Internet of Things based Intelligent waste segregation and management system for smart home application

M.Bhuvaneswari, Assistant Professor Department of Mechatronics Engineering, Sri Krishna College of Engineering and Technology, Coimbatore

K. Tansin, Student Department of Mechatronics Engineering, Sri Krishna College of Engineering and Technology, Coimbatore

S. Tazmeel Ahamed, Student Department of Mechatronics Engineering, Sri Krishna College of Engineering and Technology, Coimbatore

N.Tharun Sri ram, Student Department of Mechatronics Engineering, Sri Krishna College of Engineering and Technology, Coimbatore

S. Venu Prasath, Student Department of Mechatronics Engineering, Sri Krishna College of Engineering and Technology, Coimbatore

Abstract:
The Internet of Things (IoT) has a significant impact on research for real time data monitoring. Waste segregation and control based on IoT is a significant task in metropolitan cities and municipal corporations. The advancement of key enabling technologies dependent on IoT enabled devices. Waste segregation and disposal mechanisms are among the severe problems associated with smart cities, which have a negative impact on our society and health. The trash bin monitoring and control is carried out through a microcontroller is proposed in this work. An IoT enabled smart bin utilizes a microcontroller with multiple sensors. In this study, inductive proximity sensors are used to detect metal trash, while temperature and humidity sensors are used to separate wet and organic wastes. The capacity of the bin is analyzed using Infrared sensors. IoT with sensor communication module allows remote control of real-time data. While Bluetooth allows for short-range waste monitoring via a mobile app. Waste is piled at various levels in the trash bins. The centralized controller is enabled and the filled bins are managed effectively with the deep learning technique. The waste collection is monitored by setting up a training model based on Deep Learning (DL). The intelligent GUI will track the unfilled levels of each trash bin as proposed.

Key words: Internet of Things (IoT), microcontroller, Rain and Humidity sensor, Inductive proximity sensor, Bin, Deep Learning.

Abbreviations:
IoT: Internet of Things
CNN: Convolution Neural Network
LCD: Liquid crystal display
Wi-Fi: Wireless Fidelity
DL: Deep Learning

I. INTRODUCTION:

The Internet revolution has advanced both communication systems and important computer applications. Traditional communication processes, say message transfer protocols, Machine-to-Machine (M2M), real-time audio/video processing, sensory data transfer and other things are all rapidly improving every day. Dedicated attention to the amount of waste generated and how it is handled is a challenge in this information and technology era. all rapidly improving every day. It is essential to concentrate on waste management companies' low operating costs and provide residents and businesses with the same high-quality service regardless of location. In this paper, the most promising applications of IoT in waste segregation and management processes are presented. A modern-day problem in the modern world is the accumulation of garbage wastes all around us. Different types of garbage were easier to classify in the past, and people living at the time had more time to sort the waste into the appropriate category. However, as the world progresses and modernity emerges, the types of garbage produced become more varied, and people have less and less time to identify the wastes.

In the modern world, waste management in cities is a major issue, as people have little time to take care of domestic chores while trying to keep up with the rest of the world. Because landfill separation is inconvenient and ineffective, residential waste separation takes only an hour. Waste management is a hot topic these days, thanks to increased industrialization and a lack of time to manage garbage at home. Waste management must be considered from a variety of angles, including effectively collecting waste from various locations, transporting it to a facility that processes, recycles, and disposes of the waste correctly and without errors. Solutions for waste segregation can be presented as a solution to these types of problems. The process of sorting trash into different types using a variety of methods and processes is known as waste segregation. Waste segregating machines separate waste by type, such as organic or inorganic waste,

recyclable or non-recyclable waste, dry or metallic waste, wet waste, and so on. There are a variety of waste segregation machines available, and this is the most basic of them all. Automatic trash segregation is especially beneficial because it simplifies the recycling process.

According to literature reviews, the solid waste segregation and management methods need certain hybrid protocols for effective handling of solid waste in smart cities applications. This work proposed an effective solution based on IoT technology for the purpose. The following are the main focus of this paper.

• Hybrid architecture to monitor the household trash bins.

• To collect household trash and notify the municipal network for collection, using a centralized controller with a Bluetooth module is embedded.

• Intelligent Sensors are used to monitor the status of each trash can in the house and can identify and split the type of waste.

The following sessions are organized as follows. The literature review for the proposed project is depicted in Session II. The materials and methods used for this work are displayed in Session III. The design calculations are shown in session IV. While Session V presents the project's conclusion and future scope.

II. LITERATURE REVIEW:

To automate the process, the IoT-enabled automatic waste segregation and management system uses a mechanical system [1]. Every household feels compelled to use two different trash cans and sort the garbage manually. This project helps the user to avoid the need for a second trash bin and human interaction during the waste separation process. Based on data gathered from the sensors the type of trash is also displayed on the LCD display. When the trash trays are full, ultrasonic sensors on the trays send data to the node MCU, which is then transmitted to the user's phone via an open-source app.

The information detailing the integration of the different sensors to the Arduino microcontroller is proposed in [2]. The various types of wastes and segregation is discussed. The study focuses on the Municipal Solid Waste Management system and identifies the areas that require expansion. The garbage monitoring system study is described [3]. It demonstrated garbage separation and collection in real time application. It is proposed to design a sensor network that detects the target and sends signals to the board. If the bin is frequently filled by the user, sensors will send a signal to the nearest vehicle driver. Communication and sensing are handled by the various modules [4]. The use of ultrasonic sensors to monitor the amount of waste in the bin and gas sensors to detect the stench of the gases is proposed. The sensors are built in the AVR microcontroller, which connects to the LCD display and displays the bin status.

The paper discussed how a smart bin sends information to the end user so that they can take the appropriate action [5]. The sensors are used to keep track of how well the garbage is being collected. The device's decisions are updated on a specified server using the Node MCU. The device's status can be monitored. Contamination is addressed in order to achieve efficient recycling [6]. The microcontroller is used for controlling purposes. The supervision of sensors in a stage-by-stage and better working method is described. The effectiveness of using an LCD with an Arduino microcontroller for trash classification is discussed.

This paper discussed the control of environmental issues such as inadequate waste treatment, collection, and recycling [7]. A review of garbage bin tracking is presented. When the bins are full, an alert message is sent so that the garbage can be properly managed. Components such as an ultrasonic sensor, a node MCU, a servo motor, and microcontrollers are employed. The paper describes how to create a smart bin to communicate with the user and take appropriate action [8]. There is a discussion on how to use the appropriate sensors for the appropriate waste. Node MCU is used to update the device's decisions on a specified server. The device status can be tracked at every level. By addressing contamination, the initiative will help to improve recycling efficiency when fully implemented. The architecture for monitoring the garbage system using IoT and image processing is discussed [9]. The operation of the garbage overflow system and its monitoring system is detailed. The data is also sent to the appropriate officials for action. The architecture of the garbage system is done in an efficient manner such that the process of garbage monitoring and segregation is done in an easier way [10]. The process of garbage monitoring using IoT is detailed. IR sensor is used to identify the level of the garbage bins and notifies the user about the level [11]. An app is made with the help of ThingSpeak to send the user about the level of the garbage bin [12].

III. MATERIALS AND METHODS:

3.1 Components required:

The proposed system comprises following components like sensors, Microcontrollers, motors and communication module. The components details and its specifications are given in the table 1.

The Arduino UNO is a microcontroller board. It is a piece of open-source hardware that includes a physical board as well as software with an IDE. As a result, the board will be easier to program. The board includes a USB port for easy uploading of software

code. Boards are classified according to their function and application. The Node MCU serves as an integrated semiconductor in this proposed model, allowing access to the IoT environment. The Arduino Uno board provides the control.

This board includes a Wi-Fi module as well as digital and analogue pins for interacting with other devices. The user can gain access to information such as waste type and bin filling level details by using Node MCU. The ESP8266 model was chosen for the proposed work. The NodeMCU based on ESP8266 is efficient for this product since it is inexpensive. It is also easy to integrate with the Arduino Uno board.

On a single board, it integrates GPIO, PWM, IIC, 1-Wire, and ADC. As a result, it facilitates the coding of functions and the delivery of networking functionality to the end user.

Table 1 Components required and its specification

S. No	Components required	Specification
1)	Stepper motor	Oriental Motors RK564BC-N36, 5-Phase Micro-stepping motor
2)	Servo motor	Tower pro MG90 Servo Motor
3)	Node MCU	ESP8266
4)	Arduino UNO	ATmega328P based board
5)	Inductive Proximity Sensor	M8 Inductive Proximity sensor
6)	Ultrasonic Sensor	HC-SR04 Ultrasonic Sensor
7)	Temperature Humidity Sensor	Evelta SHT20 I2C Rain & Humidity Sensor
8)	Liquid Crystal Display	16x2 Alphanumeric Display JHD162A
9)	Wi-Fi Module	HC-05 Wireless Bluetooth RF Transceiver Module

Sensors can be used to analyze various types of waste. Various sensors, including an inductive proximity sensor, a temperature and humidity sensor, and an ultrasonic sensor, are used in this work. The electromagnetic induction principle is used by the Inductive proximity sensor to detect metal targets. This sensor detects metal targets without the need for physical contact. As a result, it is used to distinguish metal waste from solid waste. When a current is passed through an inductor in the sensor, it produces a magnetic field. When the magnetic field passing through an inductor changes, current flows through the circuit. This sensing is affected by the magnetic field. Non-metallic substances do not interact with the magnetic field. It is efficient to operate in wet or dry conditions.

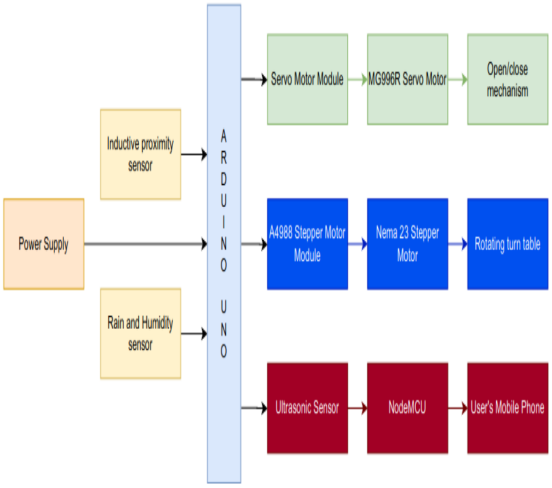

Fig 1. Block Diagram of Automatic Waste segregation machine

3.2 Proposed system model

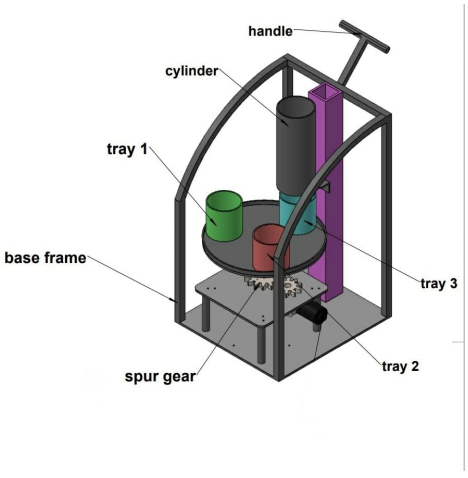

Fig. 2 Proposed 3D diagram of the proposed model

An ultrasonic sensor is used to calculate the distance between objects. The sensor emits ultrasonic vibrations. The time between emission and reception is used to calculate the distance. Each bin has an

ultrasonic sensor that warns the user when it is full. The sensor is highly accurate and does not miss the target. The vibrations produced by this sensor are of extremely high quality, ensuring that no failures occur. Vibrations are sent when an object (trash) is detected by the ultrasonic sensor. It will search for any objects that are blocking its field and, if found, will send a signal to the board. In this work, an ultrasonic sensor operates in free run mode.

A temperature and humidity system is used to detect the waste's temperature and humid state. The sensor contains an 8 bit microcontroller and a Negative temperature coefficient. The data received as serial data is efficient by the microcontroller. The values are sent as serial data to the Arduino microcontroller. When this sensor is manufactured, it is pre-calibrated so that it can be used with other devices. This sensor is capable of detecting moisture garbage from bins. This sensor is available as a sensor as well as a module. However, the accuracy and functionality remain unchanged. The Temperature and Humidity will measure temperature from 0°C to 50°C and humidity from 20% to 90% with a 1°C and 1% accuracy. Because it is factory calibrated and can easily connect to the board and set.

The servomechanism, abbreviated as servo, is a rotating actuator that is used for precise control movements of linear or angular position, velocity and acceleration. The servo motor also contains a suitable motor which is coupled to a sensor which is used for the feedback of the position. The servo motor is suitable to use in closed-loop control systems. When considering the servo motor for this paper, the servo motor controls the flap on which the waste is placed. This aids in the precise control of the parameters required. For accurate flap control, the servo motor consists of a sensor connected with a conventional motor.

3.3 Motors used in the proposed model:

A brushless DC motor is contained within the stepper motor. It works on the basis of electromagnetism. This differs from a servo motor in that a complete rotation of the motor is broken into a number of smaller phases to allow for greater process control. The movement here is in a stepwise manner hence the name stepper motor. Here a number of coils are arranged in phases, when given power would cause the motor in a stepwise manner. Stepper motor is used here because the accuracy and precision of this motor is high. However, the higher current consumption compared to the DC motor adds as a disadvantage to us here. The reason we chose stepper motors here is because stepper motors have high torque at lower speeds, thus serving our need of having lower speed for the disc movement with higher accuracy.

IV. RESULTS AND DESIGN:

4.1 Proposed work Flow diagram model:

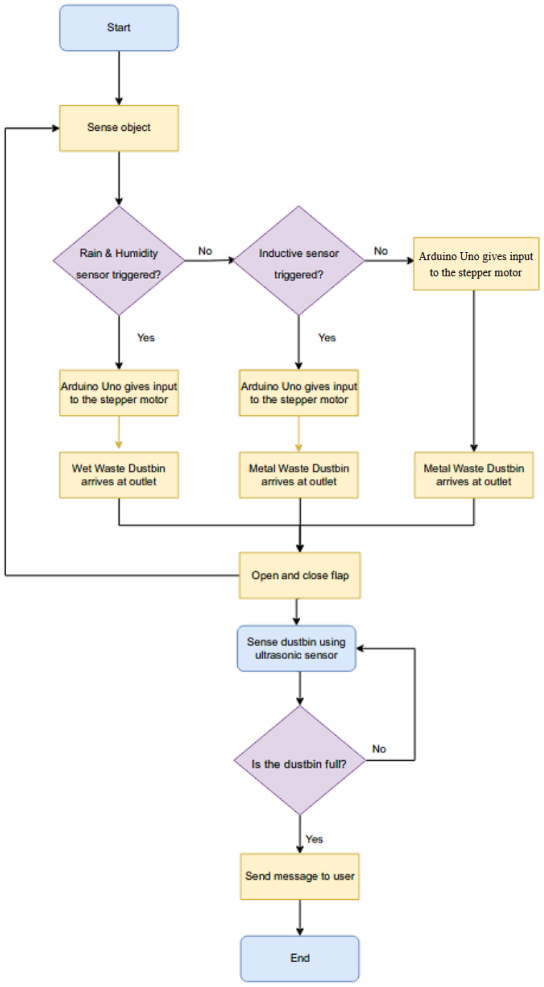

Fig 3. Flowchart for the proposed model

4.2 Proposed system working model:

Each house or an area has a unit which is connected to a Central Monitoring Unit. When the dustbin is full in any one of the houses or the area, a notification is sent to the Central Monitoring Unit from the house or the area by the help of Internet of Things. When the Central Monitoring Unit gets a notification from one of the houses, it sends a notification to the Municipal Office to ask them to collect the trash from that area, thus making it a very efficient method of all.

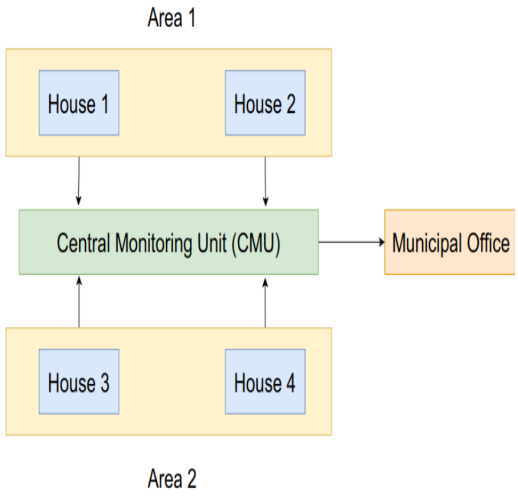

Fig 4. IoT working method

Algorithm:

1. Start segregating the waste from the hopper.
2. Analyze the waste using Sensors.
3. The proposed model is designed to identify the metal waste, wet waste and dry waste.
4. The waste is dropped appropriate to the bin placed in the turntable.
5. Identify the capacity of the bin through an ultrasonic sensor.
6. If the bin is full the detail is messaged to the municipal office zone.
7. Replace the new bin on the turntable.
8. Then the process proceeds from the first.
9. Similarly, the other bins are verified.

Calculations:

Table 2: Design consideration

S.No	**Components**	**Design Consideration**	**Result**
1	**Servo Motor**	Mechanical efficiency of a motor	0.92
2		Length of the arc of sector	104.67mm
3		Torque for servo motor	0.017 kg-cm
4		Coefficient of friction	0.1
5		External force excluded	0 N
6	**Stepper Motor**	Diameter of index table, D_T	400mm
7		Index table thickness, L_T	100mm
8		Diameter of load, D_W	150mm
9		Thickness of load, L_W	150mm
10		Material of table and load (Iron)	7.9 x 10^3 kg/m^3
11		Number of loads	3
12		Distance from center of index table to center of load, C	150 mm
13		Positioning angle, θ	120°
14		Resolution, Δθ	0.04°
15		Positioning period, t_0	0.4s
16		Required resolution, θs	0.02° x 2 (pulses)
17		Total Inertia	0.3922 kg.m^2
18	**Column calculation**	Breadth of column, b	80mm
19		Length of column	1mm
20		Total mass	2kg
21		Force	19.62N
22		Acceleration & Deceleration period t_1	0.1s
23	**Bending Stress Calculation**	yield strength of steel	420 N/mm^2
24		Moment of resistance	8025.76 N-mm
25		Moment of Inertia	0.82mm

26	**Column calculation**	Mass of disc	3000g
27		Mass of all 3 dustbins	750g
28		Mass of total waste	600g
29		Mass of stepper motor	5000g
30		Mass of plate	3000g
31		Area of circle	6mm
32		Area of cross section of circle	7 mm^2

The fabricated model is shown in the figures below. Significant experiments were carried out to assure and validate the process of the IoT based waste segregation model. At first, an experiment was carried out to validate the process of the waste segregation based on the type of the waste. Second, an experiment was carried out to validate the process of sending a notification to the Central Monitoring Unit to notify that the dustbin has been full. Finally, the life expectancy of the proposed model is estimated under hypothetical conditions.

4.3 Experimental Prototype:

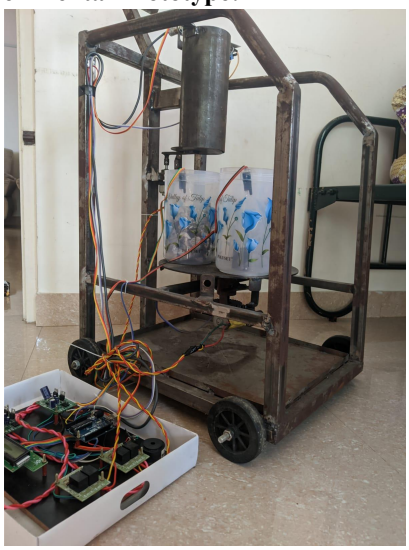

Fig 5. Experimental Prototype

Fig 5. shows the experimental prototype model of the waste segregation product. When tested, the three sensors used here do a good job of identifying the type of waste dropped in the bin and help us to separate the wastes. With a delay time of 2 to 3 seconds for identifying the type of waste, the entire operation takes a total of 7 seconds. With two sensors being non-contact, and only the temperature and humidity sensor being contact sensors, a better alternative to this type of sensor might be added to our project in the future. With the Wi-Fi module getting a voltage of 3V, all the other components require a voltage of 5V. Hence to supply a constant power source two voltage boards are connected to the power supply with two voltage regulators (7805 and 7812) respectively. The 16x2 LCD does a good job of indicating to the user the type of waste dropped here and indicates to them if the bin is full. The 2 channel relays used for controlling the motors take a delay time of 3 seconds which can be reduced to two seconds in the future.

V. CONCLUSION AND FUTURE SCOPE

The domestic garbage separator functions as a smart bin, separating waste into three categories: wet, dry, and metallic. The proposed system would employ sensors to monitor the trash and alert the user using an open source application. A flap is added to a servo motor to buy time for the sensors to detect the different sorts of trash and separate it. The turntable on which the bins are positioned is moved by a stepper motor. The Arduino microcontroller is used to control all of the sensors, while the ESP 32 node MCU is utilized to relay the data to the user. When the garbage bin is full, with the help of IoT, a message is sent to the user and the Central Municipality that the garbage bin is full. The garbage bin is then replaced to recycle it. The garbage bin module is also connected to the centralized control unit of the smart home to alert the user about the garbage bin.

To minimize trash size and make recycling easier, the inlet can be modified to include a crusher mechanism. The crusher can be automated with the help of smart homes. When the bin is filled, the bins can be upgraded to include a packing mechanism. To avoid leakage, a dryer mechanism might be used to dry the moist waste. An odor detection sensor can be used to alert the user to the presence of a noxious odor. Solar panels can be utilized to provide power.

References:

[1] Namratha A M,Nandini S,Nanditha K, “Automatic Waste Management and segregation system using IoT” International Journal of Engineering and Technology, NCCDS-2021 Conference Proceedings.

[2] Parkash, Prabu, “IoT Based Waste Management for Smart City” Vol. 4 Issue 2 February 2016.

[3] Lilyan Anthony, Pradnya Chavan, Astrid Ferreira, Prerana Gadhave, Archana Shirke, “Garbage Monitoring System for Smart Cities,” International Journal of Advanced Technology in Engineering and Science, April 2017, Vol. No.5, Issue No.04

[4] Ms. Puja k. Dhotrel , Ms. A. L. Borker “A Review on Smart Garbage Monitoring System Using Internet of Things (IOTs)” September 2017 ISBN:978-93-86171-66-5
[5] T. Saminathan, Akash Musipatla, P. Manideep Varma, P. Shahid Khan, G. Mahesh Kumar, “IOT Based Automated Waste Segregator for Efficient Recycling”, Oct 2019
[6] Chethan Siddeshwar K R, Gunasagar, C M, Hemanth S, “Automated Waste Segregator”, Visvesvaraya Technological University, 2020-2021
[7] Padmakshi Venkateshwara Rao, Pathan Mohammed Abdul Azeez “IoT based waste management for smart cities” International conference on computer communication and information (ICCCI), Coimbatore, India, Jan 22-24, 2020.
[8] Saminathan T, Akash Musipatla, “IoT based Automated Waste Segregator for Efficient Recycling”, International Journal of Innovative Technology and Exploring Engineering, Volume-8 Issue-6S,April2019.
[9] Chetna Kaushal, Anshu Singla "Architecture for Garbage Monitoring System using Integrated Technology"15 September 2020.
[10] Ms. Akhila Joseph, Ms. Anjali “Smart garbage management system”, International Research Journal of Engineering and Technology (IRJET),Volume: 07 Issue: 06 | June 2020 .
[11] Vikrant Bhor, Pankaj Morajkar, Maheshwar Gurav, Dishant Pandya, Amol Deshpande, “Smart Garbage Management System” International Journal of Engineering Research & Technology ISSN: 2278-0181 IJERTV4IS031
[12] Mustafa M.R and Ku Azir K.N.F,”Smart Bin: Internet-of-Things Garbage Monitoring System”,MATEC Web of Conferences 140, 01030 (2017)