An Internship Report

On

Smart Garbage Monitoring System using IoT

Submitted in partial fulfilment of the requirements for the award of the degree of

BACHELOR OF TECHNOLOGY

In

COMPUTER SCIENCE AND ENGINEERING

By

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CERTIFICATE

This is to certify that the project entitled **"Smart Garbage Monitoring System using IoT "**, is a bonafide work of **K.V.N.D.S.S.Vasuki Gourav (22NN1A0586), B. Bhargavi(22NN1A0566), P. Dedeepya(22NN1A05A6), S . Tejasri(22NN1A05B3),** submitted to the faculty of Computer Science and Engineering, in the partial fulfilment of the requirements for the award of degree of **BACHELOR OF TECHNOLOGY** in **COMPUTER SCIENCE AND ENGINEERING** from **VIGNAN'S NIRULA INSTITUTE OF TECHNOLOGY AND SCIENCE FOR WOMEN, GUNTUR.**

Project Guide	**Head of the Department**
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EXTERNAL EXAMINER

DECLARATION

We hereby declare that the work described in this project work, entitled "**Smart Garbage Monitoring System using IoT"** which is submitted by us in partial fulfilment for the award of **Bachelor of Technology** in the Department of **Computer Science and Engineering** to the **Vignan's Nirula Institute of Technology and Science for women,** affiliated to Jawaharlal Nehru Technological University Kakinada, Andhra Pradesh, is the result of work done by us under the guidance of **Dr .A.Senthil Kumar**, Associate Professor.

The work is original and has not been submitted for any Degree/ Diploma of this or any other university.

Place:

Date:

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SMART GARBAGE MONITORING SYSTEM USING IOT

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LIST OF ACRONYMS

IOT	**Internet of Things**
IIOT	**Industries leverage Industrial IoT**
IR	**Infrared**
MCU	**Micro-controller unit**
PID	**Proportional-Integral-Derivative**

ABSTRACT

This Smart Garbage Monitoring project aims to develop a smart garbage monitoring system that utilizes an IR sensor, an ultrasonic sensor, and a buzzer to efficiently manage waste collection. The primary objective of the system is to monitor the fill level of garbage bins in real-time and provide immediate alerts when the bins are full, thereby optimizing waste collection schedules and reducing overflow incidents.

The system incorporates an ultrasonic sensor to measure the distance from the top of the bin to the garbage level, effectively determining the fill status. An IR sensor detects the presence of an object near the bin, indicating an attempt to dispose of waste. When the garbage level exceeds a predefined threshold and the IR sensor detects an object, the system activates a buzzer to alert users that the bin is full and needs emptying.

This project involves designing and implementing the hardware components, programming the microcontroller to process sensor data, and integrating the buzzer for real-time alerts. The system is intended to be cost-effective, easy to deploy, and scalable for use in various environments such as residential areas, public places, and commercial establishments.

Through this smart garbage monitoring system, we aim to enhance the efficiency of waste management practices, reduce manual checks, and contribute to a cleaner and more sustainable environment.

CHAPTER – 1

INTRODUCTION

1.1 Introduction to Project

Effective waste management is a critical aspect of maintaining hygiene and sustainability in urban environments. Traditional waste collection methods often involve periodic checks and scheduled pickups, which can lead to inefficiencies such as overflowing bins, unnecessary trips, and increased operational costs. To address these challenges, there is a growing need for intelligent solutions that can optimize waste management processes.

This project focuses on the development of a smart garbage monitoring system that leverages advanced sensor technology to provide real-time information on the fill levels of garbage bins. The system incorporates an ultrasonic sensor, an IR sensor, and a buzzer to monitor and manage waste levels effectively.

The ultrasonic sensor is responsible for measuring the distance from the sensor to the garbage surface, thereby determining the fill level of the bin. The IR sensor detects the presence of objects near the bin, indicating that someone is attempting to dispose of waste. When the bin reaches a critical fill level, and the IR sensor detects disposal activity, the system activates a buzzer to alert maintenance personnel that the bin is full and requires immediate emptying.

The smart garbage monitoring system is designed to be cost-effective, scalable, and easy to deploy. It can be implemented in various settings, including residential complexes, public spaces, and commercial facilities. By providing timely alerts and real-time data, the system aims to optimize waste collection schedules, reduce instances of bin overflow, and minimize the need for manual checks.

Through the implementation of this smart garbage monitoring system, we aim to enhance the efficiency of waste management practices, contribute to cleaner environments, and promote public health and safety. This project represents a significant step towards modernizing waste management systems and addressing the challenges associated with traditional waste collection methods.

Fig:1.1: GARBAGE MONITOR

1.2 Introduction to Embedded System

An embedded system is a computer system that is designed to perform a specific task or set of tasks. It is a combination of computer hardware and software that is integrated into a larger system. Embedded systems are used in various applications such as home appliances, transportation, healthcare, business sector & offices, defence sector, aerospace, and agricultural sector. The three main components of an embedded system are hardware, software, and firmware. Hardware refers to the physical components of the system such as microprocessors or microcontrollers.

Software refers to the programs that run on the hardware. Firmware is a type of software that is embedded in the hardware and is responsible for controlling the system. An Embedded system is a special- purpose system in which the computer is completely encapsulated by or dedicated to the device or system it controls. Unlike a general-purpose computer, such as a personal computer, an Embedded System performs one or few predefined Tasks usually with very specific requirements. Since the system is dedicated to specified tasks, design engineers can optimize it, reducing the size and cost of the product. Embedded Systems are often mass produced, benefiting from economies of scale.

Characteristics of Embedded System:

- An embedded System is any computer system hidden inside a product other than a computer.
- Throughput – Our system may need to handle a lot of data in short period of time.

• Response – Our system may need to react to events quickly.

• Test ability- Setting up equipment to test embedded software can be difficult.

• Debug ability- Without a screen or a keyboard, finding out what the software is doing wrong is a troublesome problem.

• Reliability – Embedded Systems must be able to handle any situation without human intervention.

• Memory Space - Memory is limited on Embedded Systems, and you must make the software and the data fit into whatever memory exists.

• Power Consumption – Portable systems must run on battery power, and the software in these systems must conserve power.

• Processor hogs- Computing that requires large amounts of CPU time can complicate the response problem.

1.3 Introduction to IOT

INTERNET OF THINGS (IoT) is the networking of physical objects that contain electronics embedded within their architecture in order to communicate Interaction amongst each other or with respect to the external environment. In the upcoming years, IoT-based technology will offer advanced levels of services and practically away people lead their daily lives. Advancements in medicine, power, gene therapy agriculture, smart cities, and smart homes are just a very few of the categorical example where IoT is strongly established.

IoT is network of interconnected computing devices which are embedded in everyday objects, enabling them to send and receive data. With more than 7 billion connected IOT devices today, experts are expecting this number to grow to 10 billion by 2020 and 22 billion by 2025. Oracle has a network of device partners.

The most important features of IoT on which it works are connectivity, integrating, active engagement, and many more. Connectivity refers to establish a proper connection between all the things of IoT platform it may be server or cloud. After connecting the IoT devices, it needs a highspeed messaging between the devices and cloud to enable reliable, secure and bi-directional communication. IoT makes things smart and enhances life through the use of data. For example, if we have a coffee machine whose beans have going to end, then the coffee machine it orders the coffee beans of your choice from the retailer. The most important features of IoT on which it works are connectivity ,analysing, integrating, active engagement, and many more. Some of them are listed below:

Connectivity: Connectivity refers to establish a proper connection between all the things of IoT platform it may be server or cloud. After connecting the IoT devices, it needs a high speed messaging between the devices and cloud to enable reliable,secure and bi-directional communication.

Analysing: After connecting all the relevant things, it comes to real-time analysing the data collected and use them to build effective business intelligence. If we have a good insight into data gathered from all these things, then we call our system has a smart system.

Integrating: IoT integrating the various models to improve the user experience as well.

Artificial Intelligence: IoT makes things smart and enhances life through the use of data. For example, if we have a coffee machine whose beans have going to end, then the coffee machine it orders the coffee beans of your choice from the retailer.

Sensing: The sensor devices used in IoT technologies detect and measure any change in the environment and report on their status. IoT technology brings passive networks to active networks. Without sensors, there could not hold an effective or true Iot environment.

Active Engagement: IoT makes the connected technology, product, or services to active engagement between each other.

Endpoint Management: It is important to be the endpoint management of all the IoT system otherwise, it makes the complete failure of the system. For example, if a coffee machine itself order the coffee beans when it goes to end but what happens when it orders the beans from a retailer and we are not present at home for a few days, it leads to the failure of the IoT system.

1.4 Need of IoT

The Internet of Things (IoT) stands as a transformative force, reshaping our interactions with the world and revolutionizing diverse aspects of our daily lives. At its core, IoT thrives on connectivity, fostering seamless communication between devices and promoting interoperability.. Through automation, IoT enhances efficiency by enabling devices to operate autonomously based on predefined conditions or real-time data, reducing the need for constant human intervention. In the realm of smart cities, IoT contributes to urban development by introducing intelligent transportation systems, energy management, and sustainable practices, thereby enhancing overall quality of life.

Health care benefits from IoT through wearables and remote monitoring tools, offering personalized insights and timely interventions. Industries leverage Industrial IoT (IOT) to optimize manufacturing processes, monitor equipment health, and implement predictive maintenance strategies, leading to increased productivity and cost savings. From smart homes with connected appliances to environmental monitoring and supply chain optimization, IoT's impact is far-reaching, creating a more connected, efficient, and intelligent world across various domain.

CHAPTER-2

LITERATURE SURVEY

2.1 Introduction:

The management of waste is a critical issue that urban areas around the world face today. Traditional methods of waste collection often lead to inefficiencies such as overflowing bins, untimely waste pickups, and increased operational costs. The advent of smart technologies offers promising solutions to these challenges by introducing automation and real-time monitoring into waste management systems.

This literature survey aims to explore the existing body of research and technological advancements in smart waste management systems, focusing on the use of sensors and automation to enhance efficiency and effectiveness. By examining previous studies, this survey identifies the current state of technology in waste monitoring and management, the benefits and limitations of various approaches, and the gaps that still need to be addressed.

Key components of smart waste management systems, such as ultrasonic sensors for measuring bin fill levels, infrared (IR) sensors for detecting disposal activities, servo motors for automating bin lid movements, and buzzers for alerting maintenance personnel, are reviewed. Additionally, the survey looks into case studies where these technologies have been successfully implemented, providing insights into their practical applications and impacts.

The integration of these technologies can lead to significant improvements in waste management, including optimized collection schedules, reduced operational costs, and minimized environmental pollution. However, challenges such as dependency on advanced communication networks and the need for cost-effective, scalable solutions persist.

This literature survey sets the stage for the development of a smart garbage monitoring system that addresses these challenges by combining ultrasonic sensors, IR sensors, servo motors, and buzzers into a cohesive and efficient solution. The proposed system aims to enhance waste management practices by providing real-time monitoring and alerts, thus ensuring timely waste collection and preventing bin overflow.

2.2. Smart Waste Management Systems:

- **Overview**: Smart waste management systems have been widely researched and developed to address inefficiencies in traditional waste collection methods. These systems typically incorporate various sensors and communication technologies to provide real-time monitoring and data analysis.
- **Key Findings**: Studies have shown that smart waste management systems can significantly reduce operational costs, optimize collection routes, and prevent environmental pollution by ensuring timely waste collection.
- **Gaps**: While many systems utilize advanced communication technologies like Wi-Fi and IoT networks, there is a need for solutions that operate without reliance on such infrastructure, particularly in areas with limited connectivity.

2.3 Ultrasonic Sensor-Based Monitoring

- **Overview**: Ultrasonic sensors are widely used in smart waste management for measuring the fill level of bins. These sensors emit ultrasonic waves and measure the time taken for the waves to reflect back, determining the distance to the waste surface.
- **Key Findings**: Ultrasonic sensors are effective in providing accurate measurements of bin fill levels. They are also cost-effective and easy to implement.
- **Gaps**: The integration of ultrasonic sensors with other sensing technologies, such as IR sensors, to enhance monitoring accuracy and functionality is less explored.

2.4. IR Sensor Applications in Waste Management

- **Overview**: Infrared (IR) sensors are used to detect the presence of objects, making them suitable for monitoring disposal activity in garbage bins. These sensors can help identify when the bin is being used, providing additional context to fill level data.
- **Key Findings**: IR sensors are effective in detecting nearby objects and can complement ultrasonic sensors in smart waste management systems.
- **Gaps**: There is limited research on combining IR sensors with ultrasonic sensors and buzzers to create a comprehensive alert system for waste management.

2.5 Servo Motors in Automated Systems

- **Overview**: Servo motors are utilized in automated systems for precise control of angular position, velocity, and acceleration. In waste management systems, servo motors can be used to automate the opening and closing of bin lids.
- **Key Findings**: Servo motors are effective for applications requiring precise and controlled movements. They can enhance the functionality of smart waste management systems by automating certain processes.
- **Gaps**: The use of servo motors in conjunction with sensor-based monitoring systems for comprehensive waste management solutions is under-explored.

2.6 Alert Systems Using Buzzers

- **Overview**: Buzzers are simple yet effective alert mechanisms used in various monitoring systems. In waste management, buzzers can be used to notify maintenance personnel when bins are full.
- **Key Findings**: Studies have shown that using buzzers as an alert system can significantly reduce response times for waste collection.
- **Gaps**: The use of buzzers in conjunction with sensor-based monitoring to provide real-time alerts for waste management needs further exploration.

2.7 Case Studies of Smart Waste Management Implementation

- **Overview**: Several case studies demonstrate the successful implementation of smart waste management systems in urban environments. These systems use a combination of sensors, data analytics, and communication technologies to enhance waste collection efficiency.
- **Key Findings**: Case studies highlight the benefits of smart waste management, including reduced operational costs, optimized collection routes, and improved environmental sustainability.
- **Gaps**: Many implementations rely on advanced communication networks, which may not be feasible in all areas. There is a need for more accessible and scalable solutions.

II. LITERATURE REVIEW

Effective waste management is essential for maintaining urban hygiene and sustainability. Traditional waste collection systems often encounter challenges such as inefficient scheduling, overflowing bins, and unnecessary operational costs. Recent advancements in sensor technology and automation offer potential solutions to these issues. This literature review examines key studies and technologies relevant to the development of a smart garbage monitoring system, highlighting their benefits, limitations, and areas for further research.

1. Smart Waste Management Systems:

Smart waste management systems integrate various sensors and communication technologies to provide real-time monitoring and data analysis. These systems aim to optimize waste collection routes, reduce operational costs, and prevent environmental pollution.

Key Findings:

- Studies have demonstrated significant improvements in waste collection efficiency and cost savings through the use of smart waste management systems.
- Advanced communication technologies, such as IoT and wireless networks, facilitate real-time data transmission and remote monitoring.

Limitations:

- Dependence on reliable communication infrastructure, which may not be available in all areas.
- High initial setup and maintenance costs can be a barrier to widespread adoption.

2. Ultrasonic Sensors in Waste Management

Ultrasonic sensors are widely used in smart waste management systems to measure the fill level of garbage bins. They operate by emitting ultrasonic waves and measuring the time taken for the waves to reflect back from the surface of the waste.

Key Findings:

- Ultrasonic sensors provide accurate measurements of bin fill levels, helping to optimize collection schedules.
- They are cost-effective, easy to implement, and reliable under various environmental conditions.

Limitations:

- Performance can be affected by the shape and material of the waste.

- Integration with other sensors and systems is necessary for comprehensive monitoring.

3. IR Sensors for Disposal Detection

Infrared (IR) sensors detect the presence of objects near the bin, indicating disposal activity. They complement ultrasonic sensors by providing additional context to fill level data.

Key Findings:

- IR sensors are effective in detecting nearby objects and identifying disposal attempts.
- They enhance the accuracy of monitoring systems by distinguishing between full bins and active usage.

Limitations:

- Limited detection range and susceptibility to environmental interference.
- Need for regular calibration and maintenance to ensure accuracy.

4. Servo Motors for Automation

Servo motors provide precise control of angular position, velocity, and acceleration, making them suitable for automating the opening and closing of bin lids in smart waste management systems.

Key Findings:

- Servo motors enable automation of bin lids, reducing manual intervention and improving hygiene.
- They offer precise and reliable movement control, essential for automated systems.

Limitations:

- Higher power consumption compared to other types of motors.
- Complexity in integrating with sensor systems and ensuring synchronized operation.

5. Buzzer Alert Systems

Buzzers serve as simple yet effective alert mechanisms in waste management systems. They notify maintenance personnel when bins are full, ensuring timely waste collection.

Key Findings:

- Buzzers provide immediate and audible alerts, reducing response times for waste collection.
- They are easy to implement and cost-effective.

Limitations:

- Limited to providing audible alerts, which may not be suitable in all environments.
- Integration with sensor data is necessary to trigger alerts accurately.

6. Case Studies of Smart Waste Management Implementations

Several case studies demonstrate the successful implementation of smart waste management systems in urban environments. These systems use a combination of sensors, data analytics, and communication technologies to enhance waste collection efficiency.

Key Findings:

- Case studies highlight significant operational cost reductions and environmental benefits.
- Successful implementations emphasize the importance of real-time data and automated responses.

Limitations:

- Many implementations rely on advanced communication networks, which may not be feasible in all areas.
- Need for customizable solutions to fit specific urban or regional requirements.

CHAPTER-3

DESIGNED SYSTEM

3.1 Introduction

The designed smart garbage monitoring system integrates advanced sensor technologies and automation components to address inefficiencies in traditional waste management practices. This system aims to provide a cost-effective, reliable, and scalable solution for real-time waste level monitoring and timely alerts, ensuring optimal waste collection and preventing overflow.

Key Components of the System:

1. **Ultrasonic Sensor**: This sensor measures the distance between the sensor and the surface of the waste within the bin. By continuously monitoring this distance, the system can accurately determine the fill level of the bin. Ultrasonic sensors are known for their reliability and accuracy in various environmental conditions.
2. **IR Sensor**: The infrared sensor is used to detect the presence of objects near the bin, indicating attempts to dispose of waste. This sensor provides additional context to the fill level data by identifying active usage of the bin. It enhances the system's accuracy by distinguishing between full bins and those still in use.
3. **Servo Motor**: The servo motor automates the opening and closing of the bin lid. This feature not only improves hygiene by reducing manual contact with the bin but also helps in maintaining the cleanliness of the surroundings by preventing overflow and littering.
4. **Buzzer**: The buzzer serves as an alert mechanism, sounding an alarm when the bin reaches a predefined fill level and when further disposal attempts are detected by the IR sensor. This immediate notification ensures that maintenance personnel are promptly alerted to empty the bin, preventing overflow.

3.2 Objectives

1. **Enhance Waste Collection Efficiency**:
    - Enable real-time monitoring of bin fill levels.

- Optimize waste collection schedules and routes.

2. **Reduce Operational Costs**:
    - Decrease the need for manual bin inspections.
    - Minimize the number of unnecessary waste collection trips.
3. **Prevent Bin Overflow and Environmental Pollution**:
    - Provide timely alerts to prevent bins from overflowing.
    - Reduce environmental pollution caused by overflowing waste.
4. **Improve Hygiene and Sanitation**:
    - Automate the opening and closing of bin lids.
    - Reduce manual contact with waste, enhancing public health.
5. **Provide Real-Time Alerts and Notifications**:
    - Use buzzers to alert maintenance personnel when bins are full.
    - Notify personnel of disposal attempts detected by the IR sensor.
6. **Increase Scalability and Adaptability**:
    - Design a system that can be deployed in various environments (residential, commercial, public spaces).
    - Ensure the system can be easily scaled and adapted to different waste management needs.
7. **Promote Environmental Sustainability**:
    - Contribute to more efficient waste management practices.
    - Support long-term environmental sustainability goals.
8. **Utilize Cost-Effective and Reliable Technology**:
    - Integrate ultrasonic sensors, IR sensors, servo motors, and buzzers.
    - Ensure the system is economically viable and reliable.
9. **Enhance Data Collection and Analysis**:

- Collect data on waste disposal patterns and bin usage.
- Use data to inform and improve future waste management strategies.

10. **Ensure Ease of Maintenance and Operation**:
    - Design a system that is user-friendly and requires minimal maintenance.
    - Facilitate easy operation by waste management personnel.

3.3 Block Diagram

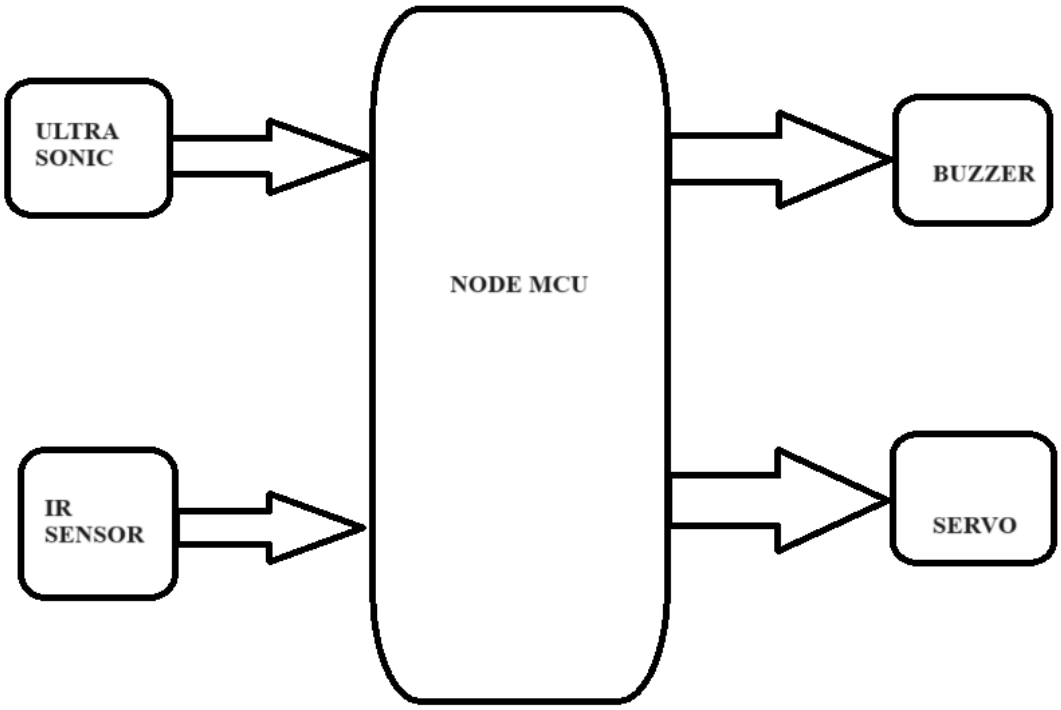


Fig 3.1: Block Diagram

3.4 Tools Required

3.4.1 Hardware Components

- Power Supply
- Node MCU

- Buzzer
- Servo Motor
- IR Sensor
- Ultrasonic Sensor

3.4.2 Software Requirements

- Arduino IDE
- Code develops through Embedded C
- Proetus

3.4.3 Techniques Used

The smart garbage monitoring system employs a combination of advanced technologies and techniques to achieve efficient and effective waste management. The primary techniques used in this project include:

1. Ultrasonic Sensing:
    - Technique: Ultrasonic sensors emit sound waves at a frequency higher than human hearing. The sensor measures the time taken for the waves to reflect off the surface of the waste and return to the sensor.
    - Application: Used to measure the distance between the sensor and the waste surface, determining the fill level of the garbage bin.
2. Infrared (IR) Sensing:
    - Technique: IR sensors detect the presence of objects by measuring the amount of infrared light reflected from the objects. The sensor's detection range can be adjusted to suit the environment.
    - Application: Monitors disposal activities by detecting objects near the bin, providing additional context to the fill level data.
3. Servo Motor Control:

- Technique: Servo motors use feedback mechanisms to provide precise control of angular position. The motor adjusts its position based on input signals, allowing for accurate movements.
- Application: Automates the opening and closing of the bin lid, reducing manual contact and maintaining hygiene.

4. Buzzer Alert System:
    - Technique: Buzzers are electronic sound-producing devices that emit a loud, attention-grabbing sound when activated.
    - Application: Provides auditory alerts to maintenance personnel when the bin reaches a specified fill level or when disposal attempts are detected.
5. Data Processing and Integration:
    - Technique: Microcontrollers or processors are used to collect data from sensors, process this data, and execute control commands. Integration of different sensors allows for comprehensive monitoring.
    - Application: Combines data from ultrasonic and IR sensors to determine bin status and trigger the servo motor and buzzer based on predefined conditions.
6. Power Management:
    - Technique: The system may use battery power or solar panels to ensure continuous operation. Power management techniques are employed to optimize energy consumption and prolong battery life.
    - Application: Ensures the system operates efficiently in environments with varying power availability.
7. Wireless Communication (Optional):
    - Technique: While not used in the core system described, optional wireless communication techniques such as Bluetooth or Zigbee can be integrated for remote monitoring and data transmission.
    - Application: Facilitates remote monitoring and control if desired, though the primary system operates without reliance on wireless networks.

8. Programming and Control Logic:
    - Technique: Software algorithms are programmed into the microcontroller to handle sensor data, perform calculations, and execute control commands for the servo motor and buzzer.
    - Application: Manages the overall functionality of the system, ensuring accurate and timely responses to sensor inputs.

By integrating these techniques, the smart garbage monitoring system provides a comprehensive solution for efficient waste management, combining real-time monitoring, automation, and alerts to optimize waste collection processes and improve overall system performance.

3.5 WORKING

1. System Setup:

   Component Installation: Install ultrasonic sensors, IR sensors, servo motors, and buzzers in the garbage bin.

2. Initialization:
    - Sensor Calibration: Calibrate the ultrasonic and IR sensors to ensure accurate measurements and detection. Adjust the detection range and sensitivity as needed.
    - System Configuration: Program the microcontroller with the necessary algorithms to process sensor data and control system components.
3. Monitoring and Data Collection:
    - Ultrasonic Sensing:
        - The ultrasonic sensor emits sound waves towards the waste surface.
        - The sensor measures the time taken for the sound waves to reflect back to the sensor.
        - Calculate the distance between the sensor and the waste surface to determine the fill level of the bin.
    - IR Sensing:

        - The IR sensor detects the presence of objects near the bin.
        - The sensor measures the amount of reflected infrared light to identify disposal attempts.

4. Data Processing:
    - Fill Level Calculation:
        - The microcontroller processes the data from the ultrasonic sensor to calculate the bin’s fill level.
    - Disposal Detection:
        - The microcontroller analyzes data from the IR sensor to detect when disposal activity occurs.
5. Decision Making:
    - Threshold Checking:
        - Compare the fill level data to predefined threshold values to determine if the bin is full or approaching full capacity.
        - Evaluate IR sensor data to identify if disposal activity is occurring and whether the bin is being used.
    - Action Determination:
        - If the bin reaches the predefined fill level or disposal activity is detected, prepare to trigger the servo motor and buzzer.
6. Control Actions:
    - Servo Motor Operation:
        - If the bin is being used, the servo motor may adjust the lid to allow for waste disposal.
        - If the bin is full, the servo motor may close the lid or lock it to prevent further use.
    - Buzzer Activation:

        - When the bin reaches a full capacity or disposal activity is detected, activate the buzzer to alert maintenance personnel.

7. Alerts and Notifications:
    - Auditory Alerts:
        - The buzzer emits a loud sound to notify personnel that the bin requires attention or is nearing full capacity.
    - Operational Response:
        - Maintenance personnel respond to the alert, empty the bin, and perform any necessary maintenance.
8. System Maintenance:
    - Regular Checks:
        - Periodically check and calibrate the sensors to ensure continued accuracy.
    - Battery/Solar Panel Monitoring:
        - Monitor the power supply and replace or recharge batteries as needed or ensure the solar panel remains functional.
9. Data Logging and Analysis (Optional):
    - Data Collection:
        - If integrated, collect and log data on bin fill levels and disposal activity.
    - Analysis:
        - Analyze the data to optimize waste collection routes and schedules, and identify patterns in waste disposal.
10. System Upgrades and Adjustments:
    - Software Updates:
        - Update the microcontroller's software to improve functionality or add new features.

- Hardware Adjustments:
    - Make any necessary hardware adjustments based on system performance and user feedback.

By following these steps, the smart garbage monitoring system operates efficiently to manage waste effectively, providing timely alerts, automating lid control, and ensuring that maintenance personnel are promptly informed of any issues.

ADVANTAGES

1. Increased Efficiency:
    - Optimized Collection Schedules: Real-time monitoring of bin fill levels allows for dynamic scheduling of waste collection routes, reducing the frequency of unnecessary trips and ensuring bins are emptied at the optimal time.
    - Improved Resource Utilization: Efficient route planning and scheduling help in better utilization of waste collection resources and personnel.
2. Cost Savings:
    - Reduced Operational Costs: Minimizes costs associated with manual bin inspections and redundant waste collection trips, leading to significant savings in fuel and labor expenses.
    - Efficient Resource Management: Reduces the need for additional waste collection vehicles and staff by optimizing the collection process.
3. Enhanced Environmental Sustainability:
    - Prevention of Overflow: Timely alerts and automated lid control help prevent bins from overflowing, reducing littering and environmental pollution.
    - Support for Sustainable Practices: Efficient waste management practices contribute to a cleaner and more sustainable urban environment.
4. Improved Hygiene and Sanitation:
    - Automated Lid Control: Reduces the need for manual contact with the bin, enhancing hygiene and reducing the risk of contamination.

- Prevention of Odors: By ensuring timely bin emptying, the system helps control odors associated with overflowing or poorly maintained bins.

5. Real-Time Alerts and Notifications:
    - Immediate Response: Buzzers provide instant auditory alerts to maintenance personnel, ensuring that full bins are addressed promptly.
    - Proactive Maintenance: Alerts help in identifying and addressing issues before they escalate, improving overall waste management efficiency.
6. Scalability and Adaptability:
    - Versatile Deployment: The system can be easily scaled and adapted for use in various environments, including residential areas, commercial establishments, and public spaces.
    - Customizable Solutions: The system can be tailored to meet specific waste management needs and requirements of different locations.
7. Data Collection and Insights:
    - Pattern Analysis: The system can collect data on waste disposal patterns and bin usage, providing valuable insights for improving waste management strategies.
    - Informed Decision-Making: Data-driven insights help in making informed decisions regarding waste collection schedules and resource allocation.
8. Reduced Manual Labor:
    - Automation of Lid Operation: Automates the opening and closing of bin lids, reducing the need for manual handling and improving operational efficiency.
    - Minimized Physical Effort: Reduces the physical effort required by waste collection personnel, enhancing their safety and comfort.
9. Enhanced Public Health:
    - Prevention of Waste Overflow: Helps in maintaining cleaner surroundings and reducing health hazards associated with overflowing waste.

- Improved Waste Management: Contributes to a healthier urban environment by ensuring effective and timely waste collection.

10. Cost-Effective Technology:
    - Affordable Components: Utilizes cost-effective and reliable technologies such as ultrasonic sensors, IR sensors, and servo motors, making the system economically viable.
    - Low Maintenance: Designed to be easy to maintain and operate, reducing long-term maintenance costs.

Overall, the smart garbage monitoring system offers a range of advantages that improve the efficiency, cost-effectiveness, and environmental sustainability of waste management practices. By integrating advanced technologies, the system provides a comprehensive solution for modern waste management challenges.

CHAPTER-4

HARDWARE IMPLEMENTATION

4.1 Node MCU ESP8266

4.1.1 Description

Node MCU ESP8266 Description Node MCU is an open-source firmware for which open source prototyping board designs are available. The name “Node MCU” combines “node” and “MCU” (micro-controller unit). The term “Node MCU” strictly speaking refers to the firmware rather than the associated development kits. Both the firmware and prototyping board designs are open source. Node MCU ESP8266 and Node MCU ESP32 are becoming very popular and are almost used in more than 50% IoT based projects today.

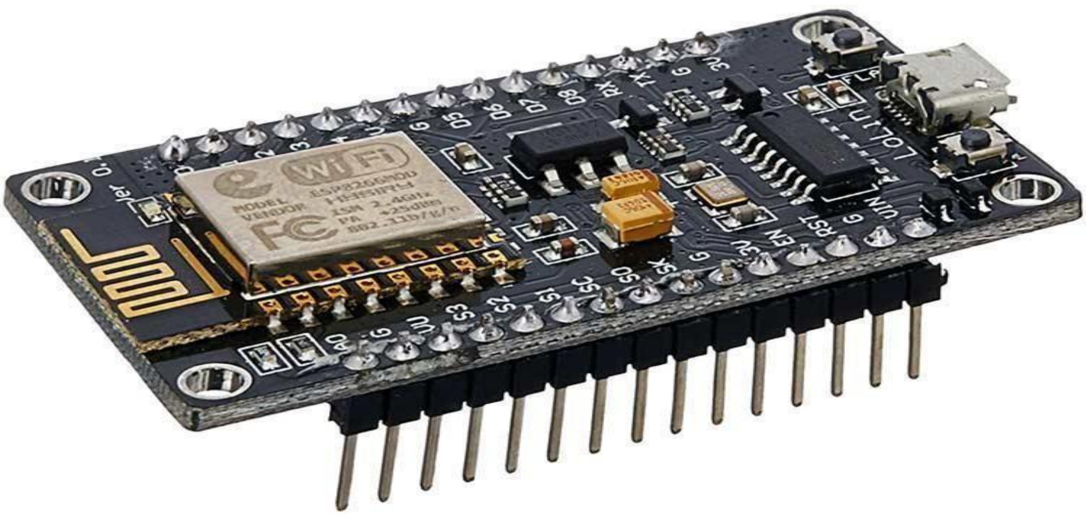


Fig 4.1: Node MCU

The firmware uses the Lua scripting language. The firmware is based on the eLua project and built on the Express if Non-OS SDK for ESP8266. It uses many open-source projects, such as luacjson and SPIFFS. Due to resource constraints, users need to select the modules relevant for their project and build a firmware tailored to their needs. Support for the 32-bit ESP32 has also been implemented. The prototyping hardware typically used is a circuit board functioning as a dual in-line package (DIP) which integrates a USB controller with a smaller surface-mounted board containing the MCU and antenna. The choice of the DIP format allows for easy prototyping on bread boards. The design was initially was based on the ESP-12 module of the ESP8266, which is a WiFi SoC integrated with a Tensilica Xtensa LX106 core, widely used in IoT applications.

About the Node MCU ESP8266 Pinout:

Node MCU ESP8266 Wi-Fi Module is an open-source Lua based firmware and development board specially targeted for IoT based applications. It includes firmware that runs on the ESP8266 Wi-Fi SoC from express if Systems, and hardware which is based on the ESP-12 module.

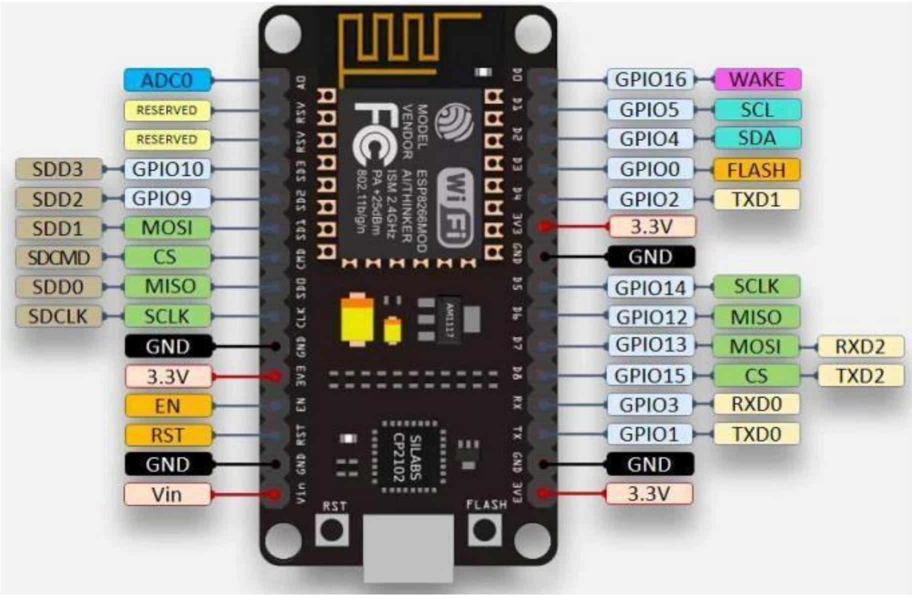


Fig 4.2 Pin Diagram of Node MCU

4.1.2 Node MCU ESP8266 Features:

Microcontroller: Tensilica 32-bit RISC CPU Xtensa LX106
Operating Voltage: 3.3V

Input Voltage: 7-12V

Digital I/O Pins (DIO): 16

Analog Input Pins (ADC): 1

UARTs: 1

SPIs: 1

I2Cs: 1

Flash Memory: 4 MB

SRAM: 64 KB

Clock Speed: 80 MHz

USB-TTL based on CP2102 is included onboard, Enabling Plug n Play PCB

Antenna Small Sized module to fit smartly inside your IoT projects

Pin Code Arduino alias

A0 A0 A0

D0 GPIO 16 16

D1 GPIO 5 5

D2 GPIO 4 4

D3 GPIO 0 0

D4 GPIO 2 2

D5 GPIO 14 14

D6 GPIO 12 12

D7 GPIO 13 13

D8 GPIO 15 15SD2 GPIO 9 9

SD3 GPIO 10 10

RX GPIO 3 3

TX GPIO 1 1

4.2 Ultrasonic Sensor

Ultrasonic Sensor are electronic devices that calculate the target's distance by emission of ultrasonic sound waves and convert those waves into electrical signals. The speed of emitted ultrasonic waves traveling speed is faster than the audible sound.

4.2.1 Description

An ultrasonic sensor is a type of sensor that uses ultrasonic sound waves to measure distance or detect objects. It operates by emitting a high-frequency sound wave and then measuring the time it takes for the sound wave to bounce back to the sensor after hitting an object. Here's a detailed description of how it works and its components:

1.Transmitter: The transmitter generates and emits the ultrasonic sound wave, usually at a frequency above 20 kHz, which is above the range of human hearing.

2.Receiver: The receiver detects the ultrasonic sound wave after it has bounced off an object and returned to the sensor.

3.Control Circuit: This circuit controls the timing of the emitted and received signals, processes the received signals, and calculates the distance based on the time delay between emission and reception.

4.Housing: The components are typically encased in a durable housing that protects them from environmental factors.

Fig 4.3 : Ultra Sonic Sensor

4.3 IR Sensor

An infrared (IR) sensor is a device that detects and measures infrared radiation in its environment. Infrared radiation is a type of electromagnetic radiation with wavelengths longer than visible light, typically from about 700 nanometers (nm) to 1 millimeter (mm). IR sensors are widely used in various applications, from remote controls to thermal imaging and motion detection. Here's a detailed description of IR sensors and how they work.

4.3.1 Description

Types of IR Sensors

1.Active IR Sensors:

1.Reflective Sensors: Emit IR light and measure the amount reflected back from an object. Commonly used in obstacle detection and proximity sensing.

Passive IR Sensors:

1.PIR Sensors: Detect changes in infrared radiation due to movement. They are widely used in motion detection for security systems and energy-saving applications like automatic lighting.

2.Thermal IR Sensors: Detect the heat emitted by objects. Used in thermal imaging cameras for various applications, including surveillance, firefighting, and industrial inspections.

Specific Applications

Consumer Electronics:

1.Remote Controls: IR sensors are used in remote controls to transmit commands to devices like TVs, air conditioners, and audio equipment.

2.Touchless Interfaces: IR sensors enable touchless interaction in devices like elevators and interactive kiosks.

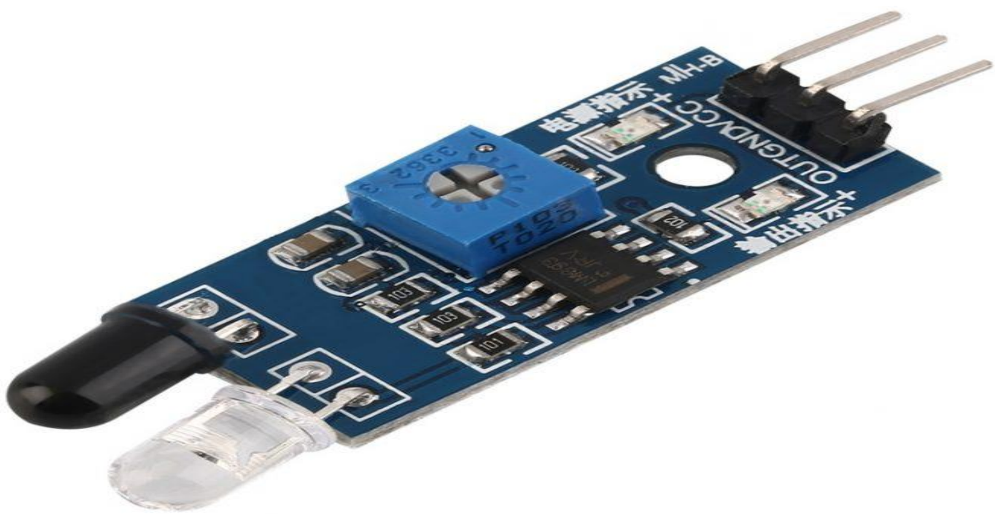


Fig 4.4: IR Sensor

4.4 Servo Motor

A servo motor is a type of electric motor that is designed to provide precise control of angular position, velocity, and acceleration. Unlike standard motors, which run continuously at a set speed, servo motors are used in applications where precise control is essential. Here's an introduction to servo motors, including their types, components, and applications.

4.4.1 Description

A servo motor is an advanced type of electric motor designed for precise control of angular position, speed, and acceleration. Unlike standard motors, which operate at a constant speed, servo motors are engineered to achieve and maintain specific positions or speeds based on external commands. This precision is facilitated by a combination of a motor, feedback mechanism, and control circuitry.

At the heart of a servo motor is the motor itself, which can be a DC motor, stepper motor, or brushless DC motor. This motor provides the basic rotational force required for movement. Attached to the motor is a feedback device, such as a potentiometer or encoder, which continuously monitors the motor's actual position or speed. The potentiometer measures position by varying resistance, while the encoder provides precise position and speed information through digital signals.

The control circuit of a servo motor processes feedback from the sensor and adjusts the motor's output to match the desired position or speed. This is typically done using a Proportional-Integral-Derivative (PID) controller, which fine-tunes the motor's performance by correcting any deviation from the target. Many servo motors also include a gearbox that reduces speed and increases torque, allowing the motor to handle more demanding tasks.

Servo motors can be classified into several types based on their applications. Standard servo motors are commonly used in hobbyist applications, such as remote-controlled vehicles, where they offer basic precision at an affordable cost. Continuous rotation servo motors provide rotational movement in either direction and are useful in applications that require rotation rather than precise positioning. Industrial servo motors are high-performance devices used in manufacturing, robotics, and CNC machinery, offering exceptional precision and reliability. Linear servo motors, on the other hand, provide precise linear motion and are employed in applications where straight-line movement is needed.

Fig 4.5: Servo Motor

Overall, servo motors play a crucial role in modern technology, offering precise control and reliable performance in a wide range of applications, from everyday consumer electronics to advanced industrial and aerospace systems.

4.5 Buzzer

A buzzer is an electromechanical device that produces a sound or alert, commonly used in various applications to indicate status, warn of events, or provide notifications. Buzzers are designed to generate audible signals that can be heard by people, making them effective for alerting or drawing attention in a wide range of settings.

4.5.1 Description

A buzzer is an electromechanical device designed to produce an audible sound, serving as an alert or notification tool in a variety of applications. Buzzers are commonly used to provide feedback, warnings, or alerts in electronic devices, ranging from household appliances and alarm clocks to industrial machinery and automotive systems. The sound generated by a buzzer can vary in pitch and volume, depending on its type and design.

Buzzers come in two main categories: electromechanical and electronic. Electromechanical buzzers include electromagnetic and piezoelectric types. Electromagnetic buzzers use an electromagnetic coil and diaphragm to produce sound by creating a magnetic field that causes the diaphragm to vibrate. This results in a loud and resonant noise. Piezoelectric buzzers, on the other hand, utilize a piezoelectric crystal that vibrates when an electric field is applied, generating sound through these vibrations. These are known for their compact size and efficiency, making them suitable for modern electronic devices.

Electronic buzzers can be classified into active and passive types. Active buzzers contain an internal oscillator that generates a fixed tone when powered, simplifying integration into circuits since they only require a power source. Passive buzzers, however, need an external signal to create sound. They produce noise based on the frequency of the applied signal, allowing for variable tones and more complex sound patterns.

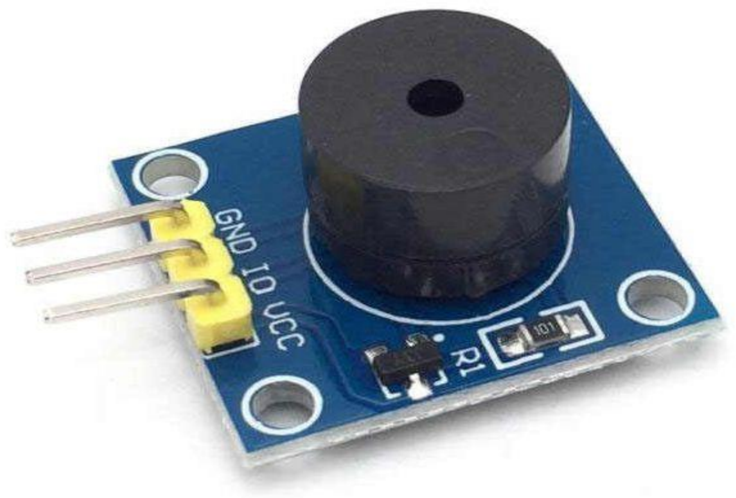


Fig 4.6:Buzzer

The advantages of buzzers include their clear and immediate audible feedback, versatility in size and tone, and generally low power consumption, especially in piezoelectric and active types. However, they may produce disruptive noise levels and have limited sound complexity compared to more advanced sound-generating devices. Overall, buzzers are essential components that offer straightforward and effective means of providing auditory notifications and alerts in diverse applications.

CHAPTER-5

SOFTWARE IMPLEMENTATION

5.1 Arduino IDE

5.1.1 Introduction to Arduino IDE

IDE stands for Integrated Development Environment - An official software introduced by Arduino.cc that is mainly used for writing, compiling and uploading the code in almost all Arduino modules/boards. Arduino IDE is open-source software and is easily available to download & install from Arduino Official Site.

In this post, I'll take you through the brief Introduction of the Software, how you can install it, and make it ready for your required Arduino module.

Let's dive in and get down to the nitty-gritty of this Software.

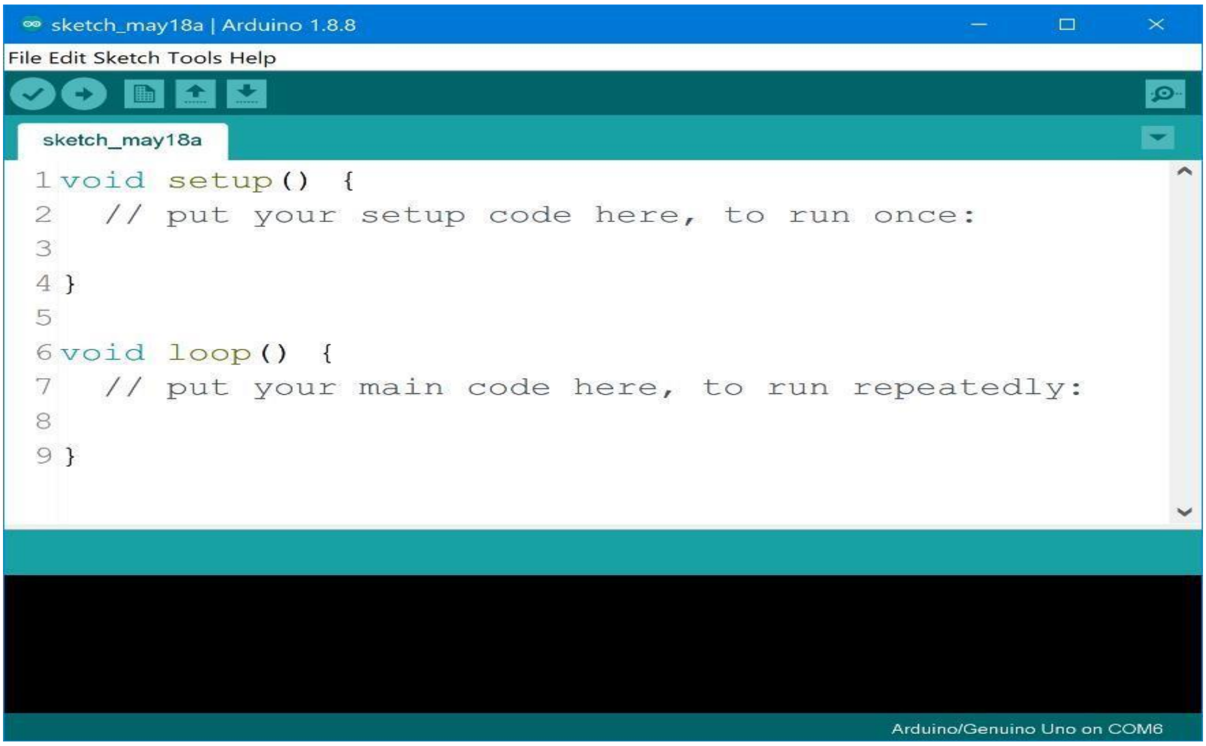


Fig 5.1: Arduino IDE Editor page

Arduino IDE is an open-source software, designed by Arduino.cc and mainly used for writing, compiling & uploading code to almost all Arduino Modules. It is an official Arduino software, making code compilation too easy that even a common person with no priot technical knowledge can get their feet wet with the learning process. It is available for all operating systems i.e., MAC, Windows, Linux and runs on the Java Platform that comes with inbuilt functions and commands that play a vital role in debugging, editing and compiling the code. A range of Arduino modules available including Arduino Uno, Arduino Mega, Arduino Leonardo, Arduino Micro and many more. Each of them contains a microcontroller on the board that is actually programmed and accepts the information in the form of code. The main code, also known as a sketch, created on the IDE platform will ultimately generate a Hex File which is then transferred and uploaded in the controller on the board. The IDE environment mainly contains two basic parts: Editor and Compiler where former is used for writing the required code and later is used for compiling and uploading the code into the given Arduino Module.

This environment supports both C and C++ languages.

5.1.2 How to Download Arduino IDE

You can download the Software from Arduino main website. As I said earlier, the software is available for common operating systems like Linux, Windows, and MAX, so make sure you are downloading the correct software version that is easily compatible with your operating system.

8.1 or Windows 10, as the app version is not compatible with Windows 7 or older version of this operating system.

You can download the latest version of Arduino IDE for Windows (Non admin standalone version), by clicking below button:

Arduino IDE Download

The IDE environment is mainly distributed into three sections.

1.Menu Bar

2.Text Editor

3.Output Pane

As you download and open the IDE software, it will appear like an image below:

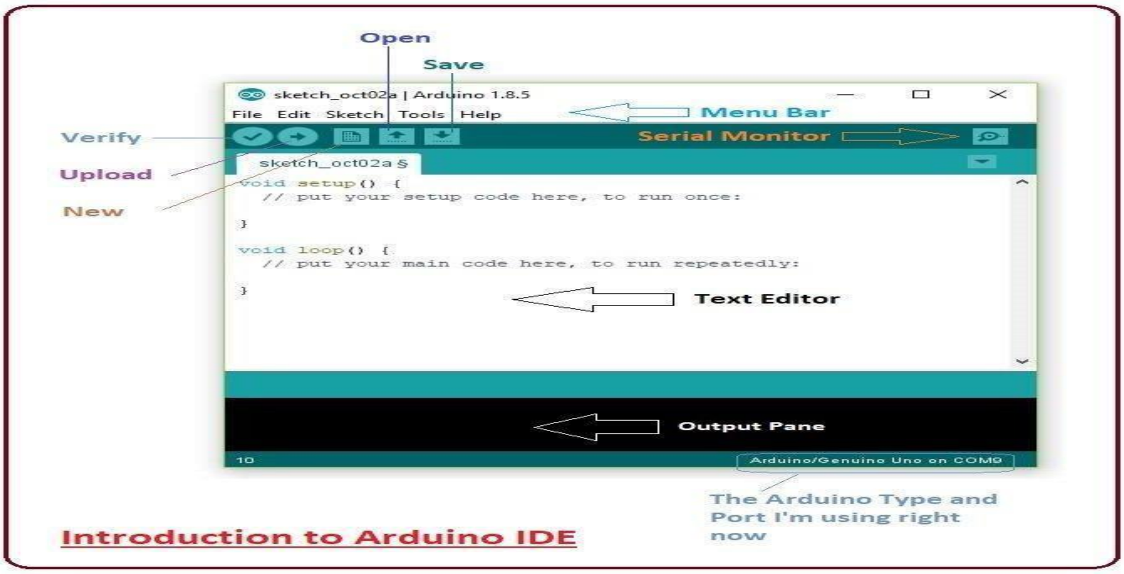


Fig 5.2: Introduction to Arduino IDE

The bar appearing on top is called Menu Bar that comes with five different options as

File-You can open a new window for writing the code or open an existing one. The following table shows number of further subdivisions the file option is categorized into:

File	
New	This is used to open new text editor window to write your code
Open	Used for opening the existing written code
Open Recent	The option reserved for opening recently closed program
Sketchbook	It stores the list of codes you have written for your project
Examples	Default examples already stored in the IDE software
Close	Used for closing the main screen window of recent tab. If two tabs are open, it will ask you again as you aim to close the second tab
Save	It is used for saving the recent program
Save as	It will allow you to save the recent program in your desired folder
Page setup	Page setup is used for modifying the page with portrait and landscape options. Some default page options are already given from which you can select the page you intend to work on
Print	It is used for printing purpose and will send the command to the printer
Preferences	It is page with number of preferences you aim to setup for your text editor page
Quit	It will quit the whole software all at once

Fig 5.3: File subdivisions in Arduino IDE

As you go to the preference section and check the compilation section, the Output Pane will show the code compilation as you click the upload button.

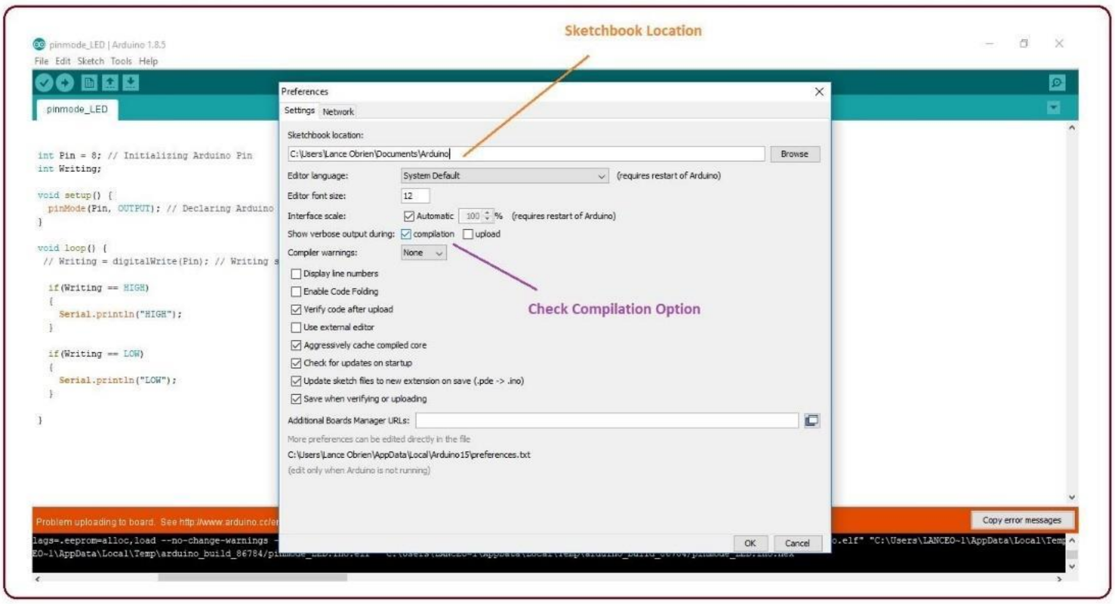


Fig 5.4: Selection of compilation

And at the end of the compilation, it will show you the hex file it has generated for the recent sketch that will send to the Arduino Board for the specific task you aim to achieve.

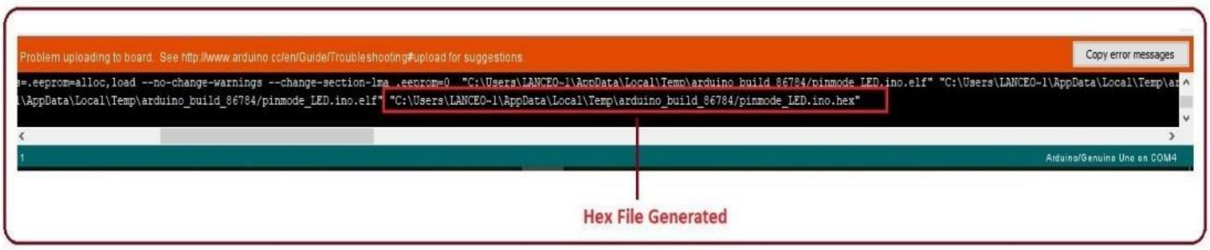


Fig 5.5: Hex file generation

• Sketch - For compiling and programming

• Tools - Mainly used for testing projects. The Programmer section in this panel is used for burning a boot loader to the new microcontroller.

• Help - In case you are feeling Edit - Used for copying and pasting the code with further modification for font

• sceptical about software, complete help is available from getting started to troubleshooting.

• The Six Buttons appearing under the Menu tab are connected with the running program as follows.

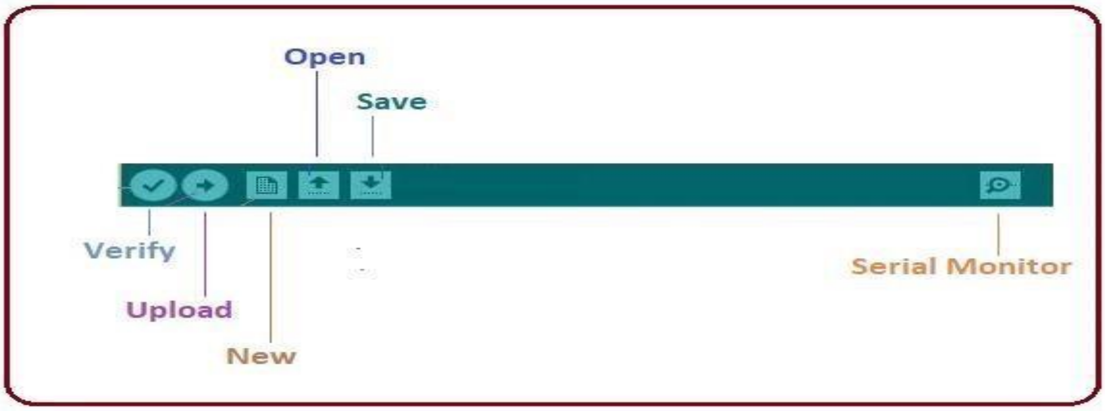


Fig 5.6: Serial monitor

• The check mark appearing in the circular button is used to verify the code. Click this once you have written your code.

• The arrow key will upload and transfer the required code to the Arduino board.

• The dotted paper is used for creating a new file.

• The upward arrow is reserved for opening an existing Arduino project.

• The button appearing on the top right corner is a Serial Monitor - A separate pop-up window that acts as an independent terminal and plays a vital role in sending and receiving the Serial Data. You can also go to the Tools panel and select Serial Monitor, or pressing Ctrl+Shift+M all at once will open it instantly. The Serial Monitor will actually help to debug the written Sketches where you can get a hold of how your program is operating. Your Arduino Module should be connected to your computer by USB cable in order to activate the Serial Monitor.

• You need to select the baud rate of the Arduino Board you are using right now. For my Arduino Uno Baud Rate is 9600, Monitor, the output will show as the image below

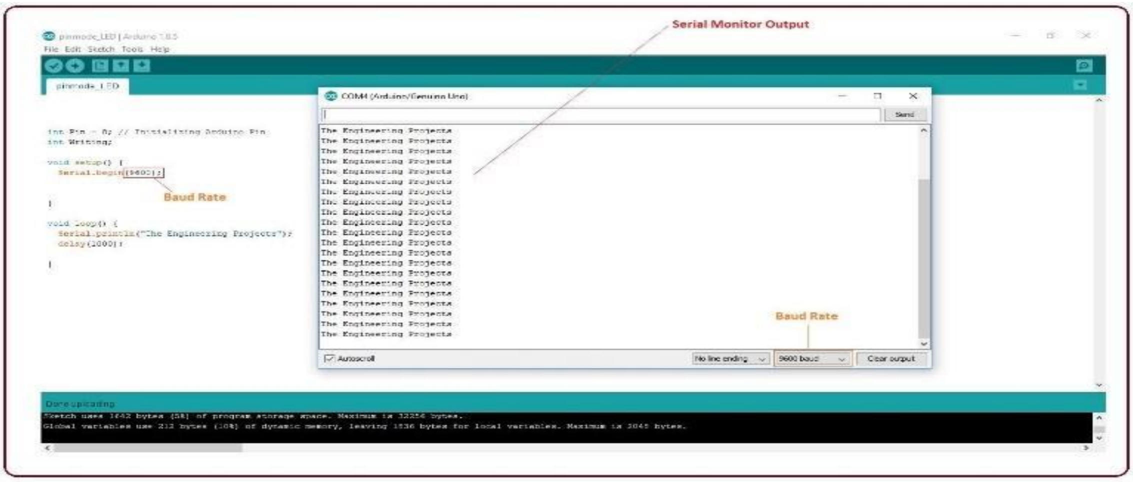


Fig 5.7: output of the serial monitor

The main screen below the Menu bard is known as a simple text editor used for writing the required code.

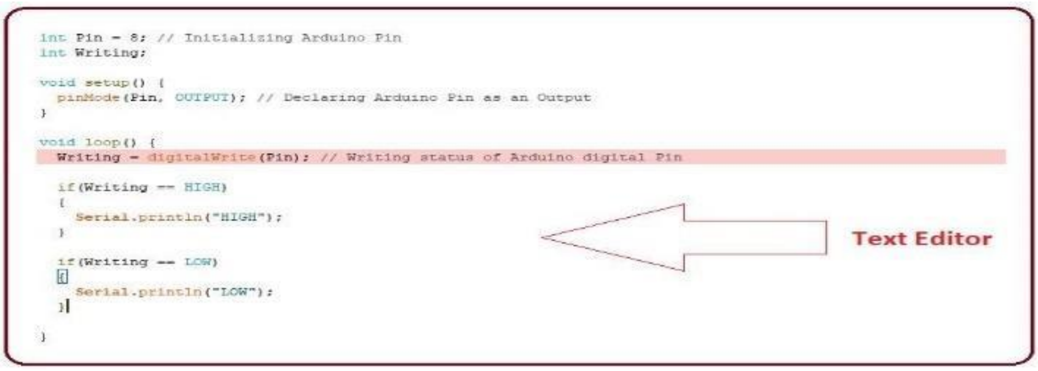


Fig 5.8: Text editor

Output Pane that mainly highlights the compilation status of the running code: the memory used by the code, and errors that occurred in the program. You need to fix the bottom of the main screen is described as those errors before you intend to upload the hex file into your Arduino Module.

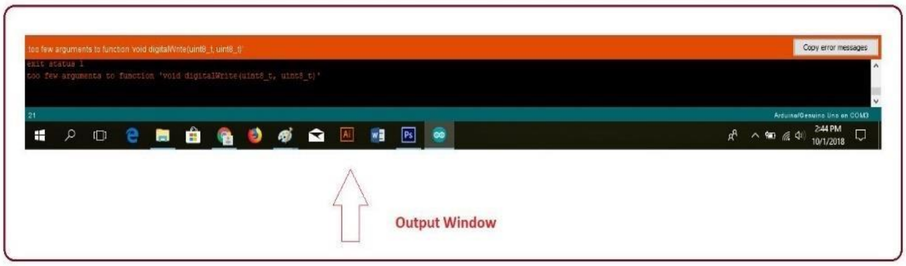


Fig 5.9: output window

More or less, Arduino C language works similar to the regular C language used for any embedded system microcontroller, however, there are some dedicated libraries used for calling and executing specific functions on the board.

5.1.3 Libraries

• Libraries are very useful for adding extra functionality into the Arduino Module.

• There is a list of libraries you can check by clicking the Sketch button in the menu bar and going to Include Library.

• As you click the Include Library and Add the respective library it will be on the top of the sketch with a #include sign. Suppose, I Include the Liquid Crystal library, it will appear on the text editor.

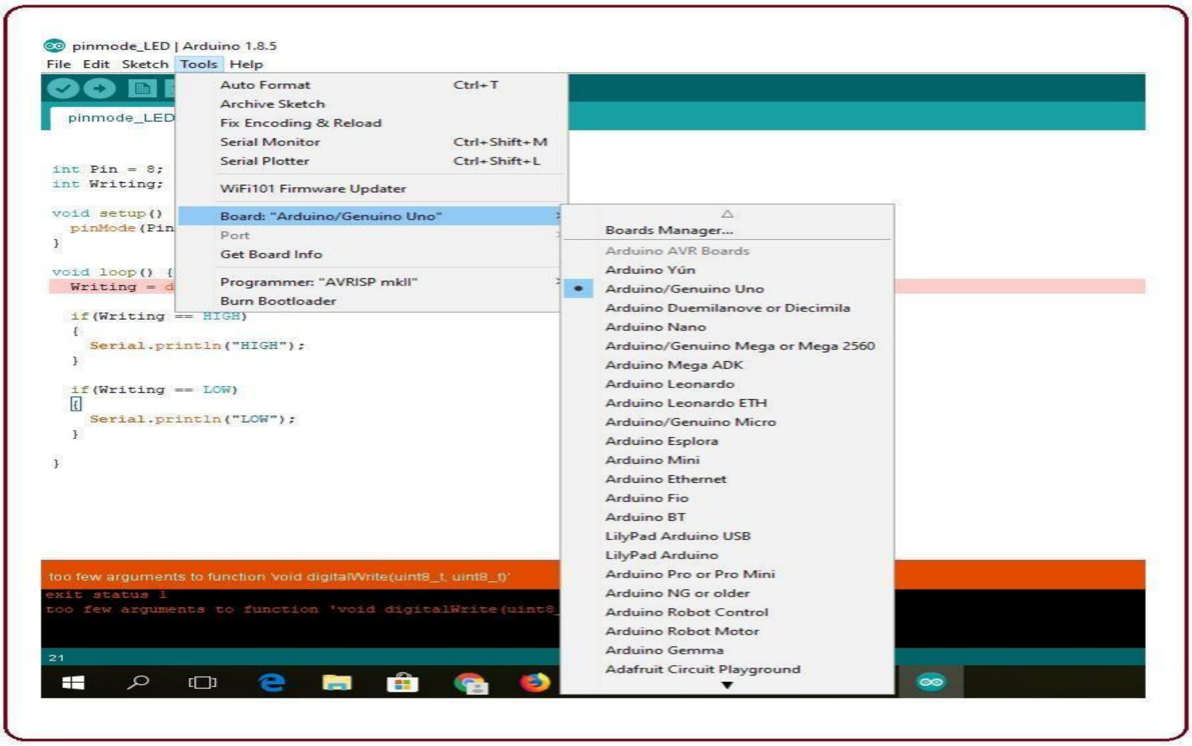


Fig 5.10: Selection of tools

• As you click the Include Library and Add the respective library it will be on the top of the sketch with a #include sign. Suppose, I Include the Liquid Crystal library, it will appear on the text editor as #include <Liquid Crystal.h>

• Most of the libraries are preinstalled and come with the Arduino software.

However, you can also download them from external sources.

5.1.5 How to Select the Board

• In order to upload the sketch, you need to select the relevant board you are using and the ports for that operating system.

• As you click the Tools on the menu, it will open like the figure below:

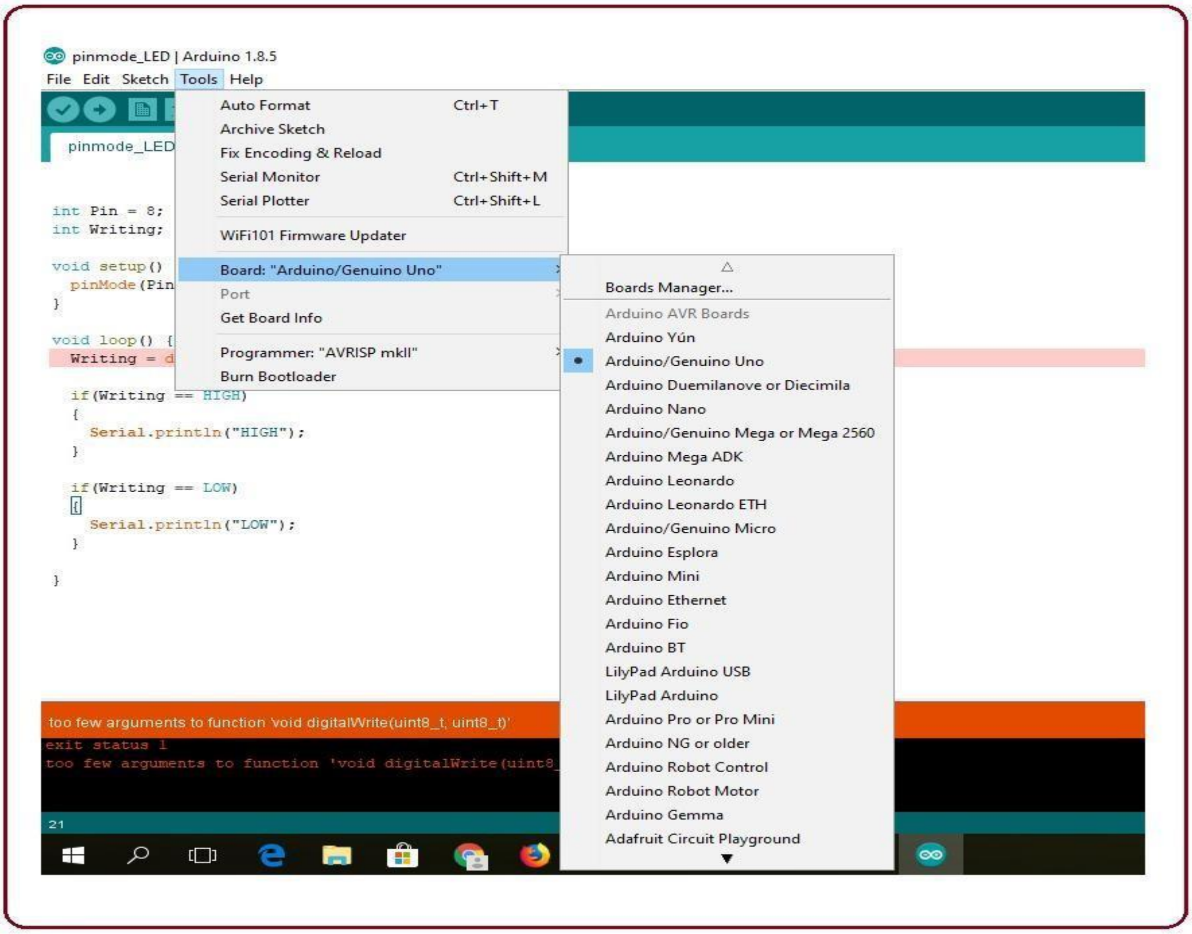


Fig 5.11: Selection of board manager

• Just go to the "Board" section and select the board you aim to work on. Similarly, COM1, COM2, COM4, COM5, COM7 or higher are reserved for the serial and USB board. You can look for the USB serial device in the port section of the Windows Device Manager.

• The following figure shows the COM4 that I have used for my project, indicating the Arduino Uno with the COM4 port at the right bottom corner of the screen.

• After correct selection of both Board and Serial Port, click the verify and then upload button

appearing in the upper left corner of the six-button section or you can go to the Sketch section and press verify/compile and then upload.

• The sketch is written in the text editor and is then saved with the file extension into. It is important to note that the recent Arduino Modules will reset automatically as you compile and press the upload button the IDE software, however, the older versions may require the physical reset on the board.

• Once you upload the code, TX and RX LEDs will blink on the board, indicating the desired program is running successfully.

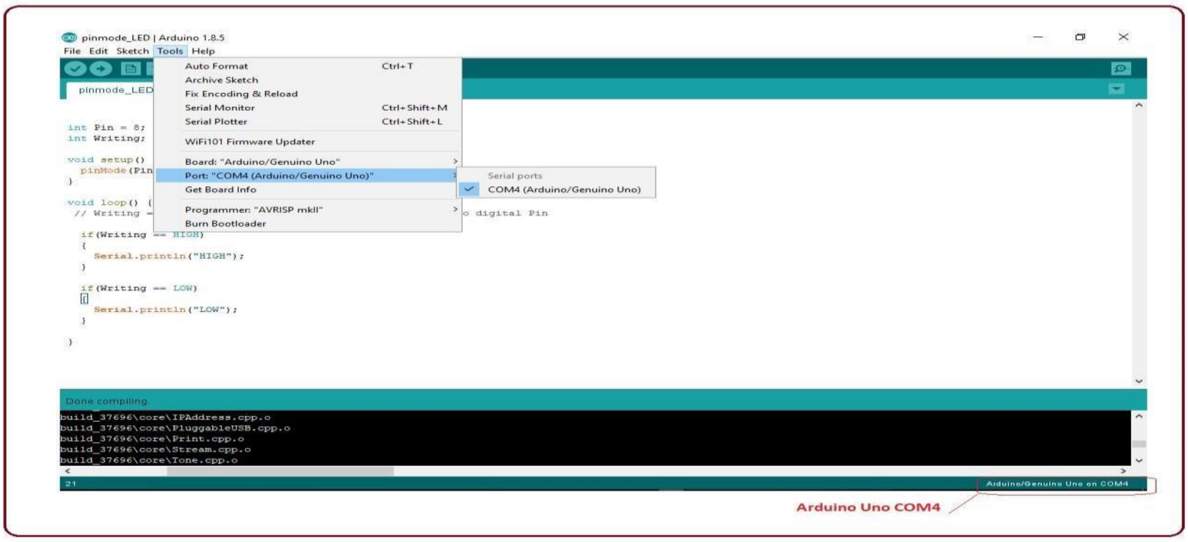


Fig 5.1: Selection of port

Note: The port selection criteria mentioned above are dedicated to Windows operating system only, you can check this Guide if you are using MAC or Linux.

The amazing thing about this software is that no prior arrangement or bulk of the mess is required to install this software, you will be writing your first program within 2 minutes after the installation of the IDE environment.

5.1.6 Uploading

After writing your code, click on the upload button which is above the window and the code will be directly uploaded into the Node MCU with a cable wire connector.

CHAPTER-6

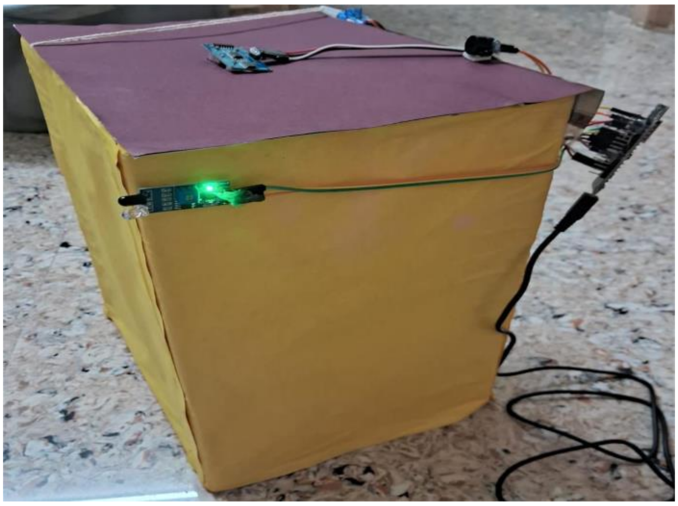
RESULT

The Smart Garbage Monitoring System using IoT proved to be a highly efficient and scalable solution for waste management. The system seamlessly integrated IoT sensors to monitor garbage levels in real time, providing accurate and immediate data transmission to the central monitoring system. This constant flow of data ensured that waste collection could be scheduled based on actual needs, reducing unnecessary collections and optimizing resource allocation.

The IoT network showed strong connectivity, with minimal data loss or transmission delays even in areas with multiple sensor nodes. The sensors themselves were accurate, requiring only minimal calibration, and they effectively measured waste levels over extended periods. Automated alerts were sent to waste management personnel when bins reached predefined thresholds, improving response time and reducing the reliance on manual checks.

This system demonstrated excellent scalability, handling the addition of multiple sensors without performance degradation. Additionally, its energy efficiency contributed to a sustainable and cost-effective solution, proving that IoT-based monitoring can make a significant impact on urban waste management practices.

Fig 6.1: Garbage with Sensors & Buzzer



CONCLUSION

This Smart Garbage Monitoring System using IoT has proven to be an innovative and effective solution for modern waste management. By leveraging real-time data collection, seamless communication between sensors, and automated notifications, the system enhances operational efficiency, reduces costs, and minimizes human intervention. The system's scalability ensures its adaptability to various environments, whether for small communities or large urban areas. Additionally, the insights derived from the collected data enable better decision-making, improving waste collection schedules and resource management. Overall, this IoT-based approach is not only technologically advanced but also contributes to sustainable urban management, making it a valuable tool for future smart cities. The success of this system highlights the potential of IoT in transforming waste management practices, driving more efficient, cost-effective, and environmentally conscious solutions.

FUTURE SCOPE

The Smart Garbage Monitoring System holds significant potential for further development and expansion. In the future, the system could be enhanced by integrating advanced machine learning algorithms to predict waste generation trends based on historical data, weather patterns, and special events. This predictive capability could lead to even more optimized waste collection schedules and reduce operational costs. Additionally, integrating the system with smart city infrastructure, such as traffic management systems, could enable real-time coordination between waste collection vehicles and traffic flow, improving route planning and further minimizing delays.

Furthermore, the system's scope can be expanded to include more sophisticated sensors that can not only detect garbage levels but also assess the type of waste, allowing for better sorting and recycling. The addition of automated waste sorting systems at collection points could increase the recycling rate and reduce landfill waste.

There is also the potential to extend the system's use to monitor waste levels in other areas, such as street bins, parks, or public spaces, creating a comprehensive waste management network. As IoT technology continues to advance, the integration of energy-efficient devices, solar-powered sensors, and wireless charging for IoT nodes will help reduce the environmental footprint of the system.

Lastly, global implementation of this system could enable data sharing across cities, promoting collaboration and bench-marking between municipalities to develop best practices for waste management on a global scale.

SOURCE CODE

```
#include <Servo.h>
Servo myservo;
const int ir=8;
const int servo=6;
const int trigpin=2;
const int echopin=3;
const int buzzer=11;
void setup() {
  // put your setup code here, to run once:
pinMode(8,INPUT);
pinMode(trigpin, OUTPUT);
pinMode(echopin, INPUT);
myservo.attach(servo);
Serial.begin(9600);
}

void loop() {
  // put your main code here, to run repeatedly:
digitalWrite(trigpin, LOW);
delayMicroseconds(2);
digitalWrite(trigpin, HIGH);
delayMicroseconds(10);
digitalWrite(trigpin, LOW);
int duration=pulseIn(echopin,HIGH);
int distance=duration*0.034/2;
int a=digitalRead(8);
Serial.print("distance");
Serial.println(distance);
if(distance<=10)
{
  digitalWrite(buzzer, HIGH);
}
else{
  digitalWrite(buzzer, LOW);
}
if(a==1)
```

```
{
  myservo.write(0);
  delay(5000);
}
else{
  myservo.write(180);
  delay(1000);
}
}
```

REFERENCES

[1] Liu, X., & Zhang, Y. (2020). IoT-based smart waste management system: A review. *International Journal of Environmental Science and Technology, 17*(4), 2119-2134.

[2] Sharma, A., & Agarwal, R. (2019). Design and implementation of a smart waste management system using IoT. *Journal of Green Engineering, 9*(5), 409-424.

[3] Bedi, P., & Singh, S. (2021). Real-time waste management using IoT: A study of smart garbage collection systems. *Sustainable Cities and Society*, *64*, 102537.

[4] IoT Alliance. (2023). IoT-based waste management systems: Trends and future developments.

[5] Singh, S., & Ghosh, A. (2020). Smart cities and IoT-based waste management systems: Case studies and future directions. *Computers, Environment and Urban Systems, 80*, 101417.

[6] Ahmed, H., & Ali, M. (2022). Enhancing waste collection efficiency with IoT-based systems: Opportunities and challenges. *Environmental Monitoring and Assessment, 194*(10),

CERTIFICATION

INTERNSHIP COMPLETION CERTIFICATE

PROUDLY PRESENTED TO:

K V N D S S VASUKI GOURAV

Student of Vignan's Nirula Institute of Technology and Science for Women,

Reg No: 22NN1A0586 has successfully completed an Internship on IOT Internship (13-05-2024 to 06-07-2024) program at Vijayawada. During her internship program with us, She was found punctual, hardworking and inquisitive.

This certificate was awarded by:

Md. Mobina

MOBINA MD

Managing Director

06-07-2024

Issue Date

INTERNSHIP COMPLETION CERTIFICATE

PROUDLY PRESENTED TO:

Basam Bhargavi

Student of Vignan's Nirula Institute of Technology and Science for Women, Reg No: 22NN1A0566 has successfully completed an Internship on IOT Internship (13-05-2024 to 06-07-2024) program at Vijayawada. During her internship program with us, She was found punctual, hardworking and inquisitive.

This certificate was awarded by:

Md. Mobina

MOBINA MD

Managing Director

PURPLE TECHNOLOGIES PTS

06-07-2024

Issue Date

INTERNSHIP COMPLETION CERTIFICATE

PROUDLY PRESENTED TO:

PULAGAM DEDEEPYA

Student of Vignan's Nirula Institute of Technology and Science for Women, Reg No: 22NN1A05A6 has successfully completed an Internship on IOT Internship (13-05-2024 to 06-07-2024) program at Vijayawada. During her internship program with us, She was found punctual, hardworking and inquisitive.

This certificate was awarded by:

Md. Mobina

MOBINA MD

Managing Director

06-07-2024

Issue Date

INTERNSHIP COMPLETION CERTIFICATE

PROUDLY PRESENTED TO:

Tejasri Soupati

Student of Vignan's Nirula Institute of Technology and Science for Women, Reg No: 22NN1A05B3 has successfully completed an Internship on IOT Internship (13-05-2024 to 06-07-2024) program at Vijayawada. During her internship program with us, She was found punctual, hardworking and inquisitive.

This certificate was awarded by:

Md. Mobina

MOBINA MD

Managing Director

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