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Original Article

Revolutionizing Waste Management in Developing Cities A Cutting-Edge Novel Optimization Approach to IoT

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Abstract *- People throw waste everywhere without thinking of the consequences in today's world, which can result in harmful illnesses. Consequently, one of the main problems in developing cities is waste management. The main issue with waste management is that trash cans at public locations are frequently overfilled well before the next cleaning process begins. It attracts various dangers, such as foul odours and offensiveness to that location, which may be the primary cause of the spread of various diseases. Therefore, with the aid of an Arduino UNO microcontroller, a novel Internet of Things-based smart dustbin is developed in this paper. The primary focus of this paper is to monitor the dustbin filling status and whether it is filled or not. The procedure is assisted by the two ultrasonic sensors which are adapted with Arduino UNO to monitor whether the person is nearer to the smart dustbin or not and send the notification to the municipal systems. Moreover, the newly designed smart dustbin can be used for a Waste Management System where the municipal comities can empty and clean the smart dustbin, which is based on the message notification. Additionally, the African Buffalo Optimization algorithm is implemented to invert the innovative model. Message notifications are obtained through the PYTHON application, which serves as the software platform.*

Keywords *- IOT, Optimization, Smart Dustbin, Waste Management, Ultrasonic Sensor.*

1. Introduction

With wireless technologies, sensors, and embedded systems, the Internet of Things (IoT) is the newest and most sophisticated technology for connecting a large number of information-transferring devices [1]. Reliability frameworks or mobile networks are the terms used here to describe wireless technology [2]. This kind of technology can create a smart way to live with all types of creators in daily routines [3]. Wearable devices, automatic driving vehicles and machines are termed IoT devices, which interact with the computer to machine operating systems [4]. The utilization of IoT gadgets in businesses and urban communities is quickly expanding because of their exceptional features, such as skills in decision-making and productive service [5]. It has exceptional key attributes containing availability, enormous scaling, knowledge, sensing, heterogeneity structure, and dynamic nature [6]. It very well may be utilized in a huge number of utilizations of these wearable, smart households, medical care systems, traffic organization, smart cultivating, associated vehicles, modern industrial internet, and smart cities [7]. There are three layers needed to develop the IoT structure such as device, access layer and platform layer. Moreover, each layer contains separate functions like cloud storage, sensing, and acquisition [8]. Initially, it will gather all environmental-related information from the atmosphere. This collected information is termed unreadable data, which is converted into usable information with the help of the acquisition function. After that, usable information is fed into the sensing stage. Finally, the gathered data was stored in the cloud storage system [9]. In the modern era, there is an extreme increase in urbanization garbage since several houses and condos underlying the fast urbanization region because of high requests for lodging raised, because of which relocation expanded from towns to urban areas to find work and to oblige in the metropolitan region [10]. Meanwhile, there is a development in squandering creation and removal of strong waste [11]. The overflowing of waste could cause illnesses like malaria also dengue. Moreover, the smart city straightforwardly incorporates a smart garbage administration framework [12]. The inorganic and natural waste created from business or family exercises and the significant sources of waste material is gathered from family. The best way to gather family squander is the dustbins or the trash receptacles, which are likewise positioned before social orders or then again open spots which are here and there overfull due to the expansion in the waste material consistently and negative such appropriate administration of waste material which leads to serious wellbeing dangers and different sicknesses. It is contaminated to encompass climate [13]. Different types of dustbins for different waste materials are shown in Figure 1.

Fig. 1 Different types of dustbins for different waste materials

The fast development of the populace came about in sloppy rubbish removal. Moreover, waste management takes additional time and requires an enormous number of individuals. Garbage removal has turned into a significant issue lately [15]. Impromptu waste removal, which is unloaded in landfill locales, is the most familiar method of waste removal [16]. This procedure is harming every single living creator [17]. This approach can contaminate surface and underground water with fluid leachate and other parasites, as well as spread perilous illnesses that damage the climate's aesthetic worth [18]. Commonly, dustbins are used to throw waste [19]. The smart dustbin is used to throw the garbage find the filling level of that garbage, and also give the notification [20]. These operations can be done as some electronic components like motors, sensors, etc. [21]. While comparing the normal type of dustbins IoT, based smart dustbins are very effective [22]. IoT-based smart dustbins are integrated with a lot of hardware components and function as software programming [23]. Six sections make up the remainder of this article: A review of the literature on the production process of smart devices is presented in the second section. The motivation is covered in Section III. The design process is introduced in Section IV, which also examines the suggested platform. The results are covered in Section V. In Section 6, conclusions and future directions are discussed.

2. Related Work

Cong wang, Jiongming Qin et al. [24] have developed the Deep Learning (DL) based cloud computing strategy to diminish the waste classification cost and increase classification accuracy. Moreover, the proposed technique is very useful for the Municipal Waste Management (MWM) team. The main concept of this work is to divide the waste into six categories such as paper, glass, metal, plastic, fabric and others. Here, DL is applied to classify the waste and IoT devices are used to exchange the information from the Waste Management Centre (WMC). It has attained a higher classification accuracy rate of 94.26%, and its running time is 261 ms. In the modern era, IoT is one of the prominent application areas for smart city developments. In that, waste collection is a noticeable issue for the MWM centre. To tackle this issue IoT based smart waste monitoring, prediction and disposal system is developed by Jacob John, Mariam Varkey, et al.[25]. The developed approach is to enhance the smart city infrastructure, public utilities, etc. Here, weight sensors, an Arduino microcontroller, and Global Positioning Systems are used to design the smart dustbin. Moreover, the communication is done on a cluster network with backend-connected Wi-Fi. Also, the LSTM module is used to predict the upcoming garbage from garbage generation patterns. Dustbin status notification is sent with the help of the Firebase cloud messaging programming application. To develop the automation and digital world, the IoT is incorporated with a large number of data service centres. This development, unfortunately, affected the waste that overflowed from the dustbins in the public areas. Consequently, a lot of dangerous issues occur for this overflow. To address this issue, Dipesh Yadav, Anish Pandey et al [26] have introduced an IoT-based smart dustbin alarm system to alert the municipal wastes to clean the garbage immediately. The proposed work has the additional capacity to take more waste from overflowed dustbins. Here, a Passive Infrared (PIR) sensor is used to detect the distance of the person coming in front of the dustbin. This will help to avoid the hazardous diseases spread in the world.

Madrol Sathveek, Shreemanth et al. [27] have developed a waste collection Arduino microcontroller-enabled robot to clean smart cities. It is mainly based on cutting-edge operations. Moreover, the proposed system can give the proper results during the garbage collection process. The robot is covered with metal and a 12V battery power system is connected to the robot. This newly designed robot can collect waste from public regions such as schools, colleges, parks, roads, etc. Also, this robot is more applicable to muddy environments.

M. Karthik, Sreevidya et al. [28] have developed a low-cost embedded system to clean and create a healthy environment. Here, the ultrasonic sensor is enabled to predict the trash filling status and continuously monitor it. Moreover, the pre-setted limit is used to send the information to the bin collector automatically. The mobile phone network is connected to the bin collector and will proceed with immediate performance. The key contribution of this proposed work is summarized as follows - the dustbin is designed with the help of various electronic components. Then, the garbage is stored in the newly designed smart dustbin. Here, the dustbin cap is automatically opened when the person is in front of the bin with the help of ultrasonic sensor-1. The second ultrasonic sensor checks the filling status of the smart dustbin. Send the notification to Wi-Fi using a mobile hotspot. Municipalities come to the spot and start the cleaning process immediately.

Algorithm:1-ABO

start

Objective function (alert system)

Step-1 *Initialization: randomly locates all hardware components*

Step-2 *Initiate fitness function*

$$a.n+1 = a.n + lz_1(bs2_{max_{max}} \quad (1)$$

Where, $a.n$*and* $d.n$*denotes exploration and exploitation fitness function of the* n^{th} *buffalo, learning parameters are denoted as* lz_1 *and* lz_2*,* bs_{max}*and* bt_{max}*is denoted as herd and single buffalo fitness, respectively*

Step-3 *Update ultrasonic sensor function-1* *// it will sense the person near the dustbin*

Step-4 *Initiate location of smart dustbin*

$$d.n = \frac{(d.n+a.n)}{\pm 0.5} \quad (2)$$

Step-5 *Updating ultrasonic sensor function-2* *// it will detect the dustbin filling status*

Criteria are not matched; return to step 2

Output: *Finest result*

stop

3. Motivation

Nowadays, waste management is a challenging problem that can affect human beings. Despite a significant workforce of garbage, waste gatherers, scrap sellers, and recyclers are convoluted in dealing with the loss in brilliant urban communities [29]. Moreover, the most impacted area in the garbage removal framework process incorporates the unrecognizing waste collectors who structure the country's biggest casual area [30]. Most people are not aware of waste management and waste collection. Then municipal garbage is very hazardous because of improper classification as well as disposal [32]. So, effective garbage management is essential to avoid the improper classification of waste. Therefore, to overcome this issue Internet of Things (IoT) based optimization is one of the famous advanced modern technology. This technology can provide an effective waste management module to collect waste.

4. Proposed Methodology

The developed optimization technique will design the IoT-based smart dustbin with the help of optimization techniques. Moreover, the proposed design transmits the notification whether the dustbin is filled or not. This designed system will help the municipal agencies of correspondent cities. To find whether smart dustbins were filled or not, their capacity was measured with the help of the optimization fitness function. Here, the African Buffalo Optimization (ABO) algorithm is incorporated to design the IoT-based smart dustbin system. The designed smart dustbin system can perform the following operations,

- Finding the filled dustbin
- Indication ON/OFF system
- Communication between IoT nodes

The developed structure will stay away from the overflow of any dustbin and decrease the unhygienic circumstances in the city. Moreover, this procedure would be useful in the enhancement of strategies as well as human resources organizations of urban communities.

4.1. Process of ABO

ABO algorithm has two main functions such as communication and intelligence. These three parameters are tuned as IoT-based smart dustbin monitoring performance, such as the person sensing phase and filling level phase.

4.2. Working Principle of Smart Dustbin

The designed smart dustbin's working performance is in the following manner: here, two ultrasonic sensors are used first one is equipped outside of the bin with Arduino UNO and sensors. Initially, the ultrasonic sensor predicts a person and garbage when the garbage and hand are located near that sensor immediately after the dustbin cap is opened and the person throws the collected waste. This is the first ultrasonic sensor operation. Then, another sensor is equipped inside the dustbin, and it is connected to the cap of the dustbin. This second sensor can monitor the filling status of the garbage inside the dustbin. Then, the measuring distance is sent as a notification to Wi-Fi using a mobile hotspot. The flowchart of the proposed design is demonstrated in Figure 2.

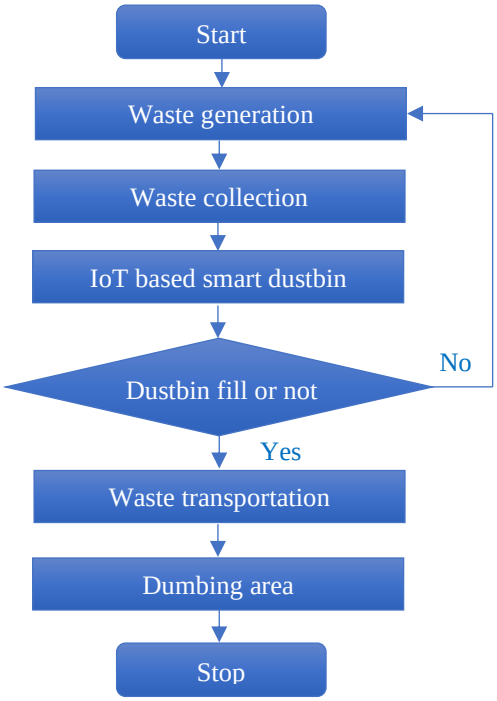

Fig. 2 Working flow

4.3. Hardware Setup

In this article smart dustbin was implemented based on the correspondent IoT nodes, which are constructed on the latest version Arduino UNO platform combined with an ultrasonic sensor, LED, and servo motor. Here, the two ultrasonic sensors used are equipped on top of the dustbin. Moreover, the threshold level was set based on the ABO fitness function. The main principle of the developed smart dustbin is that the connected ultrasonic sensor can sense the person in front of the dustbin, and immediately, the message notification is transferred to the servo motor using an Arduino UNO microcontroller. The hardware connection is illustrated in Figure 3. At the point when the human comes nearer to the smart dustbin, then the dustbin top will be opened automatically for your garbage through, and after some time it will be closed automatically.

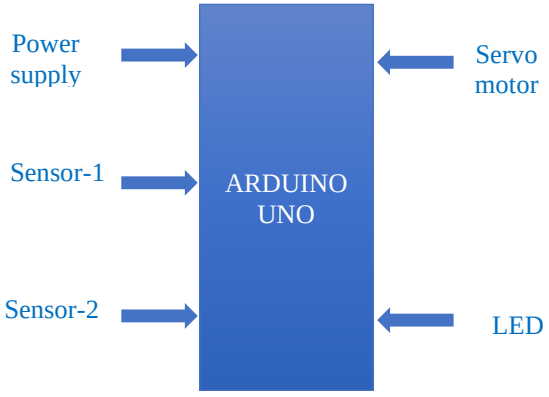

Fig. 3 Block diagram of hardware setup

4.3.1. Arduino UNO

Arduino UNO microcontroller contains 14 digital pins, and it has 6 analog input pins, 6 PWM output pins, a power connector and an ICSP header pin. Moreover, the Arduino UNO microcontroller has entire required components to operate it continuously. Then battery or AC-to-DC converter is connected through the computer with USB bins to supply the power. Also, the Arduino UNO microcontroller board is equipped on the ATmega328 datasheet. The hardware structure of the Arduino UNO microcontroller is shown in Figure 4.

4.3.2. Ultrasonic Sensor

Generally, the ultrasonic sensor is to compute the distance from an object. Consequently, the proposed IoT-based smart dustbin contains two ultrasonic sensors that are equipped in dustbin. Detection is the main performance of these ultrasonic sensors. When the person comes near the dustbin, it is open; otherwise, it is closed. The hardware structure of the ultrasonic sensor is shown in Figure 5. Moreover, this type of sensor can utilise the transducer to transfer the information in the correspondent element. Then the system will alert at different echo patterns. Also, these offer both analog and digital outputs. Arduino UNO microcontroller also communicates with these two ultrasonic sensors to monitor when someone near the dustbin will open. According to this operation the entire system will perform.

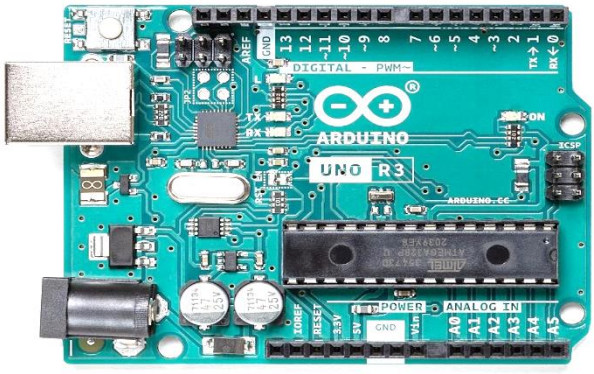

Fig. 4 Arduino UNO microcontroller

Fig. 5 Ultrasonic sensor

4.3.3. Servo Motor

The Servo motor helps with the opening and closing process of the cap of the developed smart dustbin. Here, the Arduino UNO microcontroller functions in a new manner to detect the garbage-filling status using an ultrasonic sensor; the cap should automatically open with the help of a servo motor. The hardware structure of the servo motor is shown in Figure 6.

5. Experimental Setup

Initially, compile and upload the code when the coding part and hardware setup are finished. Here, the code is uploaded to the Arduino UNO microcontroller through the UCB cable that is connected to Wi-Fi using a mobile hotspot. The status of the dustbin was monitored with the help of an ultrasonic sensor with an Arduino UNO microcontroller. All these connections are located inside and outside portion of the dustbin as a smart dustbin. Then, monitor the waste level of the dustbin using an ultrasonic sensor. The battery value is 9V, and Arduino UNO is powered by 3.3V. The experimental setup is illustrated in Figures 7, 8, 9 and 10.

Fig. 6 Servo motor

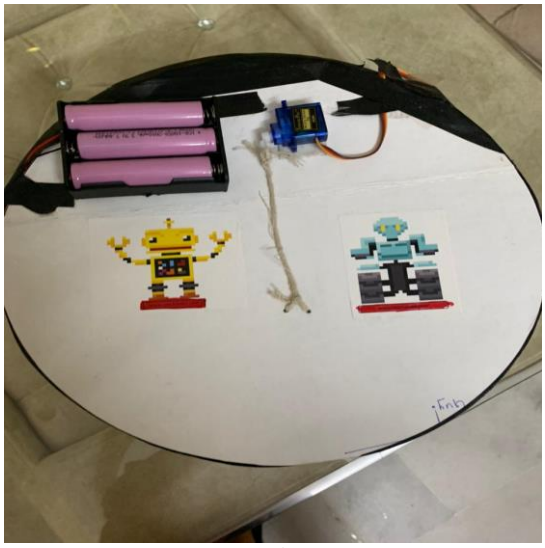

Fig. 7 Top portion of the smart dustbin

Fig. 8 Lid open when a human is near the dustbin

Fig. 9 Inside portion of the smart dustbin

Fig. 10 Outer portion of the smart dustbin

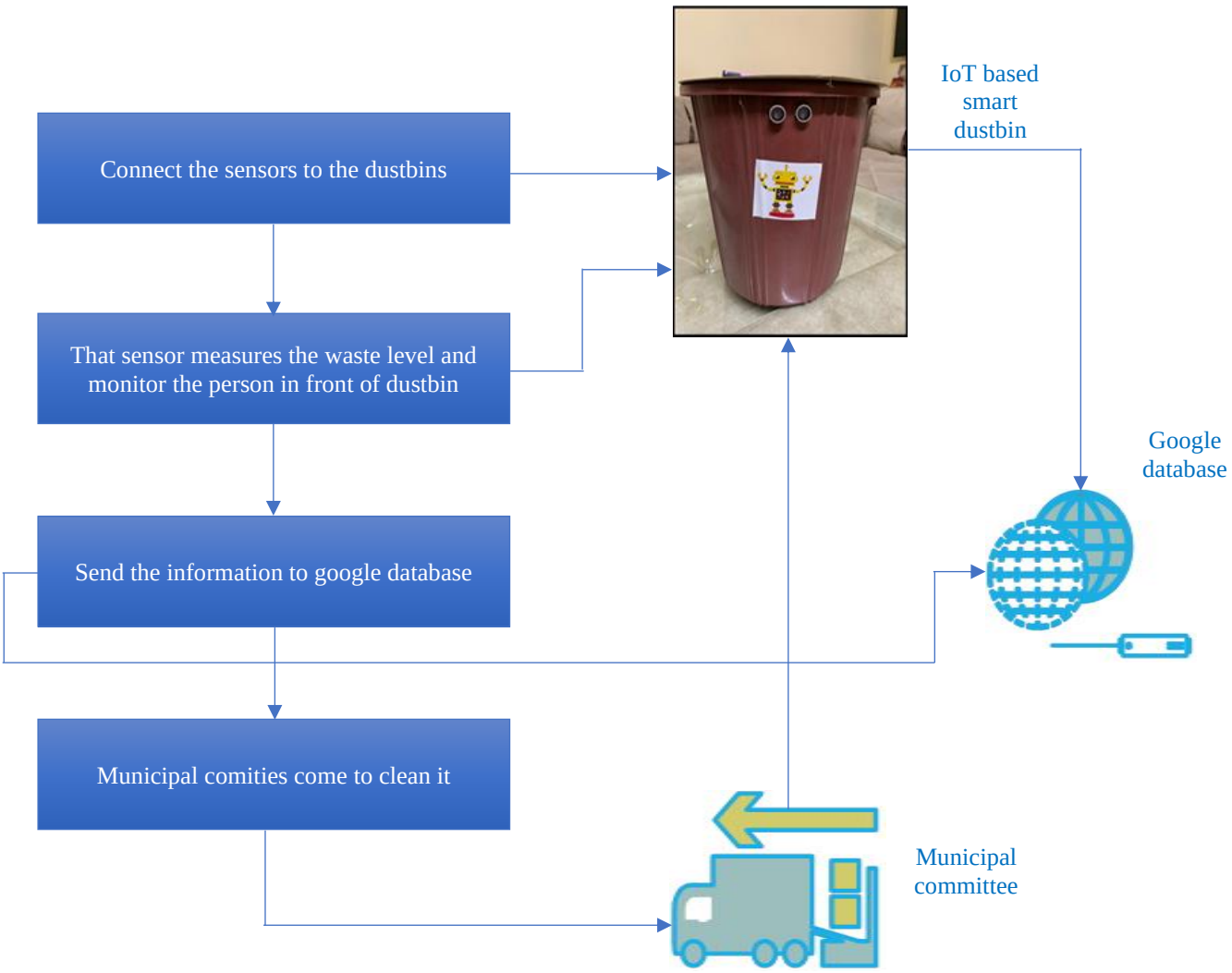

Fig. 11 Case study of the monitoring system

Table 1. Comparison of accuracy

S.no	Techniques	Accuracy (%)
1	Machine Learning (ML) algorithm [14]	92.65
2	Convolution Neural Network (CNN) [31]	96
3	Deep Learning (DL) based cloud computing strategy [24]	94.26
4	Proposed	98.4

To evaluate the success score of the proposed model, key matrices were calculated, which were validated using conventional techniques, e.g. Machine Learning (ML) algorithm [14], Convolution Neural Network (CNN) [31] and Deep Learning (DL) based cloud computing strategy [24], which are demonstrated in Table 1 and case study of monitoring system is shown in Figure 11—moreover, the performance metrics like accuracy.

6. Conclusion

IoT-based smart dustbins can help people to deal the waste effectively and assist them with diminishing work by calling for the municipal comities to make the region clean and make a healthier climate to live in. There will not be any sort of infections, and individuals will be fit and are not inclined to infections brought about by these waste materials. Moreover, a developed dustbin with Arduino UNO microcontroller hardware setup can guarantee the dustbin cleaning process properly when the garbage filling level reaches its most extreme.

Consequently, this process is performed with the help of a battery power supply and ultrasonic sensor functions. Sometimes, the dustbins are not cleaned properly, and the alert system can pass through the other municipal agents to take suitable activity against the concerned project worker. It at last assists in keeping the encompassing with cleaning, and the squandering of the board can be a lot more straightforward.

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