International Journal of Electrical, Electronics and Computers
Vol-11, Issue-2 | Apr-Jun, 2026
Available: https://aipublications.com/ijeec/
Peer-Reviewed Journal

Auto-Lid: An Automated Ultrasonic-Based Waste Management System

Dr Jyoti Shukla[1], Aniruddh Gautam[2], Anuj Tak[3], Gaurav Singh Chauhan[4], Harsh Garu[5]

[1]Associate Professor, Department of Electrical Engineering, Swami Keshvanand Institute of Technology Management and Gramothan, Jagatpura, Jaipur, India
[2,3,4,5]UG Student, Department of Electrical Engineering, Swami Keshvanand Institute of Technology Management & Gramothan, Ramnagariya, Jagatpura, Jaipur, India

Received: 23 Mar 2026; Accepted: 21 Apr 2026; Date of Publication: 25 Apr 2026

Abstract*— *Managing waste and keeping public areas clean are big problems in many developing regions where people still use regular trash bins. Handling the lid of a trash bin by hand can spread germs, cause bad smells, and make places less clean. This study introduces a low-cost, easy-to-make smart trash bin system that uses an Arduino microcontroller. The system uses an ultrasonic sensor to sense when someone's hand or object is near the bin and automatically opens the lid with a motor. It also has an infrared sensor that checks how full the bin is and stops the system from working when it's full. The system is built with affordable and easy-to-find parts like an ESP 32, HC-SR04 ultrasonic sensor, L298N motor driver, DC gear motor, and a buzzer. The goal is to create a touch-free, clean way to dispose of waste that works in homes, offices, and public areas. The prototype works well, detecting objects, controlling the lid automatically, and runs efficiently. This project shows how simple technology can improve sanitation and help create better waste management systems in the future.

Keywords*— *Smart Trash Bin, Arduino, Waste Management, Touch-Free Disposal, Sanitation Automation

I. INTRODUCTION

Cities and communities are producing more waste because of rapid urban growth and increasing population. In many places, people still use regular trash bins that need to be opened and closed by hand. These types of bins can lead to hygiene issues, especially in public areas, hospitals, and schools where many people use the same bin. Touching trash can spread germs, create bad smells, and make areas dirty. Recent advances in embedded systems and sensors have made it possible to create automated systems for daily tasks.

Smart waste management is now an important part of modern smart cities. Automated trash bins with sensors and microcontrollers can reduce the need for human contact with waste and make areas cleaner. However, many smart bins on the market are expensive and rely on complex Internet of Things (IoT) systems, which makes them hard to use in places with limited resources.

This research focuses on making a low-cost, do-it-yourself (DIY) smart trash bin that opens and closes automatically when someone approaches. The system uses an Arduino microcontroller, an ultrasonic sensor, and a motor. The main goal is to show a practical and affordable way to automate waste disposal that can be used in homes, offices, and public buildings.

II. LITERATURE REVIEW

Automation is increasingly being used in waste management to improve efficiency and cleanliness. Many researchers have studied sensor-based trash bins that can detect people and control the lid automatically. Ultrasonic sensors are often used because they accurately measure distance and are relatively cheap.

Some smart waste systems also use IoT technology to

monitor how full bins are and send alerts when they need to be emptied. Wireless modules like Wi-Fi or GSM allow bins to send data to a central system. This helps with better planning of waste collection routes and prevents bins from overflowing.

Despite these improvements, large-scale smart systems can be very costly and require advanced infrastructure. In many developing areas, traditional bins are still used because of financial limits. As a result, there's growing interest in creating low-cost prototypes that show the benefits of automated waste management without needing advanced tech.

This DIY smart bin fills that need by using simple, affordable hardware. By combining sensors, a microcontroller, and a motor, the system gives a practical example of how automation can improve sanitation while staying cost-effective and easy to build.

III. SYSTEM DESIGN AND ARCHITECTURE

The smart bin is designed to detect when someone is near and automatically open the lid without touching it. The system has three main parts: the sensing unit, the control unit, and the actuation unit. The sensing unit includes an ultrasonic sensor and an infrared sensor.

The ultrasonic sensor uses sound waves to measure the distance between the sensor and nearby objects. If the distance is below a certain limit, it sends a signal to the microcontroller, indicating that a person is about to use the bin. The control unit is based on an ESP 32 microcontroller, which processes the data from the sensors and decides what to do.

If an object is detected within the set range, the microcontroller sends a command to the motor driver to operate the lid. The actuation unit has a DC gear motor connected to the lid. The motor moves in different directions to open or close the lid as directed by the microcontroller. A buzzer might also be added to give sound alerts when the bin is full or when the system takes action.

IV. HARDWARE COMPONENTS

1. ESP 32

The ESP32 is a budget-friendly, energy-efficient system-on-chip (SoC) microcontroller made by Espressif Systems. It's commonly used in embedded systems, IoT projects, and automation because it has built-in Wi-Fi and Bluetooth. The ESP32 is an upgraded version of the earlier ESP8266. It has more processing power, extra GPIO pins, and improved performance.

It includes various features like wireless communication, analog inputs, digital connections, and security features, which make it a good choice for modern smart devices.

Key Features of ESP32 are Built-in Wi-Fi (802.11 b/g/n) for connecting wirelessly, Integrated Bluetooth (Classic and BLE), Dual-core processor that allows handling multiple tasks at once, Low power usage with several sleep modes to save energy, Wide range of peripherals (ADC, DAC, PWM, UART, SPI, I2C), Fast processing speed, Support for secure boot and encrypted flash memory

This method utilizes the Tensilica Xtensa LX6 architecture, which is a dual-core processor capable of operating in single-core mode based on application needs. It operates at a maximum clock speed of 240 MHz, delivering strong processing power for embedded systems. The device runs on a 3.3-volt supply and can be powered via a 5-volt input. The main challenge lies with the cement and gravel, as it includes 4 MB of flash memory for program storage and approximately 520 KB of SRAM for data processing and execution.In terms of connectivity and peripherals, the microcontroller supports Wi-Fi based on the

802.11 b/g/n standards, along with Bluetooth version 4.2, which includes both classic Bluetooth and Bluetooth Low Energy (BLE) functionality.

It offers up to 34 general-purpose input/output (GPIO) pins, allowing for flexible interfacing with external devices. The analog-to-digital converter (ADC) provides 12-bit resolution with multiple input channels, while the digital-to-analog converter (DAC) features 2 output channels with 8-bit resolution. Additionally, it includes 16 PWM channels for precise control of motors and other devices. The microcontroller supports a variety of communication interfaces, including UART, SPI, I2C, I2S, and CAN protocols, making it highly versatile. It is also designed for reliable operation within a temperature range of -40°C to +125°C, making it suitable for industrial and environmental applications.

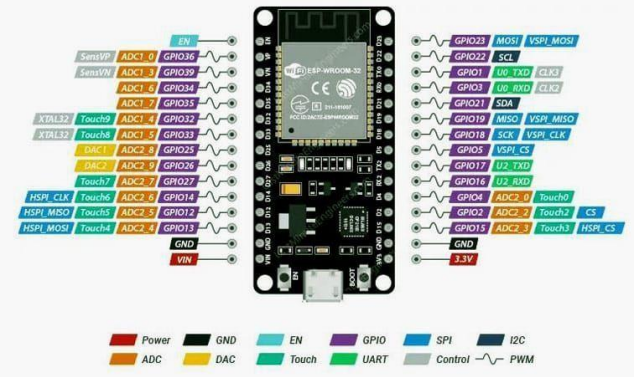

Fig 1: ESP 32

2. Ultrasonic Sensor (HC-SR04)

An effective way to figure out what is near your Arduino is by using ultrasonic technology. The basic idea is to send out a sound wave, wait for it to bounce back, and then use the time it takes to come back to find out if something is there and how far away it is. Bats and dolphins use a similar technique called echolocation to find things in the dark or under water, but they use lower frequencies than what you can use with your Arduino.

The HC-SR04 Ultrasonic Sensor is an affordable sensor that measures distance and is commonly used in robotics for avoiding obstacles. It's also used in parking sensors, water level detection, and turret systems. The HC-SR04 is widely used in automation and robotics projects because it helps measure distance accurately. In this project, it's used to detect how much rubbish is inside a dustbin and to sense if a hand or any object is near it. The HC- SR04 works based on ultrasonic sound waves.

This is as an ultrasonic sensor module that operates within a voltage range of 3.3 V DC to 5 V DC, making it compatible with most microcontrollers such as Arduino and ESP32. It consumes less than 2 mA of current when idle and draws up to 15 mA during active operation. The sensor functions at a frequency of 40 kHz, enabling accurate distance measurement using ultrasonic waves. It is capable of detecting objects within a range of 2 cm to 400 cm, with an accuracy of approximately ±3 mm.

Additionally, the sensor has a minimum sensitivity of -65 dB and generates a sound pressure level of 112 dB during operation.It features a detection angle of 15 degrees, allowing for focused and precise distance measurement. The module is designed with a 4- pin interface (VCC, Trig, Echo, GND) arranged in a 2.54 mm pitch for easy connection to development boards. In terms of physical characteristics, it measures 45 mm in length, 20 mm in width, and 15 mm in height, and weighs approximately 9 grams, making it compact and lightweight for embedded system applications.

Fig 2: Ultrasonic Sensor (HC-SR04)

3. 12V Centre Shaft DC Gear Motor

The lid of the DIY Smart Dustbin System opens and closes automatically using a servo motor or a DC motor. The microcontroller, which is an ESP 32, uses signals from the ultrasonic sensor to control the motor. A servo motor is a special type of motor that can rotate to a specific angle.

It is commonly used in robotics and automation when precise movement is required. The Arduino sends a control signal, known as a PWM signal, to the servo motor. In response, the motor shaft turns to a set angle like 0°, 90°, or 180°.

In this project, the servo motor is used to smoothly open and close the dustbin lid.When the ultrasonic sensor detects an object, the Arduino activates the motor, which then opens the dustbin lid. After a short delay, the motor automatically closes the lid.This method serves as a DC gear motor operating at a rated speed of 30 RPM, making it suitable for low-speed, high-torque applications.

It is designed to run on a 12 V DC power supply and is equipped with a plastic spur gearbox that helps reduce speed while increasing torque output. The motor features a 6 mm diameter shaft with an internal hole, allowing easy coupling with wheels, pulleys, or other mechanical components.In terms of performance, the motor provides a torque of approximately 5 kg-cm, making it capable of handling moderate loads efficiently.

It draws a maximum no-load current of around 60 mA, ensuring low power consumption when running freely, while the current can increase up to 300 mA under load conditions. This combination of moderate

torque, low speed, and efficient current usage makes it ideal for robotics, automation systems, and small mechanical projects.

Fig 3: 12V Centre Shaft DC Gear Motor

4. L298N Motor Driver Module

The commonly used L298 Dual H-Bridge Motor Driver IC forms the base of this dual motor controller. With this circuit, you can easily control two motors, each capable of handling up to 2A of current in both forward and reverse directions.

It's ideal for robotics projects and can be connected to a microcontroller with just a few control wires per motor. It also works well with relays, TTL logic gates, simple switches, and more. The board includes protective diodes, a built-in +5V voltage regulator, and LEDs to show power status.

This is as an instruction for a dual H-bridge DC motor driver, designed to manage the speed and direction of two DC motors simultaneously. It operates on a wide power supply range from 5V to 35V DC, making it adaptable for numerous motor control applications. The module can handle a peak current of up to 2 Amps, while the operating current typically ranges from 0 to 36 mA.

The real challenge lies with the control circuitry. The control signal input voltage ranges are defined such that a low-level signal lies between -0.3V to 1.5V, and a high-level signal ranges from 2.3V up to the supply voltage (Vss). Similarly, the enable signal input follows the same voltage levels, where a low signal (-0.3V to 1.5V) disables the control function, and a high signal (2.3V to Vss) enables it.

The module has a maximum power dissipation capability of 20 Watts at a temperature of 75°C and can be stored safely within a temperature range of -25°C to +130°C. Additionally, the L298N module includes an onboard 5V regulated output, which can be used to power external controller boards such as Arduino, eliminating the need for a separate power source. In terms of physical dimensions, the module measures approximately 3.4 cm in length, 4.3 cm in width, and 2.7 cm in height, making it compact and easy to integrate into embedded and robotics projects.

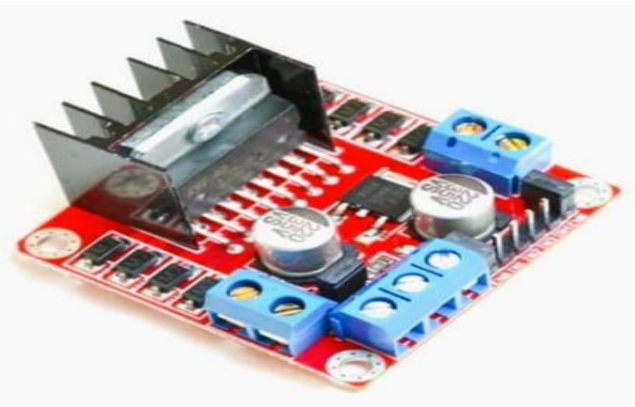

Fig 4: L298N Motor Driver Module

Other parts like jumper wires, a power supply, and the bin container are also included to build the system. These components make sure the electrical connections are safe, the power is stable, and the electronic parts are properly supported.

5. InfraRed IR Obstacle Detector

This infrared obstacle sensor includes two sensors: one that sends out infrared light and another that receives it. The infrared LED sends out the light, and if something blocks the path, the light bounces back and is picked up by the receiver LED.

When the sensor detects an obstacle, the LED lights up and sends out a low-level signal through the OUT pin. The sensor can detect objects from 2 to 30 centimeters away. You can change how far it can detect by turning the potentiometer on the sensor.

The IR Obstacle Sensor Module works with a voltage of 3 to 5 volts DC, making it easy to use with microcontrollers like Arduino and ESP32. It gives a digital signal, which is either a 0 or 1, depending on whether something is in its sensing area.This sensor can detect objects between 2 and 30 centimeters away, and you can adjust the sensing range using the potentiometer on the board for better accuracy depending on what you're using it for.

It also has a 3 millimeter mounting hole, so you can install it easily in your projects. The board is small, about 3.2 centimeters long and 1.4 centimeters wide, making it perfect for use in space-limited applications like embedded systems, robotics, and automation.

ISSN: 2456-2319
https://dx.doi.org/10.22161/eec.112.3

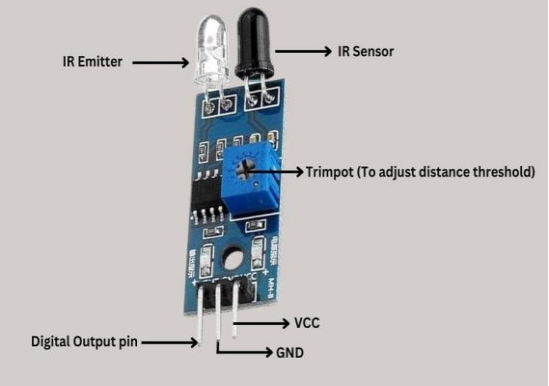

Fig 5 Infrared IR Sensor

V. SOFTWARE IMPLEMENTATION

The software is written using the Arduino IDE. A program, or sketch, is created in the Arduino language and uploaded to the microcontroller. The program continuously reads

data from the sensors and controls the motor. When the ultrasonic sensor detects an object within the set distance, the Arduino turns on the motor driver, which makes the motor move to open the lid.

After a short pause to allow the user to dispose of waste, the motor reverses direction and closes the lid automatically. The system has a simple feature to stop repeated triggers

while the lid is moving. Also, if the infrared sensor detects that the bin is full, the system can stop the lid from opening and activate a buzzer. This helps prevent overflow and lets people know the bin needs to be emptied.

VI. WORKING

The Smart Dustbin System works by using sensors and a microcontroller to detect when something is near. An ultrasonic sensor is placed at the front of the bin to keep checking the distance to nearby objects. When someone puts their hand or trash close to the sensor, the sensor sends out sound waves and measures how long it takes for the echo to come back. The ESP 32 microcontroller then uses this time to figure out how far away the object is. If the distance is within a set range, the microcontroller tells the dustbin to open its lid.

Once the object is detected, the Arduino sends a signal to the L298N motor driver, which powers a DC gear motor connected to the lid. The motor turns in one direction to lift the lid, letting the user throw away trash without touching the bin. After a few seconds, the motor turns the other way to close the lid again. Also, an infrared sensor can check how full the bin is. If it gets too full, the system can make a buzzer sound and stop the lid from opening. This automatic process helps keep things clean, avoids contact with germs, and improves overall hygiene.

Fig 6: Hardware Circuit

VII. CONCLUSION

This study introduced a low-cost, do-it-yourself smart dustbin system made with an Arduino microcontroller. The system automatically detects a person and opens the lid without needing physical contact, which improves hygiene and makes waste disposal more convenient.

By using cheap sensors and simple hardware, the solution shows that effective automated waste systems can be made at a low cost. The project shows how embedded systems can improve everyday sanitation. With more development, the system could include IoT-based monitoring, waste level tracking, and integration with smart city waste management systems. These improvements could help create cleaner environments and more efficient waste handling processes.

REFRENCES

[1] Gopi, A., Jacob, J. A., Puthumana, R. M., AK, R., & Manohar, B. (2021, July). IoT based smart waste management system. In 2021 8th International Conference on Smart Computing and Communications (ICSCC) (pp. 298-302). IEEE.

[2] Tejaswi, Sivaprashanth, J. Sivaprashanth, G. Bala Krishna, M. Sridevi, and Sandeep Singh Rawat. "Smart Dustbin

Using IoT." In International Conference on Advances in Computational Intelligence and Informatics, pp. 257-265. Singapore: Springer Nature Singapore, 2023.

[3] G. K. Shyam, S. S. Manvi and P. Bharti, "Smart waste management using Internet-of- Things (IoT)," 2017 2nd International Conference on Computing and Communications Technologies (ICCCT), Chennai, India, 2017.

[4] P. Raghavendra and K. Sireesha, "Automatic Garbage Sorting Using Deep Learning and Robotic Arm," 2025 International Conference on Information, Implementation, and Innovation in Technology (I2ITCON), Pune, India, 2025.

[5] Daud, S. A., et al. "Application of Infrared sensor for shape detection." 2013 IEEE 4th International Conference on Photonics (ICP). IEEE, 2013.

[6] Yin, Liuliu, et al. "Application of drive circuit based on L298N in direct current motor speed control system." Advanced laser manufacturing technology. Vol. 10153. SPIE, 2016.