Smart Object Detection System in Automated Vehicle

Report On Major Project (IOT-2083)

Bachelor of Technology

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CERTIFICATE

This is to certify that the Case Study Project Report entitled as "**Smart Object Detection System in Automated Vehicle**" submitted by Prince Bhatt (0108IO211044) in the partial fulfillment of the requirements for the award of degree of Bachelor of Technology in the Specialization of Internet Of Things (IOT) from Samrat Ashok Technological Institute, Vidisha (M.P.) is a record work carried out by them under my supervision and guidance. The matter presented in this report has not been presented by them elsewhere for any other degree.

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Acknowledgement

I take this opportunity to express our heartfelt gratitude to all those who supported and guided us throughout the successful completion of our major project, "**Smart Object Detection System in Automated Vehicle.**"

First and foremost, we extend our sincere thanks to our project supervisor, **Prof. Sheena Kumar** for their invaluable guidance, continuous encouragement, and constructive feedback at every stage of this project. Their support played a crucial role in helping us bring our ideas to reality.

We are also thankful to the faculty and staff of the Department of Information Technology, **Samrat Ashok Technological Institute, Vidisha [M.P.],** for providing the necessary resources and environment to work on this project.

A special thanks to our families and friends for their patience, motivation, and moral support throughout the journey.

CANDIDATE’S DECLARATION

I Prince Bhatt (0108IO211044) hereby declare that the work presented in this Major Project entitled "**Smart Object Detection System in Automated Vehicle**", submitted in partial fulfilment of the requirements for the award of the degree of Bachelor of Technology in Internet of Things, is an original and authentic record of our own work.

This project has been carried out at Samrat Ashok Technological Institute, Vidisha (M.P.), under the esteemed guidance of Prof. Sheena Kumar, Department of Information Technology.

We further declare that the content of this report has not been submitted previously, in part or full, for the award of any other degree or diploma at any university or institution.

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Abstract

This project presents the design and implementation of a **"Smart Object Detection System in Automated Vehicle"** that combines sensor technology, embedded systems, and Internet of Things (IoT) to enable autonomous navigation and obstacle avoidance. The primary goal is to develop a smart vehicle capable of detecting obstacles in real-time and altering its path to avoid collisions without human intervention. The system is built using a microcontroller (such as Arduino or ESP32), ultrasonic sensors for obstacle detection, and a motor driver to control the vehicle's movement. The integration of IoT allows for remote monitoring and control through a mobile application or cloud platform, making the system more versatile and user-friendly. Experimental tests demonstrate that the vehicle responds accurately and promptly to objects in its path, validating its effectiveness in real-world conditions. The project has promising future applications in fields like robotics, surveillance, smart delivery systems, and assistive technologies, offering a cost-effective and scalable solution for autonomous navigation.

1. INTRODUCTION

The rapid advancement of technology has paved the way for the development of intelligent systems that aim to improve safety, efficiency, and automation in various sectors. One such innovation is the **IoT-based automatic obstacle detecting vehicle**, which combines the power of the **Internet of Things (IoT)** with **sensor-based automation** to create smart, self-navigating systems.

These vehicles are designed to automatically detect and avoid obstacles in their path using various sensors such as ultrasonic, infrared, and camera-based modules. The integration of IoT enables real-time communication, remote monitoring, and data processing, making the vehicle not only autonomous but also connected to a larger ecosystem. Such systems have wide applications in areas like **autonomous delivery**, **search and rescue operations**, **military reconnaissance**, and **smart transportation**.

The core idea behind this project is to develop a vehicle that can intelligently navigate through unknown environments by detecting and avoiding obstacles without any human intervention. The use of IoT allows the vehicle to send and receive data to/from cloud platforms or mobile devices, enabling enhanced decision-making, control, and monitoring.

This project aims to design and implement a prototype of an IoT-based automatic obstacle detecting vehicle using microcontrollers (such as Arduino or ESP32), sensors, and wireless communication modules. The system will be capable of real-time obstacle detection, dynamic path adjustment, and remote access, showcasing the potential of combining automation with IoT in modern vehicle systems.

2. INTRODUCTION TO MAJOR FIELDS/AREA

1) Internet of Things (IoT):

The **Internet of Things (IoT)** is a modern technological concept that enables physical devices to connect, communicate, and exchange data over the internet. In the context of obstacle-detecting vehicles, IoT allows the integration of sensors and microcontrollers with communication modules to send and receive data in real-time. This connectivity enhances the vehicle's ability to be monitored, controlled, and updated remotely.

Methods

- Devices connect through internet-based protocols (e.g., MQTT, HTTP).
- Sensors collect data and transmit it to a cloud or mobile app.

Functions

- Data acquisition
- Real-time monitoring
- Remote control
- Analytics

Terminology and Types

- **Node**: A device with sensing or control capability.
- **Gateway**: Routes data between nodes and the cloud.
- **Cloud**: Stores and processes the collected data.
- **Protocols**: MQTT, HTTP, CoAP.

Advantages

- Remote access and control
- Real-time data collection
- Efficient monitoring and maintenance

Disadvantages

- Requires reliable internet connectivity
- Vulnerable to cyber threats

Limitations

- High power consumption
- Data privacy and security issues

2) Embedded Systems:

An **embedded system** is a combination of hardware and software designed to perform specific functions within a larger system. In this project, microcontrollers such as **Arduino** or **ESP32** act as the brain of the vehicle, processing sensor inputs and controlling motors based on programmed logic. These systems are compact, power-efficient, and ideal for automation applications.

Method

- Uses programming (C/C++) to define behavior based on sensor inputs.

Functions

- Real-time decision making
- Interfacing with sensors and actuators
- Motor control

Terminology and Types

- **Microcontroller**: Arduino, ESP32, Raspberry Pi
- **Actuators**: Motors, servos
- **Real-Time Systems**: Systems that respond in a defined time frame

Advantages

- Low cost
- Energy-efficient
- Small and customizable

Disadvantages

- Limited computing power
- Limited memory

Limitations

- Not suitable for high-performance applications

3) Sensor Technology:

Sensor technology plays a crucial role in obstacle detection. Devices such as **ultrasonic sensors**, **infrared (IR) sensors**, and **proximity sensors** are used to detect objects and measure distances. These sensors provide real-time data to the microcontroller, allowing the vehicle to make intelligent navigation decisions.

Method

- Use principles like echo time (Ultrasonic), reflection (IR), and image processing (Camera).

Functions

- Distance measurement
- Obstacle detection
- Environmental monitoring

Terminology and Types

- **Ultrasonic Sensor**: Uses sound waves
- **IR Sensor**: Uses infrared light
- **LiDAR**: Uses laser light
- **Camera Sensor**: Uses image recognition

Advantages

- Accurate and fast detection
- Real-time response

Disadvantages

- Prone to interference (IR in sunlight, ultrasonic in noise)
- Limited range and precision

Limitations

- Can't detect all material types or shapes accurately
- Higher-end sensors like LiDAR are expensive

4) Wireless Communication:

To enable real-time control and monitoring, **wireless communication technologies** such as Wi-Fi, Bluetooth, or GSM modules are used. These allow the vehicle to interact with mobile devices or cloud platforms, making remote operation and data transmission possible.

Method

- Uses Wi-Fi, Bluetooth, or GSM modules.

Functions

- Remote control
- Cloud synchronization
- Data logging

Terminology and Types

- **Wi-Fi Modules**: ESP8266, ESP32
- **Bluetooth Modules**: HC-05, BLE
- **GSM Modules**: SIM800L

Advantages

- Easy integration with mobile apps
- Real-time interaction

Disadvantages

- Limited range (Bluetooth)
- Dependent on network availability

Limitations

- May not work in remote/no-network areas
- Requires additional power

5) Automation and Robotics:

The project falls under the domain of **automation and robotics**, where the goal is to reduce human intervention by creating intelligent machines. The vehicle operates autonomously, navigating its environment and avoiding obstacles without manual control, showcasing practical implementation of robotic automation.

Method

- Uses programmed logic to perform repetitive or complex tasks automatically.

Functions

- Path planning
- Obstacle avoidance
- Task execution

Terminology and Types

- **Autonomous Robots**: Self-navigating
- **Semi-Autonomous Robots**: Partial manual control
- **Path Planning Algorithms**: Dijkstra, A*, etc.

Advantages

- Increases efficiency and safety
- Operates in hazardous environments

Disadvantages

- High initial cost
- Complexity in implementation

Limitations

- Limited adaptability to unstructured environments
- Dependence on battery life

3. LITERATURE REVIEW

Takadir S Pin jar[1], Assistant Professor, Department of Electrical Engineering, Trinity College of Engineering and Research, In this paper, the solar charging station that gives the¬ electricity to charge the battery. The charging station has integrated battery storage that allows for off-grid operation. The DC charging uses the DC power from the photovoltaic panels directly for charging the vehicles battery without the utilization of an AC charging adapter. This paper presenting the solar charging station for sort of electric vehicles, which is generally used to avoid use of nonrenewable source of energy to charge for all intents and purposes electric vehicles, which is fairly significant. This study develops a model that really combines the solar power station and EVs to mostly reduce pollutants emission from the power generation and transportation sector in a suitable way. Chinmay A. Dandekar[2] (Electrical Department, VIVA Institute of Technology, India) VIVA Institute of Technology 9th National Conference on Role of Engineers in Nation. This paper gives you a basic overview about designingand implementing the process of solar electric vehicle. A solar car does not use any combustion thus it is free from any cause for global warming. This paper proposes a method to design multi-seated solar car different from the one available in market, in a cheaper way. The most essential equipment for building a solar vehicle are the solar panels. The photovoltaic panels of 250W are connected as a photovoltaic array to charge a lithium-ion battery bank of 48V and 78Ah during the day hours. With the help of this technology, we aim to make solar energy powered car in our project Tejas Sonawane[3], Sinhgad Academy of Engineering, Kondhwa, Pune, Maharashtra, Sonawane Tejas etc all International Journal of Advance Research, Ideas and Innovations in Technology.

- ❖ Some References includes:
  - Takadir S Pinjar, Assistant Professor, Department of Electrical Engineering, Trinity College of Engineering and Research.
  - Chinmay A. Dandekar (Electrical Department, VIVA Institute of Technology, India) VIVA Institute of Technology 9th National Conference on Role of Engineers in Nation.

4. PROJECT DESIGN AND METHODOLOGY

1) Block Diagram :

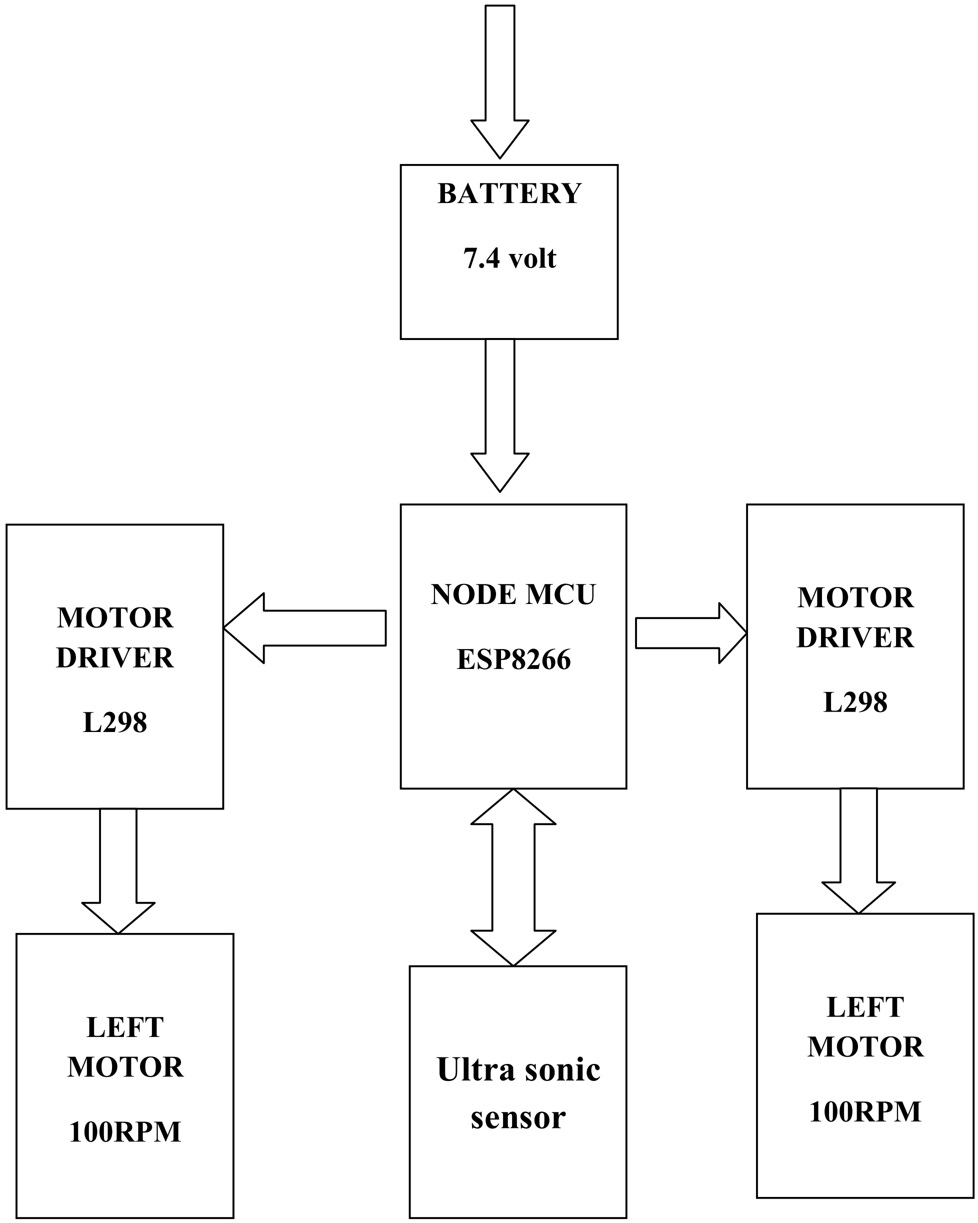

Fig.1: Block Diagram

2) CIRCUIT DIAGRAM:

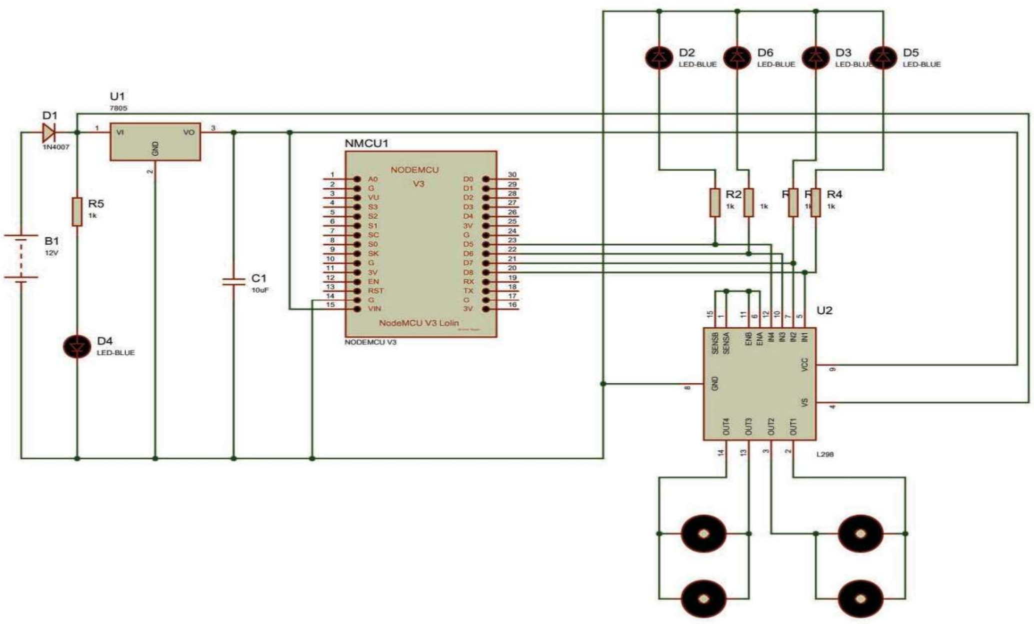

Fig. 2: Circuit Diagram

I. Project design:

Autonomous vehicles have revolutionized the automotive industry, promising safer and more efficient transportation. One of the key components in developing such vehicles is building a robust object detection system capable of accurately identifying and tracking objects in real time. In this article, we will explore the implementation of an advanced object detection application for autonomous vehicles using YOLOv7, Intel Optimization for PyTorch, 3D segmentation, and real-time tracking.

II. Understanding Object Detection:

Object detection is the task of identifying and localizing objects of interest within an image or video stream. It plays a crucial role in enabling autonomous vehicles to perceive and interact with their surroundings. Traditional methods involved using sliding windows and handcrafted features, but recent advancements in deep learning have led to more efficient and accurate approaches.

III. **3D Segmentation:**

While 2D object detection is essential, adding a third dimension to the detection process can provide a more comprehensive understanding of the environment. 3D segmentation techniques, such as LiDAR-based point cloud analysis, allow us to differentiate objects in terms of their depth and shape. This information can be critical for autonomous vehicles to accurately perceive and navigate their surroundings.

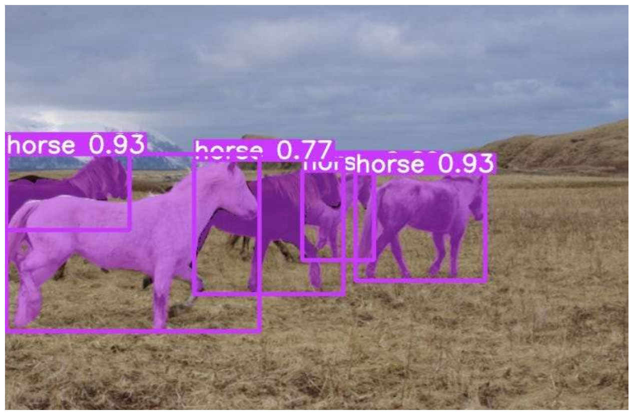

Fig. 3: 3D segmentation

IV. **Real-time Tracking**:

Tracking objects over time is a crucial aspect of autonomous vehicle perception. Real-time tracking algorithms enable the system to maintain a continuous understanding of object movements and trajectories. By combining object detection with tracking mechanisms, we can ensure consistent and reliable object identification and tracking, even in complex scenarios.

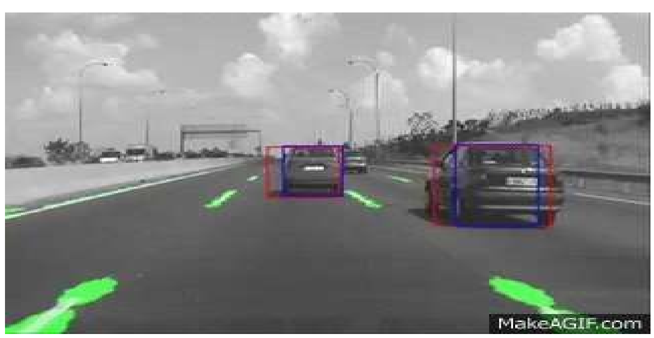

Fig. 4: Real-Time Tracking

V. Methodology:

a) Building the Application:

To build an object detection application for autonomous vehicles incorporating YOLOv7, Intel Optimization for PyTorch, 3D segmentation, and real-time tracking, follow these steps:

i. Data Collection: Gather a diverse dataset containing annotated images and videos that represent various driving scenarios.
ii. Model Training: Train the YOLOv7 model on the collected dataset using PyTorch. Fine-tune the model to suit specific autonomous vehicle requirements.
iii. Intel Optimization: Optimize the trained model using Intel Optimization for PyTorch to leverage hardware-specific optimizations and achieve faster inference times.
iv. 3D Segmentation: Integrate a 3D segmentation technique, such as LiDAR-based point cloud analysis, to provide depth information for improved object perception.
v. Real-time Tracking: Implement a real-time tracking algorithm, such as Kalman filters or deep learning-based trackers, to track objects across frames and maintain consistent identification.
vi. System Integration: Integrate the object detection application with the autonomous vehicle's overall perception system, ensuring seamless data flow and interaction with other components.

b) Sensor Fusion:

A critical aspect of autonomous vehicle technology is sensor fusion, which combines data from multiple sensors to improve the accuracy and reliability of perception systems. Early sensor fusion techniques generate 3D object detections directly from image and LiDAR data, enhancing performance in tasks like object detection. This approach minimizes the reliance on independent object detectors and allows for a more integrated perception system.

i. Benefits of Early Sensor Fusion

- **Improved Accuracy**: By merging data from various sensors, the system can achieve a more comprehensive understanding of the environment.
- **Robustness**: Sensor fusion helps mitigate the weaknesses of individual sensors, such as LiDAR's limitations in fog or rain.
- **Efficiency**: A unified approach reduces processing time and resource consumption compared to a multi-stage pipeline.

c) Hardware Specifications

The hardware components of autonomous vehicles are designed to support the complex processing required for real-time decision-making. Key components include:

i. **Processing Unit**: For example, a NODEMCU, which provides the computational power necessary for running advanced algorithms.
ii. **Depth Cameras**: Such as the Intel Real Sense D435i, which are essential for depth perception and 3D Maping.

5. IMPLEMENTATION

S.No	Component	Description
1.	**Chassis/Robot Base**	The frame or base that holds all components and provides structure to the vehicle.
2.	**Microcontroller (Arduino UNO / ESP32 / Raspberry Pi)**	The brain of the system that processes sensor data and controls movement.
3.	**Ultrasonic Sensor (HC-SR04)**	Measures distance to detect obstacles using sound waves.
4.	**IR Sensor**	Detects nearby obstacles using infrared reflection (used for short-range).
5.	**Motor Driver Module (L298N / L293D)**	Controls the speed and direction of DC motors.
6.	**DC Motors (2 or 4)**	Provides motion to the wheels of the vehicle.
7.	**Wheels**	Attached to motors for movement.
8.	**Power Supply (Battery Pack)**	Powers the microcontroller, motors, and sensors.
9.	**Wi-Fi Module (ESP8266 / ESP32 built-in)**	Enables IoT functionality and real-time data transmission.
10.	**Jumper Wires**	Connects various components on the breadboard or microcontroller.
11.	**Switch (On/Off)**	Used to start or stop the system.
12.	**LED**	Used as indicators (e.g., for obstacle warning or status).
13.	**Resistors**	Used with LEDs or sensors to limit current.
14.	**Cloud Platform or Mobile App (e.g., Blynk / Firebase / MQTT Dashboard)**	For remote control, monitoring, and data logging.

1) SOFTWARE USE FOR PCB LAYOUT DESIGN

CIRCUIT WIZARD: We designed a compact and efficient PCB layout to integrate all components of the obstacle-detecting vehicle, ensuring proper connectivity and minimal signal interference. The circuit design includes motor drivers, ultrasonic sensors, IR sensors, and the NodeMCU, all precisely arranged to optimize performance, reduce wiring complexity, and enhance the overall reliability of the system.

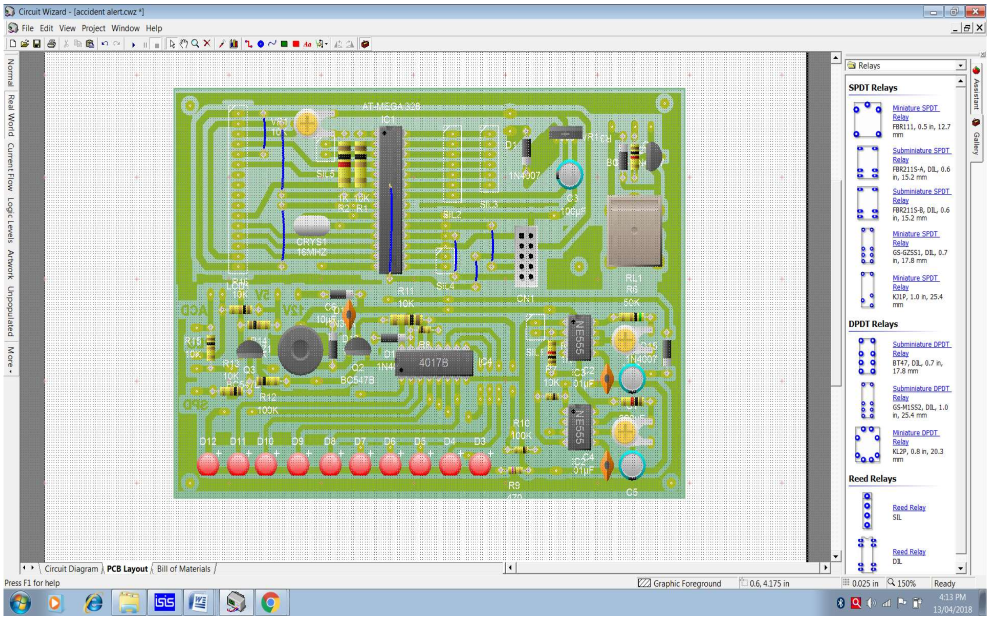

Fig. 5: PCB Circuit Design

2) SOFTWARE USE FOR PROGRAMING

ARDUINO IDE: We utilized the Arduino IDE for programming, incorporating a variety of essential libraries to enable hardware control, sensor integration, and real-time communication features. Our source code is written in Embedded C, a specialized subset of the C language optimized for programming microcontrollers and interfacing with hardware components efficiently. Using the authentication token provided by Blynk IoT, we successfully integrated and deployed the source code onto the NodeMCU, enabling seamless real-time communication between the hardware and the Blynk mobile application for remote control and monitoring of the vehicle's operations.

3) ALGORITHM OF SOURCE CODE:

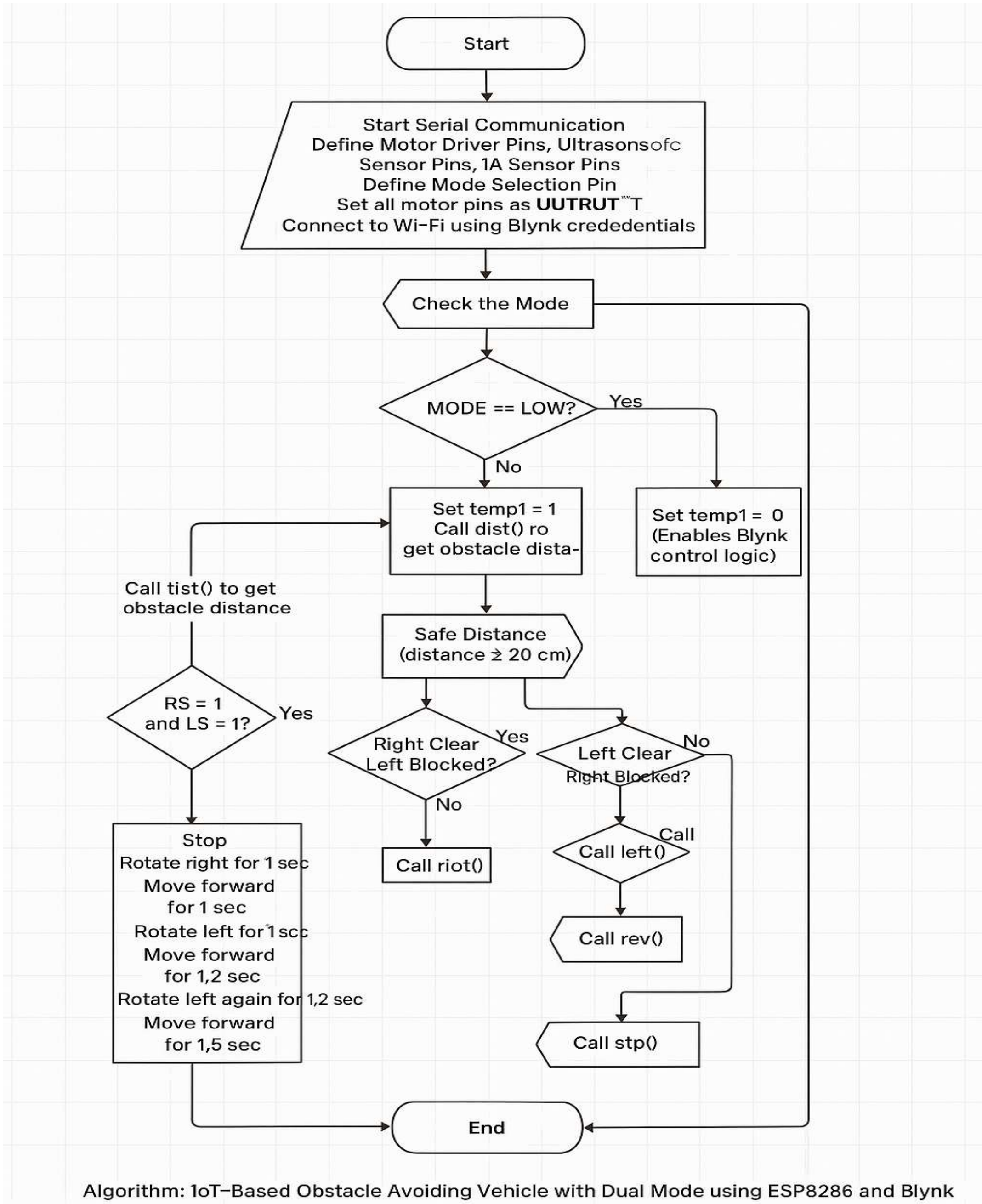

Fig. 6: Source Code Algorithm

- Source Code Link: https://github.com/princebhatt03/Major-Project
  - The Source Code distribution is maintained by GitHub

4) ANDROID APPLICATION USE IN PROJECT

BLYNK IOT PLATFORM: Blynk IoT Platform is a powerful and user-friendly Internet of Things (IoT) platform that enables developers to build, control, and monitor IoT devices remotely. It provides a mobile app, web dashboard, and cloud infrastructure that connect microcontrollers like NodeMCU, ESP8266, or Arduino to the internet. Blynk supports features like real-time data visualization, device control via virtual pins, and automation through widgets such as buttons, sliders, and gauges. It also enables secure communication using authentication tokens and supports multiple devices and users. Blynk simplifies IoT development by eliminating complex networking code and offering seamless integration with sensors and actuators through its libraries.

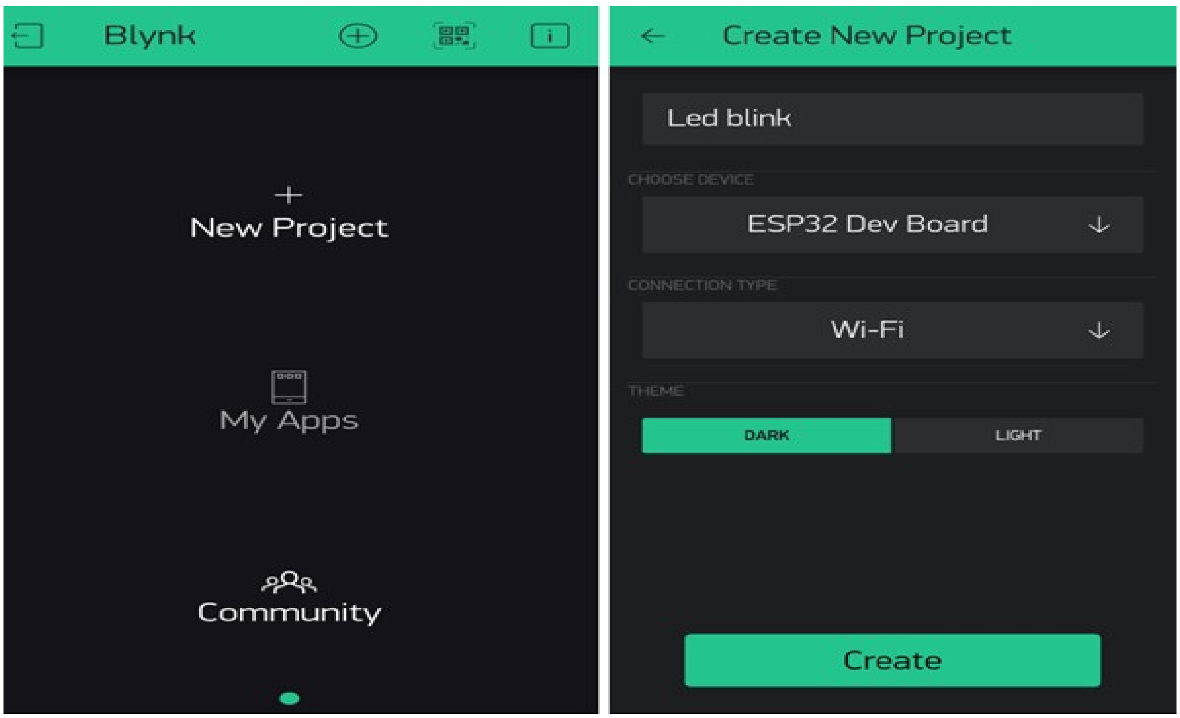

Fig. 7: Blynk IOT Interface

6. Components Used:

1) NodeMCU:

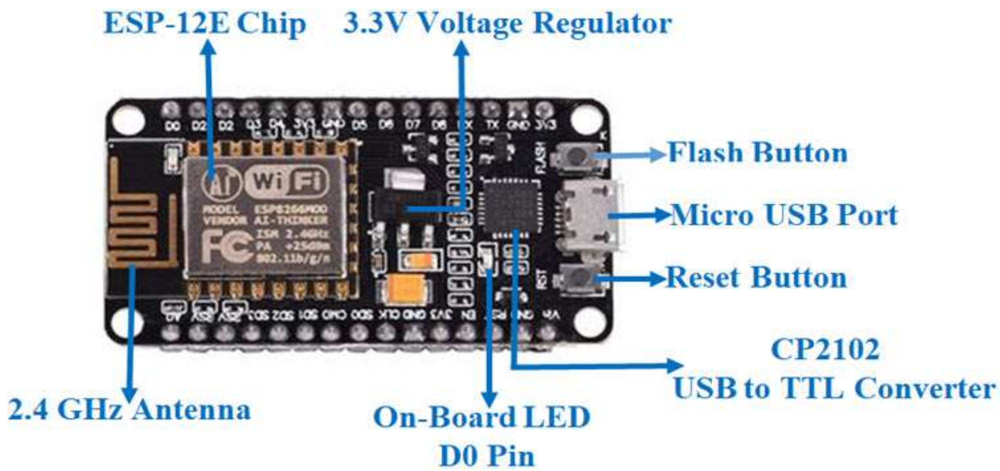

Fig. 8: NodeMCU

The **NodeMCU** is the main component of our project which controls the project. The **NodeMCU ESP8266 development board** comes with the ESP-12E module containing ESP8266 chip having Tensilica Xtensa 32-bit LX106 RISC microprocessor. This microprocessor supports RTOS and operates at 80MHz to 160 MHz adjustable clock frequency. NodeMCU has 128 KB RAM and 4MB of Flash memory to store data and programs. Its high processing power with in-built Wi-Fi / Bluetooth and Deep Sleep Operating features make it ideal for IoT projects. NodeMCU can be powered using Micro USB jack and VIN pin (External Supply Pin). It supports UART, SPI, and I2C interface.

Applications of NodeMCU

- Prototyping of IoT devices
- Low power battery operated applications
- Network projects
- Projects requiring multiple I/O interfaces with Wi-Fi and Bluetooth functionalities

2) Ultra Sonic Sensors:

Fig. 9: Ultra Sonic Sensor

An **Ultrasonic Sensor** is a distance-measuring device that uses ultrasonic sound waves to detect objects. It emits high-frequency sound waves through a transmitter, which bounce back upon hitting an object. The receiver detects the echo, and the time taken for the echo to return is used to calculate the distance between the sensor and the object.

In our project, the ultrasonic sensor plays a critical role in **obstacle detection**. It continuously monitors the path ahead of the vehicle. When an obstacle is detected within a certain range, the sensor triggers the vehicle to stop or take an alternate path, ensuring autonomous navigation and collision avoidance.

3) IR Sensors:

Fig. 10: IR Sensor

An **IR (Infrared) sensor** is an electronic device that detects infrared radiation emitted or reflected by objects in its surroundings. It typically consists of an IR LED that emits infrared light and a photodiode that detects the reflected light. When the emitted IR light hits a surface and reflects back, the photodiode measures the intensity, helping determine the presence, position, or nature of an object or surface.

In our project, **IR sensors are primarily used for path detection and navigation**. They assist the vehicle in identifying and following the correct path by detecting black or white surface contrasts, line boundaries, or turns. When the sensors detect a deviation or curve in the path, they send signals to the microcontroller, prompting the vehicle to adjust its direction. This ensures accurate movement, lane tracking, and smooth autonomous navigation, even in complex or curved paths.

4) Resistors:

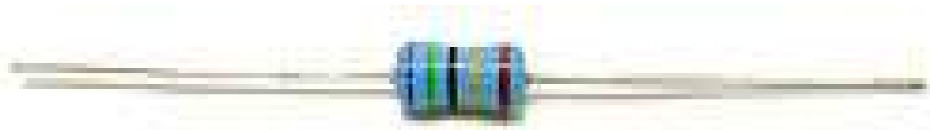

Fig.11: Resistance

The electrical resistance of an electrical conductor is the opposition to the passage of an electric current through that conductor. The inverse quantity is electrical conductance, the ease with which an electric current passes. Electrical resistance shares some conceptual parallels with the mechanical notion of friction. The SI unit of electrical resistance is the ohm (Ω), while electrical conductance is measured in Siemens (S).

An object of uniform cross section has a resistance proportional to its resistivity and length and inversely proportional to its cross-sectional area. All materials show some resistance, except for superconductors, which have a resistance of zero.

The resistance (R) of an object is defined as the ratio of voltage across it (V) to current through it (I), while the conductance (G) is the inverse:

$$R = \frac{V}{I}, \qquad G = \frac{I}{V}, \qquad G = \frac{1}{R}$$

For a wide variety of materials and conditions, V and I are directly proportional to each other, and therefore R and G are constant (although they can depend on other factors like temperature or strain). This proportionality is called Ohm's law, and materials that satisfy it are called "Ohmic" materials.

In other cases, such as a diode or battery, V and I are not directly proportional, or in other words the I–V curve is not a straight line through the origin, and Ohm's law does not hold. In this case, resistance and conductance are less useful concepts, and more difficult to define. The ratio V/I is sometimes still useful, and is referred to as a "chordal resistance" or "static resistance",[1][2] as it corresponds to the inverse slope of a chord between the origin and an I–V curve. In other situations, the derivative $\frac{dV}{dI}$ may be most useful; this is called the "differential resistance

5) Capacitor:

Fig.12: Capacitor

A capacitor (originally known as a condenser) is a passive two-terminal electrical component used to store energy electrostatically in an electric field. The forms of practical capacitors vary widely, but all contain at least two electrical conductors (plates) separated by a dielectric (i.e., insulator). The conductors can be thin films of metal, aluminum foil or disks, etc. The 'non conducting' dielectric acts to increase the capacitor's charge capacity. A dielectric can be glass, ceramic, plastic film, air, paper, mica, etc. Capacitors are widely used as parts of electrical circuits in many common electrical devices. Unlike a resistor, a capacitor does not dissipate energy. Instead, a capacitor stores energy in the form of an electrostatic field between its plates.

When there is a potential difference across the conductors (e.g., when a capacitor is attached across a battery), an electric field develops across the dielectric, causing positive charge (+Q) to collect on one plate and negative charge (-Q) to collect on the other plate. If a battery has been attached to a capacitor for a sufficient amount of time, no current can flow through the capacitor. However, if an accelerating or alternating voltage is applied across the leads of the capacitor, a displacement current can flow.

The capacitance is greater when there is a narrower separation between conductors and when the conductors have a larger surface area. In practice, the dielectric between the plates passes a small amount of leakage current and also has an electric field strength limit, known as the breakdown voltage. The conductors and leads introduce an undesired inductance and resistance.

Capacitors are widely used in electronic circuits for blocking direct current while allowing alternating current to pass.

6) P–n junction diode:

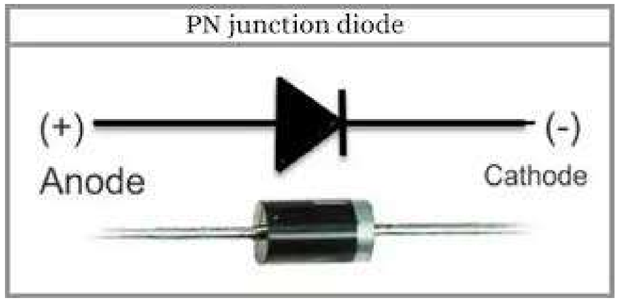

Fig.13: Diode

A P–N junction diode is one of the most fundamental and essential components in semiconductor electronics. It is formed by joining two types of semiconductor materials: P-type (which contains an abundance of holes or positive charge carriers) and N-type (which contains a high concentration of electrons or negative charge carriers). The interface where these two regions meet is called the P–N junction, and it exhibits unique electrical properties that make it suitable for various applications such as rectification, signal demodulation, voltage regulation, and switching.

Biasing of the Diode

The operation of the diode depends on how it is biased, i.e., how the external voltage is applied across it:

Forward Bias: When the positive terminal of an external power supply is connected to the P-region and the negative terminal to the N-region, the diode is said to be in forward bias. This reduces the width of the depletion region and lowers the potential barrier. Once the applied voltage exceeds the threshold (cut-in) voltage, the diode starts to conduct electric current freely. The current increases exponentially with a small increase in voltage, making the diode highly conductive in this region.

Reverse Bias: When the polarity is reversed (positive terminal to the N-region and negative terminal to the P-region), the depletion region widens, and the potential barrier increases. As a result, the flow of majority carriers is blocked, and only a very small reverse saturation current flows due to the movement of minority carriers. If the reverse voltage is increased beyond a certain point, the diode may undergo breakdown, leading to a large reverse current. This phenomenon is safely utilized in Zener diodes for voltage regulation, but can damage ordinary diodes.

7) Voltage Regulator IC (7805):

Fig.14: 7805 IC

A voltage regulator is designed to automatically maintain a constant voltage level. A voltage regulator may be a simple "feed-forward" design or may include negative feedback control loops. It may use an electromechanical mechanism, or electronic components. Depending on the design, it may be used to regulate one or more AC or DC voltages. Electronic voltage regulators are found in devices such as computer power supplies where they stabilize the DC voltages used by the processor and other elements. In automobile alternators and central power station generator plants, voltage regulators control the output of the plant. In an electric power distribution system, voltage regulators may be installed at a substation or along distribution lines so that all customers receive steady voltage independent of how much power is drawn from the line.

The 78xx (sometimes L78xx, LM78xx, MC78xx...) is a family of self-contained fixed linear voltage regulator integrated circuits. The 78xx family is commonly used in electronic circuits requiring a regulated power supply due to their ease-of-use and low cost. For ICs within the family, the xx is replaced with two digits, indicating the output voltage (for example, the 7805 has a 5 volt output, while the 7812 produces 12 volts). The 78xx line are positive voltage regulators: they produce a voltage that is positive relative to a common ground. There is a related line of 79xx devices which are complementary negative voltage regulators. 78xx and 79xx ICs can be used in combination to provide positive and negative supply voltages in the same circuit. 78xx ICs have three terminals and are commonly found in the TO220 form factor, although smaller surface-mount and larger TO3 packages are available. These devices support an input voltage anywhere from a couple of volts over the intended output voltage, up to a maximum of 35 to 40 volts depending on the make, and typically provide 1 or 1.5 amperes of current (though smaller or larger packages may have a lower or higher current rating).

8) Light-Emitting Diode:

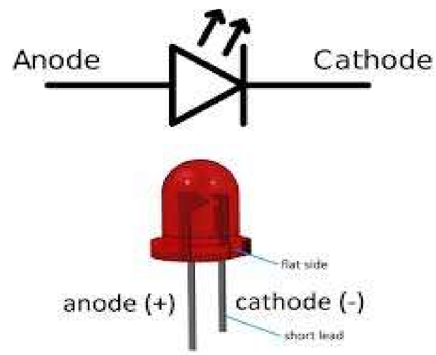

Fig.15: Light Emitting Diode

A light-emitting diode (LED) is a two-lead semiconductor light source that resembles a basic pn-junction diode, except that an LED also emits light. When an LED's anode lead has a voltage that is more positive than its cathode lead by at least the LED's forward voltage drop, current flows. Electrons are able to recombine with holes within the device, releasing energy in the form of photons. This effect is called electroluminescence, and the color of the light (corresponding to the energy of the photon) is determined by the energy band gap of the semiconductor. An LED is often small in area (less than 1 mm^2), and integrated optical components may be used to shape its radiation pattern. Appearing as practical electronic components in 1962, the earliest LEDs emitted low-intensity infrared light. Infrared LEDs are still frequently used as transmitting elements in remote-control circuits, such as those in remote controls for a wide variety of consumer electronics. The first visible-light LEDs were also of low intensity, and limited to red. Modern LEDs are available across the visible, ultraviolet, and infrared wavelengths, with very high brightness. Early LEDs were often used as indicator lamps for electronic devices, replacing small incandescent bulbs. They were soon packaged into numeric readouts in the form of seven-segment displays, and were commonly seen in digital clocks. Recent developments in LEDs permit them to be used in environmental and task lighting. LEDs have many advantages over incandescent light sources including lower energy consumption, longer lifetime, improved physical robustness, smaller size, and faster switching. Light-emitting diodes are now used in applications as diverse as aviation lighting, automotive headlamps, advertising, general lighting,traffic signals, and camera flashes. However, LEDs powerful enough for room lighting are still relatively expensive, and require more precise current and heat management than compact fluorescent lamp sources of comparable output.

9) DC motor:

Fig.16: DC Motor

A **DC motor** is any of a class of electrical machines that converts direct current electrical power into mechanical power. The most common types rely on the forces produced by magnetic fields. Nearly all types of DC motors have some internal mechanism, either electromechanical or electronic, to periodically change the direction of current flow in part of the motor. Most types produce rotary motion; a linear motor directly produces force and motion in a straight line.

DC motors were the first type widely used, since they could be powered from existing direct-current lighting power distribution systems. A DC motor's speed can be controlled over a wide range, using either a variable supply voltage or by changing the strength of current in its field windings. Small DC motors are used in tools, toys, and appliances. The universal motor can operate on direct current but is a lightweight motor used for portable power tools and appliances. Larger DC motors are used in propulsion of electric vehicles, elevator and hoists, or in drives for steel rolling mills. The advent of power electronics has made replacement of DC motors with AC motors possible in many applications.A coil of wire with a current running through it generates an electromagnetic field aligned with the center of the coil. The direction and magnitude of the magnetic field produced by the coil can be changed with the direction and magnitude of the current flowing through it.A simple DC motor has a stationary set of magnets in the stator and an armature with one or more windings of insulated wire wrapped around a soft iron core that concentrates the magnetic field. The windings usually have multiple turns around the core, and in large motors there can be several parallel current paths. The ends of the wire winding are connected to a commutator. The commutator allows each armature coil to be energized in turn and connects the rotating coils with the external power supply through brushes.

10) Lithium Battery:

Fig.17: Lithium Battery

A **Lithium battery** is a device consisting of one or more electrochemical cells with external connections provided to power electrical devices. A discharging battery has a positive terminal, or cathode, and a negative terminal, or anode. The terminal marked negative is the source of electrons that when connected to an external circuit will flow and deliver energy to an external device. When a battery is connected to an external circuit, electrolytes are able to move as ions within, allowing the chemical reactions to be completed at the separate terminals and so deliver energy to the external circuit. It is the movement of those ions within the battery which allows current to flow out of the battery to perform work.[3] Historically the term "battery" specifically referred to a device composed of multiple cells, however the usage has evolved to additionally include devices composed of a single cell. Primary (single-use or "disposable") batteries are used once and discarded; the electrode materials are irreversibly changed during discharge. Common examples are the alkaline battery used for flashlights and a multitude of portable devices. Secondary (rechargeable batteries) can be discharged and recharged multiple times; the original composition of the electrodes can be restored by reverse current. Examples include the lead-acid batteries used in vehicles and lithium-ion batteries used for portable electronics. Batteries come in many shapes and sizes, from miniature cells used to power hearing aids and wristwatches to battery banks the size of rooms that provide standby power for telephone exchanges and computer data centers.

11) Other Components:

The Various other Components include; Jumper wires, sand board, rubber wheel, switch to on-off buttons, PCB etc.

7. EXPERIMENTAL RESULTS AND DISCUSSION

The IoT-Based Automatic Obstacle Detecting Vehicle was successfully designed and implemented using components such as an ultrasonic sensor, Arduino (or ESP32), DC motors, and a motor driver module. The obstacle detection system was tested in various indoor and outdoor environments to evaluate its accuracy, responsiveness, and reliability. During the experiments, the ultrasonic sensor effectively detected obstacles within a range and the vehicle responded by automatically stopping or changing direction to avoid collisions. The system consistently maintained stable operation, and the motor driver responded accurately to the control signals sent by the microcontroller. Additionally, the IoT feature enabled real-time monitoring through a mobile application (or cloud platform), allowing users to observe the vehicle's behavior remotely.

The vehicle demonstrated smooth and autonomous navigation in obstacle-rich environments. It showed a quick response time to sudden obstructions and maintained an average reaction time. However, the performance slightly dropped in environments with highly reflective or soft surfaces, where the ultrasonic sensor occasionally gave inaccurate readings. These limitations were identified as opportunities for improvement, such as integrating additional IR sensors or camera-based vision systems for more accurate object recognition.

Overall, the experimental results confirmed the effectiveness of the system in achieving its primary objective—autonomous navigation and obstacle avoidance. The IoT functionality added convenience and opened up possibilities for future enhancements like remote control, live tracking, and cloud data analysis. With minor upgrades, the system can be deployed in real-world applications such as smart delivery, surveillance, or automated assistance.

The results confirm that the core functionality of the project — automatic detection and avoidance of obstacles using IoT and sensor-based technology — was successfully achieved. The system is scalable and can be enhanced with better sensors, advanced algorithms, and integration with cloud platforms for real-world application.

The IoT-based Automatic Obstacle Detecting Vehicle was successfully developed with dual operational modes—Manual Mode (via Blynk IoT app) and Autopilot Mode (using ultrasonic and IR sensors)—integrated with NodeMCU ESP8266 as the central microcontroller. The experimental results demonstrate the system's efficiency in obstacle detection, path correction, and remote control operation.

1) Dual Mode Operation:

The vehicle supports the following working modes:

- **Manual Mode:** Controlled using the Blynk IoT Mobile App, which communicates with NodeMCU over Wi-Fi. The app interface includes buttons for directional control (Forward, Backward, Left, Right), Stop, and Mode Switch. In this mode, the user sends commands directly, and the vehicle responds in real-time using motor driver L298N.
- **Autopilot Mode:** Activated via Blynk or physical switch. In this mode, the vehicle becomes autonomous, relying on Ultrasonic Sensor (HC-SR04) for obstacle detection and IR Sensors for line/path following and obstacle side detection to make path decisions.

2) Sensor Implementation and Observations:

- **Ultrasonic Sensor (HC-SR04)**

Working Range: 2 cm to 400 cm

Accuracy: ±3 mm

Use Case: Detects obstacles in the front of the vehicle. If an obstacle is within a critical distance, the vehicle stops and changes direction.

Sample Calculation for Distance:

Distance (cm) = Time (μs) × 0.034/2

If the time taken for echo is 600 μs:

Distance = 600 × 0.034/2 = 10.2 cm

Distance = 2 600×0.034 = 10.2 cm

If the distance is < 15 cm, the vehicle immediately stops and checks side IR sensors.

- **IR Sensors (TCRT5000 or Similar)**

Range: 2 mm to 30 mm (ideal for close-proximity detection)

Use Case: Used for line-following and determining side clearance when an obstacle is detected in front.

Behavior:

Left IR = LOW, Right IR = HIGH: Turn Right

Left IR = HIGH, Right IR = LOW: Turn Left

Both IR = HIGH: Continue Forward

Both IR = LOW: Stop and wait or reverse

Turning Logic:

A soft turn is achieved by stopping one wheel and running the other.

A hard turn (90°) is achieved by reversing one wheel while the other moves forward.

3) Component Interaction

- **NodeMCU ESP8266**

  a. Central controller, processes data from sensors.
  b. Communicates with Blynk App (via Wi-Fi) and controls motor driver based on command or sensor values.

- **L298N Motor Driver**

  a. Controls the direction and speed of the motors.
  b. Receives HIGH/LOW signals from NodeMCU to rotate motors accordingly.

- **Example Control Signal:**

a. IN1 = HIGH, IN2 = LOW → Motor A moves Forward
b. IN1 = LOW, IN2 = HIGH → Motor A moves Backward
c. Both LOW → Stop

4) Experimental Observations:

Scenario	Sensor Input	Action Taken	Outcome
Obstacle < 15 cm	Ultrasonic = 10 cm	Stop, check IR	Vehicle turns based on IR
Clear Front	Ultrasonic > 25 cm	Move forward	Smooth navigation
Left IR LOW	Path blocked on left	Turn right	Avoids obstacle
Right IR LOW	Path blocked on right	Turn left	Avoids obstacle

5) Sensor Calibration & Turning Calculations:

- Motor Speed: Approx. 150 RPM
- Wheel Diameter: 6 cm → Circumference = π * D ≈ 18.84 cm
- Turning Radius: ~15 cm (for 90° turn)
- For 90° Turn (Hard Left/Right):

  Each wheel needs to rotate approx. 1/4 of a circle →

  Distance=418.84≈4.71 cm

  Time taken (if speed = 10 cm/sec):

  t=104.71≈0.47 sec

So, turning delays are set around 400-500 ms using delay (500) in code.

8. PROJECT IMAGES

1) TOP VIEW:

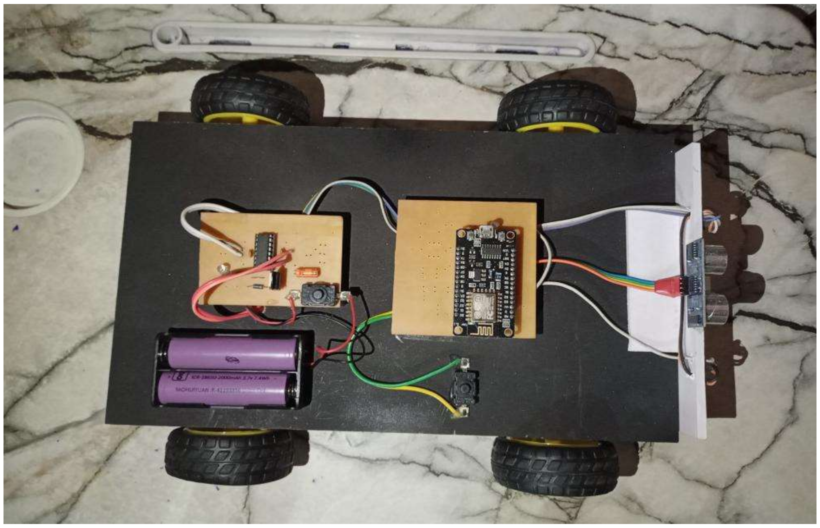

Fig.18: Project Image (Top View)

2) FRONT VIEW:

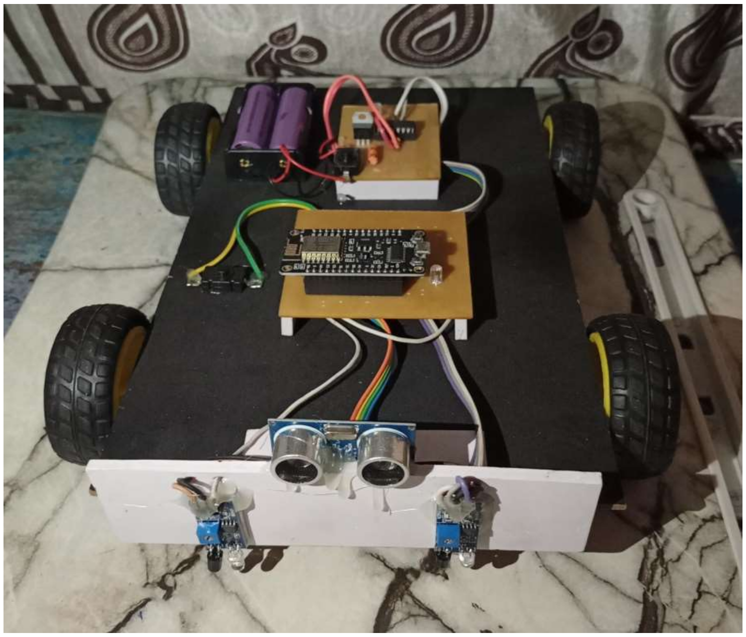

Fig.19: Project Image (Front View)

9. CONCLUSION AND FUTURE SCOPE

1) Conclusion:

The development and testing of the IoT-Based Automatic Obstacle Detecting Vehicle successfully demonstrate the application of embedded systems, sensor technology, and IoT in creating a functional and intelligent autonomous system. The vehicle was able to detect obstacles in real-time and respond by stopping or changing direction, effectively avoiding collisions. The integration of ultrasonic sensors with a microcontroller and motor driver allowed for smooth navigation and decision-making. Moreover, the addition of IoT functionality enabled real-time monitoring and control, opening possibilities for remote operation and future automation. The experimental results confirm the efficiency, reliability, and potential of the system for real-world applications such as smart delivery, surveillance, or assistance for differently-abled individuals. This project lays a solid foundation for further research and innovation in the field of autonomous and IoT-enabled robotic systems.The development and testing of the IoT-Based Automatic Obstacle Detecting Vehicle successfully demonstrate the application of embedded systems, sensor technology, and IoT in creating a functional and intelligent autonomous system. The vehicle was able to detect obstacles in real-time and respond by stopping or changing direction, effectively avoiding collisions. The integration of ultrasonic sensors with a microcontroller and motor driver allowed for smooth navigation and decision-making. Moreover, the addition of IoT functionality enabled real-time monitoring and control, opening possibilities for remote operation and future automation. The experimental results confirm the efficiency, reliability, and potential of the system for real-world applications such as smart delivery, surveillance, or assistance for differently-abled individuals. This project lays a solid foundation for further research and innovation in the field of autonomous and IoT-enabled robotic systems.

2) Future Scope:

The IoT-Based Automatic Obstacle Detecting Vehicle has vast potential for future advancements and real-world applications. With the integration of Artificial Intelligence (AI) and Machine Learning (ML), the vehicle can be made smarter by enabling it to learn from its surroundings and make better decisions over time. Object classification can also be implemented to differentiate between various types of obstacles, such as humans, animals, or static objects. By adding a GPS module, the vehicle can be guided through long-distance or predefined routes using path planning algorithms. Incorporating camera modules and computer vision technology would allow the system to recognize objects more accurately and understand its environment better. Additionally, cloud connectivity can be used to store and analyze data for improving navigation and performance. A mobile application can be developed to provide real-time control, monitoring, and alerts, and voice command features can be introduced for ease of operation. Moreover, future versions can be designed to work in coordination with other vehicles (swarm robotics), making them useful in applications like warehouse automation, surveillance, and search-and-rescue missions. With improvements in power efficiency through the use of renewable energy sources like solar panels, the system can also be made more sustainable. Overall, this project holds great promise in shaping the future of autonomous systems and smart transportation.

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