International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

IOT Based Waste Management and Segregation System

Beena K[1], Ms Santhi P[2]

[1]PG Scholar, Department of Computer ScienceIES College of Engineering, Thrissur, India
[2]Asst. Professor, Department of Computer ScienceIES College of Engineering, Thrissur, India

Abstract

Both urban and rural life depend heavily on the handling and collection of waste. A poorly planned and inefficient waste collection system raises costs and harms the general public's health. The existing method of collecting conventional garbage is neither the best or most efficient. By enabling intelligent, adequate, and self-sufficient systems, the Internet of Things, or IoT, has proven important in boosting human well-being. Thus, the paper suggests an Internet of Things- based efficient waste collection system with smart bins. This selects the bins that require emptying at the beginning of each garbage collection cycle and tracks them in real time.0ur waste segregation system can be sent straight for processing with the help of our affordable, user-friendly Automatic Waste Segregator. The garbage will be divided into three categories: dry, wet, and metallic waste. Hardware design incorporates machine learning- based algorithms to identify plastic garbage. The project also intends to incorporate an Internet of Things communication system to notify the waste collection authorities when the waste container is filled. The ultrasonic waste level sensor and the esp32 wall board, which regulate system functions, make up the proposed system. In order to ensure that the trash gets picked up right away, it can also send an IoT-based warning message to the municipality when the trash can is almost full or full. Reducing human resources and efforts in addition to enhancing the Smart City vision is a key aim of this project. In addition, it is expected that the efficiency of solid waste management will be improved.

Index Terms: Internet of Things (IoT), smart cities, smart bins, sensors, and smart trash monitoring and control

INTRODUCTION

Living in a healthy environment is ideal. One of the several ways that the ecosystem is being contaminated is through improper trash disposal. Inefficient methods of getting rid of waste, such dumping it in landfills, are bad for the environment and for people. It wouldn't be inaccurate to say that the majority of cities' problems stem from inadequate or nonexistent garbage management. [1].The recycling of urban solid waste is a significant function of rag pickers in India. In addition to a high frequency of mouse, dog, and other vermin attacks, rag pickers and workers at conservancies are more likely to suffer from infections of the skin, lungs, gastrointestinal tract, and other systems.If segregation occurs at the site of municipal garbage generation, reliance on the rag-pickers may be reduced. Waste has a better chance of recovery and can be recycled and reused when it is divided into fundamental streams like wet, dry, and metallic. [2] The following are the main goals of this work: low-cost architecture, time savings, sensor node flexibility, fast data access, accuracy, dependability, data integrity, and ease of deployment. [3] Since the process is entirely manual, we must put in place a clever system for tracking and getting rid of trash. This work suggests a sensor-based Internet of Things (IoT) method for tracking trash and disposing of it. [4] A ”smart bin” is a self-contained rubbish collection container that has the ability to independently detect its waste level and determine when it should be emptied. Additionally, it notifies the system authorities and publishes the observed data on the server. [5]

RELATED WORKS

One of the main objectives of the effort is to offer workable and efficient methods for gathering and dividing domestic trash into three groups: biodegradable, plastic, and metal.After that, the garbage is disposed of according to its compositionin the proper section of the dumpster. [1]

In addition to dividing dry waste into paper and plastic, this work attempts to divide garbage into three main classes: metallic, moist, and dry. The work's most salient aspect isthat it is compact and cost-effective, with a simpler design that strengthens the case for the waste management system. The Arduino UNO, which they use in this work, simplifies the design and allows for smooth, convenient system operation.Once the appropriate sensors have detected each of these wastes, they are all disposed of in the appropriate containers so that they can either be recycled or immediately used again. [2]

Three crucial performance evaluation indicators are taken into account in the proposed work.specifically,light,humidity and temperature.An entire sensor network is constructed using the integrated Proteus and Arduino design environments.A functional prototype was created and put into practice.The experimental technique comprises creating the hardware architecture of the transmitting nodes in addition to designing the receiving master node and communication channels.

Low-cost digital output sensors were used by the data acquisition system to measure temperature, relative humidity, and light dependency. A secure digital card with the measured parameters' values was affixed to the Arduino board, which served as the base station. TheThrough the process of recording sensor readings under different conditions on the secure digital card, the constructed prototype generates experimental data. [3]

In this study, an efficient waste collecting system incorporating Internet of Things-based smart bins is suggested. It selects which garbage cans need to be emptied during each waste collection cycle by keeping a watch on them in real time. The system also features an enhanced navigation system that shows the best route for collecting rubbish from the assigned containers. It is assumed that four garbage cans are positioned at random intervals across the city of Mount Pleasant, Michigan. The scenario under review results in a 30.76 decrease in the average trip distance. Because real-time monitoring and enhanced navigation are made feasible, it lowers the cost of fuel and labor, optimizing and enhancing the system's efficiency. [4]

In this paper, an efficient waste collecting system incorporating Internet of Things-based smart bins is proposed. It selects which garbage cans need to be emptied during each waste collection cycle by keeping a watch on them in real time. The system also features an enhanced navigation system that shows the best route for collecting rubbish from the assigned containers. Consequently, this reduces the expense of both fuel and labor, permitting enhanced navigation and real-time monitoring, ultimately optimizing and streamlining the system. [5]

They offer a ground-breaking method in the suggested study whereby, by estimating the chance of the waste level in garbage cans, effectively and vigorously manages waste. The waste collection process can be optimized by the system through the utilization of graph theory and machine learning.This article describes an investigation case that was put into practice at the actual Ton Duc Tang University campus in Vietnam in order to assess the system’s functionality and viability.They examine the advantages of the proposed system, which is built around an easy-to-use, affordable, and replaceable circuit, and they demonstrate data transfer using the LoRa module. Our technology saves timeby figuring out the best route for managing waste pickup. [6]

Based on the cleanliness and hygiene sector, the proposed work makes use of the automation idea in waste management systems.In poorer countries, it is common practice to throw garbage into the streets and public areas, which mainly results in unhygienic conditions and detrimental impacts on the environment.In order to address these issues, According to a concept called ”smart netbin,” users can access free internet resources for a set amount of time by connecting a Wi-Fi system to a regular trash can. This is accomplished by combining hardware and software technologies. By rewarding the user for maintaining a clean environment, the technology contributes to effective waste management in a community. [7]

The suggested study suggests smart trash bin monitoring and an Internet of Things-based municipal solid waste management system.With regard to waste material management and IoT-based waste collection for smart cities, this solution helps to resolve problems. The recommended approach might efficiently gather waste, identify fraud in waste products, and forecast the production of new waste. The internet-of-things gadget monitors and controls the electric trash cans. These devices are wirelessly connected to the central hub in order to transmit data on the bins’ filling level with the current location. The system’s ability to collect waste items on time, avoid bin overflow, and aid in environmental preservation is a significant advantage. [8]

The idea behind the work proposed in this paper is an efficient waste collection system based on the Internet of Things, with smart bins. It selects which garbage cans need to be emptied during each waste collection cycle by keeping a watch on them in real time. The system also features an enhanced navigation system that shows the best route for collecting rubbish from the assigned containers. In the city of Mount Pleasant, Michigan, four garbage cans are presumed to be placed at random locations. [9]

The work proposes a rapid and effective way to manage waste by setting up a network of smart dustbins with sensors and microcontrollers throughout a city, managed by a central control unit. This will expedite the process and eliminate dangerous conditions brought on by the current slow system. The problem of incorrect internet connectivity is also taken into consideration by the suggested approach. [10]

The concept presented in this work can interpret the current state of all the bins located across the city and notify city personnel when a dustbin needs to be cleaned right away. This notification will be sent depending on the temperature, moisture content, and waste fill level. It minimizes the need for manual monitoring and verification. [11]

From the research and study, we implemented an idea to manage and segregate the waste. Instead of using Things of speak IoT and aurdino Uno microcontroller, we are using Blynk IoT and ESP 32 wroom board which are user friendly and can do complex task also.

PROPOSED METHODOLOGY

There are two components to the suggested system.Machine learning is the other, and embedded systems are the first.

EMBEDDED SYSTEM

With the assistance of sensors at the panel, waste de- posited into the dustbin is separated into several segments and disposed of by opening the correct segment valves. In order to continuously monitor the threshold level of garbage in the dustbin, a Wi-Fi module is connected to the data service. A notification alerting the user that a specific segment needs to be disposed of is issued when the waste level is reached. Every operation in the trash can is controlled by an ESP32 controller. Similar to plastic garbage, metal waste is identified and divided into its corresponding portions with the use of machine learning algorithms and metal sensors.The waste can be sent straight for processing with the help of this affordable and user-friendly Automatic Waste Segregator. Its purpose is to separate the garbage into three categories: dry, moist, and metallic waste. Hardware design incorporates machine learning-based algorithms to identify plastic bottles. The project also intends to incorporate an Internet of Things communication system to notify the waste collection author- ities when the waste container is filled. The ultrasonic waste level sensor and the Arduino board, which controls system functions, make up the proposed system. When the trash can is almost full or full, it can also send an IOT warning message to the municipality so that the trash can be picked up.

A. System architecture:

We can monitor waste levels, send an Internet of Things- based alert to authorities when a container is full, and send a warning message to higher-ups if waste is not collected until a critical level by using ultrasonic sensors.servo motor mechanism used to temporarily close the waste bin lid at critical level filling. Metal waste, wet waste, and miscellaneous waste are separated in the waste segregation unit. The waste bin lid closes and opens when a person approaches using infrared sensors. Machine learning is employed to detect plastic bottles.

B. Circuit diagram:

It contains a metal sensor, moisture sensor, ultrasonic sensor, IR sensor, ESP32wroom board, servomotors and laptop.Metal sensor is used for detecting metal waste,moisture sensor is used for detecting wet waste.Ultrasonic sensor is used for detecting waste level and IR sensor is used for detecting human presence.Servomotor is used for opening and closing of the lid of the bin and waste segregation.Esp32 wroom board gives IoT connectivity and micro controller functions.Laptop is used for image processing.

MACHINE LEARNING

Deep Learning based algorithms are included in hardware design to detect and classify plastic .Acquiring a plastic classification algorithms are utilized for the extraction of images and features. After that, the characteristics of the

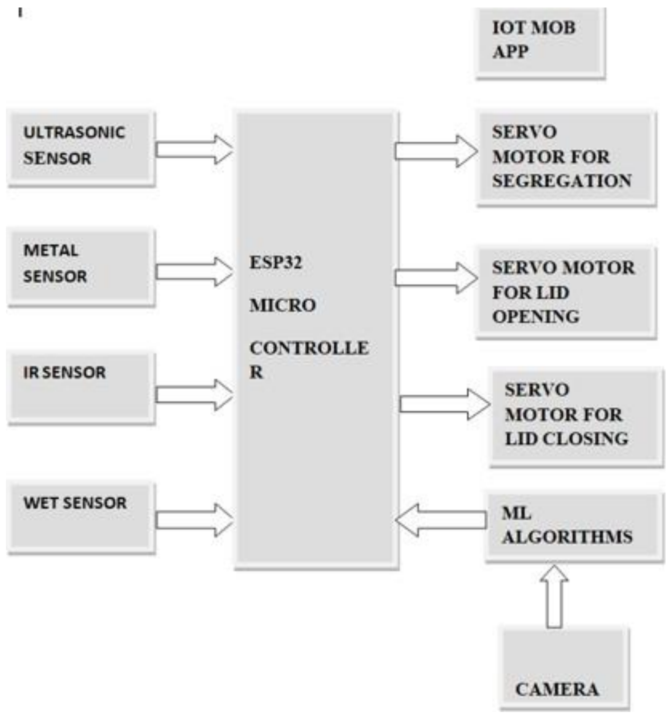

Fig. 1. BLOCK DIAGRAM

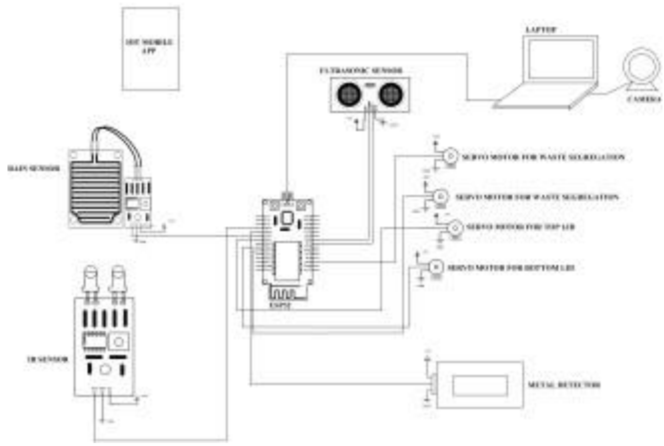

Fig. 2. CIRCUIT DIAGRAM

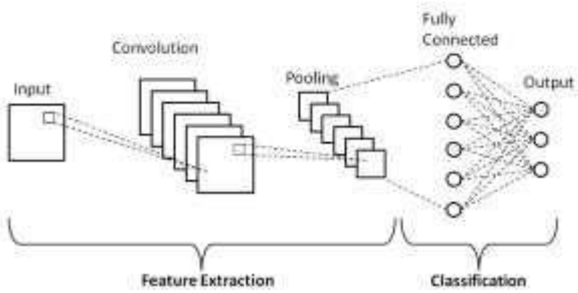

Fig. 3. Architecture Diagram of CNN

plastics are classified, and the type of plastic class is determined using a conventional neural network classifier. Proper plastic identification is provided by the suggested design.CNN models are used for classification and detectionof object.

1. **Convolutional neural network:** An image can be fed into a convolutional neural network (ConvNet/CNN), whichis a deep learning technique that can distinguish one object from another by giving distinct parts of the image varying weights and biases. ConvNet requires a lot less pre-processing than other classification techniques. While filters are manually designed using more archaic techniques, ConvNets may learn these filters and attributes with sufficient training.

DATASETS DESCRIPTION

The process of building a machine learning dataset for plas- tic detection usually entails obtaining pictures or sensor data that show instances of plastic objects, coupled with labels des- ignating whether or not each occurrence is plastic.Roboflow Universe datasets can be used to train a model that recognizes plastics images.Typically, we would characterize the dataset in terms of its size, composition, labeling technique, and any prepossessing processes used in order to train and evaluate a plastic detection model.

D. Preprocessing

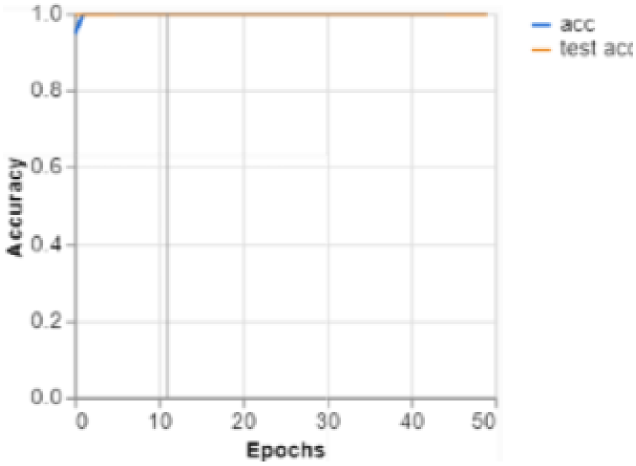

Fig. 4. Accuracy per epoch

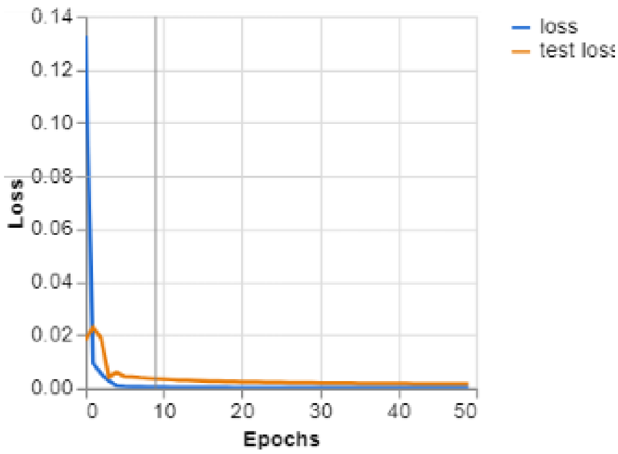

Fig. 5. Loss per epoch

A. Size

The dataset consists of a total of 10,000 samples. - Training Set: 7,000 samples - Validation Set: 1,500 samples - Testing Set: 1,500 samples

B. Composition

- The collection includes pictures taken in both indoor and outdoor settings. Images include a wide variety of plastic items, including bags, containers, wrappers, bottles, and more.

- In order to enhance model generalization and add context, non-plastic objects are also incorporated.

C. Labeling Methodology

The labels ”plastic” and ”non-plastic” are carefully applied to each image. - Human annotators assigned labels based on visual observation. - To minimize the risk of class imbalance during training, labels are distributed evenly throughout the dataset. To make model training easier, images were scaled to a consistent 224 by 224 pixel resolution. - The range [0, 1] was used to normalize pixel values. - To improve dataset diversity, data augmentation techniques like rotation, flipping, and random cropping were used. - The dataset was cleansedof noisy samples and samples with poor image quality.

D. Distribution

To provide balanced training and assessment, the distribu- tion of classes is about equal across the testing, validation, andtraining sets.

MODULES

- Wet /Dry detection:- To determine if waste materials are wet or dry, moisture sensors are used in Internet of Things-based waste management systems.
- Metal detection:- Deploying metallic sensors in an Internet of Things-based waste management system to

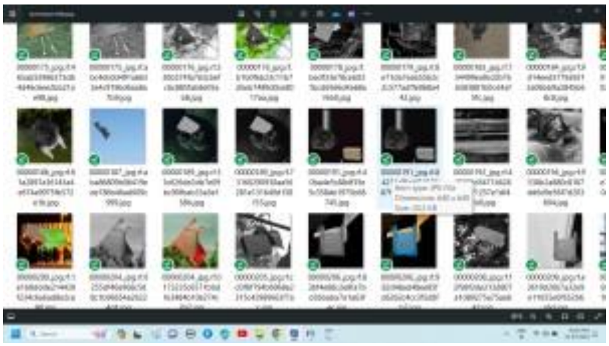

Fig. 6. DATASETS

identify and detect the presence of metal objects in the waste stream is known as metallic waste detection.

- **Object detection:** Identifying and locating objects in the waste stream through the use of ultrasonic waves is known as object detection utilizing ultrasonic sensors, and it is a feature of Internet of things-related waste management systems.
- **Human presence detection:** Identifying people’s presence in certain locations, like waste collection sites or processing facilities, requires the deployment of infrared (IR) sensors in an Internet of Things (IoT)-based waste management system.
- **Image processing:** Image processing are used in the case of plastic waste detection and classification.

COMPONENTS REQUIRED

A. Hardware Components

- **ESP32 Micro controller:** The robust, general-purpose Wi-Fi-BT-BLE MCU module ESP WROOM 32 is designed to tackle a broad range of activities, from demanding MP3 decoding, voice encoding, and music streaming to low-power sensor networks.
- **Servo Motor (SG90):** This servo motor is small and hasa powerful output. An exact control of an angular motion is achieved by the employment of a linear or rotary actuator.
- **IR Sensor:** Infrared (IR) obstacle detection works on the basic principle of sending out an IR signal (radiation) in a certain direction, and then receiving a signal at the IR receiver when the radiation bounces back off an object's surface.
- **Rain Sensor:** To detect rain, utilize the Raindrops Detection sensor module. It is also used to gauge the severity of rainfall.
- **Metal Sensor:** A common component in the automatic control industry for non-contact switching, detection, and control is the inductive PNP-NO proximity sensor switch, commonly referred to as the approach sensor.

Sensor	The waste bin	Threshold	Steps taken
Ultrasonic sensor	Metallic bin	I=8cm	Notification is sent
IR sensor	The common bin	IR value="low"	Human detected
Wet sensor	The common bin	Moisture value>3000	Dry waste detected
Wet sensor	The common bin	Moisture value<3000	Wet waste detected
Metal sensor	The common bin	Metal value="High"	Metal waste detected

Fig. 7. output

- **Ultrasonic Sensor :-** Usually, a target receives a brief burst of ultrasonic sound from these devices, and the target reflects the sound back to the sensor.

B. Software Components

- **Arduino IDE:** Writing code and uploading it to the board is made simple by the open-source Arduino Software (IDE).
- **Blynk IoT:** The entire Blynk software suite facilitates the deployment, remote control, and prototyping of networkedelectrical devices at any size.

RESULT ANALYSIS

Table (Figure 7) displays the matching smart bin threshold values. Additionally, it displays the appropriate actions per- formed when the sensors' threshold is exceeded.

A. Epoch

One epoch means that each and every sample in the training dataset has been fed through the trainig model at least once.

B. Batch size

A batch size is a set of samples used in one iteration of training.

C. Learning Rate

Even small difference can have huge effects on how wellthe model learns.

Accuracy per class

CLASS	ACCURACY	# SAMPLES
plastic	1.00	1,710
non plastic	0.98	331

Confusion Matrix

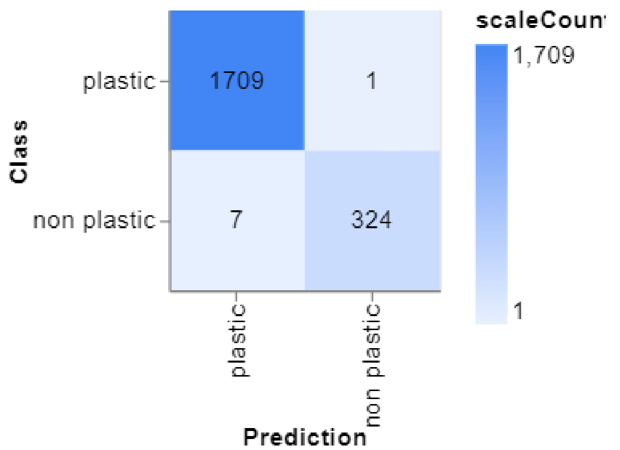

Fig. 8. Result and Analysis

CONCLUSION

The automatic garbage segregator that we proposed in this work can separate plastic, metal, and wet bottles. This is generally applicable to different municipal corporations. All of the sensors have been interfaced using ESP 32.In order to enable direct processing, this paper suggests an Automated Waste Segregater, a low-cost, user-friendly segregation system option. Its purpose is to separate the garbage into three categories: dry, moist, and metallic waste. Hardware designed to detect plastic waste includes machine learning based algorithms. An Internet of Things communication system is also intended to be included in the project in order to notify the garbage collection authorities when the waste bin is filled. The ultrasonic waste level sensor and the Arduino board, which controls system functions, make up the proposed system. In order to ensure that the trash is picked up right away, it can also send an IOT warning message to the municipality when the trash can is nearly full or full.

REFERENCES

1. B. R. S Kumar, N. Varalakshmi, S. S. Lokeshwari, K. Rohit, Manjunath, and D. N. Sahana, "Eco-friendly IOT based waste segregation and management," 2017 International Conference on Electrical, Electronics, Communication, Computer, and Optimization Techniques (ICEECCOT), Dec. 2017, doi: https://doi.org/10.1109/iceeccot.2017.8284686.
2. A. Sharanya, U. Harika, N. Sriya, and S. Kochuvila, "Automatic waste segregator," IEEE Xplore, Sep. 01, 2017. https://ieeexplore.ieee.org/abstract/document/8126023
3. Sani ABBA and Itse Musa NYAM Abubakar Tafawa Balewa University (Federal University of Technology),"Design and Evaluation of a Low-Cost and Flexible Data Acquisition System Using

Sensor Network for Smart Homes ” ATBU, Yelwa campus Dass road, P.M.B. 0248, Bauchi State, Nigeri

4. P. Chowdhury, R. Sen, D. Ray, P. Roy and S. Sarkar, ”Garbage Monitoring and Disposal System for Smart City Using Iot,” 2018 Second International Conference on Green Computing and Internet of Things (ICGCIoT), Bangalore, India, 2018, pp. 455-460, doi: 10.1109/ICGCIoT.2018.8753060.
5. K. F. Haque, R. Zabin, K. Yelamarthi, P. Yanambaka and A. Abdelgawad, ”An IoT Based Efficient Waste Collection System with Smart Bins,” 2020 IEEE 6th World Forum on Internet of Things (WF-IoT), New Orleans, LA, USA, 2020, pp. 1-5, doi: 10.1109/WF- IoT48130.2020.9221251.
6. Tran Anh Khoa, Cao Hoang Phuc, Pham Duc Lam, Le Mai Bao Nhu, Nguyen Minh Trong, Nguyen Thi Hoang Phuong, Nguyen Van Dung, Nguyen Tan-Y, Hoang Nam Nguyen, Dang Ngoc Minh Duc, ”Waste Management System Using IoT-Based Machine Learning in University”, Wireless Communications and Mobile Computing, vol. 2020, Article ID 6138637, 13 pages, 2020, doi.org/10.1155/2020/6138637
7. Tejashree Kadus , Pawankumar Nirmal , Kartikee Kulkarni, 2020, Smart Waste Management System using IOT, International journal of engineering research technology (IJERT) Volume 09, Issue 04 (April 2020).
8. Ali, T., Irfan, M., Alwadie, A.S. et al. IoT-Based Smart Waste Bin Monitoring and Municipal Solid Waste Management System for Smart Cities. Arab J Sci Eng 45, 10185–10198 (2020), doi.org/10.1007/s13369-020-04637-w.
9. A. Gopi,J.A.Jacob,R.M.Puthumana, R.A.K,K.S and B. Manohar, ”IoT based smart waste management system,” 2021 8th International Conference on Smart Computing and Communications (ICSCC), Kochi, Kerala, India, 2021, pp. 298-302, doi: 10.1109/ICSCC51209.2021.9528293.
10. S. Pargaien, A. V. Pargaien, D. Verma, V. Sah, N. Pandey and N. Tripathi, ”Smart Waste Collection Monitoring System using IoT,” 2021 Third International Conference on Inventive Research in Computing Applications (ICIRCA), Coimbatore, India, 2021, pp. 11-16, doi: 10.1109/ICIRCA51532.2021.9544982.
11. John, J., Varkey, M.S., Podder, R.S. et al. Smart Prediction and Monitoring of Waste Disposal System Using IoT and Cloud for IoT Based Smart Cities. Wireless Pers Commun 122, 243–275 (2022), doi.org/10.1007/s11277-021-08897-z
12. Kaggle.com. 2020. Speech Emotion Recognition. [online] Available at: ¡https://www.kaggle.com/shivamburnwal/speech-emotion-recognition¿[Accessed 28 April 2021].
13. Kaggle.com. 2019. Speech Emotion Recognition with CNN. [on- line] Available at: ¡https://www.kaggle.com/ritzing/speech-emotion-recognition-with-cnn¿ [Accessed 28 April 2021].