processing algorithms, the classification of waste can be carried out with higher accuracy and in a shorter time. Classification of waste is a crucial step before the separation of waste can be performed. A deep learning method such as a convolutional neural network allows for the extraction of unique features from the image and then classifies them into each class with high accuracy . Tensorflow is an open-source, deep-learning library used for machine learning applications. It is capable of speech recognition , image classification , object detection , text classification, etc. With the intelligence gained from deep learning and an IoT, which integrates millions of smart devices together, the existing infrastructure for waste management systems can be improved. Challenges in achieving sustainable waste management have been summarized in. Insufficient technologies and facilities due to the increasing rate of waste generation have resulted in the failure to cope with land filling. The lack of a recycling market has also hindered the effectiveness of waste recycling implementation . Waste minimization is a costly operation, the lack of funds among industry practitioners has resulted in a reluctance to apply proper waste management techniques . Besides that, insufficient regulations imposed by authorities have allowed the practitioners to apply their way of waste management . Industry practitioners do not have an awareness of the importance of implementing a regulated waste management system based on the predefined waste management hierarchy . The present methods and infrastructures used are discussed in . The existing infrastructures are carry high operating costs and offer only limited accuracy.

PROPOSED METHODALOGY

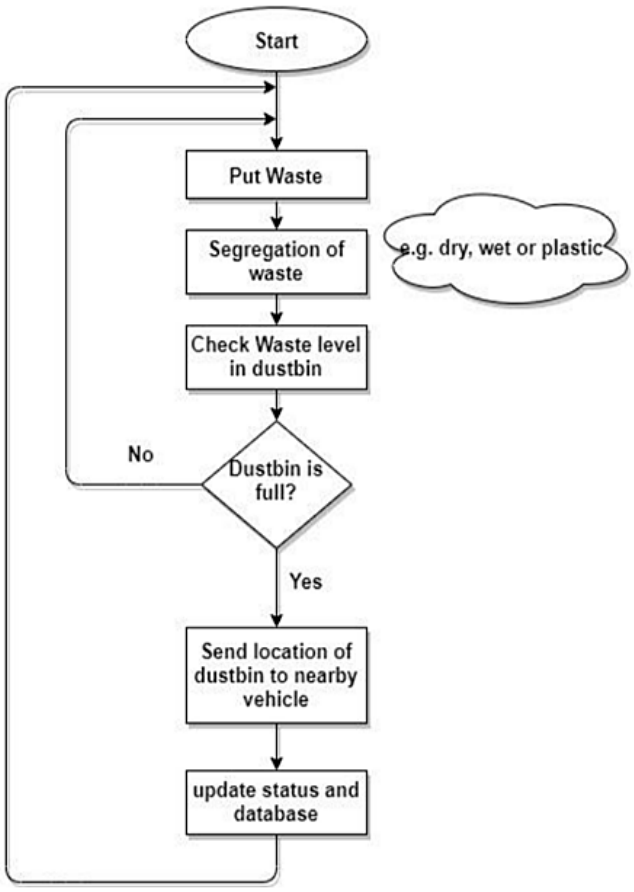
As shown in the figure 1 block diagram represents how the sensors and other components are connected to the Arduous. In our model the waste is placed in the plate fitted with the colour sensor and the metal sensor. When the waste is placed in the plates with the help of the colour sensor the type of waste is detected, the detection is based the RGB color scale. The colour sensor works on the principle of intensity of reflected light.

Each object has different intensity of reflected light with these differences the waste is segregated as Bio-degradable and Non-bio degradable



For Bio-degradable waste the sensing value is from 0-500 in digital value or 0-2.5 v in analog value as volts and for the Non-biodegradable waste the sensing value is from 500-1024 in digital value or 2.5-5.0 v in analog value as volts. The metal sensor is used to detect the metal waste like copper,silver, steel, iron, lead, aluminium and etc. The sensing range for ferrous metals like steel, iron, aluminium is 3-5 cms and for non-ferrous materials like silver, tin, lead is 1-1.5 cms. These sensed values are given into the Arduino UNO, it acts as analog to digital convertor, these converted digital values are fed into the Node MCU, the node mcu has integrated Wi-Fi module which is used for communication. The dustbins are embedded with the ultrasonic sensors at the top to calculate the level of garbage in the dustbins. After the segregation part, when the

dustbin attains a certain level (75%) an alert message is sent to the respective garbage collector with the location of the dustbin to collect the waste. If he collects the waste and empties the dustbin an acknowledgement is sent to the municipality corporation. If the waste is not collected after a period of time a warning message is sent to the garbage collector even then if he didn't collect the waste a complaint is filed against the garbage collector at the municipality corporation. And then the process continues. The system intends to examine the already available waste management system and collect the data to create more optimised waste management system. The system not only notifies the trash level but also alerts the person working on it. It will help the Municipal corporations, Government organisations also individuals who till date use manual ways for collecting garbage from dustbins. It also aims at minimizing the process time and the interference of humans in the processes. It may also be used to file complaint on application if the garbage is not collected. In today's growing world continuously managing the rapidly increasing waste is a difficult job. In many cities where numerous of dustbins are placed, keeping watch on all dustbins is difficult task. Human interrogation is not that efficient to manage huge number of dustbins. A proper framework using IoT is needed for that purpose. Efficiency of the waste management is not up to mark. If dustbin gets filled before time, it will be very hard to know the dustbin location. So, proper infrastructure is required to know location and collecting waste from dustbin which is developed as follows



ARCHITECTURE

Placement of different dustbins in specific areas with location IDs. Each Dustbin contains one ultrasonic sensor and segregator using moisture sensor with motor. These all dustbins located on a server for data collection. After distance measurement from ultrasonic sensor cross specific limit, it will show Dustbin is full with a mail sent to nearby vehicle with location. This will carried out using path optimisation method which is used Cab services. Updation of dustbin empty will be automatically updated on server. Fig.2 specifies the components of proposed system. Following are the details of the components used in the Fig.2. • Ultrasonic Sensor: Measurement of level of waste in dustbin is estimated using ultrasonic sensor which is placed at the top of dustbin. • Moisture Sensor: Dustbin will have various types of waste. Hence to detect

the kind of waste moisture sensor is used. • Arduino: The Arduino IDE is background framework for sensors in the system. It will connect different sensors which are working together to form the system. • DC Motor: The separation of waste is carried out in different compartments in dustbin. So DC motor is used to separate waste in dustbin. • ESP8266: ESP8266 is a Wi-Fi module. It is used for hosting the application. Fig.2 specifies the flow diagram in which as soon as the waste is thrown into the dustbin the waste is segregated into dry, wet, plastic. After the process of segregation of waste the level of waste in the dustbin is checked. If the dustbin is not full, more waste can be put in the dustbin. On the other hand, if the dustbin is full, the location of the dustbin is send to the nearby vehicle by using path optimization method and the status of the dustbin is updated in the database. This process is repeated for all the dustbins.

PROPOSED WORKING

This proposed system works with the help of Ultrasonic sensors, Moisture sensor. The ultrasonic sensor will sense the waste level in the bin as soon as the bin will start filling with waste, the ultrasonic sensor will measure the depth. The ultrasonic sensor is placed at the top of the dustbin and as soon as the dustbin starts filling it will emit sound waves. The transmitter will measure the level of garbage in the bin and emit a sound wave and the receiver will listen to the sound wave. In this way the distance between the ultrasonic sensor and garbage in the dustbin is calculated. This collected data is then stored at the backend in the database. After storing the data in database the system will notify the user and will send a message to the nearby waste collector van through cell phone using GSM technology. Upon receiving the message, the operator will go and collect the waste in the van. To know the location of dustbin, Global Positioning System (GPS) is used. GPS will show location in form of latitude and longitude to user which will help to reach at dustbin in mean time. The dustbin will consist of two plates at a certain inclination. As soon as waste is kept on the area where the two plates meet, the moisture sensor will sense the waste using the principle of the specific moisture level which is separating dry and wet things. The specific moisture level in this case is a function of water content. The sensor creates a voltage which is proportional to the specific moisture level and hence the water content in the waste is calculated and separated. The moisture level of a wet waste material will be more as compared to dry waste. Hence, like this the moisture sensor will

segregate the waste as dry or wet. When moisture level is calculated, then the waste on the two plates will be deposited according to moisture level in respective compartment. For this DC motor will open the plate in which the waste is to be placed. If any or both of the chambers get full it will send notification to the nearby garbage collector operator and the operator will come and empty the bin. This process is repeated for all the smart dustbins.

PROPOSED DESIGN

The basic concept of smart waste management system in cities is to handle the waste from initial to the disposal. The design is as follows:

A. General System:

As the bin gets full it will be detected by the ultrasonic sensor, then a message will be sent to a nearby garbage collector operator, then the operator will come and collect the garbage in the garbage collector van. Also, the waste is separated in the bin itself by using moisture sensor, which will separate the waste in two compartments i.e. dry and wet..

B. Ultrasonic Sensor:

It calculates the distance from the waste to itself i.e. sensor by sending sound waves and calculating the time required the wave to travel from transmitting till it bounces back.

C. Moisture Sensor:

It measures the moisture in the waste collected and separate it on the basis of moisture level in it.

D. GSM Module:

GSM is used to provide message service to enable communication. Using GSM module the concerned person will receive message regarding the dustbin location through SMS. Using Optimization, we reducing fuel consumption and time of operation. Proper database of waste collected can be updated on server which will be developed on a system.

CONCLUSION

The proposed system will provide a better waste management system. With proper use of integrity of software and hardware, this idea can develop a better waste control in over populated cities and town. Continuous monitoring of the level of the dustbin prevents the overflow of the dustbin which in turn leads to a greener environment. Since the dustbin the

cleaned with standard time intervals foul smell of the garbage is prevented. Segregating of waste at the Basic stage will make the waste management more productive and useful. Eco friendly system. The paper contains details about how to establish a Waste Management System using IoT and its applications. With proper use of integrity of software and hardware, this idea can develop a better waste control in over populated cities and towns. The curriculum of this paper is just to focus on existing systems and solutions to improve the existing system. Future work will include the path optimization technique to reduce fuel consumptions and provide better transition system in metropolitan cities. Also segregation of different types of wastes such as e-waste, plastic, metal, etc. can be included in our system. Peripheral work of project is based upon development of smart cities and overall development of our country in terms of hygiene issues.

REFERENCES

Gopal Kirshna Shyam, Sunilkumar S. Manvi, Priyanka Bharti, " Smart Waste Management using Internet-of-Things (IoT)", 2017 2nd International Conference on Computing and Communications Technologies (ICCCT), July 2017.

Arshiya Khan, Ajitkumar Khachane, "Survey on IOT in Waste Management System", 2018 2nd International Conference on ISMAC (IoT in Social, Mobile, Analytics and Cloud) (I-SMAC)ISMAC (IoT in Social, Mobile, Analytics and Cloud) (I-SMAC), 2018 2nd International Conference on, February 2019.

Dung D. Vu, Georges Kaddoum, "A Waste City Management System for Smart Cities Applications", 2017 Advances in Wireless and Optical Communications (RTUWO), December 2017.

Ajitkumar Shitole and Manoj Devare, "TPR, PPV and ROC based Performance Measurement and Optimization of Human Face Recognition of IoT Enabled Physical Location Monitoring", International Journal of Recent Technology and Engineering, ISSN: 2277-3878, Volume: 8, Issue: 2, pp. 3582-3590, July 2019.

Zainal Hisham Che Soh, Mohamad Azeer Al-Hami Husa, Syahrul Afzal Che Abdullah, Mohd Affandi Shafie, "Smart Waste Collection Monitoring and Alert System via IoT", 2019 IEEE 9th

Symposium on Computer Applications & Industrial Electronics (ISCAIE), June 2019.

Luca Catarinucci, Riccardo Colella, Stefano Irno Consalvo, Luigi Patrono, Alfredo Salvatore, Ilaria Sergi, “IoT-oriented Waste Management System based on new RFID-Sensing Devices and Cloud Technologies”, 2019 4th International Conference on Smart and Sustainable Technologies (SpliTech), August 2019.

G Sai Rohit, Shaurabh Saha, M Bharat Chandra, Debanjan Das, “ Dual Smart Dustbin for Managing Waste in Cities”, 2018 3rd International Conference for Convergence in Technology (I2CT), November 2018.

Aksan Surya Wijaya, Muhammad Niswar, Zahir Zainuddin, “Smart Waste Dustbin for Managing Waste”, 2017 5th International Conference on Instrumentation, Control and Automation (ICA), October 2017.

Mohammad Aazam, Ioannis Lambadaris, Marc St-Hilaire, ChungHorng Lung, “Smart Waste Management using Cloud”, 2016 IEEE 21st International Workshop on Computer Aided Modelling and Design of Communication Links and Networks (CAMAD), May 2016.

Sangita S. Chaudhari, Varsha Y. Bhole, “Solid Waste Collection in Metropolitian Cities using Iot”, 2018 International Conference on Smart City and Emerging Technology (ICSCET), Jan 2018.

Tommaso Addabbo, Ada Fort, Alessandro Mecocci, “IoT Sensor Node based on LoRa for Waste Management”, 2019 IEEE Sensors Applications Symposium (SAS),May 2019.

F achmin F olianto, Wai Leong Yeow, Y ong Sheng Low, “Smart Dustin for Waste Management”, 2015 IEEE Tenth International Conference on Intelligent Sensors, Sensor Networks and Information Processing (ISSNIP) Demo and Video Singapore, 7-9 April 2015.

U.S. Environmental Protection Agency, Advancing Sustainable Materials Management: 2017 Fact Sheet, November 2019. “https://www.eia.gov/energyexplained/biomass/waste-toenergy.php”

Zainal Hisham Che Soh, Syahrul Afzal Che Abdullah, Mohd Affandi Shafie, Mohamad Azeer Al-Hami Husa, “Waste Collection and sending SMS to system”, 2019 IEEE 9th Symposium on Computer Applications and Industrial Electronics (ISCAIE), 27-28 April 2019