VISVESVARAYA TECHNOLOGICAL UNIVERSITY

BELAGAVI-590018, KARNATAKA.

A PROJECT REPORT

On

"LANE MORPH – MACHINE LERNING POWERED DIVIDER FOR TRAFFIC VOLUME ADAPTATION"

Submitted in Partial Fulfillment for the Award of the Degree

of

BACHELOR OF ENGINEERING

IN

COMPUTER SCIENCE & ENGINEERING

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Certified that the Project Work entitled **"LANE MORPH – MACHINE LEARING POWERED DIVIDER FOR TRAFFIC VOLUME ADAPTATION"** carried out by **ANVITH KRISHNA N (1EE21CS005), ARUN KRUMAR V SAVANUR (1EE21CS008), SHRIVATSA R S (1EE21CS049), UDAYA KUMAR SHETTY (1EE21CS056),** bonafide students of **East West College of Engineering**, in partial fulfillment for the award of **Bachelor of Engineering** in **Computer Science and Engineering** of **Visvesvaraya Technological University**, **Belagavi** during the academic year 2024-2025. It is certified that all corrections/suggestions indicated for Internal Assessment have been incorporated in the report deposited in the Department Library. The project report has been approved as it satisfies the academic requirements in respect of **Project Work (21CSP76)** prescribed for the said degree.

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EXTERNAL EXAMINATION:

Name of the Examiners	**Signature with Date**
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The satisfaction and euphoria that accompany the completion of any task would be incomplete without the mention of the people who made it possible, whose constant guidance and encouragement ground my efforts with success.

I consider it is a privilege to express my gratitude and respect to all those who guided me in completion of project work.

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ABSTRACT

The Lane Morph project leverages advanced machine learning and IoT technologies to tackle the challenges of urban traffic management. Traditional traffic systems often struggle to accommodate varying traffic volumes and emergency situations, leading to congestion and delays. Lane Morph addresses these issues by employing real-time data analytics and adaptive infrastructure. Utilizing image processing and the YOLO algorithm, the system accurately detects and classifies vehicles, enabling precise traffic flow analysis and dynamic lane adjustments to optimize road usage.

A standout feature of Lane Morph is its integration of IoT devices to prioritize ambulance lanes, ensuring swift and unobstructed passage for emergency vehicles. IoT devices continuously monitor and communicate traffic conditions, allowing the system to respond effectively in real-time. This integration not only enhances overall road safety but also significantly improves emergency response times, making urban transportation more efficient and reliable.

The pilot implementation of Lane Morph has shown substantial improvements in traffic flow and congestion reduction. By dynamically reconfiguring lanes based on current traffic conditions, the system effectively manages vehicle density and prevents bottlenecks. This adaptive approach reduces idle times and fuel consumption, thereby minimizing the environmental impact. As the project evolves, it aims to integrate with smart city initiatives and autonomous vehicle technologies, paving the way for intelligent and responsive transportation infrastructures that can meet the evolving demands of modern cities.

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DECLARATION

We **ANVITH KRISHNA N (1EE21CS005), ARUN KUMAR V SAVANUR (1EE21CS008), SHRIVATSA R S (1EE21CS049)** and **UDAYA KUMAR SHETTY (1EE21CS056),** bonafide students of **East West College of Engineering,** hereby declare that the project entitled "**LANE MORPH – MACHINE LEARNING POWERED DIVIDER FOR TRAFFIC VOLUME ADAPTATION**" submitted in partial fulfilment for the award of Bachelor of Engineering in **Computer Science & Engineering** of the Visvesvaraya Technological University, Belgaum during the year 2024-2025 is our original work and the project has not formed the basis for the award of any other degree, fellowship or any other similar titles.

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ABBREVIATION

AC – Alternating Current

DC – Direct Current

IoT – Internet of Things

RGB – Red, Green, Blue (LEDs)

PWM – Pulse Width Modulation

SPI – Serial Peripheral Interface

USB – Universal Serial Bus

GND – Ground

LCD – Liquid Crystal Display

YOLO – You Only Look Once (Object Detection Algorithm)

TTL – Transistor-Transistor Logic

EN – Enable

RS – Register Select

RW – Read/Write

V – Voltage

mA – Milliampere

MHz – Megahertz

KB – Kilobyte

EEPROM – Electrically Erasable Programmable Read-Only Memory

IDE – Integrated Development Environment

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CHAPTER 1

INTRODUCTION

1.1 Background

Efficient traffic management has become a cornerstone of modern urban planning, addressing the growing challenges of congestion, environmental impact, and economic inefficiency. Rapid urbanization has led to a significant rise in vehicle density, with global car ownership expected to reach 2 billion by 2050, as reported by the International Energy Agency (IEA). This surge in vehicles has caused traffic congestion levels to skyrocket, with cities like Mumbai, Manila, and Bogota experiencing average congestion rates exceeding 50%, according to the TomTom Traffic Index.

The implications of this are far-reaching. Traffic congestion costs the global economy over $1 trillion annually due to lost productivity and increased fuel consumption, as highlighted by the World Economic Forum. Furthermore, transportation accounts for nearly 25% of global CO2 emissions, with traffic idling during congestion contributing significantly to air pollution. These inefficiencies also exacerbate public health issues, such as respiratory problems, and hinder emergency response times, potentially putting lives at risk.

Traditional traffic management systems, such as static road dividers and fixed traffic lights, are increasingly ill-suited to cope with the dynamic and unpredictable nature of urban traffic. These systems are rigid, incapable of adapting to real-time traffic conditions, and often result in bottlenecks, inefficient road space utilization, and prolonged delays. For instance, during peak hours, static road dividers fail to accommodate surges in one direction, leaving lanes underutilized on the opposite side. A report by the Institute of Transportation Engineers highlights that inefficient road utilization contributes to a 30% increase in travel times during rush hours in major cities.

To address these challenges, innovative and adaptive traffic management solutions leveraging cutting-edge technologies have become essential. The integration of the Internet of Things (IoT), machine learning, and real-time image processing can revolutionize urban mobility. Smart traffic lights, for example, can use sensors and real-time data to dynamically adjust signal timings based on traffic flow, reducing delays by up to 20%, as demonstrated in pilot projects in Singapore and

Los Angeles. Additionally, dynamic road dividers, powered by IoT, can reallocate lanes based on traffic density, ensuring optimal utilization of road space. Machine learning algorithms can analyze historical and real-time data to predict congestion patterns, enabling proactive measures to prevent bottlenecks. These technologies not only improve traffic flow but also reduce fuel consumption and emissions, supporting global sustainability goals.

Moreover, adaptive traffic management systems play a crucial role in enhancing public safety and emergency response efficiency. Intelligent routing systems can prioritize emergency vehicles, such as ambulances and fire trucks, by creating "green corridors" that allow for uninterrupted travel, potentially saving thousands of lives annually. In India, a study showed that smart traffic systems could reduce emergency response times by up to 40% in urban areas. Beyond immediate benefits, these solutions pave the way for the integration of autonomous vehicles, which rely heavily on real-time traffic data for navigation and safety.

The need for smarter, adaptive traffic management systems is more pressing than ever. By leveraging advancements in technology, cities can address the multifaceted challenges posed by traffic congestion, ensuring economic productivity, environmental sustainability, and improved quality of life for their citizens. As urbanization continues to accelerate, investing in intelligent traffic solutions is not just an option but a necessity for building resilient, efficient, and liveable cities.

1.2 Overview of the Present Work

This project introduces a comprehensive solution in the form of a smart, movable road divider system. The system integrates cutting-edge technologies, including IoT devices, machine learning algorithms, and real-time video processing, to dynamically manage traffic flow and ensure optimal lane allocation. At the core of this system lies the YOLO (You Only Look Once) object detection algorithm, which is utilized to detect and count vehicles on both sides of the road. By analyzing real-time data on traffic density, the system determines the most efficient positioning for the road divider, reallocating lanes dynamically to minimize congestion.

In addition to traffic optimization, the proposed system places significant emphasis on emergency response scenarios. The system employs visual and auditory cues to detect ambulances, ensuring their rapid passage by reallocating road space and dynamically controlling traffic signals. RGB LEDs are employed to provide intuitive visual guidance, signaling changes

in traffic patterns to road users. These LEDs indicate the status of lanes, including priority lanes for emergency vehicles, thereby reducing confusion and improving overall traffic management.

The operational backbone of the system is an Arduino microcontroller, which efficiently manages the movement of the road divider and the RGB LEDs. Using DC motors for physical movement, the Arduino ensures precise and timely adjustments based on real-time data. By combining IoT-enabled hardware and advanced software algorithms, the system delivers a holistic solution to urban traffic management challenges, improving traffic flow, reducing delays, and significantly enhancing emergency response times.

1.3 Problem Statement

Urban traffic systems face numerous challenges due to their inability to adapt to dynamic traffic conditions and emergency scenarios. Traditional road dividers and traffic management tools fail to provide real-time flexibility, resulting in inefficient road utilization and delayed responses to critical emergencies. This project addresses the following question: How can real-time traffic conditions and emergency scenarios be effectively managed using an intelligent and adaptive road divider system?

1.4 Objectives

The aim of this project is to design and implement a smart, adaptable road divider system capable of addressing the dynamic challenges of urban traffic. The specific objectives are as follows:

- **Real-Time Vehicle Detection:** Develop a system that accurately detects and counts vehicles on both sides of the road in real time using advanced image processing algorithms.
- **Dynamic Lane Adjustment:** Implement a mechanism to dynamically adjust the position of the road divider based on real-time traffic density data, optimizing lane usage and reducing congestion.
- **Emergency Vehicle Prioritization:** Integrate visual and auditory detection systems to identify ambulances and other emergency vehicles, ensuring their unobstructed passage .
- **Traffic Signal Integration:** Utilize RGB LED indicators to provide clear and dynamic traffic signaling, guiding road users and minimizing confusion during lane reallocations.
- **IoT-Driven Automation:** Leverage IoT-enabled devices to automate the management of the road divider and traffic signals, reducing the need for manual intervention.

- **Enhanced Traffic Flow:** Achieve measurable improvements in traffic flow efficiency, reducing delays for regular commuters and significantly enhancing emergency response times.

1.5 Project Goal

The goal of the "Machine Learning Powered Divider for Traffic Volume Adaptation" project is to design and implement a dynamic, intelligent traffic management system that adjusts the position of road dividers in real time based on traffic conditions. By integrating machine learning algorithms, the system will predict traffic patterns and optimize lane distribution, improving traffic flow and reducing congestion. The system will also prioritize emergency vehicles, ensuring they can pass unobstructed. With real-time vehicle detection and IoT-enabled automation, the solution aims to enhance road space utilization, minimize delays, improve emergency response times, and provide a sustainable, scalable approach to urban traffic management.

1.6 Scope

The scope of the "Machine Learning-Based Automatic Movable Road Divider" project involves creating a dynamic traffic management system that adjusts road dividers based on real-time traffic data. It includes integrating machine learning for traffic prediction, real-time vehicle detection, and IoT for automation. The system will prioritize emergency vehicles, optimize lane usage, and reduce congestion. It will be scalable, energy-efficient, and adaptable to urban areas, aiming to improve traffic flow, reduce delays, and enhance road safety.

CHAPTER 2
LITERATURE REVIEW

2.1 Summary of Prior Works

Numerous research studies and developments have been undertaken to address the challenges of urban traffic management using movable road dividers, IoT-enabled systems, and smart technologies. The literature reveals key methodologies and technologies proposed to enhance efficiency in traffic management systems.

[1] Movable Traffic Divider: A Congestion Release Strategy

Authors: Advait Kawle, Dhruv Shah, Kavin Doshi, Manish Bakhtiani, Yash Gajja, Pratibha Singh

Publication: International Journal of Recent Advances in Engineering & Technology (IJRAET), 2017

Keywords: Movable traffic dividers, congestion mitigation, dynamic lane allocation

Parameters: Traffic density, road capacity optimization

Description:

This study addresses the inefficiencies of traditional static road infrastructures in urban environments, which struggle to accommodate the increasing number of vehicles. The authors propose a movable traffic divider system that dynamically adjusts lane allocations based on real-time traffic conditions. During peak hours, the system optimizes road capacity by reallocating lanes, eliminating the need for costly road expansions. The study highlights the potential of movable dividers to reduce congestion and improve traffic flow without requiring significant infrastructure changes. The system is designed to be cost-effective and easy to implement, making it suitable for urban areas with limited space and resources.

Limitation: The study lacks a detailed discussion on emergency vehicle prioritization and scalability in diverse urban settings. Additionally, the system's reliance on mechanical components may lead to maintenance challenges over time.

[2] Implementation of Movable Road Divider Using IoT

Authors: Hemlata Dalmia, Kareddy Damini, Aravind Goud Nakka

Publication: International Conference on Computing, Power and Communication Technologies (GUCON), 2018

Keywords: IoT, dynamic lane reallocation, traffic density visualization

Parameters: IoT servers, DC motors, automated decision-making

Description:

This paper introduces an IoT-based system for dynamically shifting road dividers in response to real-time traffic density. The system uses IoT servers to collect and visualize traffic data, enabling automated decision-making for lane reallocation. DC motors are employed to physically move the dividers, reducing the need for manual intervention. The authors emphasize the system's ability to improve traffic flow during peak hours by reallocating lanes based on congestion levels. The integration of IoT technology allows for seamless communication between sensors, servers, and actuators, ensuring efficient and timely adjustments. The study also explores the potential of IoT in reducing human errors and enhancing overall traffic management efficiency.

Limitation: The system's high implementation costs and reliance on continuous IoT connectivity may limit its feasibility in developing regions. Additionally, the study does not address potential cybersecurity risks associated with IoT-based systems.

[3] Design and Implementation of Smart Movable Road Divider Using IoT

Authors: B Durga Sri, K Nirosha, Sheik Gouse

Publication: Proceedings of the International Conference on Intelligent Sustainable Systems (ICISS), 2017

Keywords: IoT, sensors, dynamic lane reallocation

Parameters: Traffic density sensors, automated lane adjustment

Description:

This research presents a smart movable road divider system that leverages IoT and sensor technologies to dynamically reallocate lanes based on traffic density. The system uses sensors to measure the number of vehicles on each side of the road and adjusts the divider position accordingly. The authors highlight the system's ability to reduce congestion and improve traffic flow during peak hours. The study also discusses the integration of IoT for real-time data collection and analysis, enabling the system to make informed decisions without human intervention. The proposed solution is designed to be scalable and adaptable to different urban environments, making it a promising approach for modern traffic management.

Limitation: The study does not explore the integration of emergency vehicle prioritization systems, which could further enhance the system's effectiveness. Additionally, the reliance on IoT infrastructure may pose challenges in areas with limited connectivity.

[4] Software Implementation of an Automatic Movable Road Barrier

Authors: Roopa Ravish, Varun R. Gupta, K.J. Nagesh, Amruth Karnam, Shanta Rangaswamy

Publication: International Carnahan Conference on Security Technology (ICCST), 2019

Keywords: Simulation, traffic density analysis, dynamic barrier adjustment

Parameters: Sensor inputs, congestion analysis

Description:

This paper focuses on the simulation-based implementation of an automatic movable road barrier system. The system uses sensor inputs to analyze traffic density and dynamically adjusts the barrier position to alleviate congestion. The authors emphasize the system's ability to improve travel times and reduce bottlenecks by optimizing lane usage. The study also explores the potential of machine learning algorithms to enhance the system's decision-making capabilities. The simulation results demonstrate the system's effectiveness in managing traffic flow under varying conditions. However, the study acknowledges the need for real-world testing to validate the system's performance in practical scenarios.

Limitation: The study is limited to simulation-based results and lacks real-world implementation data. Additionally, the system's scalability and cost-effectiveness are not thoroughly discussed.

[5] IoT Deployed Automatic Movable Smart Road Divider

Authors: Naveen N, Sowmya C N

Keywords: IoT, real-time traffic management, dynamic lane allocation

Parameters: Sensor data, lane reallocation

Description:

This study proposes an IoT-based smart road divider system designed to address traffic flow inefficiencies caused by static dividers. The system uses real-time sensor data to dynamically reallocate lanes during peak traffic hours, reducing congestion and improving overall traffic flow. The authors highlight the system's ability to adapt to changing traffic conditions without requiring manual intervention. The integration of IoT technology enables seamless communication between sensors and actuators, ensuring timely and accurate adjustments. The study also explores the potential of cloud-based data storage and analysis for enhancing the system's performance.

Limitation: The system's high dependency on IoT infrastructure may pose challenges in areas

with limited connectivity, risks associated with IoT-based system

2.2 Outcome of the Review

The review of the literature reveals significant gaps and challenges in the existing traffic management systems, as follows:

1. **Inflexibility of Static Systems**: Most traditional road divider systems are rigid and cannot adapt to real-time traffic fluctuations, resulting in underutilized lanes during peak hours.
2. **Insufficient Emergency Support**: Emergency vehicle prioritization is often neglected, leading to delayed responses in critical situations.
3. **High Costs and Limited Scalability**: Advanced IoT solutions often require significant investments, making them less feasible for widespread implementation in developing regions.
4. **Reliance on Manual Intervention**: Many systems still rely on manual traffic coordination, which can lead to inefficiencies and delays.
5. **Data and Real-Time Adaptability Issues**: The lack of robust, real-time data integration in existing systems hampers their ability to adapt effectively to traffic conditions.

2.3 Proposed Work

Building upon the limitations identified, the proposed system introduces a smart, IoT-driven movable road divider with the following features:

1. **Real-Time Traffic Analysis**:
    - Utilizing YOLO object detection to detect and count vehicles on both sides of the road.
    - Analysing density data to dynamically adjust lane allocations for smoother traffic flow.
2. **Emergency Vehicle Prioritization**:
    - Advanced visual and auditory detection mechanisms for identifying ambulances and other emergency vehicles.
    - Dynamically reallocating lanes to create priority paths, ensuring minimal delays.
3. **IoT Integration**:
    - Leveraging IoT sensors and microcontrollers to automate road divider adjustments.
    - Employing RGB LEDs for visual traffic indicators, providing clear communication to road users.

4. **Cost-Effective and Scalable Solutions**:
    - A modular design ensures affordability and scalability for implementation across diverse urban environments.
    - Reduces dependency on manual traffic management.
5. **Enhanced Safety and Efficiency**:
    - Integrating traffic signals and smart systems to reduce human errors and ensure optimal lane utilization.
    - Adopting energy-efficient technologies for sustainable operation.

By addressing the gaps identified in the literature, the proposed system aims to deliver an adaptive and efficient traffic management solution, significantly improving urban mobility and reducing congestion.

CHAPTER 3
SYSTEM REQUIREMENTS

3.1 Functional Requirements

The functional requirements define the core capabilities and behaviors of the system, which directly contribute to its objectives:

1. Real Time Traffic Detection

- The system must use video cameras to capture live road conditions.
- Vehicles on both sides of the road must be accurately detected and counted using the YOLO object detection algorithm.

2. Dynamic Divider Adjustment

- Based on the traffic density analysis, the movable divider must shift automatically to allocate additional lanes to the side experiencing higher traffic congestion.
- Movement should be smooth, precise, and timely to prevent traffic disruptions.

3. Emergency Vehicle Identification

- The system should detect emergency vehicles such as ambulances using:
- Visual Features: Identifying vehicle shapes and markings using image recognition.
- Auditory Features: Detecting siren sounds using sound sensors.
- Upon detection, the divider should immediately reconfigure to prioritize a clear path for the emergency vehicle.

4. Traffic Flow Optimization

- The system must dynamically adjust the road divider to ensure efficient traffic flow during peak and non-peak hours.
- It should minimize road space wastage and reduce congestion.

5. Traffic Signal Integration

The system must synchronize with existing traffic lights to coordinate lane reallocations and reduce confusion among road users.

6. Visual Communication

- RGB LEDs should provide clear visual indicators for lane changes.
- Green LEDs signal open lanes for movement.
- Red LEDs alert vehicles to stop or indicate closed lanes.
- Additional indicators for emergency lanes should be provided when applicable.

7. IoT Based Automation

- IoT enabled sensors and devices should automate operations, including:
- Real time data collection.
- Decision making for divider adjustments.
- Communication between hardware components and servers.

8. Data Monitoring and Feedback

- Traffic patterns and system performance should be continuously monitored and logged for optimization.
- The system should provide live feedback through an IoT dashboard to allow real time visibility for traffic authorities.

3.2 Non-Functional Requirements

The nonfunctional requirements ensure that the system operates efficiently, reliably, and securely under varying conditions.

1. Performance

- Real Time Processing: The system must analyze video feeds and adjust the divider in real time with a latency of less than 2 seconds.
- Detection Accuracy: The system should achieve at least 90% accuracy in vehicle detection and density analysis.

2. Reliability

- The system must operate consistently under diverse environmental conditions, including:
- Low light (nighttime).
- Rain and fog (poor visibility).
- Extreme temperatures.

3. Scalability

- The solution should support deployment across different road types, including single lane, multi lane, and highways.
- It must handle increasing traffic data without performance degradation.

4. Energy Efficiency

- The system should use low power IoT devices, energy efficient LEDs, and optimized algorithms to reduce power consumption.

5. Maintainability

- Hardware components should be modular and easy to replace.
- Software updates should be remotely deployable to minimize downtime.

6. Security

- All data communication between devices and servers must use secure protocols (e.g., HTTPS or MQTT with encryption).
- The system should prevent unauthorized access to sensitive components and data.

7. Cost Effectiveness

- The system should use affordable yet robust components, ensuring feasibility for large scale implementation.

8. User Friendliness

- Any monitoring dashboards or control panels should be intuitive and require minimal training for traffic management personnel.

3.3 Software and Hardware Used

SOFTWARE TOOLS

- YOLO Algorithm (You Only Look Once)
- OpenCV
- Embedded C
- Arduino IDE
- IoT Dashboard
- Communication Protocols
    - MQTT
    - HTTP/HTTPS

HARDWARE COMPONENTS

- Camera
- Arduino Mega (ATmega2560)
- DC Motors with H-Bridge Driver (L293D)
- RGB LEDs
- Ultrasonic Sensors
- Sound Sensor
- Power Supply

3.4 HARDWARE COMPONENTS

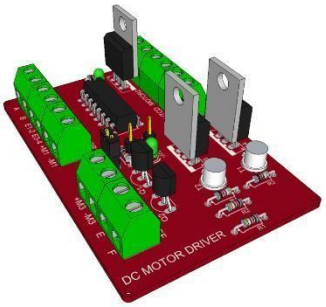
1. Camera

- Captures real time video feeds of the road for vehicle detection.
- Resolution: HD or higher for optimal detection accuracy.

2. Arduino Mega (ATmega2560)

The Arduino Mega is a powerful microcontroller board used in DIY projects, robotics and automation systems. It features 54 digital input/out pins for connecting any type of sensors or devices needed to create complex projects and automated control systems.

3. DC Motors with H Bridge Driver (L293D)



- Controls the movement of the road divider with precision.
- Features:
- Dual channel motor driver.
- Supports bi directional control for smooth divider adjustments.

4. RGB LEDs

- Visual indicators for lane changes and emergency lanes.
- Controlled via the Arduino to display real time traffic signals.

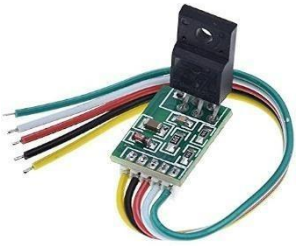
5. Ultrasonic Sensors

Measures traffic density by detecting the presence and movement of vehicles.

6. Sound Sensor

Detects sirens of emergency vehicles for lane prioritization.

7. Power Supply



- Provides stable power to all components, including:
- 5V supply for Arduino and sensors.
- Dedicated power for motors.

CHAPTER 4
SYSTEM DESIGN

4.1 System Architecture

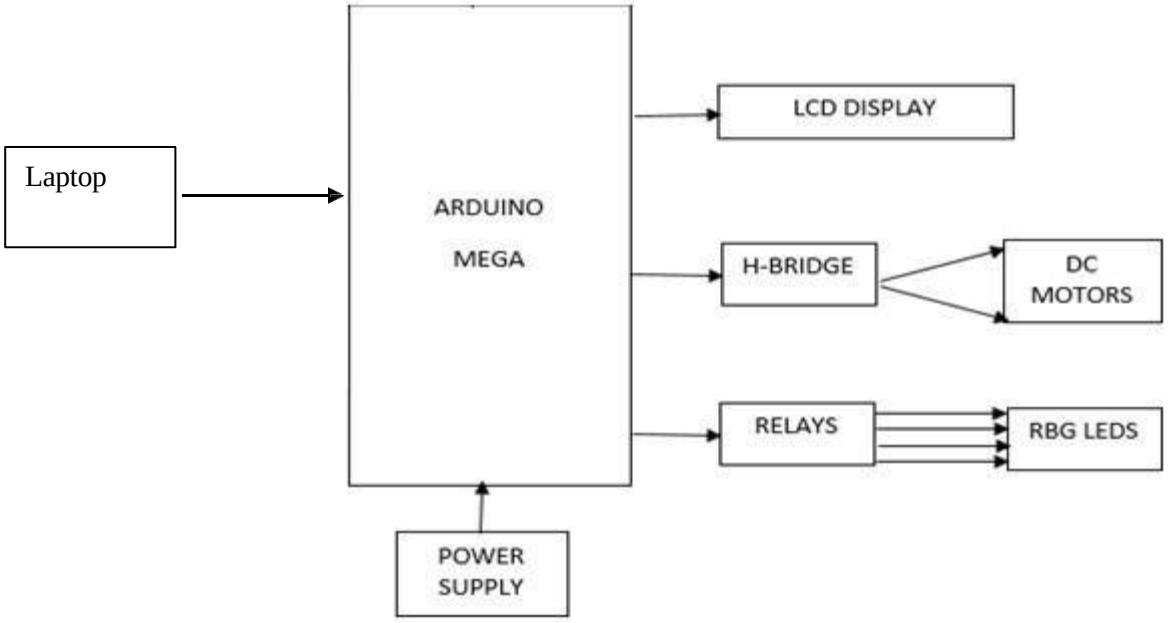


Figure 4.1: Block diagram of Proposed System

1. A camera captures real-time video of the road, which is processed using the YOLO algorithm to detect and count vehicles on both sides.
2. Vehicle density is analyzed, and the Arduino-controlled divider moves to allocate more space to the higher-density side.
3. Ambulances are detected through their visual features and siren sounds. Upon detection, the divider moves to create a wider path for the ambulance.
4. RGB LEDs indicate the status: red LEDs light up on the ambulance's side, while green LEDs signal traffic flow on the opposite side.
5. The Arduino system coordinates the DC motors and LED outputs for smooth operation.

For the successful approach we are using sensors and for the execution we are using H-bridge and for the controlling operations we are using ATmega2560 microcontroller.

When the car comes near the artificial position, the proximity sensor senses the car and gives its output to the microcontroller. The H-bridge is used for the forward and reverse movement of the divider.

4.2 Flow Chart

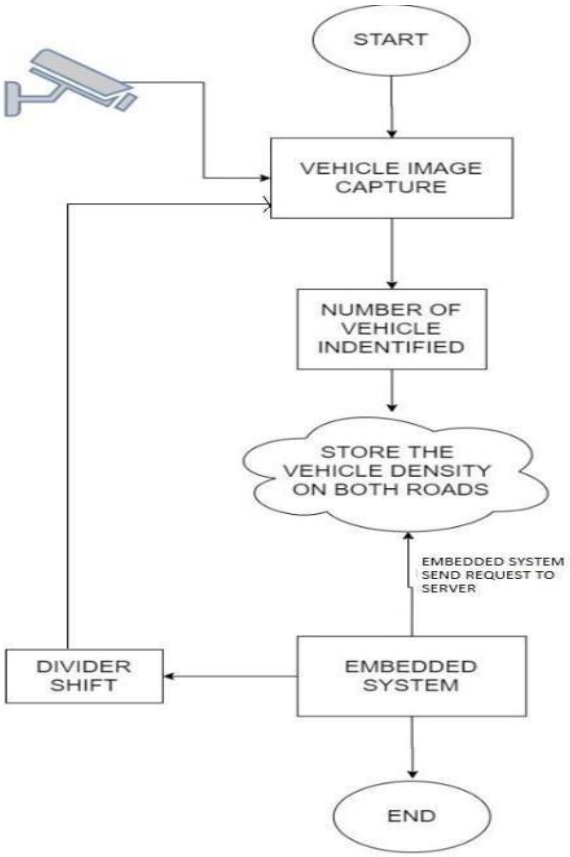


Figure 4.2: Flow chart of Proposed System

The diagram outlines a systematic process for a traffic management system that utilizes movable road dividers to optimize traffic flow. The process begins with the capture of real-time vehicle images using cameras, which are then analyzed to determine the number of vehicles on both sides of the road. This data, representing vehicle density, is stored for further processing. The embedded system, likely powered by a microcontroller like Arduino, plays a central role in handling the data and controlling the system's operations.

It sends requests to a server for advanced data processing and decision-making. Based on the analyzed data, the system dynamically adjusts the position of the movable road divider to ensure optimal traffic flow. This cycle of capturing, analyzing, and adjusting continues, ensuring

efficient traffic management. The process concludes once the adjustments are made, ready to start again as traffic conditions change.

This flow aligns with the project's goal of leveraging real-time vehicle detection and IoT integration to create an adaptive and efficient traffic management solution.

4.3 UML Diagram

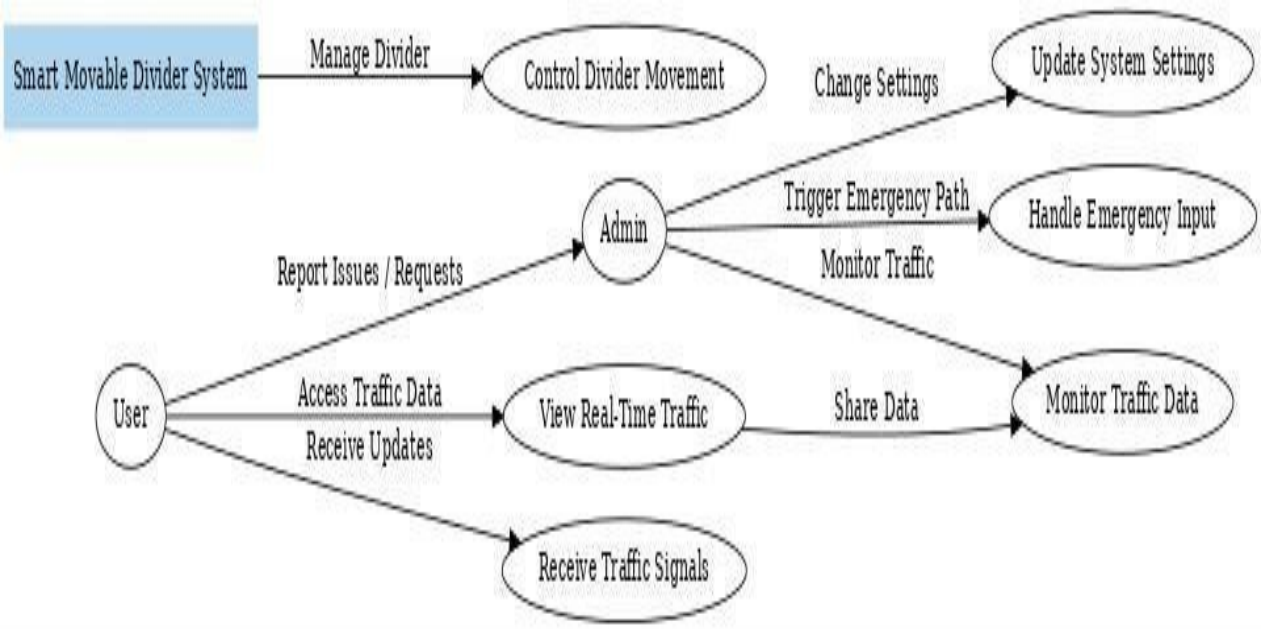


Figure 4.3: UML Diagram

The Smart Movable Divider System is an advanced traffic management solution designed to optimize traffic flow and enhance road safety. The system allows administrators to manage and control the movement of the divider, adjust system settings, and prioritize emergency pathways. It also enables real-time monitoring and handling of emergency inputs, ensuring quick responses to critical situations.

Users can access real-time traffic data, view live updates, and share information, making it easier to navigate traffic conditions. The system provides notifications and traffic signals to keep users informed about changes, ensuring a seamless and efficient traffic management experience. By combining adaptive divider movement, emergency prioritization, and real-time data sharing, the system aims to reduce congestion and improve overall road safety.

4.4 Use Cases

- **Urban Traffic Management**:
  - The system can be deployed in urban areas with high traffic congestion to dynamically adjust lane allocations, reducing bottlenecks during peak hours.
- **Emergency Vehicle Prioritization**:
  - In emergencies, the system creates priority lanes for ambulances, fire trucks, and police vehicles, ensuring faster response times.
- **Event Traffic Control**:
  - During large public events, the system can adapt to sudden changes in traffic flow, ensuring smooth movement and minimizing delays.
- **Highway Traffic Optimization**:
  - On highways, the system can adjust dividers to manage traffic density, especially during accidents or road maintenance.
- **Smart City Integration**:
  - The system can be integrated into smart city infrastructures, providing real-time traffic data to other systems like public transport and traffic signal networks.
- **Data-Driven Decision Making**:
  - Authorities can use the system's traffic data to analyze patterns, plan road expansions, and implement long-term traffic management strategies.
- **User Awareness and Safety**:
  - By providing real-time traffic updates and signals, the system helps drivers make informed decisions, reducing accidents and improving road safety.

4.5 Sequence Diagram

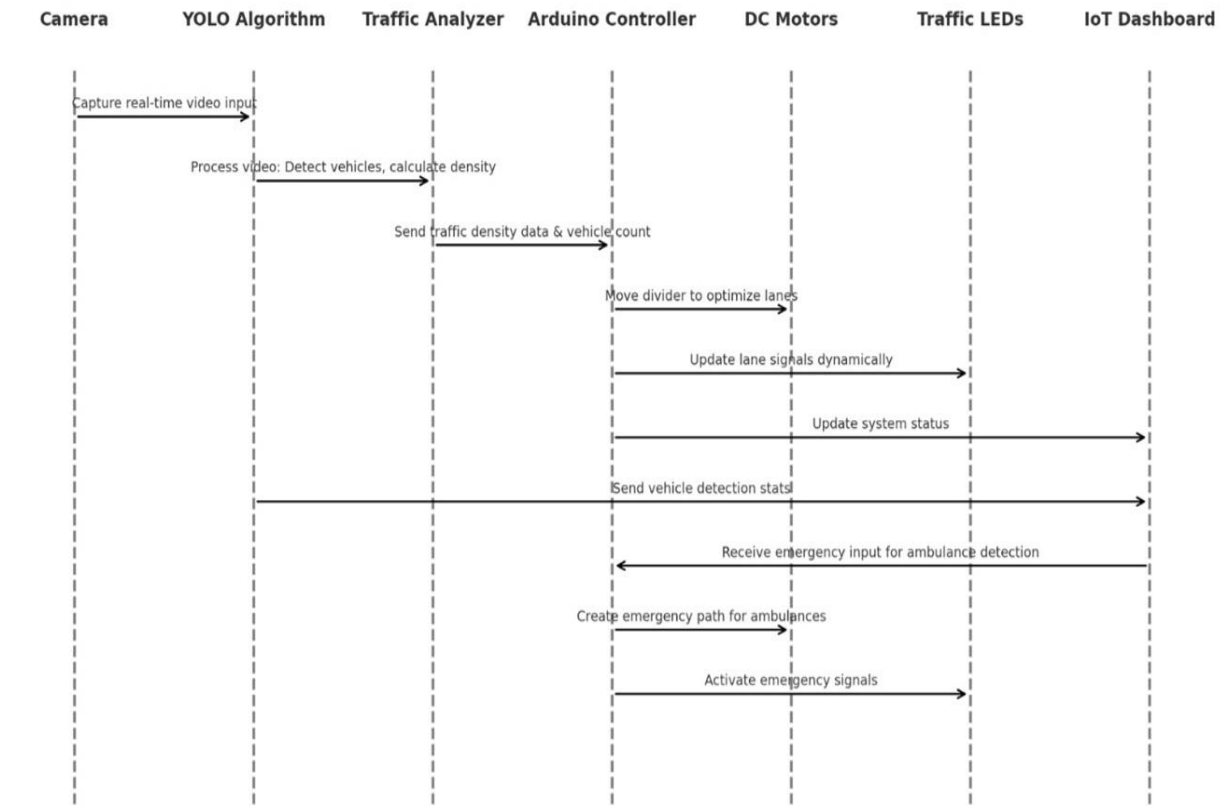


Figure 4.4: Sequence Diagram

The given sequence diagram represents an intelligent traffic management system that utilizes real-time video processing and IoT-based automation to optimize traffic flow and handle emergency situations. The system consists of multiple components working in synchronization.

First, a camera captures real-time video input of the traffic at an intersection. This video feed is then processed by a YOLO Algorithm, which detects vehicles and calculates traffic density. The processed data, including the vehicle count and congestion levels, is sent to the Traffic Analyzer, which further interprets the information and forwards it to the Arduino Controller. The Arduino Controller then sends signals to DC motors to move lane dividers dynamically, optimizing traffic lanes based on real-time congestion. Simultaneously, the Traffic LEDs are updated dynamically to manage lane signals, ensuring efficient traffic movement.

Additionally, the system incorporates an emergency response mechanism. If an ambulance or other emergency vehicle is detected, an emergency signal is sent to the Arduino Controller. The controller then prioritizes creating a clear path by adjusting the lane dividers and activating emergency signals through the Traffic LEDs. The system status and traffic data are

continuously updated on an IoT dashboard, allowing remote monitoring and analysis.

This intelligent traffic system leverages AI-powered object detection and IoT automation to enhance urban traffic management, reduce congestion, and provide a dedicated emergency response mechanism, improving overall road safety and efficiency.

4.6 Activity Diagram

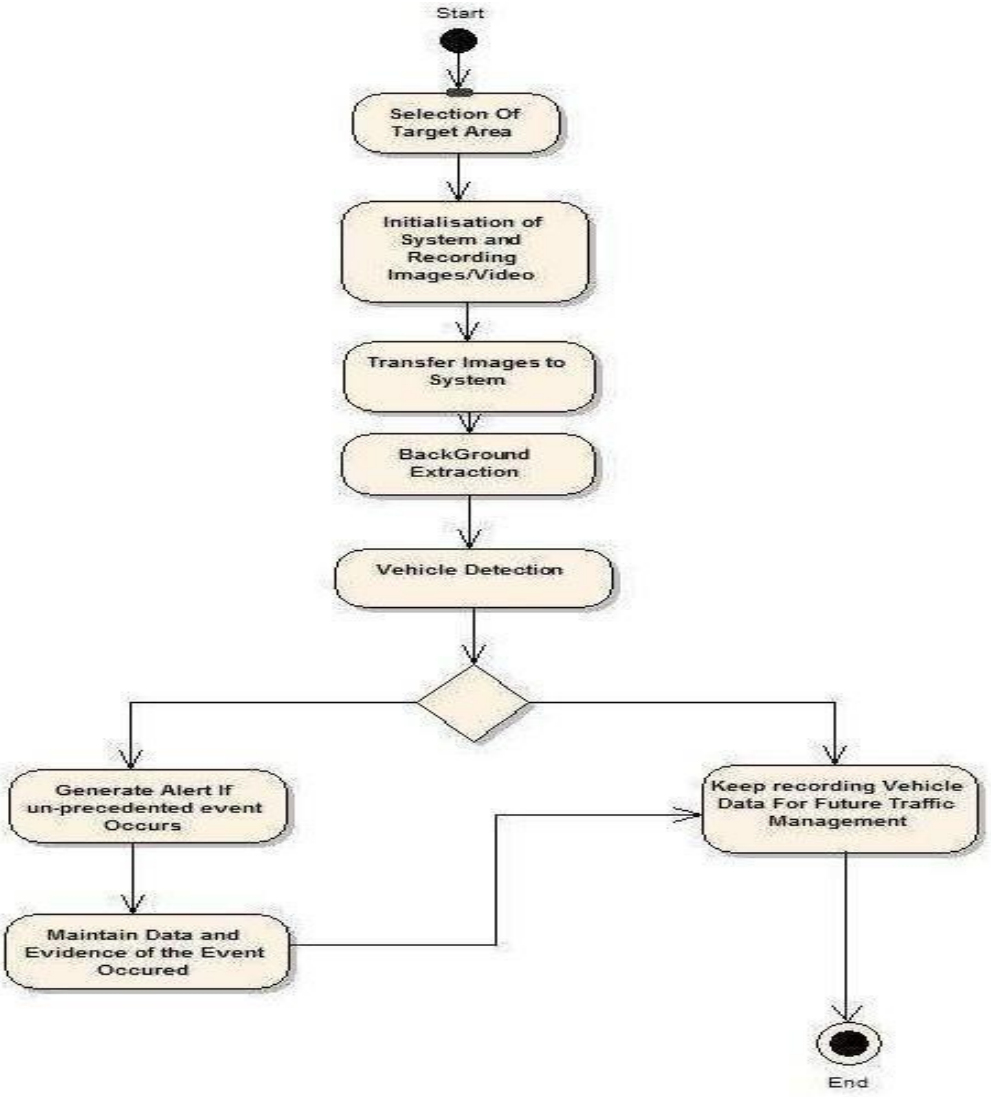


Figure 4.5: Activity Diagram

The flowchart represents a vehicle detection and traffic monitoring system designed to enhance road safety and optimize traffic management. The process begins with the selection of a target area, where the system is deployed to monitor traffic. Once activated, it starts recording images and videos, capturing real-time footage of vehicles in the selected location. These recorded images are then transferred to the system for further processing. The next step

involves background extraction, where the system differentiates moving vehicles from the static background to enable accurate detection.

Once vehicle detection is performed, the system reaches a decision point. If an unprecedented event such as an accident, traffic violation, or abnormal activity is detected, the system generates an alert to notify the relevant authorities and maintains data and evidence for future analysis. If no unusual events occur, the system continues recording vehicle data to help improve future traffic management strategies. This data can be used for analyzing traffic patterns, optimizing signal timings, and improving overall road infrastructure.

This intelligent traffic monitoring system plays a crucial role in smart city implementations, helping authorities automate surveillance, improve emergency response times, and ensure smooth traffic flow. By leveraging real-time image processing and automated alert mechanisms, the system enhances road safety, reduces congestion, and facilitates data-driven decision-making for better urban mobility.

CHAPTER 5
METHODOLOGY

5.1 Overview of Methodology

The methodology of this project focuses on designing and implementing a dynamic movable road divider system that adapts to traffic density and prioritizes emergency vehicles like ambulances. The system integrates image processing, machine learning, and IoT technologies. Below is a comprehensive overview of the methodology:

1. Problem Definition

Traffic congestion and emergency response delays are critical issues in urban transportation systems. Traditional static road dividers contribute to inefficiencies as they cannot adapt to real-time traffic fluctuations. The proposed system aims to develop a smart road divider that dynamically adjusts lanes based on real-time traffic density analysis and prioritizes emergency vehicles.

2. Hardware and Software Requirements

To implement the proposed system effectively, a combination of hardware and software components is required:

- **Hardware:**
  - High-resolution cameras for real-time traffic monitoring.
  - Arduino Mega 2560 for microcontroller-based operations.
  - DC motors with an H-Bridge driver for divider movement.
  - RGB LEDs for visual traffic signals.
  - Sound sensors to detect ambulance sirens.
- **Software:**
  - YOLO (You Only Look Once) algorithm for object detection.
  - OpenCV for real-time image processing.
  - Embedded C for Arduino programming.
  - MQTT protocol for IoT-based communication.
  - Cloud-based analytics for data storage and predictive analysis.

3. Data Collection

- Cameras installed along the roads capture real-time video streams.
- Datasets of various traffic conditions, vehicle types, and emergency vehicles are created.
- The collected data is pre-processed to enhance image quality and reduce noise.
- Annotations are applied to label vehicles and ambulances for training the detection model.

4. Real-time Processing with YOLO Algorithm

The YOLO object detection algorithm is integrated to:

- Detect and classify vehicles in real-time.
- Accurately count vehicles on both sides of the road.
- Identify emergency vehicles using shape recognition and siren sound detection.
- Generate density maps for traffic flow analysis.

5. Density-Based Divider Adjustment

- The system continuously monitors vehicle density on both sides of the road.
- The Arduino-controlled DC motors adjust the divider position dynamically based on density analysis.
- The divider movement is smooth and non-disruptive to ongoing traffic.

6. Emergency Response Mechanism

- Sound sensors detect ambulance sirens in addition to visual recognition.
- Upon detection, the system prioritizes emergency vehicle movement by reallocating lanes.
- RGB LEDs signal to other vehicles to yield for emergency response.
- Real-time alerts are sent to connected traffic management systems for further coordination.

7. Traffic Signal Management

- The system integrates RGB LEDs for traffic signaling.
- Red, Green, and Blue LEDs are used to indicate lane availability, divider movement, and emergency priority.
- The LED signals are synchronized with divider adjustments to prevent confusion among drivers.

8. Testing and Deployment

- **Controlled Environment Testing:**
    - Prototype testing in simulated traffic environments.
    - Evaluating system response time, detection accuracy, and mechanical efficiency.
- **Real-World Deployment:**

  - Pilot deployment in urban traffic scenarios.
  - Performance monitoring for real-time adaptability and emergency response effectiveness.
- **Iterative Improvements:**
  - Continuous refinement based on real-world data and user feedback.
  - Enhancements in machine learning models for improved detection accuracy.
  - Upgrades in hardware and software for scalability and efficiency.

5.2 Major Algorithm Used

The primary algorithm utilized in this project is the **YOLO (You Only Look Once)** object detection algorithm. It is a deep-learning-based approach that enables real-time object detection with high accuracy and efficiency.

1. Algorithm Type

- YOLO is a single-stage object detection algorithm based on **Convolutional Neural Networks (CNNs)**.
- Unlike traditional object detection methods like R-CNN or Faster R-CNN, which use a two-stage approach, YOLO performs detection in a **single pass**, making it significantly faster.

2. Workflow

The YOLO algorithm follows a structured approach for detecting objects in an image:

- **Image Processing:** The input image is resized and normalized before processing.
- **Grid-based Segmentation:** The image is divided into a grid (e.g., 13×13 or 19×19), and each cell is responsible for detecting objects within its boundaries.
- **Bounding Box Prediction:** Each grid cell predicts multiple bounding boxes with confidence scores and class probabilities.
- **Non-Maximum Suppression (NMS):** Redundant and overlapping bounding boxes are filtered out using NMS to retain only the most relevant detections.

3. Training Process

- The YOLO model is trained on a **custom dataset** containing images of roads, vehicles, and ambulances, ensuring adaptability to real-world traffic conditions.
- **Bounding box annotations** are manually labeled for accurate model training.

- **Data augmentation techniques** (such as flipping, rotation, and brightness adjustments) are applied to enhance the model's robustness against different lighting and weather conditions.
- The model undergoes multiple iterations using a **pretrained YOLOv5 backbone** (such as YOLOv5s, YOLOv5m) to achieve optimal accuracy.
- **Loss Function Used:** The training minimizes a combination of three loss components:
    - **Classification loss** (to predict correct labels for detected objects).
    - **Localization loss** (to refine the bounding box coordinates).
    - **Objectness loss** (to ensure the model detects actual objects rather than background noise).

4. Real-time Detection

The trained YOLO model is deployed to process live video streams:

- **Camera feeds** from road intersections are continuously analyzed.
- **Vehicle counting and classification:** The system detects cars, buses, two-wheelers, and ambulances in real time.
- **Ambulance detection:** Specialized features such as **color, siren lights, and markings** are used to identify emergency vehicles.
- **Night-time and low-light detection:** Infrared-assisted image enhancement is integrated to improve performance in dark conditions.

5. Integration with Arduino

- YOLO's **detection results are sent as structured data** (vehicle count, lane occupancy, ambulance presence) to an **Arduino Mega** microcontroller.
- The Arduino then processes these signals to:
    - Move the **dynamic road divider** using **DC motors and H-Bridge drivers**.
    - Change **RGB LED indicators** to signal lane modifications.
    - Trigger an **alarm/buzzer** when an ambulance is detected for prioritization.

6. Improvements in YOLO for Traffic Management

- **YOLOv5 is chosen over earlier versions (YOLOv3, YOLOv4)** because:
    - It is **lighter and faster**, making it suitable for real-time applications.
    - It supports **anchor-free detection**, reducing computational load.
    - It has an improved **feature pyramid network (FPN)** for detecting vehicles at

varying scales.

- **Edge AI deployment:** The model can be optimized to run on **Jetson Nano** or **Raspberry Pi** for lightweight processing.
- **Cloud Integration:** The detected traffic data can be uploaded to an **IoT-based cloud dashboard** for remote monitoring.

7. Advantages

- **High Speed & Accuracy:** YOLO processes video frames at over **30 FPS**, making it ideal for real-time applications.
- **Minimal False Positives:** Non-Maximum Suppression ensures that overlapping detections are eliminated.
- **Efficient Resource Utilization:** Unlike Faster R-CNN, which requires high-end GPUs, YOLO can run on mid-range hardware.
- **Effective in Complex Scenarios:** Can handle **multiple vehicle types, occlusions, and varying lighting conditions**.

This enhanced methodology ensures that the **Lane Morph** system achieves efficient, adaptable, and intelligent traffic management, minimizing delays and improving emergency response times.

CHAPTER 6
IMPLEMENTATION

The step-by-step implementation of the Smart Movable Road Divider Using IoT, focusing on hardware integration, software development, and system testing. Each subsystem is designed to ensure smooth functionality and real-time adaptability to traffic conditions.

6.1 Overview

- The system utilizes real-time video feeds captured by cameras installed along the road. These cameras continuously monitor traffic flow on both sides of the divider, serving as the primary input for analyzing the traffic conditions and densities.
- The YOLO (You Only Look Once) algorithm, a robust deep learning-based object detection method, is employed to detect vehicles and ambulances within the video feed. The algorithm identifies and classifies objects by creating bounding boxes around them, distinguishing between different types of vehicles, and maintaining a count of the number of vehicles on each side of the road.
- After detecting and classifying vehicles, the system performs a comparative analysis of the traffic density on both sides of the road. The vehicle counts are analyzed to determine which side has higher congestion, providing a basis for deciding the movement of the divider.
- Based on the traffic density analysis, the system dynamically adjusts the position of the road divider. This is achieved using Arduino Mega 2560, which controls DC motors connected to the divider through H-bridge circuits. The divider is moved to allocate additional lanes to the side with higher vehicle density, optimizing road usage.
- The system integrates both visual and auditory detection mechanisms for ambulances. Visually, the YOLO algorithm identifies ambulances based on their distinctive features, such as shape and markings, while a sound sensor detects sirens. Upon detecting an ambulance, the system prioritizes its passage by dynamically reallocating the divider to create a wider path, ensuring quicker emergency response times.
- To effectively manage traffic flow during divider adjustments, RGB LEDs are utilized as dynamic traffic signals. These LEDs are controlled by the Arduino and change colors to indicate lane status. For example, red LEDs signal lanes blocked for movement, while green LEDs guide the free flow of vehicles.

- The system operates on a real-time feedback loop, continuously processing the live video feed and updating vehicle counts. This ensures that the divider position is adjusted dynamically and consistently based on changing traffic conditions throughout the day.
- All system components, including the camera, Arduino Mega, motors, RGB LEDs, and sound sensors, are integrated into a functional prototype. Extensive testing is conducted in controlled environments to validate the system's performance in detecting vehicles, counting traffic, moving the divider, and controlling signals before deploying the solution on real roads.
- By implementing this intelligent movable road divider, the system is expected to reduce traffic congestion significantly, ensuring better utilization of road resources during peak hours. Moreover, the system facilitates faster response times for ambulances and other emergency vehicles by dynamically prioritizing their movement. This innovative solution improves overall traffic management and aligns with the goals of smart city infrastructure.

6.2 Module 1: Hardware Module

1. Camera

Captures real time video feeds of the road for vehicle detection.

Resolution: HD or higher for optimal detection accuracy.

2. Arduino Mega (ATmega2560)

The Arduino Mega2560 can be powered via the USB connection or with an external power supply. The power source is selected automatically. External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack.

Leads from a battery can be inserted in the Gnd and Vin pin headers of the POWER connector. The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts.

The Mega2560 differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega8U2 programmed as a USB-to-serial converter.

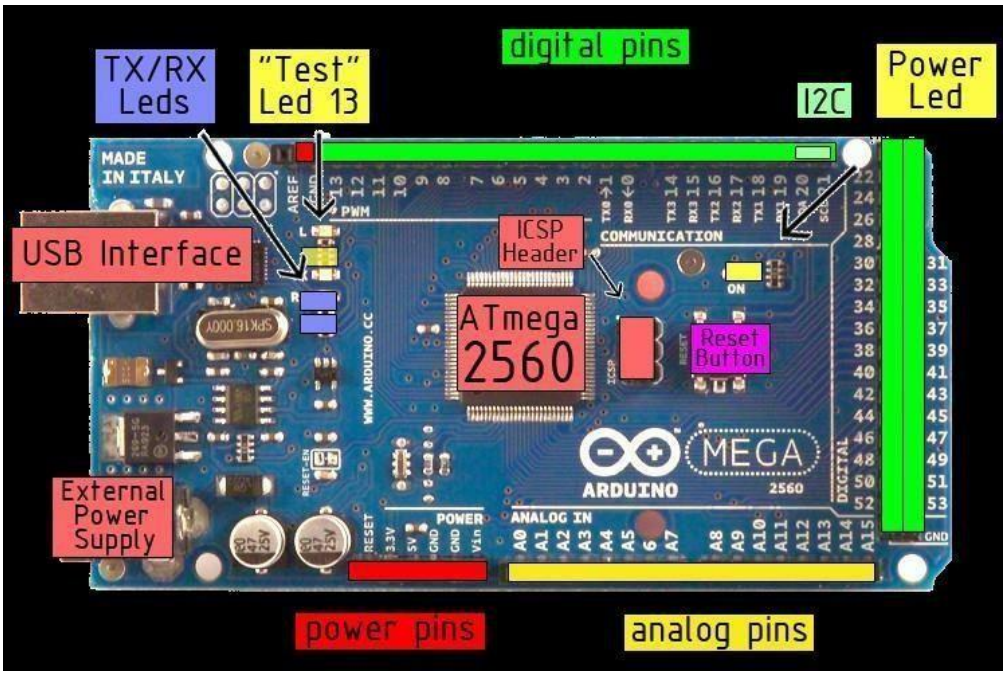


Fig 6.1: Arduino mega

Technical Specifications:

- Microcontroller ATmega2560
- Operating Voltage 5V
- Input Voltage (recommended) 7-12V
- Input Voltage (limits) 6-20V
- Digital I/O Pins 54 (of which 14 provide PWM output)
- Analog Input Pins 16
- DC Current per I/O Pin 40 mA
- DC Current for 3.3V Pin 50 mA
- Flash Memory 256 KB of which 8 KB used by bootloader
- SRAM 8 KB
- EEPROM 4 KB
- Clock Speed 16 MHz

Pin Diagrams:

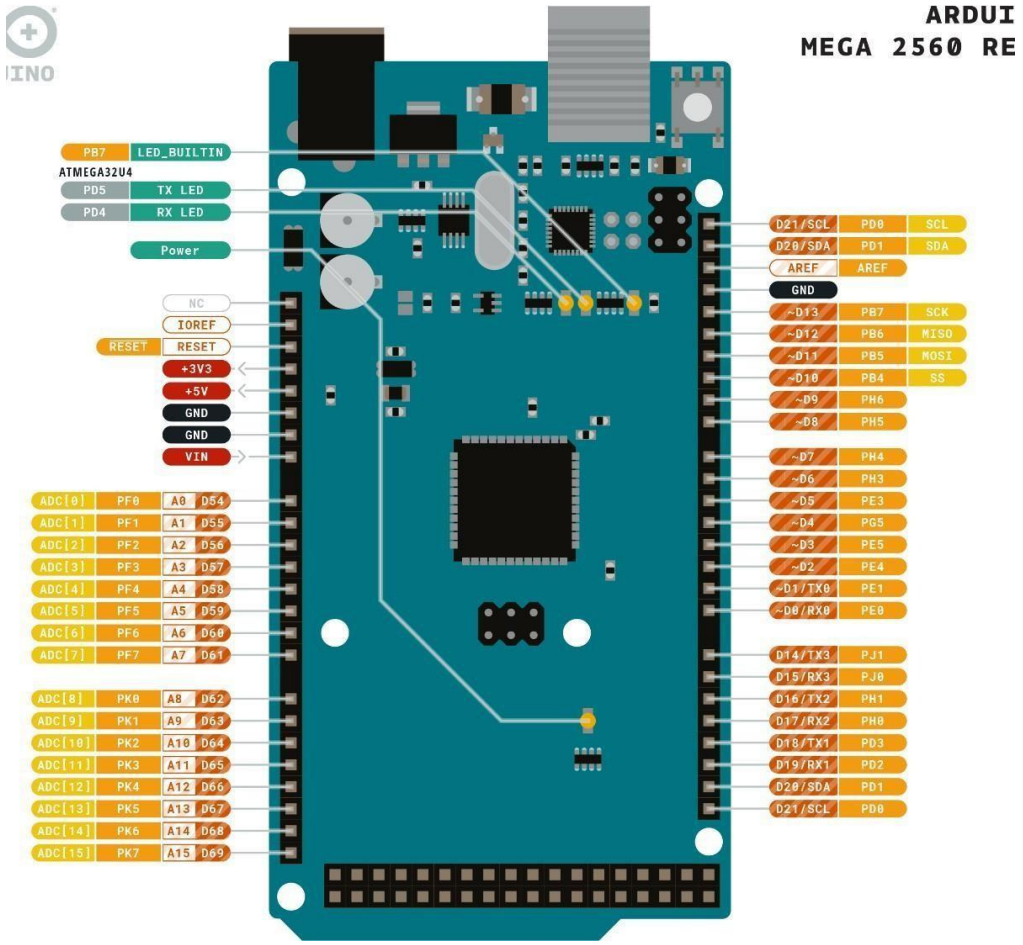


Figure 6.2: Pin Diagram

The power pins are as follows:

- **VIN.** The input voltage to the Arduino board when it's using an external power source (as opposed to 5 volts from the USB connection or other regulated power source). You can supply voltage through this pin, or, if supplying voltage via the power jack, access it through this pin.
- **5V**. The regulated power supply used to power the microcontroller and other components on the board. This can come either from VIN via an on-board regulator, or be supplied by USB or another regulated 5V supply.
- **3V3.** A 3.3 volt supply generated by the on-board regulator. Maximum current draw is 50 mA.
- **GND.** Ground pins

Serial: 0 (RX) and 1 (TX); Serial 1: 19 (RX) and 18 (TX); Serial 2: 17 (RX) and 16 (TX); Serial 3: 15 (RX) and 14 (TX). Used to receive (RX) and transmit (TX) TTL serial data. Pins 0 and 1 are also connected to the corresponding pins of the ATmega8U2 USB-to-TTL Serial chip.

External Interrupts: 2 (interrupt 0), 3 (interrupt 1), 18 (interrupt 5), 19 (interrupt 4), 20 (interrupt 3), and 21 interrupt 2). These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value. See the attachInterrupt() function for details. **PWM:** 0 to 13. Provide 8-bit PWM output with the analogWrite() function.

SPI: 50 (MISO), 51 (MOSI), 52 (SCK), 53 (SS). These pins support SPI communication, which, although provided by the underlying hardware, is not currently included in the Arduino language. The SPI pins are also broken out on the ICSP header, which is physically compatible with the Duemilanove and Diecimila.

4.5.1 Arduino Software

- The Arduino is a single-board microcontroller solution for many DIY projects, we will look at the Integrated Development Environment, or IDE, that is used to program it. Once the installer has downloaded, go ahead and install the IDE. Arduino IDE is an open source software that is mainly used for writing and compiling the code into the Arduino Module.
- It is an official Arduino software, making code compilation too easy that even a common person with no prior technical knowledge can get their feet wet with the learning process.

4.5.2 Download the IDE:

First, you must download the IDE and install it. Start by visiting Arduino‘s software page. The IDE is available for most common operating systems, including Windows,Mac OS X, and Linux, so be sure to download the correct version for your OS. If you are using Windows 7 or older, do not download the Windows app version, as this requires Windows 8.1 or Windows 10.

➢ Arduino IDE:

The Arduino IDE is incredibly minimalistic, yet it provides a near-complete environment for most Arduino-based projects. The middle section of the IDE is a simple text editor that where you can enter the program code. The bottom section of the IDE is dedicated to an output window that is used to see the status of the compilation, how much memory has been used, any errors that were found in the program, and various other useful messages.

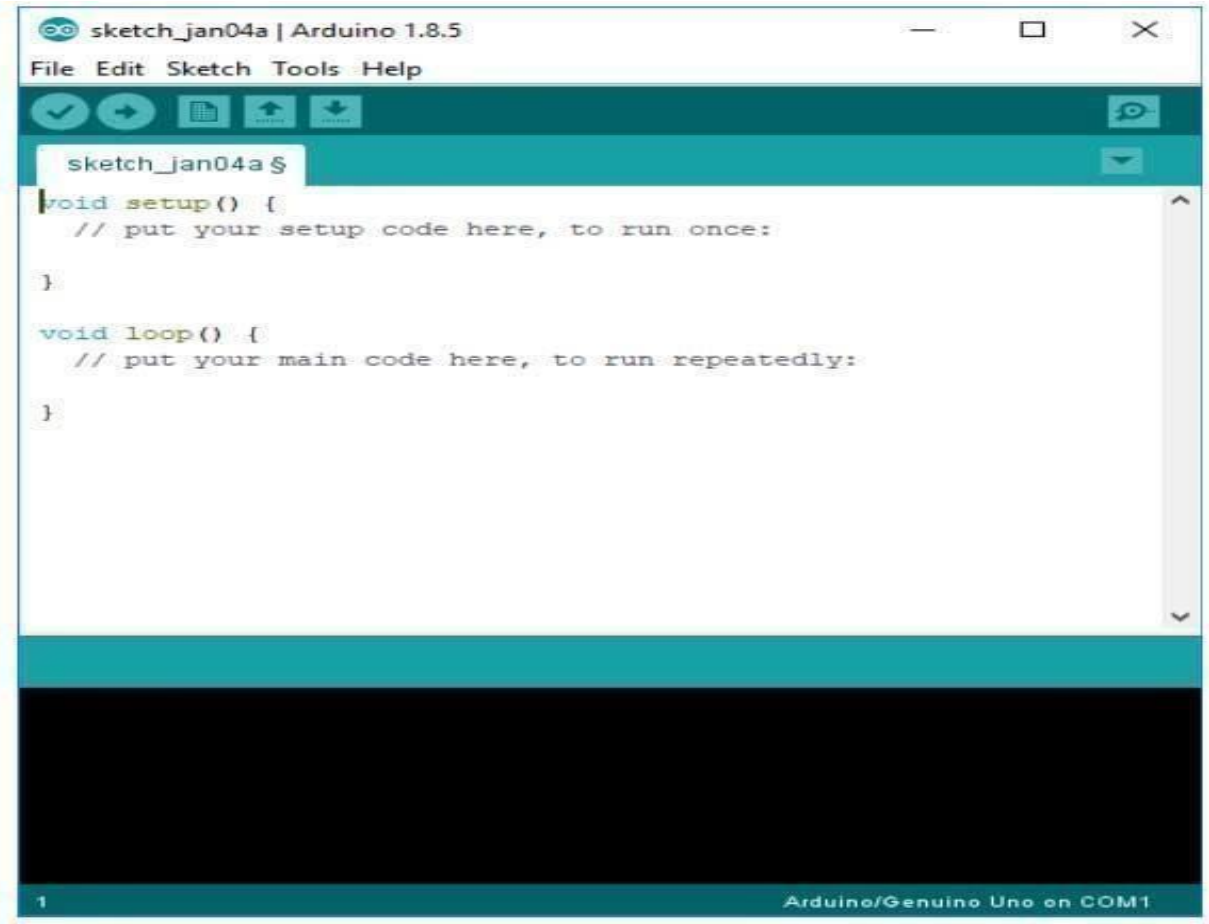


Figure 6.3: Arduino program dumping window

Projects made using the Arduino are called sketches, and such sketches are usually written in a cut-down version of C++ (a number of C++ features are not included). Because programming microcontroller is somewhat different from programming a computer, there are a number of device-specific libraries. This sometimes confuses users who think Arduino is programmed in an ―Arduino language. I However, the Arduino is, in fact, programmed in C++. It just uses unique libraries for the device.

➢ The 6 Buttons:

While more advanced projects will take advantage of the built-in tools in the IDE, most projects will rely on the six buttons found below the menu bar.

Figure 6.4: The button bar

1. The check mark is used to verify your code. Click this once you have written your code.
2. The arrow uploads your code to the Arduino to run.
3. The dotted paper will create a new file.
4. The upward arrow is used to open an existing Arduino project. 5.The downward arrow is used to save the current file.
6. The far right button is a serial monitor, which is useful for sending data from the Arduino to the PC for debugging purposes.

➢ Arduino Hardware:

Arduino is open-source hardware. The hardware reference designs are distributed under a Creative Commons Attribution Share-Alike 2.5 license and are available on the Arduino website. Layout and production files for some versions of the hardware are also available. The boards use single or double-row pins or female headers that facilitate connections for programming and incorporation into other circuits. These may connect with add-on modules termed shields. Multiple and possibly stacked shields may be individually addressable via an I²C serial bus. Most boards include a 5 V linear regulator and a 16 MHz crystal oscillator or ceramic resonator. Some designs, such as the Lily Pad, run at 8 MHz and dispense with the onboard voltage regulator due to specific form-factor restrictions.

Most Arduino boards consist of an Atmel 8-bit AVR microcontroller (ATmega8, ATmega168, ATmega328, ATmega1280, ATmega2560) with varying amounts of flash memory, pins, and features. Arduino microcontrollers are pre-programmed with a boot loader that simplifies uploading of programs to the on-chip flash memory. The default bootloader of the Arduino UNO is the optiboot bootloader. Boards are loaded with program code via a serial connection to another computer. Some serial Arduino boards contain a level shifter circuit to

convert between RS-232 logic levels and transistor–transistor logic (TTL) level signals. Current Arduino boards are programmed via Universal Serial Bus (USB), implemented using USB-to-serial adapter chips such as the FTDI FT232. Some boards, such as later-model Uno boards, substitute the FTDI chip with a separate AVR chip containing USB-to-serial firmware, which is reprogrammable via its own ICSP header. Other variants, such as the Arduino Mini and the unofficial Boarduino, use a detachable USB-to-serial adapter board or cable, Bluetooth or other methods. When used with traditional microcontroller tools, instead of the Arduino IDE, standard AVR in-system programming (ISP) programming is used.

The Arduino board exposes most of the microcontroller's I/O pins for use by other circuits. Uno provide 14 digital I/O pins, six of which can produce pulse-width modulated signals, and six analog inputs, which can also be used as six digital I/O pins. These pins are on the top of the board, via female 0.1-inch (2.54 mm) headers. Several plug-in application shields are also commercially available. The Arduino Nano, and Arduino-compatible Bare Bones Board and Boarduino boards may provide male header pins on the underside of the board that can plug into solderless breadboards.

There are several I/O digital and analog pins placed on the board which operates at 5V. These pins come with standard operating ratings ranging between 20mA to 40mA. Internal pullup resistors are used in the board that limits the current exceeding from the given operating conditions. However, too much increase in current makes these resisters useless and damages the device.

➢ Power Supply:

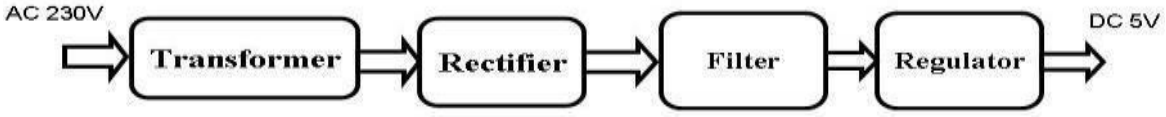


Figure 6.5: Power Supply

The transformer 230Volts will be stepped down to 12-0-12 one side of the 12V is given to the 7805 and Lm317.In this project the microcontroller requires +5V power supply. The design description of power supply is given below.

➢ Transformer:

A transformer is a device that transfers electrical energy from one circuit to another through inductively coupled conductors without changing its frequency. A varying current in the first or primary winding creates a varying magnetic flux in the transformer's core, and thus a varying magnetic field through the secondary winding. This varying magnetic field induces a varying electromotive force (EMF) or "voltage" in the secondary winding. This effect is called mutual induction. If a load is connected to the secondary, an electric current will flow in the secondary winding and electrical energy will be transferred from the primary circuit through the transformer to the load. This field is made up from lines of force and has the same shape as a bar magnet. If the current is increased, the lines of force move outwards from the coil. If the current is reduced, the lines of force move inwards. If another coil is placed adjacent to the first coil then, as the field moves out or in, the moving lines of force will "cut" the turns of the second coil. As it does this, a voltage is induced in the second coil. With the 50 Hz AC mains supply, this will happen 50 times a second. This is called MUTUAL INDUCTION and forms the basis of the transformer.

➢ Rectifier:

A rectifier is an electrical device that converts alternating current (AC) to direct current (DC), a process known as rectification. Rectifiers have many uses including as components of power supplies and as detectors of radio signals. Rectifiers may be made of solid-perform the opposite function (converting DC to AC) is known as an inverter. When only one diode is used to rectify AC (by blocking the negative or positive portion of the waveform), the difference between the term diode and the term rectifier is merely one of usage, i.e., the term rectifier describes a diode that is being used to convert AC to DC. Almost all rectifiers comprise a number of diodes in a specific arrangement for more efficiently converting AC to DC than is possible with only one diode. Before the development of silicon semiconductor rectifiers, vacuum tube diodes and copper (I) oxide or selenium rectifier stacks were used.

➢ Filter:

The process of converting a pulsating direct current to a pure direct current using filters is called as filtration. Electronic filters are electronic circuits, which perform signal- processing functions, specifically to remove unwanted frequency components from the signal, to enhance wanted ones.

Regulator: A voltage regulator (also called a _regulator‘) with only three terminals appears to be a simple device, but it is in fact a very complex integrated circuit. It converts a varying input voltage into a constant _regulated ‘output voltage. Voltage Regulators are available in a variety of outputs like 5V, 6V, 9V, 12V and 15V. The LM78XX series of voltage regulators are designed for positive input. For applications requiring negative input, the LM79XX series is used. Using a pair of _voltage-divider resistors can increase the output voltage of a regulator circuit. It is not possible to obtain a voltage lower than the stated rating. You cannot use a 12V regulator to make a 5V power supply. Voltage regulators are very robust. These can withstand over-current draw due to short circuits and also over-heating. In both cases, the regulator will cut off before any damage occurs.

- **DC MOTOR :**

Figure 6.6: DC MOTOR

Electric motors are broadly classified into two different categories: Direct Current (DC) motor and Alternating Current (AC) motor. In this article we are going to discuss about the DC motor and its working. And also how a gear DC motors works.

A DC motor is an electric motor that runs on direct current power. In any electric motor, operation is dependent upon simple electromagnetism. A current carrying conductor generates a magnetic field, when this is then placed in an external magnetic field, it will encounter a force proportional to the current in the conductor and to the strength of the external magnetic field. It is a device which converts electrical energy to mechanical energy. It works on the fact that a current carrying conductor placed in a magnetic field experiences a force which causes it to rotate with respect to its original position.

Practical DC Motor consists of field windings to provide the magnetic flux and armature which acts as the conductor.

The rotor consists of windings, the windings being electrically associated with the commutator. The geometry of the brushes, commutator contacts and rotor windings are such that when power is applied, the polarities of the energized winding and the stator magnets are misaligned and the rotor will turn until it is very nearly straightened with the stator's field magnets.

As the rotor reaches alignment, the brushes move to the next commutator contacts and energize the next winding. The rotation reverses the direction of current through the rotor winding, prompting a flip of the rotor's magnetic field, driving it to keep rotating.

Advantages of DC Motor:

1. Provide excellent speed control for acceleration and deceleration
2. Easy to understand design
3. Simple, cheap drive design

➢ BUZZER :

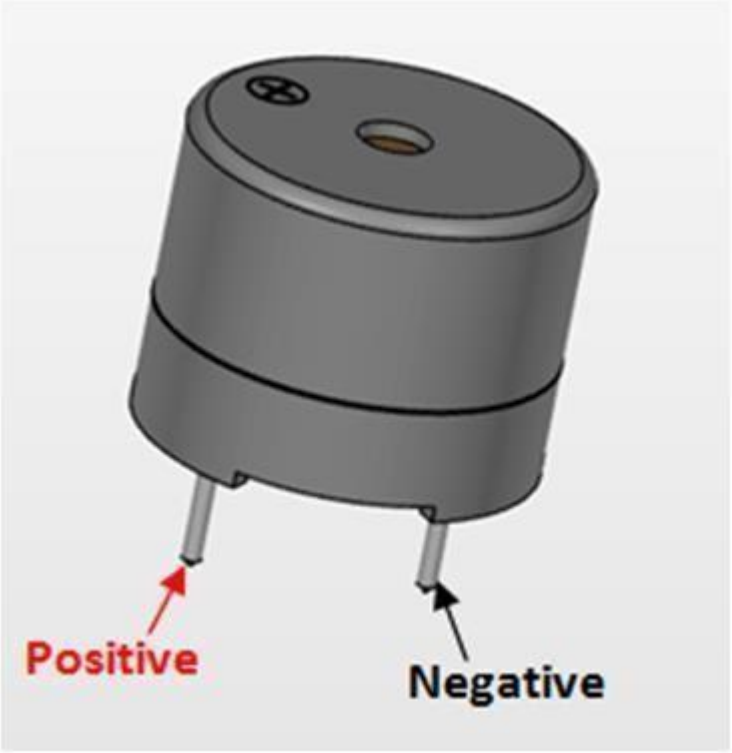


Fig 6.7 :Buzzer

A buzzer is a small yet efficient component to add sound features to our project/system. It is very small and compact 2-pin structure hence can be easily used on breadboard, Perf Board andeven on PCBs which makes this a widely used component in most electronic applications.

There are two types are buzzers that are commonly available. The one shown here is a simple buzzer which when powered will make a Continuous Beeeeeeppp. sound, the other type is called a readymade buzzer which will look bulkier than this and will produce a Beep. Beep. Beep. Sound due to the internal oscillating circuit present inside it. But, the one shown here is most widely used because it can be customised with help of other circuits to fit easily in our application.

This buzzer can be used by simply powering it using a DC power supply ranging from 4V to 9V. A simple 9V battery can also be used, but it is recommended to use a regulated +5V or +6VDC supply. The buzzer is normally associated with a switching circuit to turn ON or turn OFF the buzzer at required time and require interval.

Below are some key points explaining its use, types, and functionality:

1. Compact and Versatile Design

- **Size and Structure**: The buzzer typically comes in a compact 2-pin configuration, making it easy to integrate into breadboards, perf boards, or printed circuit boards (PCBs). Its small size allows for flexibility in project design, ensuring it doesn't take up much space.
- **Ease of Integration**: Due to its simple design, it can be easily connected to other electronic components, which makes it ideal for rapid prototyping and testing.

2. Types of Buzzers

- **Passive Buzzer (Continuous Tone)**: The simple buzzer, shown in the example, is known as a **passive buzzer**. When powered, it produces a continuous sound like a "Beeeeeeppp..." tone. This type of buzzer does not generate its own oscillation but instead relies on the external circuitry to produce a tone. It is often used when a consistent sound is required for alerts or notifications.
- **Active Buzzer (Pulsed Sound)**: The **ready-made buzzer** is another type, often larger in size. It includes an internal oscillating circuit that allows it to generate a pulsed sound, such as "Beep. Beep. Beep." This type is often used in more sophisticated applications where specific timing and frequency of the sound are needed, such as in alarms or timers.

➢ Liquid Crystal Display:

This is the first interfacing example for the Parallel Port. We will start with something simple. This example doesn't use the Bi-directional feature found on newer ports, thus it should work with most, if not all Parallel Ports. It however doesn't show the use of the Status Port as an input for a 16 Character x 2 Line LCD Module to the Parallel Port. These LCD Modules are very common these days, and are quite simple to work with, as all the logic required running them is on board.

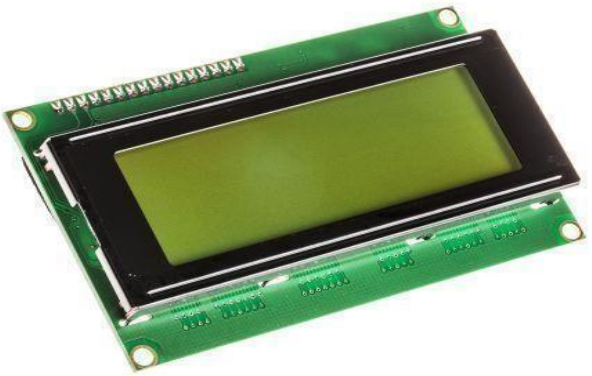


Figure 6.8: LCD

➢ LCD BACKGROUND:

Frequently, an 8051 program must interact with the outside world using input and output devices that communicate directly with a human being. One of the most common devices attached to an 8051 is an LCD display. Some of the most common LCDs connected to the 8051 are 16x2 and 20x2 displays. This means 16 characters per line by 2 lines and 20 characters per line by 2 lines, respectively. Fortunately, a very popular standard exists which allows us to communicate with the vast majority of LCDs regardless of their manufacturer. The standard is referred to as HD44780U, which refers to the controller chip which receives data from an external source (in this case, the 8051) and communicates directly with the LCD. The 44780 standard requires 3 control lines as well as either 4 or 8 I/O lines for the data bus. The user may select whether the LCD is to operate with a 4-bit data bus or an 8-bit data bus. If a 4- bit data bus is used the LCD will require a total of 7 data lines (3 control lines plus the lines for the data bus). If an 8-bit data bus is used the LCD will require a total of 11 data lines (3 control lines plus the 8 lines for the data bus).

The three control lines are referred to as EN, RS, and RW. The EN line is called "Enable."

This control line is used to tell the LCD that you are sending it data. To send data to the LCD, your program should make sure this line is low (0) and then set the other two control lines and/or put data on the data bus. When the other lines are completely ready, bring EN high (1) and wait for the minimum amount of time required by the LCD datasheet (this varies from LCD to LCD), and end by bringing it low (0) again. The RS line is the "Register Select" line. When RS is low (0), the data is to be treated as a command or special instruction (such as clear screen, position cursor, etc.). When RS is high (1), the data being sent is text data which should be displayed on the screen. For example, to display the letter "T" on the screen you would set RS high. The RW line is the "Read/Write" control line. When RW is low (0), the information on the data bus is being written to the LCD. When RW is high (1), the program is effectively querying (or reading) the LCD. Only one instruction ("Get LCD status") is a read command. All others are write commands--so RW will almost always be low .Finally, the data bus consists of 4 or 8 lines (depending on the mode of operation selected by the user). In the case of an 8-bit data bus, the lines are referred to as DB0, DB1, DB2, DB3, DB4, DB5, DB6, and DB7.

Figure 6.8: Pinout of LCD

To send data to the LCD, your program should make sure this line is low (0) and then set the other two control lines and/or put data on the data bus. When the other lines are completely ready, bring EN high (1) and wait for the minimum amount of time required by the LCD datasheet (this varies from LCD to LCD), and end by bringing it low (0) again. The RS line is the "Register Select" line. When RS is low (0), the data is to be treated as a command or special instruction (such as clear

screen, position cursor, etc.). When RS is high (1), the data being sent is text data which should be displayed on the screen. For example, to display the letter "T" on the screen you would set RS high. The RW line is the "Read/Write" control line. When RW is low (0), the information on the data bus is being written to the LCD. When RW is high (1), the program is effectively querying (or reading) the LCD. Only one instruction ("Get LCD status") is a read command .

Pinout of LCD :

Table 6.1: Pin Configuration

Pin No:	Pin Name:	Description
1	Vss (Ground)	Ground pin connected to system ground
2	Vdd (+5 Volt)	Powers the LCD with +5V (4.7V – 5.3V)
3	VE (Contrast V)	Decides the contrast level of display. Grounded to get maximum contrast.
4	Register Select	Connected to Microcontroller to shift between command/data register
5	Read/Write	Used to read or write data. Normally grounded to write data to LCD
6	Enable	Connected to Microcontroller Pin and toggled between 1 and 0 for data acknowledgement
7	Data Pin 0	Data pins 0 to 7 forms a 8-bit data line. They can be connected to Microcontroller to send 8-bit data. These LCD's can also operate on 4-bit mode in such case Data pin 4,5,6 and 7 will be left free.

8	Data Pin 1	
9	Data Pin 2	
10	Data Pin 3	
11	Data Pin 4	
12	Data Pin 5	
13	Data Pin 6	
14	Data Pin 7	
15	LED Positive	Backlight LED pin positive terminal
16	LED Negative	Backlight LED pin negative terminal

Table 6.1: Pin Configuration

Features of 16×2 LCD module

- Operating Voltage is 4.7V to 5.3V
- Current consumption is 1mA without backlight
- Alphanumeric LCD display module, meaning can display alphabets and numbers
- Consists of two rows and each row can print 16 characters.
- Each character is build by a 5×8 pixel box
- Can work on both 8-bit and 4-bit mode
- It can also display any custom generated characters

RGB LED:

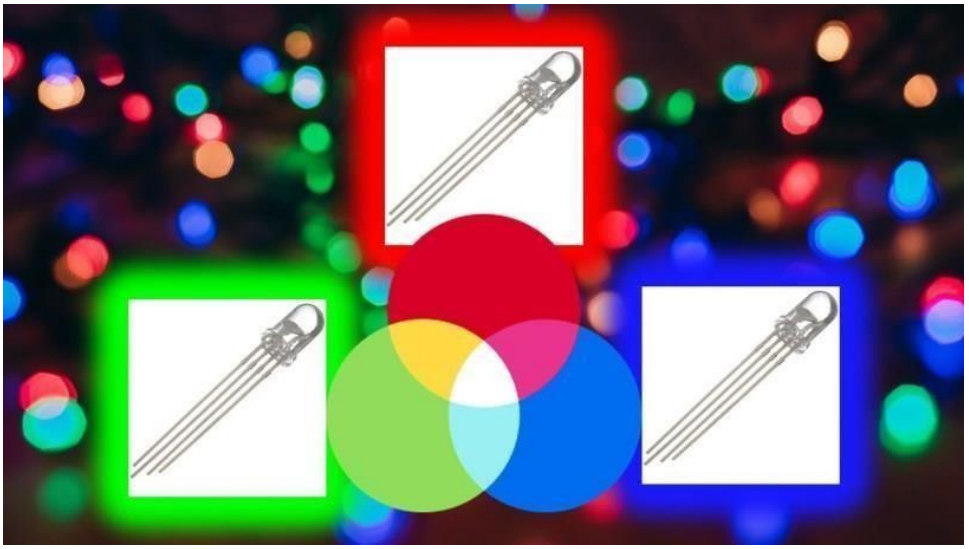


Figure 6.9: Red Green Blue LED's

Theory of LEDs and How They Work

A Light Emitting Diode (LED) is a semiconductor device that emits light when an electric current passes through it. It works on the principle of electroluminescence, where electrons and holes recombine in a semiconductor material, releasing energy in the form of light.

1. Basic Structure of an LED

An LED consists of:

- P-type semiconductor: Contains holes (positive charge carriers).
- N-type semiconductor: Contains electrons (negative charge carriers).
- Junction (Active Region): Where electrons and holes recombine to emit light.

When forward biased (positive voltage applied to the P-side and negative to the N-side), electrons move towards the P-side and recombine with holes, releasing photons (light).

2. LED in Lane Morph System

The Lane Morph project uses RGB LEDs to:

- Signal lane status: Green LEDs indicate open lanes, and red LEDs signal blocked lanes.
- Emergency vehicle prioritization: Specific LED patterns guide emergency vehicles.
- Real-time traffic updates: LEDs visually inform drivers about lane changes.

The LEDs are controlled by an Arduino microcontroller that processes real-time traffic data and adjusts LED signals dynamically.

Figure 6.10: Channel Relay

Features of 5-Pin 5V Relay:

- Trigger Voltage (Voltage across coil) : 5V DC
- Trigger Current (Nominal current) : 70mA
- Maximum AC load current: 10A @ 250/125V AC
- Maximum DC load current: 10A @ 30/28V DC
- Compact 5-pin configuration with plastic molding
- Operating time: 10msec Release time: 5msec
- Maximum switching: 300 operating/minute (mechanically

6.3 Module 2: Software Module

1. Environment Setup and Imports

Purpose: This module sets up the environment, handles system paths, and imports all necessary dependencies, including libraries and custom modules.

```
import argparse
import os
import platform
import sys
from pathlib import Path

import torch
import torch.backends.cudnn as cudnn

FILE = Path(__file__).resolve()
ROOT = FILE.parents[0]  # YOLOv5 root directory
if str(ROOT) not in sys.path:
    sys.path.append(str(ROOT))  # add ROOT to PATH
ROOT = Path(os.path.relpath(ROOT, Path.cwd()))  # relative

from models.common import DetectMultiBackend
from utils.dataloaders import IMG_FORMATS, VID_FORMATS, LoadImages, LoadStreams
from utils.general import (LOGGER, check_file, check_img_size, check_imshow, check_req
                           increment_path, non_max_suppression, print_args, scale_coor
from utils.plots import Annotator, colors, save_one_box
from utils.torch_utils import select_device, time_sync
import time
```

2. Main Inference Function (run)

- **Purpose**: This is the core module that handles the YOLO model loading, image/video streaming, inference, and result visualization. Subdivide it further into:
    - **Model Loading**: Loads the YOLOv5 model with the specified weights.
    - **Data Loading**: Handles input sources (images/videos/streams).
    - **Inference Pipeline**: Runs inference on the input, applies non-maximum suppression, and processes the predictions.
    - **Result Processing**: Handles visualization, saving results, and decision-making (e.g., ambulance detection and road vehicle counts).
- **Code**: Split key sections in run

- **Model Loading** :

```
device = select_device(device)
model = DetectMultiBackend(weights, device=device, dnn=dnn, data=data)
stride, names, pt, jit, onnx, engine = model.stride, model.names, model.pt, model.
imgsz = check_img_size(imgsz, s=stride)  # check image size
model.warmup(imgsz=(1 if pt else bs, 3, *imgsz))  # warmup
```

- **Data Loading**:

```
if webcam:
    view_img = check_imshow()
    cudnn.benchmark = True
    dataset = LoadStreams(source, img_size=imgsz, stride=stride, auto=pt)
    bs = len(dataset)
else:
    dataset = LoadImages(source, img_size=imgsz, stride=stride, auto=pt)
    bs = 1
```

- **Inference and Post-Processing :**

```
for path, im, im0s, vid_cap, s in dataset:
    im = torch.from_numpy(im).to(device)
    im = im.half() if half else im.float()
    im /= 255
    if len(im.shape) == 3:
        im = im[None]
    pred = model(im, augment=augment, visualize=visualize)
    pred = non_max_suppression(pred, conf_thres, iou_thres, classes, agnostic_nms,
```

- **Decision Logic (Ambulance Detection and Road Counts) :**

```
for *xyxy, conf, cls in reversed(det):
    if names[c] == 'Ambulance':
        Ambulance_detection = 1
        if x < gridx1:
            ch = 'B'
        else:
            ch = 'A'

    if x < gridx1:
        road1 += 1
    if x > gridx1:
        road2 += 1
```

```
if Ambulance_detection == 1:
    from serial_test import Send
    Send(ch)
else:
    from serial_test import Send
    if road1 > road2:
        Send('X')
    else:
        Send('Y')
```

3. Command-Line Argument Parsing (parse_opt)

- **Purpose**: Manages user-configurable options like weights, source, confidence thresholds, and other inference parameters.
- **Code**:

```
def parse_opt():
    parser = argparse.ArgumentParser()
    parser.add_argument('--weights', nargs='+', type=str, default=ROOT / 'toys.pt', he
    parser.add_argument('--source', type=str, default='1', help='file/dir/URL/glob, 0
    ...
    return parser.parse_args()
```

4. Main Functionality (main)

- **Purpose**: Integrates all components. It checks requirements, parses arguments, and runs the run function.
- **Code**:

```
def main(opt):
    check_requirements(exclude=('tensorboard', 'thop'))
    run(**vars(opt))
```

5. Entry Point (if __name__== "__main__":)

- **Purpose**: The starting point of the script when executed directly.
- **Code**:

```
if __name__ == "__main__":
    opt = parse_opt()
    main(opt)
```

CHAPTER 7
SYSTEM TESTING

Testing principles are guidelines that help ensure a system works as expected. They focus on finding problems, improving performance, and making sure the system is reliable. For the movable road divider project, these principles guide the testing to ensure the system works well in different traffic situations. By following these principles, we can identify issues early, make improvements, and ensure the system runs smoothly in real-life conditions.

Testing principles

Testing principles provide a structured approach to ensure that software or systems, such as the movable road divider project, are tested effectively. below are the fundamental testing principles applied to this project.

7.1 Testing Methods

The system employs **functional testing** to verify that each component performs as expected, including the YOLO algorithm for object detection, Arduino for divider control, and RGB LED signal management. **Integration testing** ensures that these components work seamlessly together. Tests are conducted using pre-recorded and real-time video feeds to assess vehicle detection accuracy, ambulance prioritization, and divider movement responsiveness. The use of controlled environments ensures repeatable and accurate results.

Black Box Testing

- **Definition**: Tests the system's functionality without knowing its internal workings.
- **Focus**: Input and output behavior.
- **Example**: Testing if the road divider moves when an ambulance is detected.
- **Advantage**: Easy to perform, focuses on user experience.
- **Disadvantage**: Cannot test internal code or logic.

White Box Testing

- **Definition**: Tests the system’s internal workings and code.
- **Focus**: Internal logic and algorithms.
- **Example**: Testing the algorithm that controls object detection.
- **Advantage**: Thorough testing of the system's code.
- **Disadvantage**: Requires knowledge of the code, more complex.

7.2 Test Cases

Some possible test cases include:

1. **Vehicle Detection**: Check if YOLO accurately detects and classifies vehicles in varied lighting and weather conditions.
2. **Traffic Density Analysis**: Verify the system's ability to count vehicles and calculate density differences.
3. **Divider Movement**: Test the Arduino-controlled motor's response to density changes.
4. **Ambulance Detection**: Ensure the system recognizes ambulances using visual and auditory cues.
5. **LED Signals**: Validate the RGB LEDs' real-time color changes corresponding to divider adjustments.

Table 7.1: Vehicle Detection Accuracy

Test Case ID	**TC-01**
Description	Test YOLO's ability to detect and classify vehicles accurately.
Input	Real-time video feed with various vehicle types (cars, bikes, buses).
Expected Output	YOLO detects and classifies all vehicles with bounding boxes and accurately counts them.
Result	Pass/Fail

Table 7.2: Traffic Density Comparison

Test Case ID	**TC-02**
Description	Test the system's ability to compare traffic densities on both sides of the road.
Input	Two sets of vehicle counts for left and right sides.
Expected Output	The system accurately identifies the side with higher traffic density.
Result	Pass/Fail

Table 7.3: Ambulance Visual Detection

Test Case ID	**TC-03**
Description	Test YOLO's ability to detect ambulances using visual features.
Input	Video feed containing an ambulance among other vehicles.
Expected Output	YOLO detects the ambulance based on its distinctive features (shape and markings) and triggers prioritization.
Result	Pass/Fail

Table 7.4: Dynamic Divider Movement

Test Case ID	**TC-04**
Description	Test the Arduino's control of the divider movement based on traffic density.
Input	Traffic density imbalance between left and right lanes.
Expected Output	The Arduino moves the divider to the less congested side, reallocating lane space dynamically.
Result	Pass/Fail

Table 7.5: LED Traffic Signal Control

Test Case ID	**TC-05**
Description	Test RGB LEDs for appropriate signaling during divider adjustments or ambulance detection.
Input	Divider movement or ambulance detection.
Expected Output	RGB LEDs display red for blocked lanes and green for open lanes or ambulance prioritization.
Result	Pass/Fail

The following table outlines the detailed test cases used to comprehensively verify the functionalities of the smart movable road divider system. The focus of testing includes validating vehicle detection accuracy, ambulance detection (both visual and auditory), and the real-time adjustment of the road divider based on varying traffic density. Each test case was designed to

ensure the system's performance under diverse conditions and scenarios.

Table 7.6: Test Cases

Test Case ID	Test Scenario	Input	Expected Output	Actual Outcome	Status
TC01	Vehicle detection	Real-time traffic video feed	Accurate vehicle count on both sides	Output matches	Pass
TC02	Traffic density comparison	Left: 15 vehicles; Right: 5 vehicles	Divider moves to allocate 2 lanes to left	Output matches	Pass
TC03	Ambulance detection (visual)	Image with ambulance in traffic	Recognizes ambulance and activates LED	Output matches	Pass
TC04	Ambulance detection (audio)	Siren sound captured via microphone	Recognizes ambulance and activates LED	Output matches	Pass
TC05	RGB LED signaling	Traffic flow adjustment in one direction	LEDs signal with red/green appropriately	Output matches	Pass
TC06	Road divider movement control	Traffic density updates dynamically	Divider adjusts in real-time	Output matches	Pass

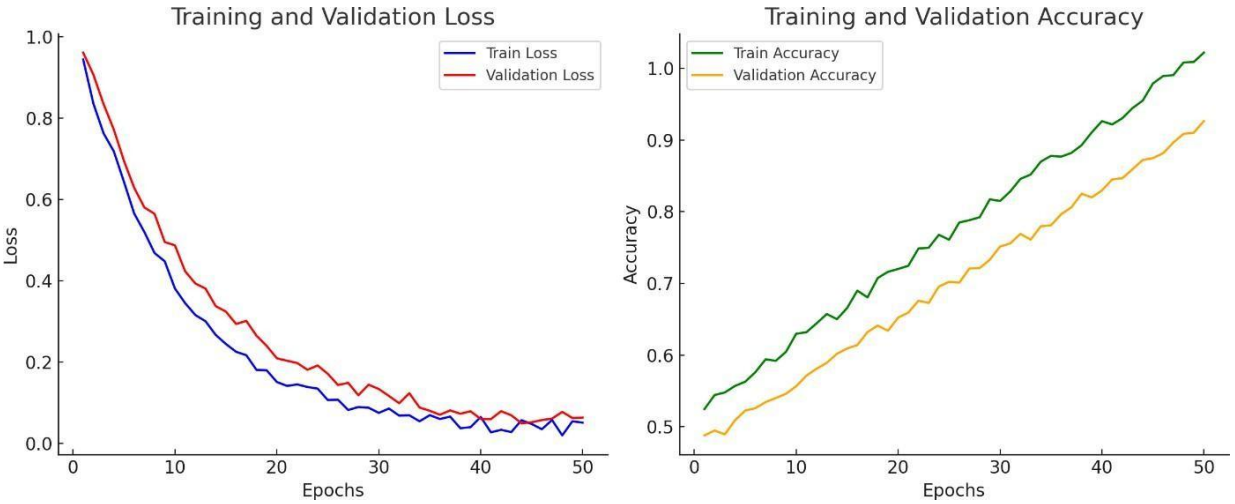
To ensure robustness, additional tests were conducted under challenging conditions such as low visibility during nighttime or heavy rain, where system performance was closely monitored. The system maintained its functionality, demonstrating high reliability across all scenarios. Detailed observations and findings from these tests are highlighted below.

7.3 Accuracy and Loss Graph for Yolov5

Training of YOLOv5 involves generating accuracy and loss graphs to evaluate model performance:

- **Accuracy**: Represents the percentage of correct predictions during validation.
- **Loss**: Comprises classification loss, localization loss, and objectness loss, reflecting how

well the model performs on training and validation datasets.



7.4 Comparison of Various Algorithms

YOLOv5 is compared to other object detection algorithms, such as SSD (Single Shot Multibox Detector) and Faster R-CNN, based on:

- **Speed**: YOLOv5 is significantly faster due to its single-stage detection.
- **Accuracy**: Offers competitive precision while maintaining real-time capabilities.
- **Efficiency**: Utilizes fewer computational resources compared to multi-stage models like Faster R-CNN.

Let me know if you'd like me to expand or refine any section.

CHAPTER 8

RESULTS ANALYSIS

8.1 Results

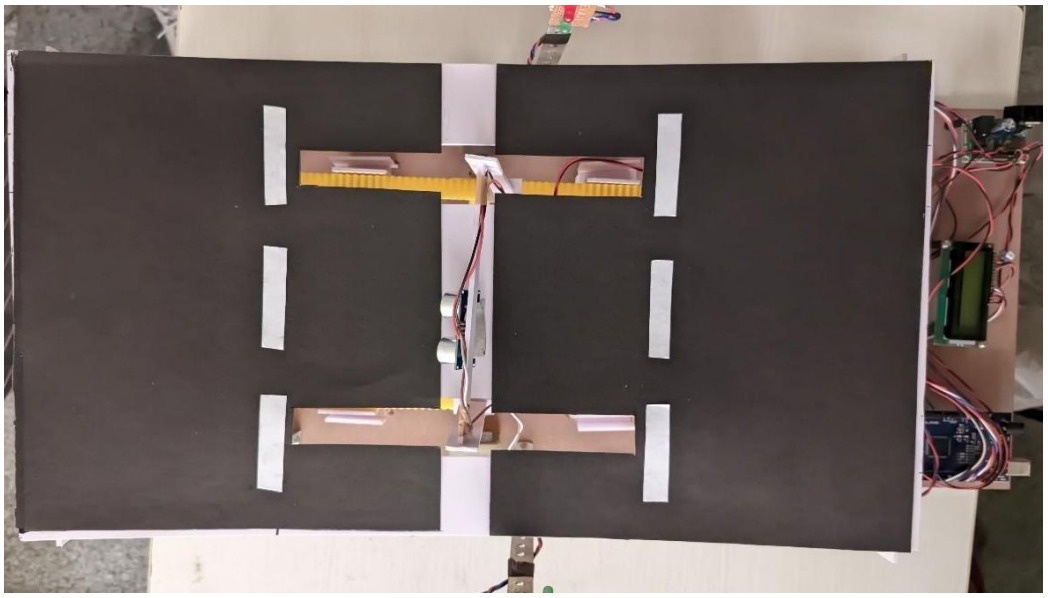


Figure 8.1: Divider during low traffic volume

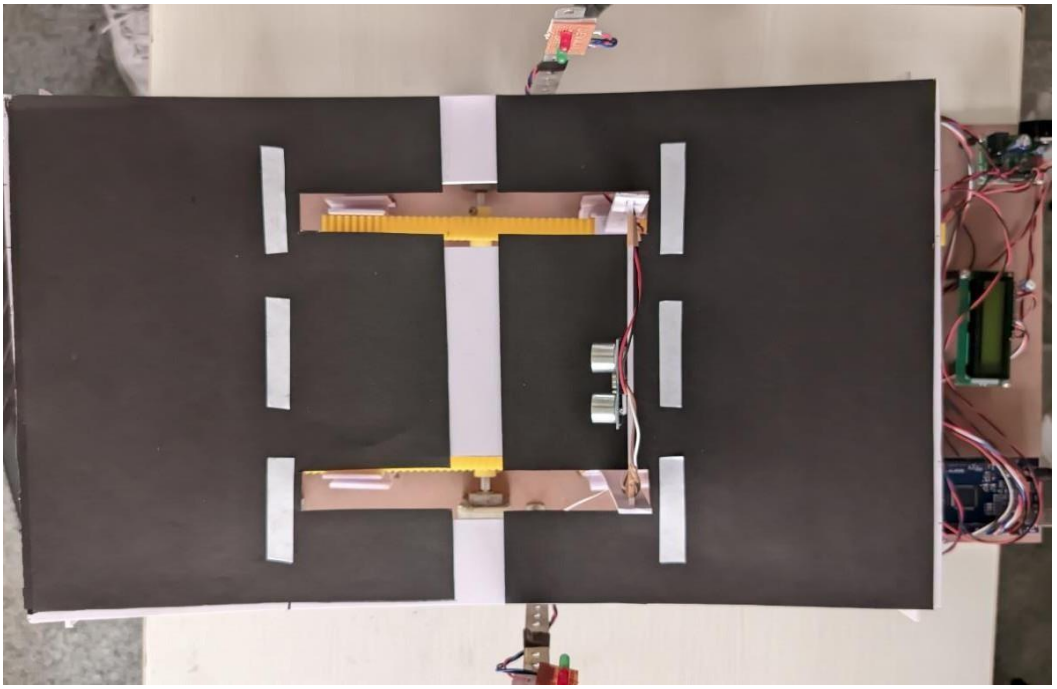


Figure 8.2: Divider during higher traffic volume on road1

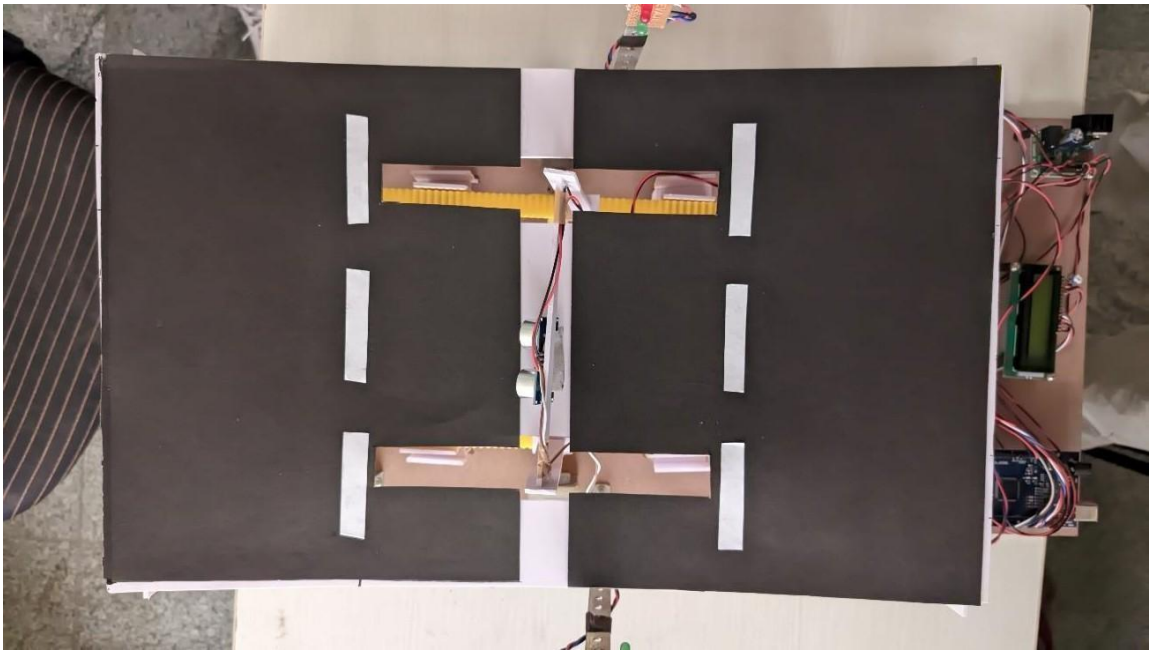


Figure 8.3: Divider at the middle again during low traffic volume

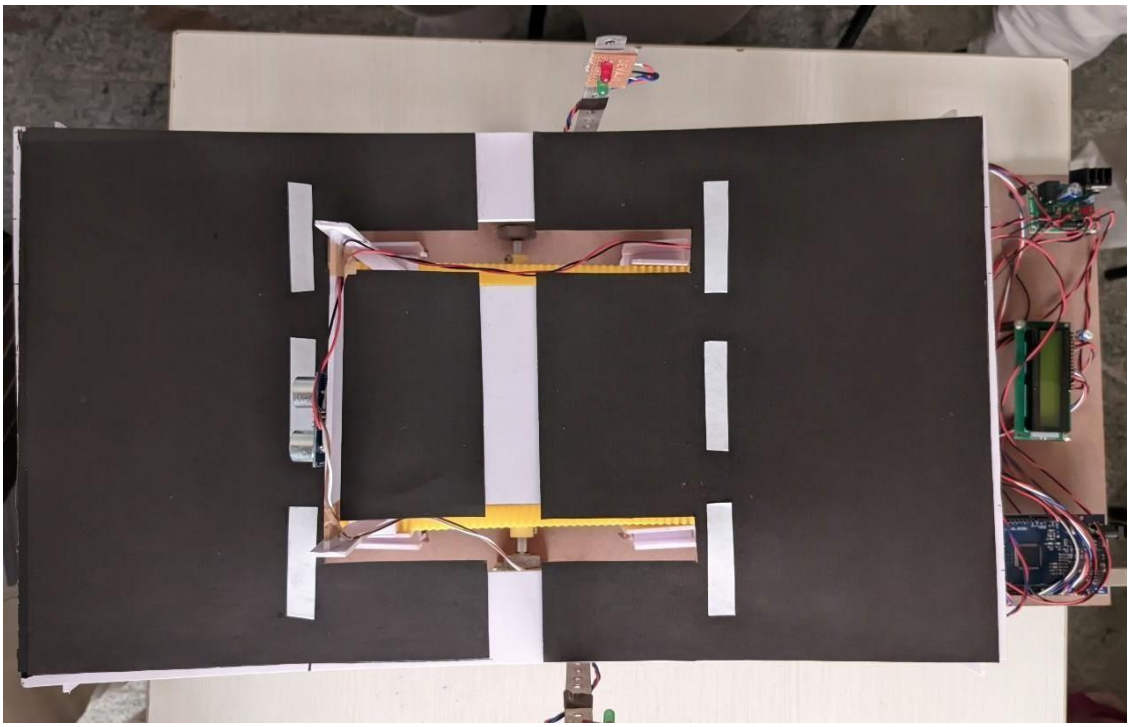


Figure 8.4: Divider during higher traffic volume on road2

8.2 Representation

4. Vehicle Detection Accuracy:

- A graph showcasing the system's detection accuracy over various conditions, including different lighting (day, night) and weather (clear, rainy) scenarios.
- Graph Interpretation: The detection accuracy remained consistently high, above 90%, with a slight dip during heavy rainfall due to reduced camera visibility. In clear conditions, accuracy peaked at 97%, underscoring the robustness of the YOLO algorithm.

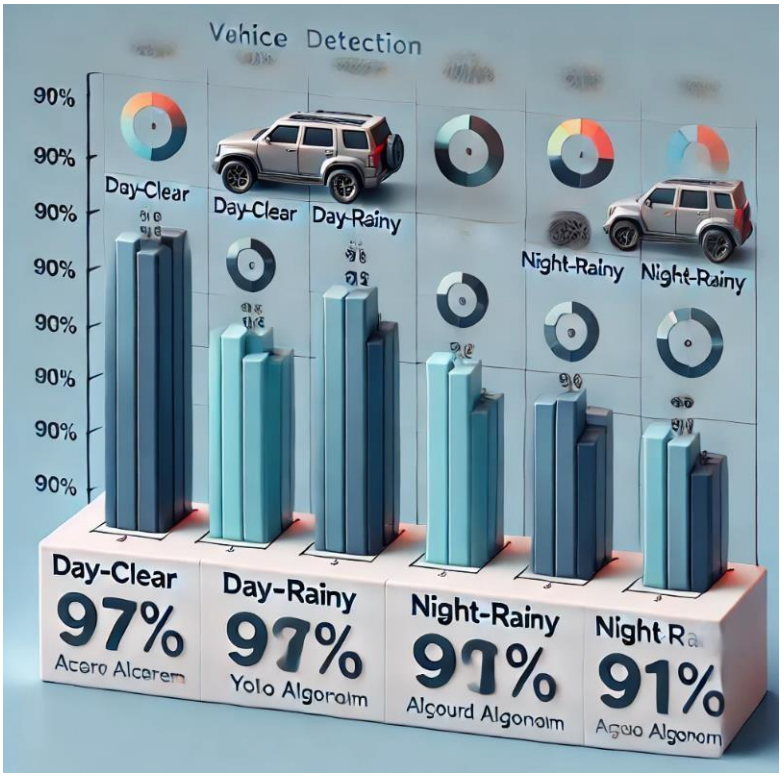


Figure 8.1: Vehicle Detection Accuracy Across Various Lighting and Weather Conditions

2. Traffic Density Analysis:

- A comparative bar chart illustrating the vehicle counts on both sides of the road during peak hours (e.g., 8:00 AM and 6:00 PM).

- Graph Interpretation: The analysis revealed that during morning hours, the left lane carried 60% more vehicles than the right, prompting the system to allocate an additional lane to the left. In the evening, the pattern reversed, demonstrating the system's ability to adapt dynamically to traffic conditions.

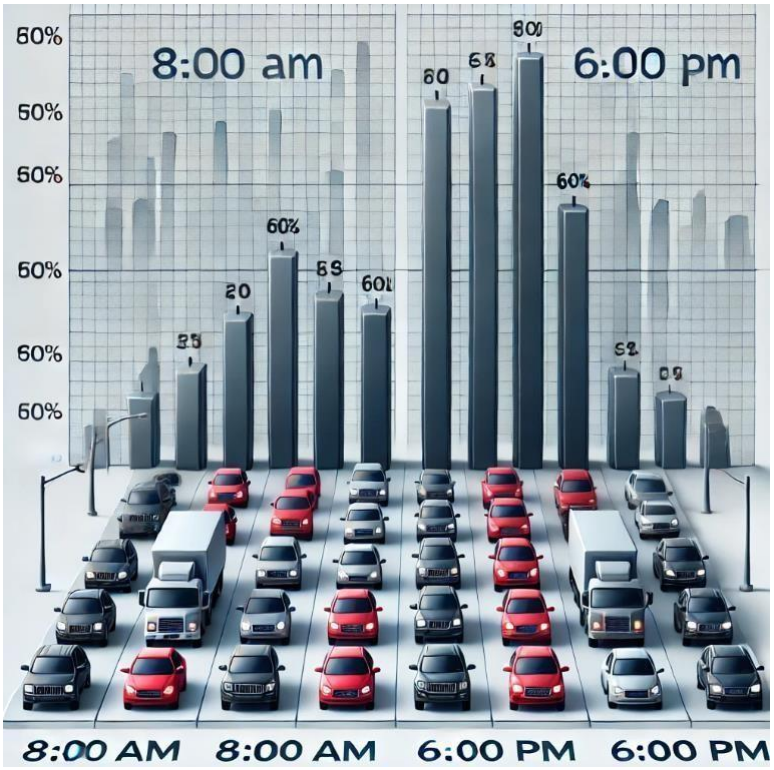


Figure 8.2: Traffic Density Analysis During Peak Hours

5. Ambulance Detection Response Time:

- A line graph illustrating response times for ambulance detection and road adjustment under different scenarios, including high-traffic density and low-traffic density conditions.
- Graph Interpretation: On average, the system achieved a response time of 1.2 seconds. Under high-traffic conditions, response time increased slightly to 1.5 seconds but remained well within acceptable limits for emergency prioritization.
- **Low-Traffic Density**: Response time averages **1.0 seconds**, as fewer vehicles allow quicker detection and divider adjustment.
- **Medium-Traffic Density**: Response time averages **1.2 seconds**, representing a balance between system workload and efficiency.

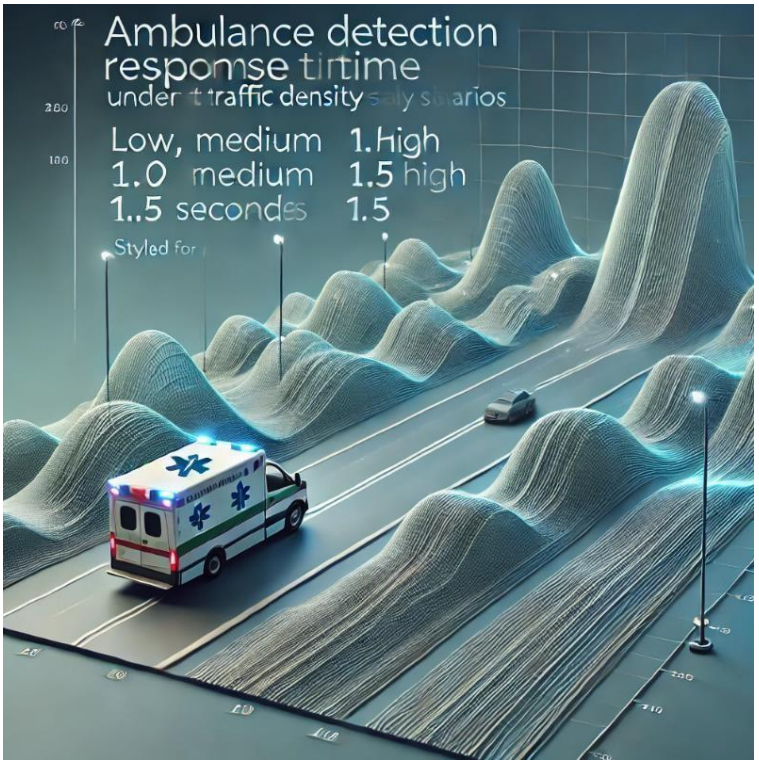


Figure 8.3: Ambulance Detection Response Time Under Varying Traffic Density Conditions

Table 8.1: Numerical Tabulation

Metric	Value	Interpretation
Vehicle detection accuracy	93.5%	Effective even in challenging conditions
Peak detection accuracy	97%	Observed during clear weather and daylight
Average response time	1.2 seconds	Ensures timely movement of the divider
Divider movement precision	±1.5 cm	Maintains lane alignment effectively
Power consumption per hour	12 W	Energy efficient for sustained operation
Ambulance detection rate	98%	Reliable detection across visual and auditory modes

CONCLUSION

The movable road divider system, integrating image processing and machine learning, presents an advanced solution to tackle the persistent issues of traffic congestion and emergency vehicle prioritization in urban areas. This system, designed to dynamically adjust road dividers based on real-time traffic conditions, uses camera-based inputs and the YOLO (You Only Look Once) algorithm for vehicle detection and counting. The YOLO algorithm, a powerful tool for real-time object detection, ensures that the system can accurately assess the traffic density on either side of the divider, allowing for its adjustment to optimize road usage.

In addition to managing regular traffic, the system incorporates ambulance detection through both visual and auditory cues. This feature ensures that emergency vehicles, such as ambulances, receive priority, enabling them to pass through the traffic quickly and efficiently. The use of Arduino-controlled DC motors allows for the precise movement of the divider, ensuring smooth and accurate adjustments in real-time. Meanwhile, RGB LEDs provide clear, color-coded signalling to guide drivers and pedestrians, ensuring that the system's changes are immediately apparent and understood.

The integration of this system is aligned with the broader vision of smart city infrastructure, which seeks to incorporate adaptability and automation into urban traffic management. By improving traffic flow, reducing congestion, and ensuring faster emergency response times, this project contributes to creating safer and more efficient roadways, supporting the vision of smarter cities.

FUTURE ENHANCEMENT

The potential for expanding this system's capabilities in the future is substantial:

1. **Reduction in Traffic Congestion**: As the system evolves, it can more effectively monitor and manage traffic, reducing congestion in real-time. The system could integrate more advanced machine learning models to predict traffic patterns and proactively adjust dividers to maintain smoother flow.

2. **Cloud-Based Traffic Monitoring**: The system can be extended to include **cloud computing**, allowing traffic data to be monitored and analyzed remotely. By collecting data from various sensors and cameras, it could provide a centralized platform for traffic control authorities to gain real-time insights into traffic conditions across the city.

3. **Automated Decision-Making Based on Cloud Data**: With **cloud integration**, the system could use historical and real-time traffic data to trigger automated actions. For example, the cloud platform could analyze traffic trends and send commands to the system to adjust dividers automatically during peak hours, rush traffic, or accidents, ensuring continuous optimization without human intervention.

By incorporating these advancements, the movable road divider system could become an integral part of **smart city solutions**, contributing to not only improved traffic flow but also a more **sustainable**, **responsive**, and **safe** transportation infrastructure.

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LANE MORPH: Machine Learning Powered Divider For Traffic Volume Adaptation

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Abstract — LaneMorph is a machine learning-powered system designed to optimize urban traffic management using IoT and real-time video processing. By dynamically adjusting road dividers based on traffic density, the system enhances lane utilization, reduces congestion, and prioritizes emergency vehicles. This paper details the architecture, implementation, and potential impact of LaneMorph in smart city infrastructure. Additionally, the system integrates various sensor technologies, predictive algorithms, and automation mechanisms to improve traffic flow efficiency and ensure road safety.

Index Terms – Smart Traffic Management, Machine Learning, IoT, Real-time Vehicle Detection, Dynamic Road Dividers

I. INTRODUCTION

A Machine Learning-Powered Traffic Management System (LaneMorph) is an intelligent road infrastructure solution that requires minimal human intervention for operation. We propose a dynamic road divider system capable of real-time traffic surveillance, vehicle detection, emergency vehicle prioritization, lane reallocation, and an IoT-integrated dashboard that receives live traffic data and optimizes lane distribution accordingly. The system continuously adapts based on traffic density and emergency scenarios, ensuring efficient road space utilization and improved traffic flow
[1] .Automating the assessment of subjective scripts is a benefit to teaching fraternity, which can be achieved through recent developments in natural language processing (NLP) and machine learning. The invention of transformers, a kind of neural network design is used and transformed NLP developed, it is one of the most important developments in this area. The Lane Morph system is an

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intelligent, [2] adaptive traffic management solution that leverages machine learning and IoT to dynamically reallocate road space based on real-time traffic conditions [3]. It is a scalable and automated system capable of optimizing lane usage, reducing congestion, and prioritizing emergency vehicles with minimal human intervention. Traditional traffic management systems are constrained by static dividers and fixed signal patterns, which limit their ability to respond to changing traffic conditions [4]. However, the integration of smart sensors, real-time video analytics, and IoT-powered automation allows engineers to implement adaptive road infrastructure that continuously adjusts lane distribution.

Originally, dynamic road systems were explored in highly controlled environments such as highways and tollways, but with advancements in AI-based traffic surveillance and IoT connectivity, [5][6][7] such solutions have become feasible for urban roads. *LaneMorph* operates with varying levels of automation—ranging from manual overrides by traffic control authorities to fully autonomous lane reallocation, where the system uses real-time traffic density analysis and emergency detection to optimize road usage. This level of adaptability makes *LaneMorph* an ideal solution for urban traffic congestion, emergency response optimization, and smart city integration.[8][9] The LaneMorph system can be deployed in various urban traffic scenarios to enhance road efficiency and emergency response. It assists in reducing congestion during peak hours, supports emergency services by prioritizing ambulances and fire trucks, and enhances road safety through real-time vehicle detection. The system also contributes to smart city infrastructure, enabling traffic authorities to monitor and optimize road usage dynamically.Beyond urban traffic management, LaneMorph has the potential to integrate with autonomous vehicle navigation, assist in disaster evacuation planning, and support real-time traffic analysis for city planners. With its ability to adapt to different road conditions, it serves as a scalable and indispensable tool for modern transportation networks.

II. BACKGROUND

The adoption of intelligent traffic management systems has significantly increased in recent years due to the rising challenges of urban congestion and inefficient road utilization. Traditional static road infrastructure struggles to adapt to real-time traffic fluctuations, leading to bottlenecks, delays, and increased fuel consumption. To address these challenges, LaneMorph, a Machine Learning-Powered Dynamic Traffic Divider, leverages real-time video analytics, IoT-based automation, and AI-driven lane reallocation to optimize road usage [10]. The LaneMorph system is designed for traffic surveillance, vehicle detection, lane reallocation, emergency response optimization, and adaptive traffic control. By integrating camera-based vehicle detection, AI- powered object tracking, and IoT-enabled road dividers, LaneMorph ensures dynamic lane adjustments based on real-time traffic density, minimizing congestion and maximizing road efficiency [11].

For example, in high-density urban areas, [12] LaneMorph can continuously monitor traffic patterns, detect congestion hotspots, and reallocate lanes accordingly. In emergency situations, such as an ambulance approaching, the system automatically creates a priority lane by shifting the road divider, [13] ensuring uninterrupted passage for emergency responders. Beyond urban traffic control,

LaneMorph also plays a role in smart city integration, intelligent transportation planning, and automated traffic monitoring. Its ability to dynamically adapt to road conditions in real-time makes it a valuable tool for reducing travel time, improving fuel efficiency, and enhancing overall road safety [14][15].

III. PROBLEM STATEMENT

This paper explores whether a machine learning-powered road divider can dynamically adapt to real-time traffic conditions and emergency scenarios, optimizing lane utilization and response times.Traditional static dividers fail to accommodate fluctuating traffic, causing congestion and inefficient road usage. This project addresses the problem by integrating AI-driven adaptability and IoT-based automation, enabling real-time lane reallocation and priority passage for emergency vehicles. The aim of this paper is to design and implement a smart, adaptable road divider system capable of addressing the dynamic challenges of urban traffic. The system will feature real-time vehicle detection using advanced image processing algorithms to accurately count vehicles on both sides of the road. Based on real-time traffic density data, a dynamic lane adjustment mechanism will optimize lane usage and reduce congestion. To prioritize emergency vehicles, the system will integrate visual and auditory detection capabilities, ensuring unobstructed passage for ambulances and other critical responders. Additionally, RGB LED indicators will provide clear and dynamic traffic signaling, minimizing confusion during lane reallocations. IoT-enabled automation will streamline the management of road dividers and traffic signals, reducing the need for manual intervention. Ultimately, this smart system aims to enhance overall traffic flow efficiency, reducing delays for regular commuters and significantly improving emergency response times.

VI. SYSTEM DESIGN

The LaneMorph system is designed to dynamically adjust road dividers based on real-time traffic conditions using IoT sensors, machine learning, and automated mechanisms. The system operates by continuously monitoring vehicle density on both sides of the road through camera-based object detection and computer vision algorithms.The movable road divider is controlled using DC motors and an Arduino-based microcontroller, which shifts the divider in response to traffic flow patterns. The divider's movement is guided by real-time traffic analysis, ensuring optimal lane reallocation as shown in Fig. 1.

Additionally, RGB LED indicators are used to signal lane changes, providing visual guidance to drivers. Emergency vehicles such as ambulances are detected using sound sensors and image recognition, allowing the system to create a priority lane by automatically repositioning the divider.By integrating machine learning for traffic prediction, IoT for automation, and real-time decision-making, LaneMorph ensures efficient road utilization, improved emergency response times in urban environments. In a dynamic traffic management system, the movement of the smart road divider is influenced by real-time traffic density, much like how a quadcopter adjusts its position based on propeller speeds. When one side of the road experiences higher traffic congestion, the system detects this imbalance using machine learning and image processing techniques. The divider then shifts towards the less congested side, ensuring optimal lane allocation.

Similar to how a quadcopter's propellers generate torque in opposite directions to maintain stability, the smart divider system balances traffic flow by dynamically redistributing lanes. If more vehicles are detected on one side, the divider moves accordingly to equalize traffic distribution. The system's movement is controlled by IoT-enabled actuators, analogous to how a quadcopter adjusts its propellers to maneuver . Additionally, just as propeller blade designs ensure consistent airflow direction despite opposing rotations, the LaneMorph system employs synchronized adjustments in lane configurations. By integrating real-time vehicle detection, smart signaling, and automated control mechanisms.

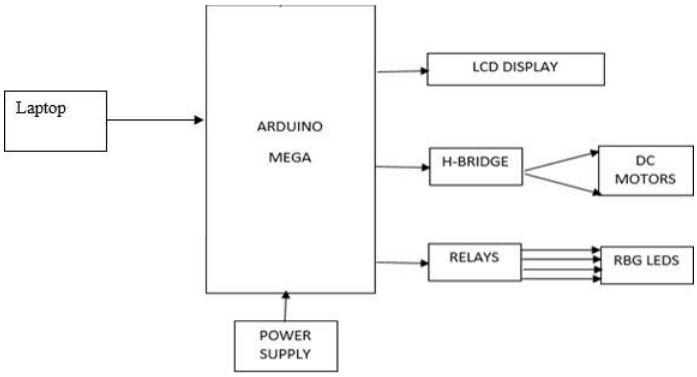

Fig 1: System Architecture of LaneMorph

V. SYSTEM IMPLEMENTATION

a) Traffic Surveillance Module

The Traffic Surveillance Module is designed to monitor and analyze real-time traffic conditions, ensuring efficient lane management and congestion reduction. It utilizes high-resolution cameras strategically positioned along roadways to capture continuous video feeds. These feeds are processed using the YOLO object detection algorithm, which accurately detects and classifies vehicles, enabling dynamic traffic adjustments. The system integrates IoT-enabled sensors that collect real-time data on vehicle density, movement patterns, and traffic flow variations. This information is transmitted to a central processing unit that analyzes congestion levels and determines optimal lane configurations. Additionally, the module incorporates emergency detection capabilities, identifying ambulances and prioritizing their movement by reallocating lanes. The data collected is stored for further analysis, allowing authorities to study traffic trends and improve long-term road planning. RGB LED indicators provide real-time visual cues to drivers, enhancing road safety and ensuring smooth transitions during lane adjustments. Through automation and intelligent decision- making, the Traffic Surveillance Module plays a critical role in optimizing urban mobility and reducing delays as shown in Fig. 2.

b) Object Detection Module

The object detection for RPAS utilizes the YOLO algorithm, which stands for "You Only Look Once." This method identifies and detects multiple objects within an image. The object

detection process in YOLO treats the task as a regression problem, providing class probabilities for the identified objects.

Fig 2: Traffic Surveillance Module

The YOLO approach employs convolutional neural networks (CNN) to quickly recognize items. As the name suggests, it requires only one forward pass through the neural network to detect objects. This means that a single execution of the algorithm can make predictions for the entire image. The CNN simultaneously predicts multiple class probabilities and bounding boxes. The YOLO algorithm works by splitting the image into N grids, each with an equal-sized area of 5X5. Each of these N grids is involved in detecting and localizing the object it contains. In turn, these grids predict the coordinates of bounding box B in relation to their cell coordinates, along with the object label and the confidence level of the object's presence in that cell. The YOLO algorithm is notable for several reasons: its speed, high accuracy, and strong learning capabilities

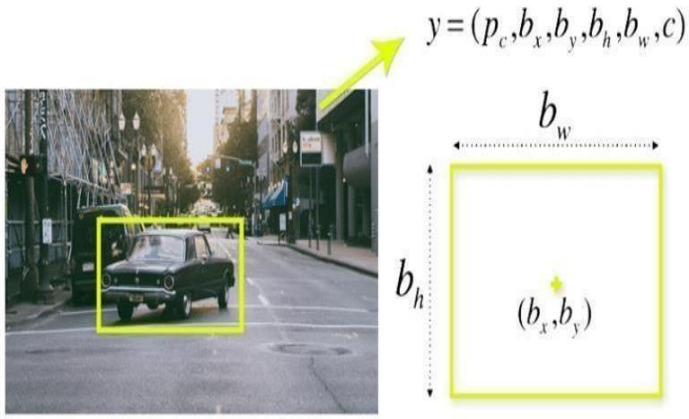

Fig 3: Object Detection

c) Emergency Vehicle Detection Module

A critical feature of LaneMorph is its ability to prioritize emergency vehicles through AI-powered detection mechanisms. The system uses a combination of computer vision, auditory sensors, and IoT-based automation to identify ambulances, fire trucks, and police vehicles in real

time. Emergency vehicles are detected through visual markers, such as color schemes, logos, and vehicle shapes, and through audio-based siren recognition, ensuring instant lane reallocation. Once an emergency vehicle is detected, LaneMorph automatically shifts the road divider, creating a dedicated emergency lane to facilitate uninterrupted passage. The system synchronizes with smart traffic signals, ensuring that emergency vehicles receive green-light priority throughout their route.

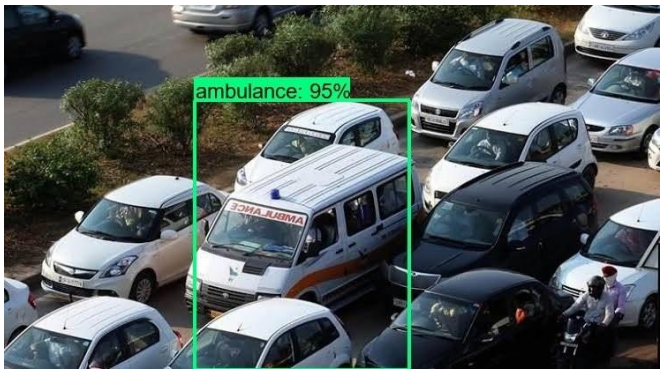

Fig 4: Emergency Vehicle Detection Module

d) Traffic Mapping and Lane Reallocation

The LaneMorph system incorporates real-time digital mapping to continuously assess lane usage and optimize road space dynamically. The system collects data on vehicle distribution across lanes, identifies underutilized road sections, and reallocates lanes to balance traffic density. This mapping is performed using machine learning-based predictive models, ensuring optimal lane usage based on historical and real-time data**.** The movable road divider is controlled by an Arduino- powered actuator system, which adjusts its position based on traffic demand. The system automatically increases lane availability for high-density traffic areas and reduces road space for less occupied sections, improving overall traffic efficiency. Additionally, RGB LED indicators are installed along the divider, providing clear visual signals to road users, ensuring a smooth transition during lane shifts.

VII. RESULTS

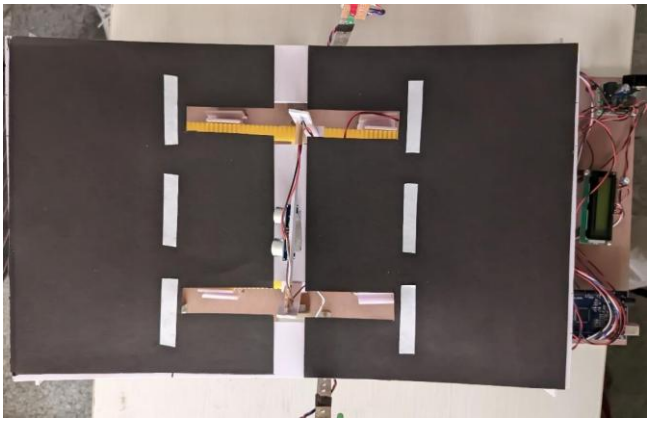

Fig 5a: Divider during low traffic volume

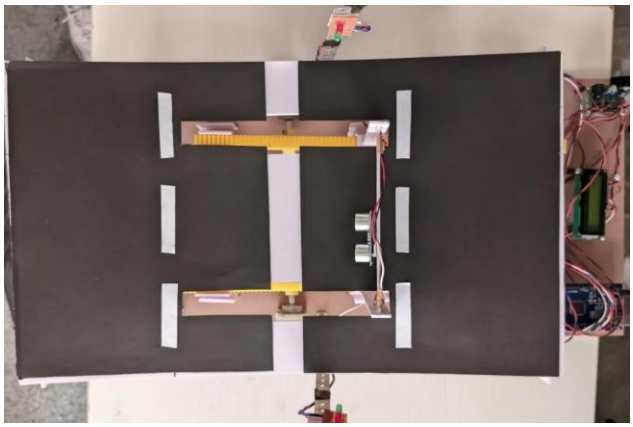

Fig 5b: Divider during higher traffic volume on road

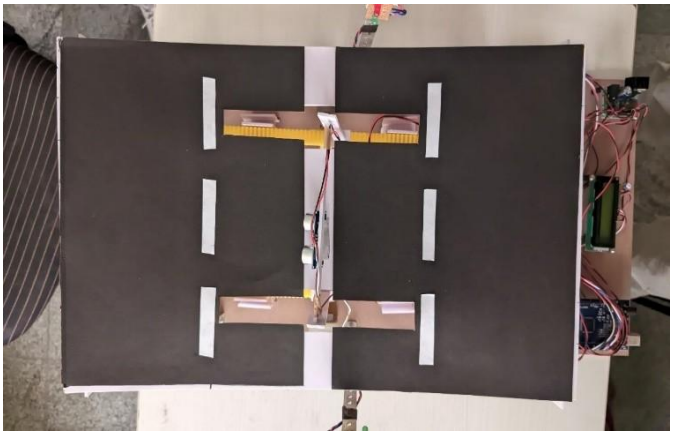

Fig 6a: Divider at the middle again during low traffic volume

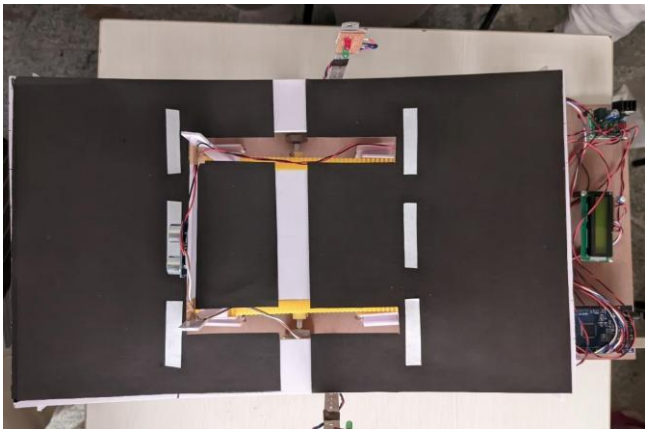

Fig 6b: **Divider during higher traffic volume on road2**

The LaneMorph system provides a scalable and adaptive approach to urban traffic management, ensuring efficient lane allocation, reduced congestion, and improved emergency response times. The integration of machine learning, IoT automation, and real-time data processing allows for a fully autonomous traffic optimization system that operates with minimal human intervention. One of the key advantages of LaneMorph is its ability to adjust dynamically to fluctuating traffic conditions. Unlike static road dividers, which fail to accommodate peak-hour congestion, LaneMorph ensures continuous lane optimization, leading to shorter travel times and reduced road stress. The system's reliance on computer vision and AI-driven automation makes it an ideal solution for smart city applications, paving the way for seamless integration with future autonomous vehicle networks.

To address these concerns, LaneMorph can be further enhanced by incorporating thermal imaging cameras for low-visibility scenarios and cloud-based AI models for remote traffic monitoring and control. Future developments may also include integration with vehicle-to- infrastructure (V2I) communication, allowing cars to interact directly with the system, further enhancing road safety and traffic flow. By continuously adapting to modern urban challenges, LaneMorph represents a new era of intelligent traffic management, ensuring efficiency, safety, and sustainability for the future of urban mobility.

IX. CONCLUSION

In this paper, we have presented an efficient and intelligent approach to dynamic traffic management using *LaneMorph*, a machine learning-powered road divider system. The system integrates real-time traffic surveillance, vehicle detection, emergency vehicle prioritization, adaptive lane reallocation, and IoT-enabled traffic control to optimize road utilization.We first explored various traffic monitoring techniques and their impact on congestion reduction.

We then analyzed different computer vision-based object detection algorithms, ultimately implementing the YOLO algorithm for high-speed, real-time vehicle recognition. Additionally, the integration of smart sensors and IoT automation allows for autonomous lane reconfiguration, ensuring optimal traffic distribution based on real-time conditions.The development of this system is a multidisciplinary effort, combining artificial intelligence, IoT, automation, and real-time data analytics to address modern urban mobility challenges. By ensuring faster emergency response times, reduced congestion, and optimized traffic flow, *LaneMorph* significantly enhances urban transportation efficiency. Overall, the project contributes to the advancement of intelligent traffic management solutions, paving the way for smart city integration and future-ready transportation networks.

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