CHAPTER 1

INTRODUCTION

Introducing the Intelligent Vehicle Speed Adjustment System: a groundbreaking advancement in road safety and driving technology that is poised to redefine the way we navigate our roads. This state-of-the-art system seamlessly integrates ultrasonic sensors and cutting-edge IoT (Internet of Things) technology to create a comprehensive network of real-time data collection and analysis.

At its core, the Intelligent Vehicle Speed Adjustment System is designed to detect the presence and movement of nearby vehicles with unparalleled precision. By utilizing ultrasonic sensors strategically placed on vehicles, this system continuously monitors the surrounding environment, providing drivers with critical insights into potential hazards and traffic conditions.

Through seamless data transmission to a cloud-based platform, the system enables the analysis of vehicle speeds and identifies potential risks ahead. This real-time information is then relayed to a user-friendly mobile application, empowering drivers with instant updates and customizable alerts tailored to their specific driving preferences and safety needs.

But the Intelligent Vehicle Speed Adjustment System goes beyond mere notification. It offers automated speed adjustments based on the analyzed data, allowing vehicles to adapt their speed accordingly to mitigate potential risks and enhance overall road safety.

Furthermore, the system's data collection capabilities extend beyond individual vehicles, providing valuable insights for traffic management and infrastructure planning. By aggregating and analyzing data from multiple vehicles in real-time, transportation authorities can make informed decisions to optimize traffic flow, improve road safety measures, and enhance the overall driving experience.

The benefits of the Intelligent Vehicle Speed Adjustment System are manifold. It not only reduces the risk of accidents by providing drivers with timely information and automated speed adjustments but also contributes to a more efficient and sustainable transportation ecosystem.

Imagine a world where every driver is equipped with the knowledge and tools to navigate the roads safely and responsibly. With the Intelligent Vehicle Speed Adjustment System, that vision becomes a reality. Welcome to a safer, smarter, and more connected future of driving.

1.1 Problem Statement:

In today's fast-paced world, road safety remains a significant concern globally. Despite advances in vehicle technology and road infrastructure, the number of accidents and fatalities on our roads continues to be alarmingly high. One of the key contributing factors to these accidents is speeding, which not only increases the likelihood of collisions but also exacerbates their severity.

Traditional speed control measures, such as speed limits and traffic signs, have proven to be insufficient in curbing speeding behavior effectively. Drivers often disregard these regulations due to various reasons, including distractions, lack of awareness, or simply a disregard for safety. As a result, there is an urgent need for innovative solutions that can address this issue and promote safer driving habits among motorists.

Moreover, the rapid expansion of urban areas and the increasing number of vehicles on the roads have made traffic management and infrastructure planning more challenging than ever before. Without accurate data on vehicle speeds, traffic patterns, and potential hazards, authorities struggle to implement effective measures to improve road safety and optimize traffic flow.

Furthermore, the existing methods for monitoring and controlling vehicle speeds often rely on manual intervention, making them prone to human error and inefficiency. There is a pressing need for automated systems that can leverage advanced technologies to detect, analyze, and respond to speed-related issues in real-time.

In light of these challenges, there is a clear demand for a comprehensive solution that can integrate cutting-edge technologies to address the root causes of speeding and improve road safety. Such a solution should not only provide drivers with real-time information and alerts but also offer automated mechanisms for speed adjustment based on analyzed data. Additionally, it should facilitate data collection for traffic management and infrastructure planning purposes, enabling authorities to make informed decisions to enhance overall road safety and driving experiences.

The Intelligent Vehicle Speed Adjustment System aims to fill this crucial gap by harnessing the power of ultrasonic sensors and IoT technology to create a dynamic network for monitoring and controlling vehicle speeds. By leveraging real-time data transmission, cloud-based analytics, and mobile applications, this system promises to revolutionize the way we approach road safety and traffic management. Through its innovative features and capabilities, the Intelligent Vehicle Speed Adjustment System seeks to pave the way for a safer, smarter, and more efficient transportation ecosystem for all road users.

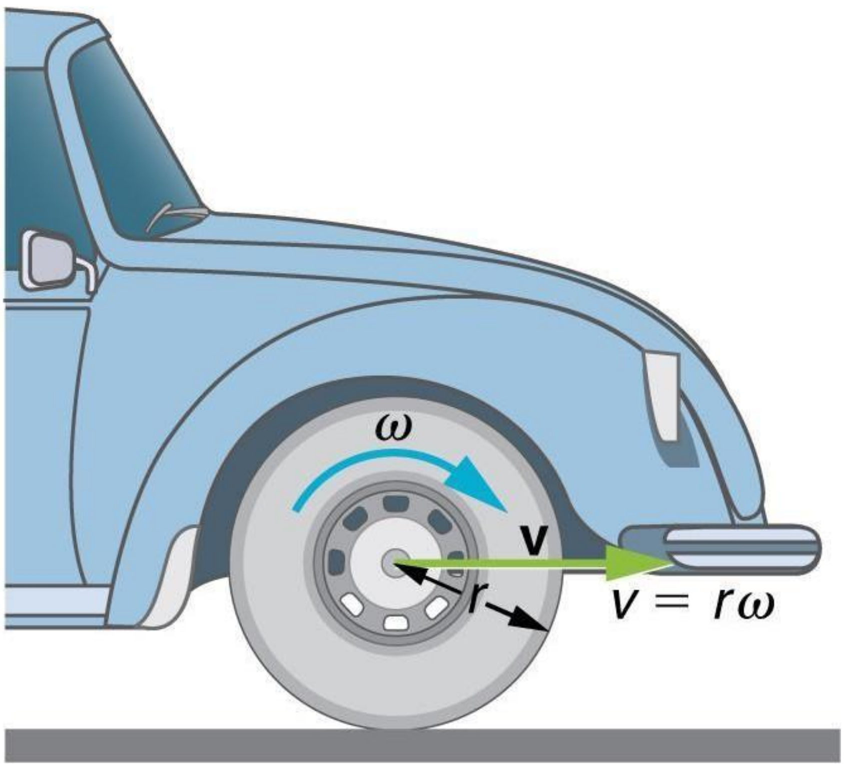

Fig 1.1: Speed adjusting of vechicle

1.2 Problem Scope:

The scope of the problem addressed by the Intelligent Vehicle Speed Adjustment System encompasses several key areas related to road safety, traffic management, and infrastructure planning. Specifically, the system aims to tackle the following challenges:

1. Speeding Behavior: The system addresses the issue of speeding among motorists, which is a leading cause of accidents and fatalities on the roads. By providing real-time detection of vehicle speeds and offering automated speed adjustments, the system seeks to mitigate the risks associated with speeding and promote safer driving habits.

2. Road Safety: Enhancing road safety is a primary objective of the system. By analyzing data on vehicle speeds and potential hazards ahead, the system aims to provide drivers with timely alerts and interventions to prevent accidents and minimize their severity.

3. Traffic Management: The system contributes to improving traffic management by collecting and analyzing data on traffic patterns, congestion levels, and vehicle speeds. This information enables authorities to implement effective measures to optimize traffic flow, reduce congestion, and enhance overall transportation efficiency.

4. Infrastructure Planning: The system supports infrastructure planning by providing valuable insights into traffic behavior and road conditions. By aggregating data on vehicle speeds, traffic volume, and road hazards, authorities can make informed decisions about road design, maintenance, and expansion to meet the evolving needs of a growing population and urban landscape.

5. Automation and Efficiency: The system aims to automate speed control mechanisms to reduce reliance on manual intervention and improve overall system efficiency. By leveraging advanced technologies such as IoT and cloud-based analytics, the system streamlines the process of monitoring and controlling vehicle speeds, enabling faster response times and more effective interventions.

Overall, the scope of the problem addressed by the Intelligent Vehicle Speed Adjustment System is comprehensive, encompassing various aspects of road safety, traffic management, and infrastructure planning. By integrating advanced technologies and innovative features, the system seeks to provide a holistic solution to improve road safety and enhance the driving experience for all roads.

1.3 Advantages of this System:

Advantages of the Intelligent Vehicle Speed Adjustment System:

1. Enhanced Road Safety: By providing real-time detection of nearby vehicles' movements and potential hazards, the system helps prevent accidents and reduce the severity of collisions, ultimately improving road safety for drivers, passengers, and pedestrians.

2. Reduction of Accidents: With automated speed adjustments based on analyzed data, the system effectively mitigates the risks associated with speeding, leading to a decrease in the number of accidents and fatalities on the roads.

3. Customizable Alerts: The system offers customizable alerts to drivers, allowing them to receive real-time updates about potential hazards and adjust their driving behavior accordingly, thereby promoting safer driving habits.

4. Improved Traffic Flow: By collecting and analyzing data on vehicle speeds and traffic patterns, the system enables authorities to implement measures to optimize traffic flow, reduce congestion, and minimize delays, leading to smoother and more efficient transportation.

5. Infrastructure Planning: The data collected by the system supports infrastructure planning efforts by providing insights into traffic behavior and road conditions, enabling authorities to make informed decisions about road design, maintenance, and expansion to meet the evolving needs of a growing population.

6. Reduced Environmental Impact: By promoting smoother traffic flow and reducing the incidence of accidents and congestion, the system contributes to a reduction in fuel consumption, emissions, and overall environmental impact associated with transportation.

7. Driver Assistance: The system serves as a valuable driver assistance tool by providing real-time updates and automated speed adjustments, helping drivers navigate safely through various road conditions and situations.

8. Cost Savings: By reducing the number of accidents, congestion-related delays, and environmental impact, the system leads to cost savings for individuals, businesses, and governments in terms of reduced healthcare costs, productivity losses, and infrastructure maintenance expenses.

9. Scalability and Adaptability: The system's modular design and scalability allow for easy integration with existing infrastructure and future expansion to accommodate evolving transportation needs and technological advancements.

10. Overall Driving Experience: By promoting safer, smoother, and more efficient driving experiences, the system enhances overall satisfaction and quality of life for road users, contributing to a positive and sustainable transportation ecosystem

1.4 Proposed Solution:

The scope of the problem addressed by the Intelligent Vehicle Speed Adjustment System encompasses various challenges related to road safety, traffic management, and infrastructure planning. At its core, the system aims to tackle the prevalent issue of speeding behavior among motorists, a leading cause of accidents and fatalities on roads worldwide. Traditional speed control measures have proven insufficient in curbing this behavior effectively, necessitating innovative solutions. Moreover, the rapid urbanization and increasing vehicle populations have made traffic management and infrastructure planning more complex. Without accurate data on vehicle speeds, traffic patterns, and potential hazards, authorities struggle to implement effective measures to improve road safety and optimize traffic flow. Additionally, existing methods for monitoring and controlling vehicle speeds often rely on manual intervention, making them prone to human error and inefficiency. Thus, there is a clear need for an automated system that can leverage advanced technologies to detect, analyze, and respond to speed-related issues in real-time. In summary, the scope of the problem addressed by the Intelligent Vehicle Speed Adjustment System is extensive, encompassing multiple facets of road safety, traffic management, and infrastructure planning to create a safer and more efficient transportation ecosystem.

1.5 Aim and Objectives:

Aim:

The aim of the Intelligent Vehicle Speed Adjustment System is to enhance road safety, improve traffic management, and support infrastructure planning by providing real-time monitoring and control of vehicle speeds. This system aims to address challenges such as speeding behavior, inadequate traditional speed control measures, and manual intervention inefficiencies by leveraging advanced technologies to detect, analyze, and respond to speed-related issues in real-time. Ultimately, the goal is to create a safer and more efficient transportation ecosystem for all road users.

Objectives:

The objectives of the Intelligent Vehicle Speed Adjustment System are to:

1. Improve Road Safety: By detecting and mitigating speeding behavior in real-time, the system aims to reduce the risk of accidents and enhance overall road safety.

2. Enhance Traffic Management: The system seeks to optimize traffic flow, minimize congestion, and reduce delays by providing authorities with real-time data on vehicle speeds and traffic patterns.

3. Support Infrastructure Planning: By collecting and analyzing data on traffic behavior and road conditions, the system assists in informed decision-making for road design, maintenance, and expansion.

4. Provide Customizable Alerts: Drivers receive real-time updates and customizable alerts through a mobile application, empowering them to adjust their driving behavior based on current road conditions and recommendations.

5. Automate Speed Adjustment: The system offers automated speed adjustments based on analyzed data to maintain safe distances, prevent collisions, and optimize traffic flow, reducing the need for manual intervention.

Overall, these objectives aim to create a safer, more efficient, and sustainable transportation ecosystem for all road users.

CHAPTER 2

LITERATURE STUDY

The Intelligent Vehicle Speed Adjustment System builds upon a rich body of literature in the fields of road safety, transportation engineering, and intelligent transportation systems. This literature review provides an overview of key studies and research findings that have influenced the development of the proposed system.

1. Road Safety Studies:

- Numerous studies have highlighted the significant impact of speeding on road safety. Research by the World Health Organization (WHO) estimates that speeding contributes to around 30% of road traffic fatalities globally each year.

- Studies have also shown that even small reductions in vehicle speeds can lead to a substantial decrease in the likelihood and severity of accidents. For example, a study by the

National Highway Traffic Safety Administration (NHTSA) found that a 5% reduction in average speeds can result in a 30% decrease in fatal crashes.

- Additionally, research has demonstrated the effectiveness of automated speed control systems, such as adaptive cruise control and speed limiters, in reducing speeding-related accidents and improving overall road safety.

2. Transportation Engineering Research:

- Transportation engineers have long studied traffic flow theory and the factors influencing traffic congestion and delays. Fundamental concepts such as traffic density, flow, and speed-density relationships have informed the design of traffic management strategies and infrastructure improvements.

- Studies have explored the benefits of real-time traffic monitoring and control systems in optimizing traffic flow and reducing congestion. Research by scholars such as Michael Zhang and Benjamin Coifman has demonstrated the effectiveness of dynamic traffic control strategies in minimizing travel times and improving overall roadway efficiency.

3. Intelligent Transportation Systems (ITS) Literature:

- The field of ITS encompasses a wide range of technologies and systems aimed at improving transportation safety, efficiency, and sustainability. Key areas of focus include real-time traffic monitoring, vehicle-to-vehicle communication, and automated driving systems.

- Research in ITS has explored the use of advanced sensors, communication networks, and data analytics techniques to enable intelligent decision-making in transportation systems. Studies have demonstrated the potential of IoT technologies, such as vehicle-mounted sensors and cloud-based analytics platforms, in enhancing road safety and traffic management capabilities.

4. Case Studies and Implementation Examples:

- Case studies and real-world implementation examples of similar systems provide valuable insights into the practical challenges and opportunities associated with intelligent speed adjustment systems. Examples include the implementation of adaptive cruise control systems in commercial fleets, the deployment of speed limit enforcement technologies in urban areas, and pilot projects testing vehicle-to-vehicle communication systems.

- Case studies from cities and regions that have successfully implemented intelligent transportation systems can provide valuable lessons learned and best practices for the design and implementation of the proposed Intelligent Vehicle Speed Adjustment System.

In summary, the literature review highlights the importance of addressing speeding behavior for road safety, the role of transportation engineering principles in traffic management, the potential of intelligent transportation systems in enhancing road safety and efficiency, and the value of case studies and implementation examples in informing the design and implementation of the proposed system. By drawing upon insights from existing research and best practices, the Intelligent Vehicle Speed Adjustment System aims to make a meaningful contribution to improving road safety and transportation efficiency.

CHAPTER 3
METHODOLOGY

The development and implementation of the Intelligent Vehicle Speed Adjustment System will follow a comprehensive methodology, integrating various stages including research, design, prototyping, testing, and deployment. This methodology draws upon established practices in systems engineering, transportation engineering, and software development to ensure the effectiveness and reliability of the system.

1. Research and Requirements Analysis:

- The first stage of the methodology involves conducting a thorough literature review to gather insights from existing studies, research findings, and best practices related to road safety, traffic management, and intelligent transportation systems.

- Stakeholder engagement sessions will be conducted to gather requirements and feedback from key stakeholders, including transportation authorities, road safety organizations, vehicle manufacturers, and end-users.

2. Conceptual Design:

- Based on the research findings and stakeholder requirements, a conceptual design of the Intelligent Vehicle Speed Adjustment System will be developed. This design will outline the system architecture, components, functionalities, and integration requirements.

- Iterative design reviews and feedback sessions will be conducted to refine the conceptual design and ensure alignment with stakeholder needs and project objectives.

3. Prototyping and Development:

- The next stage involves prototyping and development of the system components, including hardware devices, software applications, and communication protocols.

- Prototypes will be developed and tested in controlled environments to validate system functionality, performance, and reliability. This iterative process allows for early identification and resolution of potential issues.

4. Testing and Validation:

- Once the prototypes are developed, comprehensive testing and validation activities will be conducted to ensure that the system meets predefined requirements and performance metrics.

- Testing will encompass various scenarios, including simulated driving conditions, real-world field tests, and interoperability testing with existing infrastructure and vehicle systems.

5. Deployment and Field Trials:

- Following successful testing and validation, the Intelligent Vehicle Speed Adjustment System will be deployed in real-world environments for field trials and pilot implementations.

- Field trials will involve collaboration with transportation authorities, vehicle manufacturers, fleet operators, and other stakeholders to assess the system's performance, usability, and impact on road safety and traffic management.

6. Evaluation and Continuous Improvement:

- Throughout the deployment and field trial phases, ongoing evaluation and monitoring will be conducted to assess the system's effectiveness, identify areas for improvement, and gather feedback from end-users and stakeholders.

- Continuous improvement cycles will be implemented to address any identified issues, refine system functionalities, and incorporate new features or enhancements based on user feedback and evolving requirements.

7. Documentation and Knowledge Transfer:

- Finally, comprehensive documentation will be prepared to capture the system architecture, design specifications, testing results, and operational procedures.

- Knowledge transfer sessions will be conducted to train stakeholders, end-users, and maintenance personnel on system operation, maintenance, and troubleshooting procedures.

By following this methodology, the development and implementation of the Intelligent Vehicle Speed Adjustment System will be guided by a structured approach, ensuring that the system meets stakeholder needs, complies with industry standards, and delivers tangible benefits in terms of road safety, traffic management, and infrastructure planning.

3.1 NodeMCU (ESP8266)

The NodeMCU ESP8266 is a powerful and versatile platform designed for Internet of Things (IoT) development. The ESP8266 is a cost-effective Wi-Fi microchip known for its capability to enable wireless communication in IoT applications. NodeMCU, on the other hand, is an open-source firmware and development kit that simplifies the process of prototyping and programming the ESP8266. With built-in Wi-Fi connectivity, the NodeMCU ESP8266 allows devices to connect to the internet wirelessly, making it suitable for a wide range of IoT projects. One notable feature is its support for the Lua scripting language, providing a high-level programming environment for developers. Additionally, it is compatible with the Arduino IDE, allowing those familiar with Arduino to use the NodeMCU platform. Equipped with General Purpose Input/Output (GPIO) pins, the ESP8266 facilitates interfacing with various electronic components, making it ideal for applications such as home automation and sensor networks. The NodeMCU ESP8266 has garnered significant community support, resulting in an extensive collection of libraries and documentation, making it a popular choice for rapid IoT prototyping and development.

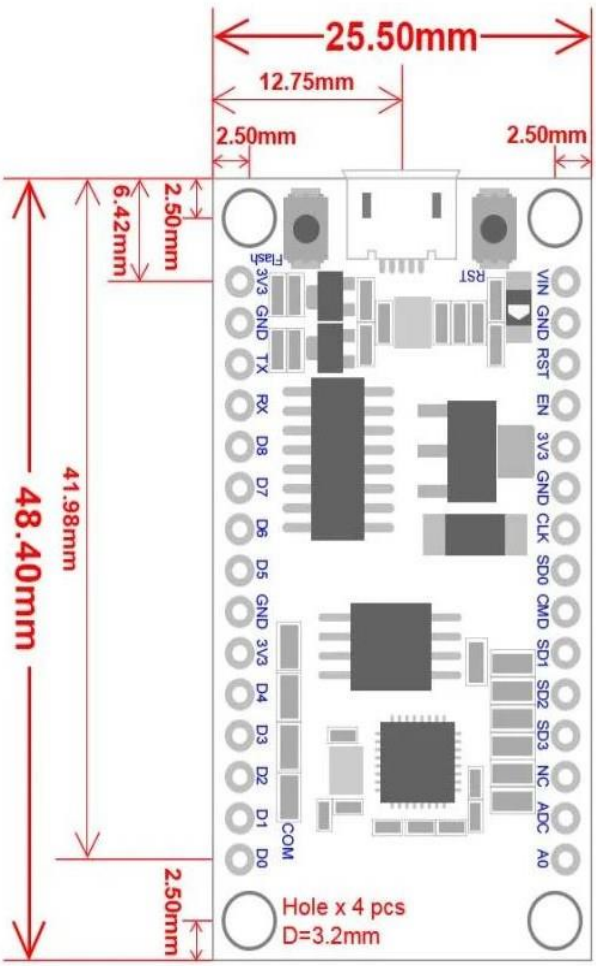

Figure 3.2 NodeMCU 2D View

NodeMCU Specification:

The NodeMCU development board is based on the ESP8266 microcontroller, and different versions of NodeMCU boards may have slight variations in specifications. As of my knowledge cutoff in January 2022, here are the general specifications for the NodeMCU ESP8266 development board:

1. Microcontroller: ESP8266 Wi-Fi microcontroller with 32-bit architecture.

2. Processor: Tensilica L106 32-bit microcontroller.

3. Clock Frequency: Typically operates at 80 MHz.

4. Flash Memory:

- Built-in Flash memory for program storage.
- Common configurations include 4MB or 16MB of Flash memory.

5. RAM: Typically equipped with 80 KB of RAM.

6. Wireless Connectivity:

- Integrated Wi-Fi (802.11 b/g/n) for wireless communication.
- Supports Station, SoftAP, and SoftAP + Station modes.

7. GPIO Pins: Multiple General Purpose Input/Output (GPIO) pins for interfacing with sensors, actuators, and other electronic components.

8. Analog Pins: Analog-to-digital converter (ADC) pins for reading analog sensor values.

9. USB-to-Serial Converter: Built-in USB-to-Serial converter for programming and debugging.

10. Operating Voltage: Typically operates at 3.3V (Note: It is crucial to connect external components accordingly to avoid damage).

11. Programming Interface: Programmable using the Arduino IDE, Lua scripting language, or other compatible frameworks.

12. Voltage Regulator: Onboard voltage regulator for stable operation.

13. Reset Button: Reset button for restarting the board.

14. Dimensions: Standard NodeMCU boards often have dimensions around 49mm x 24mm.

15. Power Consumption: Low power consumption, making it suitable for battery-operated applications.

16. Community Support: Active community support with extensive documentation and libraries.

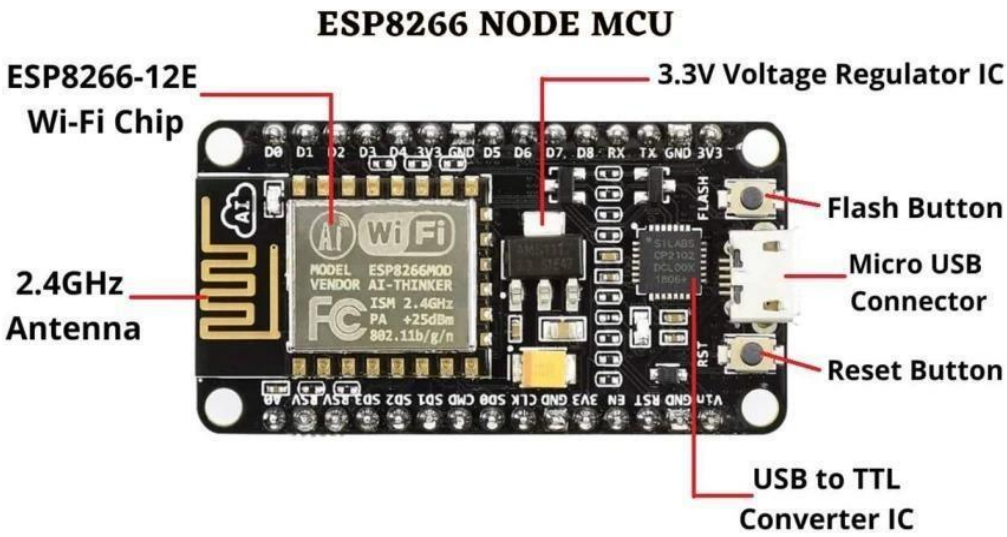

Figure 3.3: NodeMCU Parts

The NodeMCU ESP8266 development board typically has GPIO (General Purpose Input/Output) pins that can be used for various purposes, including interfacing with sensors, actuators, and other electronic components. Below is a common pinout configuration for the NodeMCU development board.

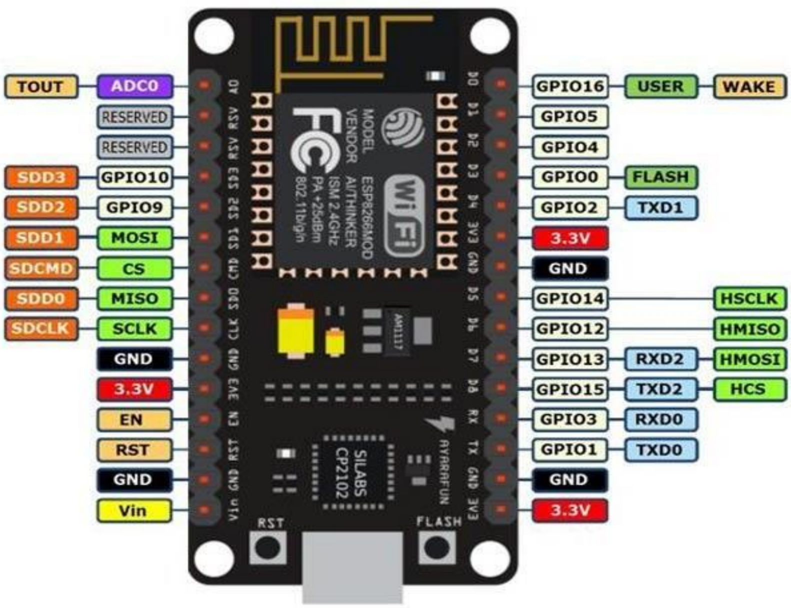

Figure 3.4: NodeMCU ESP8266 Pinout

ADC	A0	GPIO16
EN	Enable	GPIO14
D0	GPIO16	GPIO12
D1	GPIO5	GPIO13
D2	GPIO4	GPIO15
D3	GPIO0	GPIO2
D4	GPIO2	GPIO9
D5	GPIO14	GPIO10
D6	GPIO12	GPIO3
D7	GPIO13	GPIO1
D8	GPIO15	TX (GPIO1)
D9	GPIO3 (RX)	RX (GPIO3)
D10	GPIO1 (TX)	D11 (MOSI)
D11	MOSI	D12 (MISO)
D12	MISO	D13 (SCK

ADC: Analog-to-Digital Converter pin for reading analog sensor values.

EN (Enable): Enable pin.

D0-D8: Digital GPIO pins.

D9 (RX) and D10 (TX): Serial communication pins for programming and debugging.

D11 (MOSI), D12 (MISO), D13 (SCK): Pins used for SPI communication.

D14 (SDA) and D15 (SCL): Pins used for I2C communication.

It's important to note that GPIO pins labeled as "D" (Digital) are typically used for general-purpose digital input/output. Additionally, GPIO pins labeled as "A" (Analog) can be used as analog inputs with the ADC. GPIO pins 6, 7, 8, 9, 10, and 11 have additional functions, so it's advised to refer to the specific NodeMCU documentation for detailed information on pin functionality and capabilities.

3.2 Ultra Sonic Sensor:

An ultrasonic sensor, also known as a distance sensor, utilizes ultrasonic waves to measure the distance between the sensor and an object. It consists of a transmitter that emits ultrasonic waves and a receiver that detects the reflected waves. By measuring the time it takes for the waves to travel to the object and back, the sensor calculates the distance based on the speed of sound. Ultrasonic sensors are commonly used in various applications such as obstacle detection, proximity sensing, and level measurement due to their accuracy, reliability, and versatility.

Operation:

An ultrasonic sensor, often referred to as a distance sensor, is a device that utilizes ultrasonic waves to measure the distance between the sensor and an object. It operates on the principle of echolocation, similar to how bats navigate in the dark. The sensor consists of two main components: a transmitter and a receiver. The transmitter emits ultrasonic waves, typically at a frequency above the audible range of human hearing (around 40 kHz or higher), while the receiver detects the waves after they bounce off an object.

When the ultrasonic waves encounter an object in their path, they are reflected back towards the sensor. The sensor measures the time it takes for the waves to travel from the transmitter to the object and back to the receiver. Using the speed of sound in air as a constant (approximately 343 meters per second at room temperature), the sensor calculates the distance to the object based on the time it took for the waves to return.

Ultrasonic sensors come in various form factors, including single transducer modules and dual transducer modules. Single transducer modules combine the transmitter and receiver in a single unit, while dual transducer modules have separate transmitters and receivers. Additionally, ultrasonic sensors may offer features such as adjustable detection range, sensitivity, and output modes (analog or digital).

These sensors are widely used in a variety of applications due to their accuracy, reliability, and versatility. Common applications include:

- Obstacle Detection: Ultrasonic sensors are used in robotics and autonomous vehicles to detect obstacles in their path and navigate around them safely.

- Proximity Sensing: They are used in industrial and commercial applications to detect the presence of objects or individuals in proximity to machinery or equipment.

- Level Measurement: Ultrasonic sensors are used to measure the level of liquids or solids in tanks and containers by detecting the distance to the surface of the material.

Overall, ultrasonic sensors play a crucial role in modern technology, enabling precise distance measurement in a wide range of applications across industries.

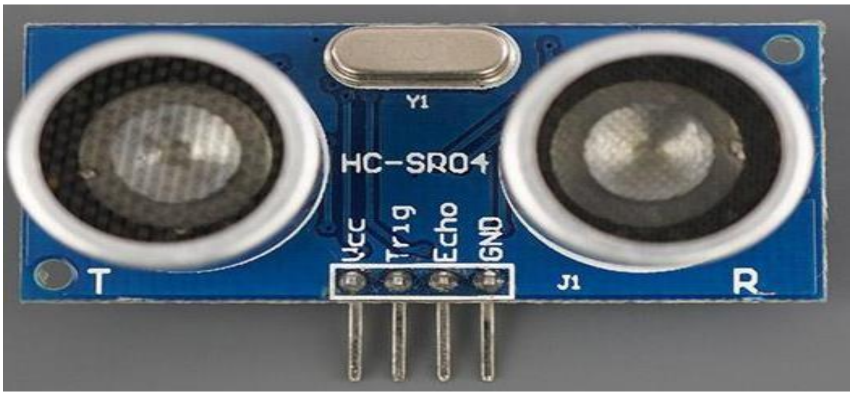

Fig 3.5: Ultrasonic sensor

Specifications:

Pin Configuration and Specifications of an Ultrasonic Sensor:

Specifications:

- Operating Voltage: Typically 5V DC
- Operating Current: Varies depending on the model, usually in the range of 15mA to 20mA
- Operating Frequency: Generally operates at a frequency of around 40kHz
- Detection Range: Varies depending on the model, typically ranges from a few centimeters to several meters
- Output Signal: Digital or analog signal corresponding to the distance measured
- Accuracy: Typically within a few millimeters to a few centimeters, depending on the model and environmental conditions
- Operating Temperature: Usually -20°C to +70°C, but may vary depending on the model

Pin Configuration:

Most ultrasonic sensors have three pins:

1. VCC (or VCC+): This pin is connected to the positive terminal of the power supply (usually 5V DC). It provides power to the sensor.

2. Trigger (or Trig): This pin is used to trigger the sensor to send out an ultrasonic pulse. It is often connected to a digital output pin of a microcontroller.

3. Echo: This pin is used to receive the ultrasonic pulse reflected back from an object. The duration of the pulse received on this pin is proportional to the distance of the object from the sensor. It is often connected to a digital input pin of a microcontroller.

- GND (or VCC-): This pin is connected to the negative terminal of the power supply (usually ground).

- Mode (or Select): This pin is used to select the output mode of the sensor (digital or analog).

- Serial Interface Pins: Some advanced ultrasonic sensors may have serial communication pins for interfacing with microcontrollers or other devices.

It's important to consult the datasheet or technical specifications provided by the manufacturer for the specific pin configuration and operating parameters of a particular ultrasonic sensor model, as they may vary depending on the manufacturer and model.

Chapter 4
Design and coding

This chapter covers the detailed design and coding of the Intelligent Vehicle Speed Adjustment System. The system uses an ultrasonic sensor and a motor control setup to adjust the vehicle's speed based on the distance from obstacles.

4.1 System Overview

The system integrates NodeMCU ESP8266, ultrasonic sensors, and a DC motor controlled by a motor driver. The objective is to continuously monitor the distance between the vehicle and any obstacles ahead. Based on the measured distance, the system adjusts the vehicle's speed automatically.

4.2 Hardware Components

NodeMCU ESP8266:

Microcontroller unit (MCU) for controlling the sensor and motor driver.

Built-in Wi-Fi for potential IoT applications (e.g., future expansion to cloud services for monitoring).

Ultrasonic Sensor (HC-SR04):

Measures distance by emitting ultrasonic waves.

Operates on the principle of echolocation.

Uses two pins**:** Trig (trigger pulse) and Echo (receive pulse).

L298N Motor Driver:

Allows for motor speed and direction control.

Uses two pins to control the motor's direction (IN1 and IN2) and one pin for speed control (PWM via ENA pin).

DC Motor:

Simulates the movement of the vehicle.

Adjusts speed according to the distance from an obstacle.

4.3 Circuit Design

The circuit wiring for this system connects the NodeMCU to both the ultrasonic sensor and the motor driver:

Ultrasonic Sensor:

Trig Pin (D5): Sends ultrasonic pulses.

Echo Pin (D6): Receives the reflected signal to calculate the distance.

Motor Driver (L298N):

ENA (D1): Controls motor speed using Pulse Width Modulation (PWM).

IN1 (D2) and IN2 (D3): Control the motor's direction (forward or reverse).

4.4 System Workflow

Distance Measurement:

The ultrasonic sensor continuously measures the distance between the vehicle and obstacles.

The time taken for the signal to hit an object and return is used to calculate the distance, which is then fed into the system to adjust the motor speed.

Motor Speed and Direction Control:

If the distance between the vehicle and an obstacle is less than 30 cm, the system slows down the motor to prevent a collision.

If the distance is greater than 30 cm, the motor runs at a normal speed, allowing the vehicle to continue moving safely.

Dynamic Speed Adjustment:

The motor speed is dynamically mapped based on the distance using the map() function to adjust between a slow and fast speed depending on proximity to obstacles.

4.5 Software Design

The software is written in Arduino IDE for the NodeMCU. The code reads the sensor data, calculates the distance, and adjusts the motor speed and direction accordingly.

Code:

```
// defines pins numbers
const int trigPin = D5; // Trigger Pin for Ultrasonic Sensor
const int echoPin = D6; // Echo Pin for Ultrasonic Sensor
#define ENA_PIN D1       // Enable Pin for motor speed control (PWM)
#define IN1_PIN D2       // IN1 for motor direction control
#define IN2_PIN D3       // IN2 for motor direction control

// defines variables
long duration;           // Time for ultrasonic signal to return
int distance;            // Calculated distance from object in cm

void setup() {
  // Set up pin modes
  pinMode(trigPin, OUTPUT);  // TrigPin as Output (sends pulses)
  pinMode(echoPin, INPUT);   // EchoPin as Input (receives pulses)
  pinMode(ENA_PIN, OUTPUT);  // Motor enable pin (speed control)
  pinMode(IN1_PIN, OUTPUT);  // Motor IN1 pin (direction control)
  pinMode(IN2_PIN, OUTPUT);  // Motor IN2 pin (direction control)

  // Initialize serial communication
  Serial.begin(9600);
}

void loop() {
  // Clears the trigPin
```

```
  digitalWrite(trigPin, LOW);
  delayMicroseconds(2);

  // Sends a 10-microsecond pulse to the trigPin to trigger measurement
  digitalWrite(trigPin, HIGH);
  delayMicroseconds(10);
  digitalWrite(trigPin, LOW);

  // Reads the echoPin and returns the sound wave travel time in microseconds
  duration = pulseIn(echoPin, HIGH);

  // Calculating the distance in centimeters (distance = speed of sound * time / 2)
  distance = duration * 0.034 / 2;

  // Print the distance to the Serial Monitor for debugging
  Serial.print("Distance: ");
  Serial.println(distance);
  delay(2000);

  // Motor control based on distance
  if (distance < 30) {
    // If object is closer than 30cm, slow down
    digitalWrite(IN1_PIN, HIGH);   // Set motor direction forward
    digitalWrite(IN2_PIN, LOW);    // Set motor direction forward

    // Adjust motor speed based on distance
    int speed = map(distance, 0, 30, 255, 150); // Map distance to speed
    analogWrite(ENA_PIN, speed);    // Control motor speed with PWM
  } else {
    // If no close object, keep motor running at normal speed
    digitalWrite(IN1_PIN, HIGH);    // Keep motor running forward
    digitalWrite(IN2_PIN, LOW);     // Keep motor running forward
    analogWrite(ENA_PIN, 200);      // Maintain moderate speed
  }
}
```

4.6 Code Explanation

Distance Measurement:

The ultrasonic sensor uses the trigger pin to emit a pulse and listens to the echo pin for the reflection. The time it takes for the signal to return is used to calculate the distance using the formula distance = duration * 0.034 / 2.

Motor Control:

The motor is controlled by IN1, IN2, and ENA pins. The motor runs forward when IN1 is HIGH and IN2 is LOW.

The speed of the motor is controlled using the ENA_PIN, which is connected to a PWM output to vary the speed.

Dynamic Speed Control:

The map() function adjusts the motor speed based on the distance from the object. The closer the object, the slower the motor runs.

If no object is detected within 30 cm, the motor maintains a default speed.

Serial Monitoring:

The serial monitor continuously prints the measured distance, which is useful for debugging and observing real-time sensor data.

4.7 Further Enhancements

Obstacle Avoidance:

You can expand the code to include additional sensors or introduce reverse motion when an object is too close.

Cloud Integration:

Using the NodeMCU's Wi-Fi capabilities, data such as speed and distance can be sent to a cloud platform for real-time monitoring and analysis.

Additional Safety Features:

Introduce an emergency stop feature if the distance drops below a critical threshold, ensuring added safety.

User Interface:

A mobile app or dashboard can be integrated, using IoT for real-time alerts and adjustments to the speed settings.