Smart waste bin system: a review

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Abstract: The recent urbanisation in the developing nations of the world, rise in population, increase in human activities. Pattern of production and consumption has resulted to generation of huge amount of waste that must be properly disposed, treated and managed to ensure sustainable environment and a decent living for the increased population. The current waste management practices are not effective and efficient enough to handle the rise in waste level. The traditional approachhas led to this challenge.This paper deals with a systematic review of existing literatures, identifying and characterizing active research activities on smart waste bin that will allow effective waste management. There is a great need for deployment of this Smart technology on a large scale in the developing nations of the world for a sustainable healthy and clean environment. However, the cost of applying such solutions is still relatively high.

Keywords: Smart: Waste; Bin; Management; Disposable; Pattern

1.0 Introduction

The fight for a sustainable future will be lost or won in the cities. Precisely, how we collect, dispose, treat and manage waste generated [1]. The urge for smart sustainable cities, technological advancement in the nations of the world, rise in population, increase in human activities and pattern of production and consumption has given rise to generation of huge volume of waste that must be properly disposed, treated and managed to ensure sustainable environment and a decent living for the increased population [2].However,the need to sustain a clean and healthy environment is a global concern[3]. Sonawane et al [4] stated that population increase translated to increase in waste generation in our environment and waste management has turn out to be a global challenge. Waste management in this present-day require taking the right decision and approach in tackling the challenges. The change in people's lifestyle has led to an increase in the generation of waste [5]. Serious challenges are posed due to the increase in waste generation. The present waste management disposal methods in our nation, such as burial, open-air burning, and open dumping, were found to be ineffective and detrimental to public health and the environment. The outdated waste management

method, where cleaners are saddled with the responsibilities to empty the waste bins periodically. Such plan has a lot of demerits. The present day situation shows that waste bins positioned in our environment are often times spill over due to the significant rise in waste generated daily. Thus creating an unhealthy environment for the citizens and producing foul odour around such location. This bring about the spread of some diseases and human illness [6].Tripathi et al., [7] alluded that one of challenges associated with waste bins in public places is the need for frequent checked so as to avoid overflow. Routine checks for disposing the waste are not efficient as waste bin often get filled early. The sight of overfull waste bin and waste being spilled out of it is common all around our nation, Large number of diseases causing organisms and insects bred on it. An improper urban waste collection may indulge in causing several problems such that it affects the environment, the nations and the citizens. In the recent times, management of waste is of crucial interest in the urban cities. Therefore, the use of smart dustbin in our nation can minimize, if not eradicate this challenge [8].

2.0 Automated Teller Waste Bin

In this paper, authors developed a smart waste bin like an Automated Teller Machine incorporated with an embedded system labelled an Automated Teller Dustbin. An object recognition and detection model for items regarded as garbage was developed using an image classifier by examining training features via convolutional neural network. In addition, labelled object are being counted and assign a price value, which can be withdrawn by individual that brought the waste. A data set of 20 images for each of the 10 categorized object was pre-trained using a CNN-based model AlexNET. However, this system is limited to certain waste material. [9].

2.1 Segregation Smart Dust Bin

Singh et al., [10] developed a smart waste bin that segregates waste into bio-degradable and non-bio-degradable. Whenever a person approaches the bin with waste in front of the sensor, it detects and separate the waste (bio-degradable or non-bio-degradable). Subsequently, when the bin is full, message will be sent to the person in charge to empty the waste bin. Many diseases are spread through improper disposal of waste. Cheap smart waste system was implemented to automatically separate wet and dry waste via moisture sensor and then sent for further processing [11].Saranya et al., [12] have made such a system that identify and separate metallic waste from non-metallic waste via RLC metal detector circuit. The bin itself is partitioned into two halves. The classification is based on the increase in inductance of the coil whenever an object is placed within the coil vicinity. If the inductance change is beyond a threshold, the object is classified as metal and plate tilts into one side of the partitioned bin. This proposed system is implemented using an Arduino and Wi-Fi powered by a 9v battery.

An Automated Waste Segregator was implemented by Kesthara et al., [13]. The proposed system sorts waste into three different categories specifically metal, dry and wet waste. This helps to optimize collection schedule. The various category has been embedded with a rejection and acceptance rate system. In addition, sensors are incorporated to monitor the status of the waste bin and at maximum capacity, instant messages are sent to waste management authority to empty the bin. In this System, an Arduino microcontroller platform which regulate the sensors (Ultrasonic sensor, Humidity sensor), GSM module and Servo Motor. However, the waste level in the bin is being measured by ultrasonic

sensor, if the fill level was more than threshold value. The Arduino board prompt GSM module to transmit message indicating which specific part of the bin is filled (dry or wet) [14].

2.2 Robot Smart Waste Bin

A robot smart waste bin has been proposed by sreejith et al., [15]. The proposed solution comprises of waste level monitoring and at filled level, the bin moves automatically to the designated collection area for the disposal of waste and returned back to its initial position via a two axis robot. Also, a gas sensor has been incorporated to detect odour and alert the people living within the location via a buzzer. In addition, a rain sensor is used to sense rain and automatically closed the lid of the bin when it senses rain. Furthermore, an Infrared sensor is interfaced with the microcontroller to monitor the waste level. The entire system is monitored on the web page via Wi-Fi module. Ghorpade-aher et al., [16] developed a system that act a smart bin and a waste collecting truck, on command when the bin is full, it act as a robot. Two ultrasonic sensors are employed; one is positioned on the rim of the bin while the other at the robot base facing forward. A Raspberry pi zero W is used as a microcontroller, waste level and weight are detected via ultrasonic sensors to ensure that the waste bin does not overflow with garbage. The waste bin move to a designated area through a predefined track, where waste collecting truck will empty its content. Once the contents of the bin are emptied, the dustbin moves back to its original position. The status of the bin will be updated from a webpage through command issued by an authorized person.

A Smart Home dustbin is also proposed using a radio frequency identification RFID technology with a door opening mechanism. It is placed at a particular height from the ground level, an interaction is enabled moving dustbin and home dustbin through the RFID. An ultrasonic sensor would indicate when the waste attains maximum level. The door opening mechanism is activated when interfaced with the moving dustbin(Binbot) and it disposes the waste. The moving dustbin is embedded with ultrasonic sensor, infrared sensor, RFID transmitter with Internet of Things IOT. There is a predefined path for the moving dustbin through a line following mechanism[17]. Rajathi et al., [18] proposed a robotic dustbin that moves along a lined path, with aid of two IR sensors that are located at the base of the robot facing forward. It is embedded with an obstacle sensor by the side that senses black colour and sound a buzzer signifying stoppage for a duration for waste to be deposited. In addition, ultrasonic sensor is placed at the rim of the bin for detection of waste level. The status of the bin is being updated on the web page via Wi-Fi module indicating whether it is full or empty. The robotic bin is programmed using an Arduino integrated development environment loaded into a microcontroller.

2.3 IOT Based Smart Waste Bin

An effective model of an automatic waste bin was developed using a network of sensors NWS for detection of waste level, opening of the dust bin lid and detection of pungent odour. The lid of the bin open automatically, once a person approaches the bin. Sensor detect the waste level, once the preset value is attained, notification is sent to the authorized personnel to empty the bin. This is to ensure foul odour that not spread out and thus making our environment health and hygienic [19] Kurre and Sharma[20], implement a smart dust bin overflow indicator using raspberry pi.IR sensor and IOT, status of dustbins is indicated on a dashboard whenever the garbage level attains its limit and a mail report is sent. If the dustbin is not emptied within a specified period, then a message is sent to the waste management personnel who then take necessary action against the affected contractor. However, the system components are vulnerable to plundering. in various ways which needs to be improved on.

In a paper presented by Muyunda and Ibrahim [21] a waste bin filled up level system was developed through the use an Arduino microcontroller, tilt sensor for orientation, level sensor, a real clock time module and a web server for receiving data from the sensor node. Nevertheless, the design temperature, fire outbreak and theft were not considered. Raju et al [22] developed a smart waste collection system with the aid of ZigBee using IOT with modules and sensors incorporated powered by solar energy. It does not only read, collect data but transmit a large amount of data over a network, which is used to monitor waste collection system when put in a cloud. This paper discusses an IOT based smart waste collection bins which were interfaced with a microcontroller comprising an IR wireless system alongside with a system indicating the status of the waste bin, via a mobile web browser with HTML page by Wi-Fi This paper discuss a smart means of handling garbage via IOT protocol for transmission of waste bin status. E-mail notification isgenerated and will be send to the waste management authority, indicating the bin status and the need for replacement, if the bin is filled up. This system utilizes ultrasonic sensor to indicate waste level and proximity sensors detect object in front of the bin. Also LCD has been integrated to show the current status of the bin. However, segregation of waste was not considered in this research [23].

Prakash and Jayalakshmi[24] implemented a smart waste system that was deployed as outdoor testbed Meshwork and cycle features were incorporated into the system, so that bin providers are able to ascertain and determine whether a particular location need an extra bin to be placed nearby or remove or relocate the existing bins by using information collected from the waste bin. This invariably aid the cleaning operators to plan better.However, it is deployed as an outdoor testbed which thus limit the usage. Chattopadhyay et al., [25] implemented a smart sensing system to every single bin inside the campus area using an Arduino board connected to a Wi-Fi module and ultrasonic sensor. The sensor is directed towards the face of the bin and each time the bin is lesser than 5cm unfilled, the bin status will be indicated as full. Also a webpage was developed for the showing bin status, Periodically, the status of the bin will be accessed and the sweepers will be notified accordingly. This paper presents a work for tracking dustbin and complaint waste management system using an IOT based bin. A mobile app was developed for tracking dustbin location and for discovering of filled dustbin in a particular residential area. Through this mobile app, complaints are being sent to the authority. However, time response of the waste truck was not considered [26].

2.4 GSM /Wi=Fi Based Smart Waste Bin

Sumit Rathi et al., [27] developed a smart waste bin based on two stereoscopic cameras detecting waste filled level, the design was based on deep simulation with processing of image on daily basis. Also, depth estimation was made through a 3Dmodel construction of captured image using an open source system. Raspberry pi model 3B was used as a microcontroller compare to the commonly used Arduino. The system proposed by Masane [28], an integrated garbage level monitoring system using flame sensor, raspberry pi, ultrasonic sensor, load sell, humidity sensor, GSM module, Wi-Fi and LCD. The proposed system assures of real time monitoring of waste level with the aid of sensors and wireless communication capabilities, thereby increasing the efficiency of waste management system.

Another method developed by Tambekar [29], this proposed system employed the use of network of sensors and GSM module to check the inefficiencies and anomalies in the waste collection and disposal method. Ultrasonic sensors were incorporated at different fill level of the bin and thus providing incessant functioning of the system even under extreme situations. The GSM module is used

for transmission of warning signals to the waste management authority through a text message. Sanjay [30] utilizes the use IR sensor, Arduino, motor, pump and Wi-Fi module for the development of Internet of Thing. A dual purpose smart waste bin that serves for both waste collection/disposal as well as waste recycling.Once garbage is not cleaned within the specific period, then a message will be sent to the user. Thus reducing overall cost and also conserving the environment towards. Rohit et al [31] developed a conceptual approach of two waste bins in which waste bin A and B cannot be used simultaneously. Waste bin B can only be in operation once waste bin A is cleared, but whenever any of the waste bin is full, message is sent to the designated officer. This is made possible with the aid of an Ultrasonic sensor, IR sensors and communicated to the appropriate authority by GSM system This paper by Kumar et al [32] presented a system supported by an integrated embedded module. With the aid of this system, waste collection is being monitored and the process follow up by the authority. Furthermore, an alternate approach could be adopted, an android app is built and linked to a web server to initiate an alert messageto the waste management authority and the cleaning process is monitored remotely.Anilkumar [33] employed the use of IR sensor in developing a smart dustbin embedded with a stepper motor for lid opening and closing. detection of waste collected and odour present through the use of sensors. An automatic message is sent to the concerned person via the use of a GSM module. Gaddam et al., [34] examined a smart solution for managing waste via IOT. Ultrasonic sensor is used for measuring waste level in the bin and also deployed raspberry pi for further processing of information. Wi-Fi module of the raspberry pi is used to send sensor data to the cloud. More so, whenever the trash passes a certain limit, the bin and location are indicated in the App via google maps. Also, present location of truck driver is indicated and the shortest path is indicated using GPS. However, the power supply limit the functionality of the system. In this paper titled" Smart Garbage Management System".

Jajoo [35] propose a level monitoring of waste bin using an Arduino Uno R3 controller, ultrasonic sensor and a Wi-Fi ESP8266 which give the Arduino to Wi-Fi network which help in sending or receiving alert messages. This implementation was done only for a single bin. However, this system can be done for several bins each having a unique identity and also engaging the principle of IoT using SQL technology and a login webpage for authorize personnel. Alsayaydeh et al., [36] developed a smart dustbin using an Apps, utilize the Arduino microcontroller between buzzer, LED, fan, Wi-Fi Module and ultrasonic sensors. The ultrasonic sensor detects approaching object. The waste level is being displayed via Blynk Apps. When the level of waste increased to pre-set value, a notice will be sent to the waste management authority to give notice that the bin will soon be full. Further notice will be sent once the bin reach maximum level, so as to empty the waste bin via the Blynk Apps and a beep sound will be initiated by a buzzer.

Siddique et al., [37] in the study conducted, proposed a system whereby waste bins are incorporated with microcontroller built system.Ultrasonic sensor is used for waste level detection and Wi-Fi module to link the internet. In addition,the real time status of the bin is being monitored through an android application. Also the shortest possible direction will be specified on map. Baihaqi [38] in this study examined time management in picking up of waste in the city through the implementation of a smart bin. Time and route were simulated using data obtained from Padang City. The proposed smart bin is outfitted with a solar panel, Infra-red sensor for opening and closing of the bin, messages are being sent to the personnel in charge via GSM module. Also an ultrasonic sensor for detection of bin load. In this paper titled "Smart Waste Bin: A New Approach for Waste Management in Large Urban Centres

", the authors proposed an integrated waste monitoring system using load cell sensor and ultrasonic sensor, message will be send via GSM/General Packet Radio Service(GPRS) and position by Global Positioning System(GPS) in order to achieve efficient waste collection scheduling via optimised routes. However, this innovation that incorporates different communication and detection system failed to provide a platform for the end users to know the status of the waste bin[39]. In this work, a low power consumption smart bin developed by Utomo et al., [40]consist of low powered embedded components ranging from ultrasonic range finder for measuring of waste level, microcontroller, network protocol and an algorithm to minimize the device power consumption. The solution is verified through proper implementation and evaluation. However, from the evaluated result, the system exhibited a low power consumption features and there is fluctuation in the waste data collected.

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3.0 Characteristic of Smart Waste Bin

3.1 Sensing Capabilities

Sensing system is fundamental to any smart waste bin in any human environments, it is also essential to wide range of functions. The reason for choosing a particular sensor is the sensor performance based on the physics of the underlying principle of operations, the characteristics of a sensor are deeply related to respective physical transduction process. Infrared(IR) Sensor is mainly use for detect object within a distance range (proximity sensor). It can also be used for level detection so as to avoid overflow of waste from waste bin. IR sensor comprises of an IR LED and an IR Photodiode; together called as Opto – Coupler. The transmitter of the IR emits radiation, it affects the object and some of the radiation echoes back to the IR receiver which is depends on the intensity of the reception by the IR receiver[24]. Ultrasonic Sensor can also be used in lieu of IR sensor in detecting waste level in a waste bin. Several authors have proposed the use of ultrasonic sensor waste monitoring. Ultrasonic sensors surmount several of the flaws of IR sensors - they measure distance irrespective of colour and lighting of hindrances. Also offer minimum distances and varied angles of detection to ensure that objects are not skipped by a sensor beam[6].

Weight sensors are also used for garbage detection; they offer the weight of the garbage in the dustbin. These sensors detect changes within physical quantities such as force, pressure or weight and yields an output that is comparative to the physical quantities. However, they do not afford any info about the waste level in the bin. They are often called Load Cell. Gas level sensors are used to detect gases so as to keep the system safe and circumvent any unforeseen hazards. There are several gas sensors to detect gases like oxygen, Carbon Dioxide, Nitrogen, methane etc. Gas sensor can also be used in detecting leakage of unsafe gases, check the air quality. Most smart garbage bins are implemented with sensors and they are linked together in network through a Wireless System Network(WSN).

3.2 Communication Capabilities

Communication is essential to any smart sensing system. The recent communication shift that envisage the future, where devices will be fitted out with microcontrollers, transceivers for digital communication and appropriate stacks that will make them communicate with other devices as well as the users through the IOT. Several authors have proposed innovative system for waste monitoring employing IOT, most of these system work in conjunction with Arduino or Raspberry pi microcontroller based board and IDE environment that runs on computer, for writing and uploading

computer codes to the physical board. Arduino codes are written using C/C++ while Raspberry pi codes are written using python.In many communications based electronic devices such as smart garbage bin, GSM Module (Global System for Mobile communication) is used, the interactions are done through the GSM network. The communication interfaces are like the Universal Serial Board(USB), which often require SIM (Subscriber Identity Module) card to activate the communication with the network. The GSM module understands AT(Attention) commands and reply appropriately. It allows the board to link with the internet, send, receive messages and make voice calls.

3.3 Display Capabilities

Display unit is important to any smart waste monitoring system. The status of the bin is often shown either full, semi full or empty via the display unit. Several authors in their various work have used Liquid Crystal Display unit [41]or Light Emitted Diode unit. Various types of LCD are available founded on the applications. Most frequently used is 16x2 LCD where 16 represents columns and 2 represents rows or lines. The major reason researchers prefer the LCD to LED are: the price reduction of LCD, simplicity of programing for characters and graphics, ability to show numbers, characters and graphics[26]. It is also used for displaying of various messages and instructions to user[42].

3.4 Future Trends

Mostly, waste is generated from both residential and industrial places, rural and urban areas. However, the tradition ways of collection are being done manually which makes it difficult and daunting to keep our environment clean. Timely identification of filled waste bin for effective disposal demands large human resources and time consumption due to frequent check on the status of the bin. Despite the provision of waste bins in various places, the sight of overfilled waste bins which serves as a breeding places for pest and rodents remain an eye sore. This often led to spread of diseases and human illness in our environment. The time is now to employ smart technology for proper collection and disposal of waste for sustainable clean environment.

4.0 Conclusion

. In this paper, we present systematic review of existing literatures on smart waste bin, current and prospective applications of smart waste management.Several researches are geared towards development of smart waste bin due to the successes recorded so far. Nevertheless, there seems not to have been an appreciably deployment of this technology on a large scale in the developing nations of the world. Waste management system requires a tailor fit solution in which the investment will be cost effective and efficient. There are numerous exciting improvements in smart waste management in recent years, which points to a prosperous future. There is a great need for deployment of this Smart technology on a large scale in the developing nations of the world for a sustainable healthy and clean environment. However, the cost of applying such solutions is still relatively high.

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