SMART PILLAR INTEGRATON FOR ENHANCED TWO-WAY ROAD SAFETY

Minor project-II report submitted
in partial fulfillment of the requirement for award of the degree of

Bachelor of Technology
in
Computer Science & Engineering

By

MOHAMMAD AVEZH SHAREEF	(21UEDS0045)	**(VTU20017)**
S. CHARAN	(21UEDS0061)	**(VTU20485)**
V. YESWANTH GUPTA	(21UEDS0068)	**(VTU20497)**

Under the guidance of
Mrs. C. Shyamala Kumari, M. E
Assistant Professor

DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING
SCHOOL OF COMPUTING

VEL TECH RANGARAJAN DR. SAGUNTHALA R&D INSTITUTE OF SCIENCE & TECHNOLOGY

(Deemed to be University Estd u/s 3 of UGC Act, 1956)
Accredited by NAAC with A++ Grade
CHENNAI 600 062, TAMILNADU, INDIA

May, 2024

SMART PILLAR INTEGRATON FOR ENHANCED TWO-WAY ROAD SAFETY

Minor project-II report submitted
in partial fulfillment of the requirement for award of the degree of

Bachelor of Technology
in
Computer Science & Engineering

By

MOHAMMAD AVEZH SHAREEF	(21UEDS0045)	**(VTU20017)**
S. CHARAN	(21UEDS0061)	**(VTU20485)**
V. YESWANTH GUPTA	(21UEDS0068)	**(VTU20497)**

Under the guidance of
Mrs. C. Shyamala Kumari, M. E
Assistant Professor

DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING
SCHOOL OF COMPUTING

VEL TECH RANGARAJAN DR. SAGUNTHALA R&D INSTITUTE OF SCIENCE & TECHNOLOGY

(Deemed to be University Estd u/s 3 of UGC Act, 1956)
Accredited by NAAC with A++ Grade
CHENNAI 600 062, TAMILNADU, INDIA

May, 2024

CERTIFICATE

It is certified that the work contained in the project report titled "SMART PILLAR INTEGRATON FOR ENHANCED TWO-WAY ROAD SAFETY" by "MOHAMMAD AVEZH SHAREEF (21UEDS0045),S. CHARAN (21UEDS0061),V. YESWANTH GUPTA (21UEDS0068)" has been carried out under my supervision and that this work has not been submitted elsewhere for a degree.

Signature of Supervisor	
Mrs. C. Shyamala Kumari, M. E	
Assistant Professor	**Signature of Professor In-charge**
Computer Science & Engineering	**Computer Science & Engineering**
School of Computing	**School of Computing**
Vel Tech Rangarajan Dr. Sagunthala R&D	**Vel Tech Rangarajan Dr. Sagunthala R&D**
Institute of Science & Technology	**Institute of Science & Technology**
May, 2024	**May, 2024**

DECLARATION

We declare that this written submission represents my ideas in our own words and where others' ideas or words have been included, we have adequately cited and referenced the original sources. We also declare that we have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in our submission. We understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

(Signature)
MOHAMMAD AVEZH SHAREEF
Date: / /

(Signature)
S. CHARAN
Date: / /

(Signature)
V. YESWANTH GUPTA
Date: / /

APPROVAL SHEET

This project report entitled “SMART PILLAR INTEGRATON FOR ENHANCED TWO-WAY ROAD SAFETY” by “MOHAMMAD AVEZH SHAREEF (21UEDS0045), S. CHARAN (21UEDS0061),V. YESWANTH GUPTA (21UEDS0068)” is approved for the degree of B.Tech in Computer Science & Engineering.

Examiners **Supervisor**

Mrs. C. Shyamala Kumari, M. E.

Date: / /

Place:

ACKNOWLEDGEMENT

We express our deepest gratitude to our respected **Founder Chancellor and President Col. Prof. Dr. R. RANGARAJAN B.E. (EEE), B.E. (MECH), M.S (AUTO),D.Sc., Foundress President Dr. R. SAGUNTHALA RANGARAJAN M.B.B.S.** Chairperson Managing Trustee and Vice President.

We are very much grateful to our beloved **Vice Chancellor Prof. S. SALIVAHANAN,** for providing us with an environment to complete our project successfully.

We record indebtedness to our **Professor & Dean, Department of Computer Science & Engineering, School of Computing, Dr. V. SRINIVASA RAO, M.Tech., Ph.D.,** for immense care and encouragement towards us throughout the course of this project.

We are thankful to our **Head, Department of Computer Science & Engineering, Dr.M.S. MURALI DHAR, M.E., Ph.D.,** for providing immense support in all our endeavors.

We also take this opportunity to express a deep sense of gratitude to our Internal Supervisor **Ms. C. SHYAMALA KUMARI, M.E.** for her cordial support, valuable information and guidance, she helped us in completing this project through various stages.

A special thanks to our **Project Coordinators Mr. V. ASHOK KUMAR, M.Tech., Ms. U.HEMAVATHI, M.E., Ms. C. SHYAMALA KUMARI, M.E.,** for their valuable guidance and support throughout the course of the project.

We thank our department faculty, supporting staff and friends for their help and guidance to complete this project.

MOHAMMAD AVEZH SHAREEF (21UEDS0045)

S. CHARAN (21UEDS0061)

V. YESWANTH GUPTA (21UEDS0068)

ABSTRACT

Innovative solutions are desperately needed in the field of road safety, as the number of accidents caused by poor visibility and communication breakdowns continues to rise. The current system has mostly focused on measuring car speeds and imposing fines in accordance with them, which is a reactive approach that frequently fails to avoid accidents. Nonetheless, a novel approach has surfaced, suggesting the incorporation of intelligent columns furnished with ultrasonic sensors and Arduino technology, arranged methodically on either side of the street. Together, these pillars form a strong network that can identify vehicle speeds in real time and quickly send notifications to other pillars that match, therefore reducing road risks in a proactive manner.The core of this solution is its multifunctionality, which goes beyond just speed limit monitoring to include a thorough improvement in road safety. Through the utilization of ultrasonic sensors and the sophisticated processing powers enabled by Arduino technology, these intelligent pillars function as watchful protectors of the integrity of the roadway. In addition to identifying instances of speeding, they also make it easier for cars and infrastructure to communicate with one another, creating a mutually beneficial connection that promotes safer driving habits.A new age of road safety marked by a sharp decline in accidents and the protection of priceless human lives is also predicted by the installation of such a system. In addition to the immediate advantages of speed control, proactive technologies allow for proactive actions like warning drivers of impending dangers or dynamically modifying speed restrictions in response to actual traffic patterns. As a result, the road becomes a more secure and peaceful place for all users, including bicycles, pedestrians, drivers, and passengers on public transportation.To put it simply, the advent of smart pillars that are equipped with ultrasonic sensors and Arduino technology is a major advancement in the field of road safety. It represents the union of technological innovation with a proactive mentality, portending a time when the goal of safer roads materializes and accidents are reduced to a minimum.

Keywords: Road accidents, Poor visibility, Communication breakdown, Speed detection, Smart pillars, Ultrasonic sensors, Arduino technology, Real-time alerts, Road safety, Innovative approach

LIST OF FIGURES

LIST OF ACRONYMS AND ABBREVIATIONS

AID	Automatic Incident Detection
EWS	Early Warning System
GDPR	General Data Protection Regulation
ISMS	Information Security Management System
ITS	Intelligent Traffic Sysytem
VFC	Vechicular Fog Computing

TABLE OF CONTENTS

Chapter 1

INTRODUCTION

1.1 Introduction

In today's fast-paced world, ensuring road safety is a paramount concern, especially amidst instances of miscommunication leading to accidents. The prevailing system predominantly relies on detecting vehicle speed and issuing automatic fines for violations. However, a proposed solution presents a sophisticated remedy through the integration of ultrasonic sensors and Arduino microcontrollers within an innovative infrastructure component - the Smart Pillar.

Strategically positioned along roadways, these pillars are equipped with advanced sensors capable of accurately gauging vehicle speeds. Leveraging the capabilities of Arduino technology, the Smart Pillar efficiently processes this data and promptly triggers real-time alerts to counterparts on the opposite side.

Utilizing light blinkers and buzzers, these alerts serve not only to warn pedestrians and other road users but also to facilitate timely and proactive responses to potential hazards. This solution holds particular promise in regions with challenging topography such as hilly areas, where visibility limitations significantly contribute to accidents.

By enhancing communication and detection, this approach aims to substantially reduce such incidents and enhance overall road safety. The Smart Pillar integration offers a scalable and adaptable solution that can be implemented across various road networks, contributing to a safer and more secure transportation infrastructure for all.

1.2 Aim of the project

The creation of a comprehensive system that makes use of cutting-edge technologies is the goal of the Smart Pillar Integration for Enhanced Two-Way Road Safety project. In order to improve real-time traffic flow monitoring, identify hazards, promptly notify drivers, and facilitate effective emergency response coordination, smart pillars outfitted with sensors, cameras, and communication devices are being integrated. This will ultimately guarantee a safer and more secure driving environment for all users.

1.3 Project Domain

Transportation infrastructure has advanced significantly with the use of Smart Pillars to improve two-way road safety. In order to promote safer roads, these pillars integrate numerous cutting-edge technology and function as multipurpose hubs.

Dynamic traffic control is made possible by Smart Pillars' live traffic updates and real-time monitoring sensors. They make it possible for cars to communicate with each other seamlessly and send out alerts about possible dangers like accidents or bad weather.

These pillars also aid in the deployment of Intelligent Traffic Systems (ITS), which prioritize emergency vehicles and optimize traffic flow through adaptive signaling. By integrating communication between vehicles and infrastructure and between vehicles and vehicles, Smart Pillars promote an all-encompassing strategy for road safety. These devices offer important insights for future road design and safety enhancements by utilizing data analytics.

1.4 Scope of the Project

The principal aim is to prevent accidents proactively and improve road safety in general. To maintain the system's efficacy, this calls for ongoing assessment and optimization. Additionally, creating user-friendly interfaces is emphasized for interaction and accessibility, encouraging usability and broad acceptance. To guarantee flawless functioning and compatibility, integration with the infrastructure and traffic management systems already in place is essential. The technology will be made to produce notifications for speed restrictions and dangerous situations, giving drivers and pedestrians alike timely notice. By taking these steps, we hope to develop a comprehensive solution that not only tackles the problems we face today, but also foresees and reduces potential threats in the future, making roads safer for everyone.

Chapter 2

LITERATURE REVIEW

Rithik, M. et.al.,(2024) [1] states that the system integrates with Dropbox to store relevant images for future access by insurance firms, streamlining the claims process, and features a user-friendly web application for easy photo uploading, ensuring a seamless experience for both automobile owners and insurance providers.

Ramya Devi, M. et.al.,(2024) [2] states that on intelligent accident detection system employing Vehicular Fog Computing (VFC) automatically identifies crash spots using smartphone sensors, aiding swift emergency response in congested traffic and adverse weather. Real-time location monitoring facilitated by VFC enables efficient ambulance navigation, optimizing emergency resource allocation.

Kayser Mehbub Siam et.al.,(2024) [3] states that next-generation sequencing of pleural tissue, along with adenosine deaminase testing and thoracoscopic pleural biopsy, plays crucial roles in diagnosing TE, particularly in cases where standard pathogen-related tests yield negative results.

Podda, A.S., et.al.,(2024) [4] states that the proposed innovative pipeline combines a custom Convolutional Neural Network for identifying anomalous events in traffic sounds with a multi-representational encoding of audio spectrograms, resulting in significantly improved recognition accuracy compared to existing methods. This pipeline achieved a 0.96 percent false positive rate on the MIVIA dataset, outperforming state-of-the-art competitors, and has been implemented in a real-world video surveillance infrastructure.

Matsui, T., Oda et.al.,(2024) [5] states that the paper introduces an accident detection system for private lavatories utilizing fuzzy control and a low-resolution thermal camera. By employing simplified fuzzy control, the system reduces computational costs, making it feasible for implementation in small, power-saving devices. Evaluation results demonstrate the system's effectiveness in detecting falls or accidents using the low-resolution thermal camera.

Ariani, L., et.al.,(2024) [6] states that an Early Warning System (EWS) at level crossings employs inductive proximity sensors to detect approaching trains, enhancing railway safety by providing signals and sounds. The system utilizes hardware components like sensors, LCD, and I2C, along with software including Arduino IDE and Visual Basic Studio. Tests demonstrate its ability to detect passing vehicles and determine axle patterns accurately when sensors are optimally placed within a range of 1-4 mm.

Chen, J., et.al.,(2024) [7] states that a novel framework, TA-NET, addresses the challenge of limited annotated training data in Automatic Incident Detection (AID) for road surveillance systems. It employs weakly supervised learning with a pre-trained model and features two key modules: AHFRB for refining feature extraction and MHLSA for contextual relationship analysis between video segments. Validated on the TAD testing dataset, TA-NET achieves high efficacy, with an AUC of 94.47 percent for the overall dataset and 70.78 percent for anomaly detection, surpassing previous state-of-the-art methods by 1.54 percent and 4.96 perecent , respectively, setting a new standard for video-based traffic incident detection.

Khatavakar, V., et.al.,(2024) [8] states that road safety is a pressing global issue, with millions of lives lost or injured annually in road accidents. Among vulnerable road users, two-wheeler riders face particularly high risks due to their exposure to traffic hazards and lack of protective barriers. Helmets stand as a critical safety measure in mitigating the severity of injuries and fatalities in motorcycle and bicycle accidents.

Gkioka, G., et.al.,(2024) [9] states that the paper introduces a framework for efficient automatic detection of non-recurring incidents in transportation, such as accidents and congestion, emphasizing their socio-economic impact. Leveraging big data and data-driven AI, the proposed methodology includes conceptual and technical architecture, along with current implementation details. It compares data-driven approaches, presents experimental findings using real-world datasets, discusses limitations and challenges in the mobility sector, and suggests future research directions.

Lakshmi, A.B., et.al.,(2024) [10] states that a solution to rampant motorbike accidents due to helmet negligence emerges with smart helmets integrating control systems. These helmets aim to enhance road safety by preventing bike ignition unless the rider wears the helmet, utilizing RF technology. The innovation, including an alcohol sensor, aims to enforce helmet usage and detect intoxication, potentially saving lives and mitigating accident consequences.

Chapter 3

PROJECT DESCRIPTION

3.1 Existing System

The incorporation of Smart Pillars offers a novel approach to improving two-way traffic safety, directly addressing the shortcomings of the current system. Road safety is currently mostly dependent on sporadic monitoring and traditional signage, which allows for human mistake and slow response times. These restrictions may lead to mishaps, gridlock on the streets, and ineffective emergency response times. This environment is completely transformed by the introduction of Smart Pillars, which create a vast network of intelligent systems. These pillars allow for immediate data collection and analysis because they are outfitted with cameras, sensors, and communication devices for real-time monitoring. Through the integration of Smart Pillars, the shortcomings of the current system are successfully solved. First off, the existing system's absence of real-time data may cause responses to on-the-road events to be delayed. With its ability to monitor continuously, Smart Pillars can give immediate updates on weather-related issues, accidents, and traffic patterns. Authorities can quickly deploy essential measures, including rerouting traffic or deploying emergency personnel, thanks to this information.

The existing system frequently depends too much on human intervention to do activities like updating road signs or modifying speed restrictions. This manual method takes a long time and is prone to mistakes. These processes are automated by Smart Pillars, guaranteeing precise and prompt modifications to the state of the road. Furthermore, the incorporation of AI algorithms can forecast possible risks based Furthermore, the current system's deficiency in gathering thorough data makes it more difficult to create long-term road safety plans that work. This restriction is circumvented by Smart Pillars, which collect massive volumes of real-time data that may be processed to find patterns, accident hotspots, and places in need of infrastructure upgrades. Authorities may put targeted safety measures in place, including installing speed cameras, increasing pedestrian crossings, or improving traffic signals, thanks to this data-driven strategy.

3.2 Proposed System

The incorporation of Smart Pillars signifies a revolutionary development in the field of traffic safety. By placing these pillars in key locations throughout two-way road systems, we can completely change how traffic movement is observed and controlled. These cutting-edge pillars, which are outfitted with Arduino microcontrollers and ultrasonic sensors, can quickly and correctly broadcast real-time notifications to their counterparts on the other side, as well as identify vehicle speeds. Proactive traffic management allows for prompt actions, like alerting drivers and pedestrians to possible dangers like oncoming traffic or unfavorable weather. Furthermore, there are a lot of benefits that the suggested methodology has over conventional techniques. It offers a scalable and reasonably priced solution that is simple to incorporate into the current infrastructure, reducing the need for major repairs. Furthermore, the system's capacity to consistently

3.3 Feasibility Study

3.3.1 Economic Feasibility

The long-term cost-effectiveness and potential savings of incorporating Smart Pillars for improved two-way road safety demonstrate the economic viability of this approach. The installation of sensors, Arduino microcontrollers, and infrastructure setup may need an initial expenditure; nevertheless, the advantages greatly exceed the expenses. Over time, the Smart Pillar system generates significant cost savings by averting accidents and mitigating the related expenditures of property damage, medical bills, and emergency response services. Furthermore, the system's scalability minimizes upfront costs by enabling a phased rollout. Further boosting the economy are the savings in fuel and travel time that result from improved traffic flow management efficiency. Moreover, integration with current infrastructure reduces the need for expensive additions or major remodeling. As a result, looking at things both short- and long-term, the economic

3.3.2 Technical Feasibility

Incorporating Smart Pillars to improve two-way road safety is a critical development in contemporary transportation infrastructure. The technological viability of the current system provides a strong basis for this creative endeavor. With its state-of-the-art sensors and real-time data processing powers, Smart Pillars provide a dynamic way to keep an eye on traffic conditions, identify any threats, and improve traffic flow. Through the smooth incorporation of these pillars into the current road networks, law enforcement can create a holistic safety ecosystem. Authorities can respond quickly to emergencies, accidents, and bad weather thanks to this system's instantaneous insights. In addition, the integration of Smart Pillars promotes efficient communication between automobiles and infrastructure, so creating a safer atmosphere for all users of the road. The cost-effective installation of road safety measures is ensured by utilizing the current technical infrastructure, which also maximizes their efficiency and efficacy. Embracing Smart Pillars is a fundamental part of our shared goal of advancing safer, more effective roads as we transition to a smarter, more integrated transportation environment.

3.3.3 Social Feasibility

Installing a Smart Pillar Integration system to enhance two-way road safety is an essential technological advancement that also advances efficient traffic control and protects human life. Real-time monitoring and proactive steps to mitigate possible threats are frequently absent from the current system. We create a network that can continuously collect data on different road conditions, traffic flow, and even driver behavior by incorporating Smart Pillars along the roads. With the use of this data, authorities are better equipped to act quickly, rerouting traffic in the event of an accident or congestion and adjusting signal timings to minimize bottlenecks. From a social standpoint, the incorporation of Smart Pillars satisfies a basic demand for road safety. The system takes a proactive stance, averting mishaps instead of responding to them. This lessens the financial and emotional strain on families and society at large in addition to saving lives. Moreover, commuters benefit from the integration since they feel more certain that their safety is a top priority. People drive more responsibly since they are aware of the monitoring capabilities. All things considered, the Smart Pillar Integration for improved two-way traffic safety is about more than simply technology.

3.4 System Specification

3.4.1 Hardware Specification

1. Ultrasonic sensors with a range of [specify range, e.g., 2 meters to 4 meters]
2. Arduino microcontrollers (e.g., Arduino Uno or Arduino Mega) with [specify RAM and storage capacity, e.g., 2KB RAM and 32KB Flash memory]
3. LED light blinkers for real-time alerts
4. Buzzers for auditory alerts
5. Weather-resistant casing to withstand outdoor conditions
6. Power source (e.g., solar panels or mains electricity) with [specify voltage and current requirements]
7. Connectivity options (e.g., Wi-Fi or cellular) for data transmission
8. Mounting hardware for secure installation on roadways
9. Compatibility with existing traffic management systems and infrastructure
10. Scalable design to accommodate future upgrades or expansions

3.4.2 Software Specification

1. Firmware developed using Arduino IDE with support for real-time data processing
2. Programming language: C/C++ for Arduino microcontrollers
3. Algorithm for accurate speed detection and real-time alert generation
4. Communication protocol (e.g., MQTT or HTTP) for transmitting data between Smart Pillars
5. User interface for configuration and monitoring, accessible via web interface or mobile application
6. Integration with existing traffic management software for seamless operation
7. Data logging and analytics capabilities for performance evaluation and optimization

8. Security features to prevent unauthorized access or tampering with system settings
9. Compatibility with open-source libraries and modules for enhanced functionality
10. Regular software updates to address bugs, vulnerabilities, and add new features

3.4.3 Standards and Policies

ISO/IEC 27001:

This standard sets out the requirements for establishing, implementing, maintaining, and continually improving an information security management system (ISMS). Compliance with ISO/IEC 27001 ensures that information security risks, including those related to data collected and processed by Smart Pillars, are effectively managed and mitigated.

Traffic Safety Regulations:

Adherence to local and national traffic safety regulations is essential to ensure that the Smart Pillar integration complies with legal requirements regarding speed detection, alert mechanisms, and data handling. Compliance with traffic safety regulations helps to uphold public safety and prevent accidents on roadways.

Data Protection Laws:

Compliance with data protection laws, such as the General Data Protection Regulation (GDPR) in the European Union or the California Consumer Privacy Act in the United States, is crucial to safeguarding the privacy and rights of individuals whose data may be collected and processed by Smart Pillars. Ensuring compliance with data protection laws helps to maintain public trust and mitigate legal risks.

Accessibility Standards:

Incorporating accessibility standards, such as the Web Content Accessibility Guidelines , ensures that user interfaces and alerts generated by Smart Pillars are accessible to individuals with disabilities. Compliance with accessibility standards promotes inclusivity and ensures that all road users can benefit from enhanced road safety measures.

Chapter 4

METHODOLOGY

4.1 Smart Pillar Architecture

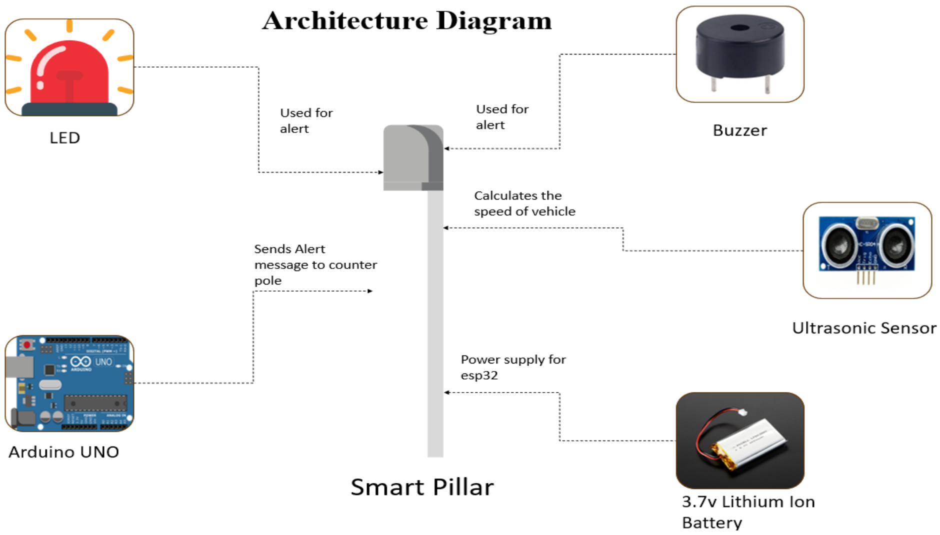


Figure 4.1: Architecture of Smart Pillar

The figure 4.1 describes overall design of the Smart Pillar integration system for improved two-way road safety consists of carefully placed pillars that are outfitted with Arduino microcontrollers and ultrasonic sensors. These pillars allow for proactive reactions to possible problems by detecting vehicle speeds and sending real-time alerts to equivalents on the other side. The system combines with the infrastructure and traffic control systems already in place and has user-friendly interfaces for accessibility and engagement. While adherence to standards and procedures, such as ISO/IEC 27001, assures data security and compliance with rules, continuous evaluation and optimization guarantee its efficacy. All things considered, this architecture provides a thorough way to improve traffic safety and reduce collisions.

4.2 Design Phase

4.2.1 Data Flow Diagram

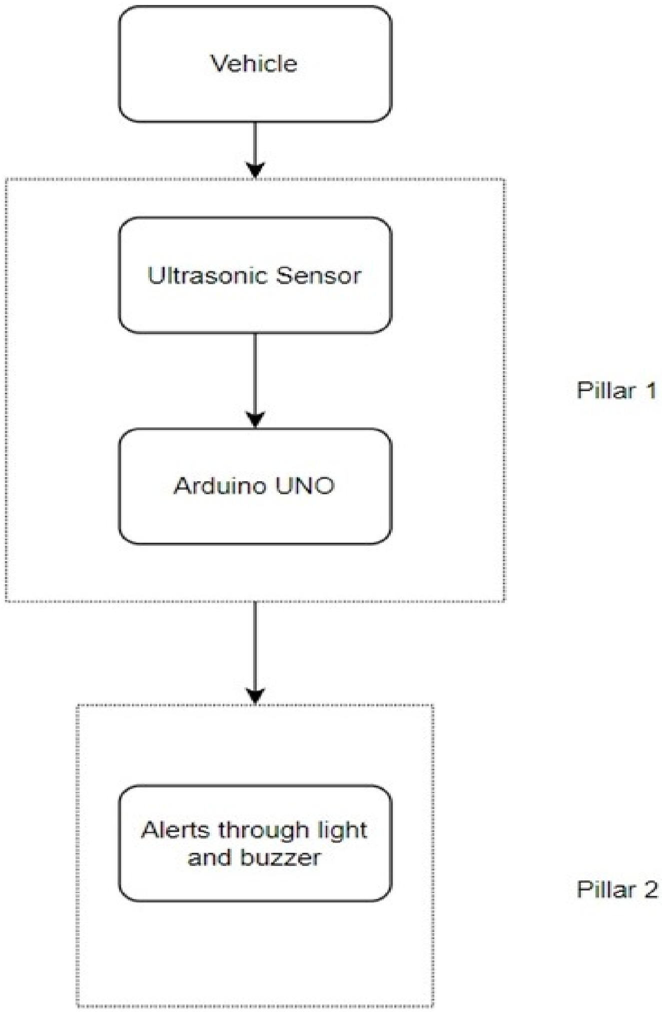


Figure 4.2: Data Flow Diagram

The figure 4.2 describes information flow within the system is depicted in the data-flow diagram for the Smart Pillar integration. Ultrasonic sensors record vehicle speed data, which is sent to Arduino microcontrollers for processing. On the basis of predetermined thresholds, real-time notifications are generated and relayed to equivalents on the other side of the road. User-friendly interfaces also make it easier for users to connect with the system through activities like monitoring and configuration changes. Data interchange is made easy by integration with current traffic management systems, and system optimization is guaranteed by ongoing review. Ensuring data security and regulatory adherence through compliance with standards and rules, such as ISO/IEC 27001, improves road safety.

4.2.2 Use Case Diagram

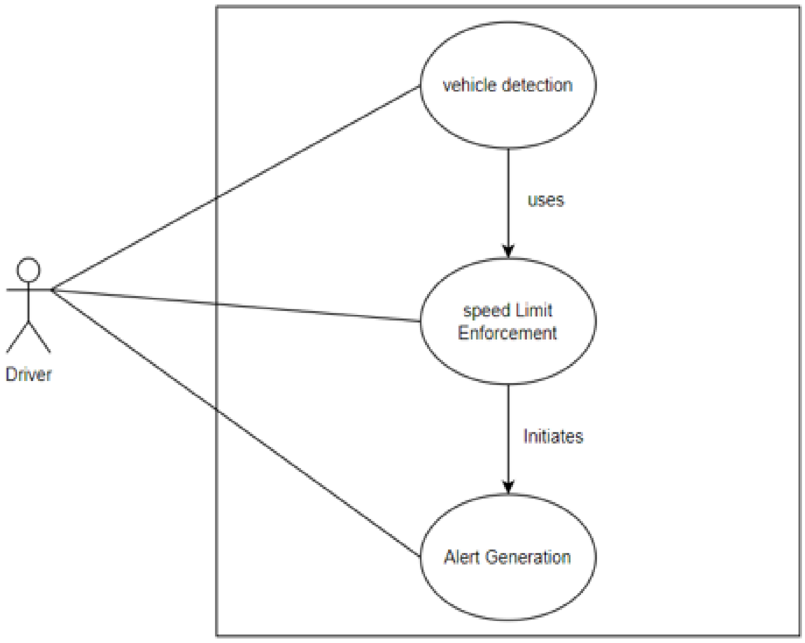


Figure 4.3: Use Case Diagram

The figure 4.3 describes interactions between various actors and the system are shown in the use case diagram for the integration of Smart Pillars. Various use cases, such as getting real-time notifications, adjusting system settings, and keeping an eye on traffic conditions, are started by actors, such as drivers, pedestrians, and traffic officials. In response, the system generates notifications based on measured vehicle speeds, integrates with pre-existing traffic control systems, and makes user interactions easier through intuitive interfaces. Ongoing assessment guarantees system efficiency, and adherence to guidelines and regulations, such ISO/IEC 27001, guarantees data protection and legal compliance. In general, the use case diagram shows how proactive monitoring and reaction mechanisms provided by Smart Pillar integration improve two-way road safety.

4.2.3 Class Diagram

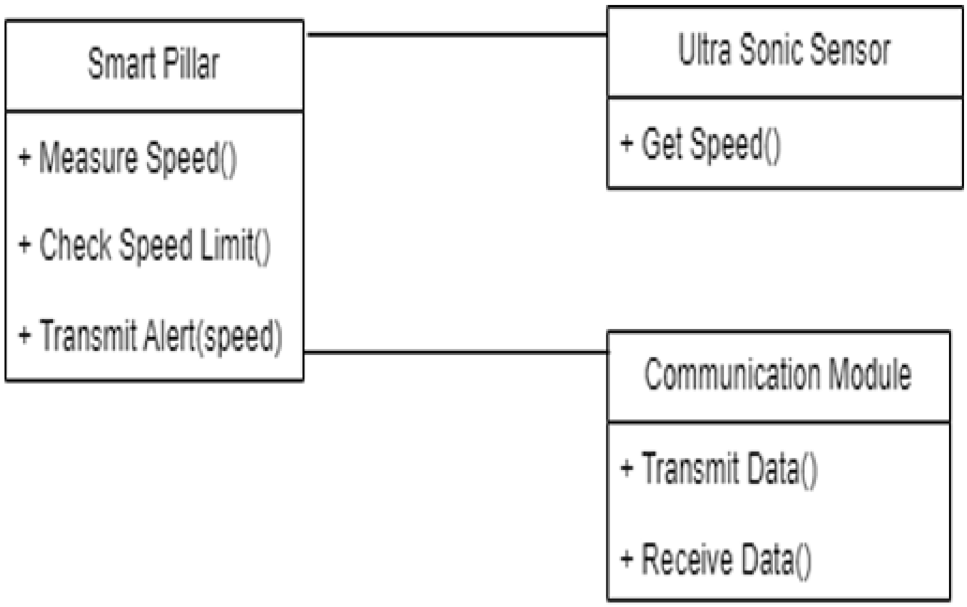


Figure 4.4: Class Diagram

The figure 4.4 describes many classes and their relationships inside the system are shown in the class diagram for the Smart Pillar integration. Among the classes are ”AlertSystem,” ”UltrasonicSensor,” ”SmartPillar,” and ”ArduinoController.” The ”UltrasonicSensor” and ”ArduinoController” classes handle speed detection and data processing, respectively, while the ”SmartPillar” class oversees the pillar’s general operation. Real-time notifications are generated by the ”AlertSystem” class in response to detected vehicle speeds. Relationships within classes show how they work together to accomplish system goals, such sending out alarms and detecting speed infractions. The class diagram facilitates system design and execution by offering a clear picture of the architecture and functionality of the system through its structured depiction.

4.2.4 Sequence Diagram

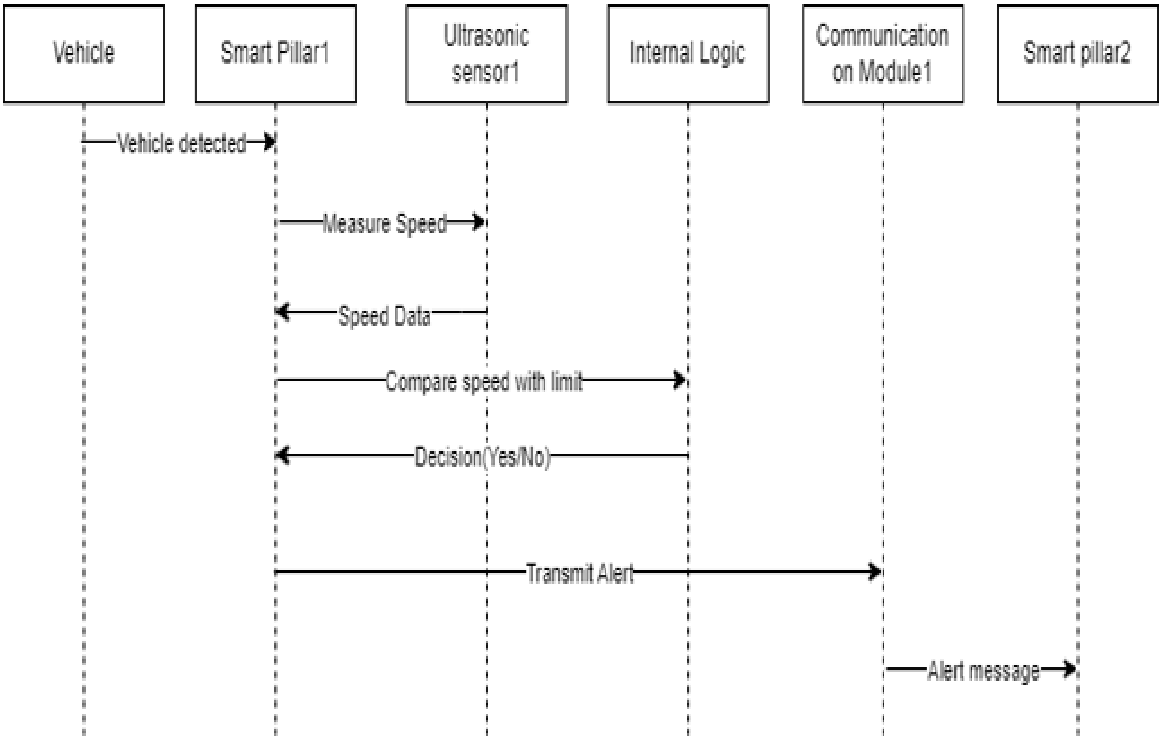


Figure 4.5: Sequence Diagram

The figure 4.5 describes interactions that occur throughout time between various system actors and components are depicted in the sequence diagram for Smart Pillar integration. It shows the series of messages that are sent back and forth between the ”Traffic Management System,” ”Smart Pillar,” and ”Vehicle.” The ”Ultrasonic Sensor” first measures the vehicle’s speed, after which the ”Arduino Controller” processes the data. The ”Alert System” then uses predetermined thresholds to generate real-time alerts. The ”Traffic Management System” receives these alerts and takes appropriate action. The sequence diagram offers a thorough picture of how the system operates in response to vehicle speed detection and alert production through this sequential representation.

4.2.5 Collaboration Diagram

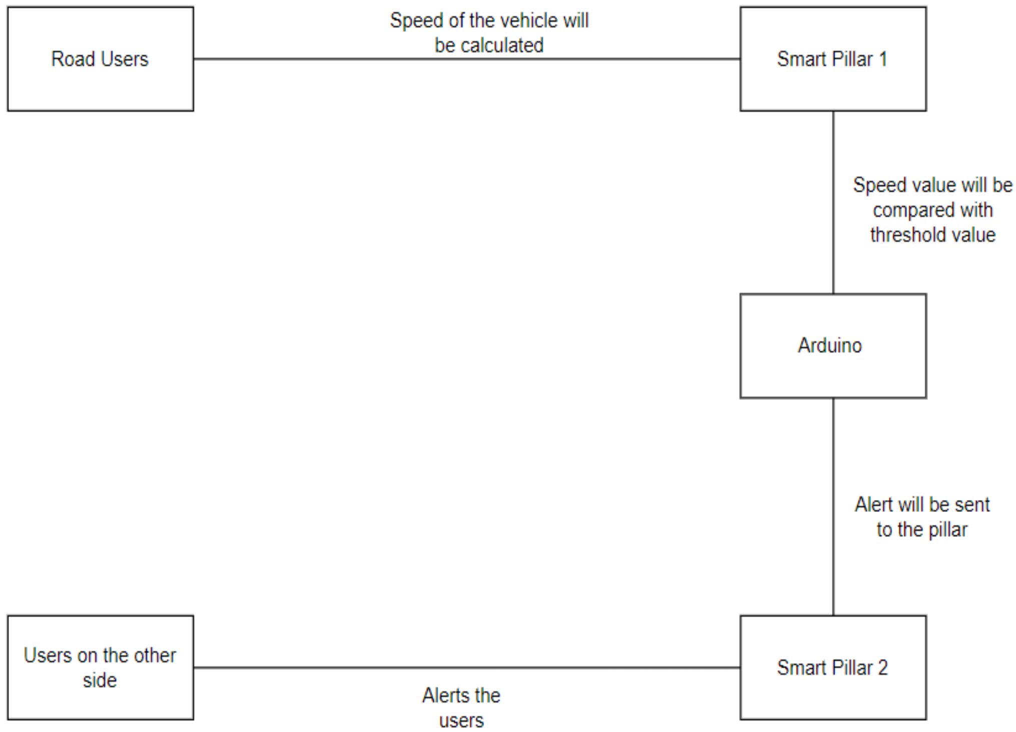


Figure 4.6: Collaboration Diagram

The figure 4.6 describes about linkages and interactions between various items or classes within the system are depicted in the collaboration diagram for the Smart Pillar integration. It demonstrates how these items work together to accomplish particular functions, such warning creation and vehicle speed detection. Labeled lines linking the objects show their respective roles and interactions with one another. The diagram gives insights into the data flow and control within the system by giving a visual depiction of the cooperation between objects. This makes the architecture of the system easier to comprehend and makes it easier for development teams to collaborate and communicate with one another during the implementation stage.

4.2.6 Activity Diagram

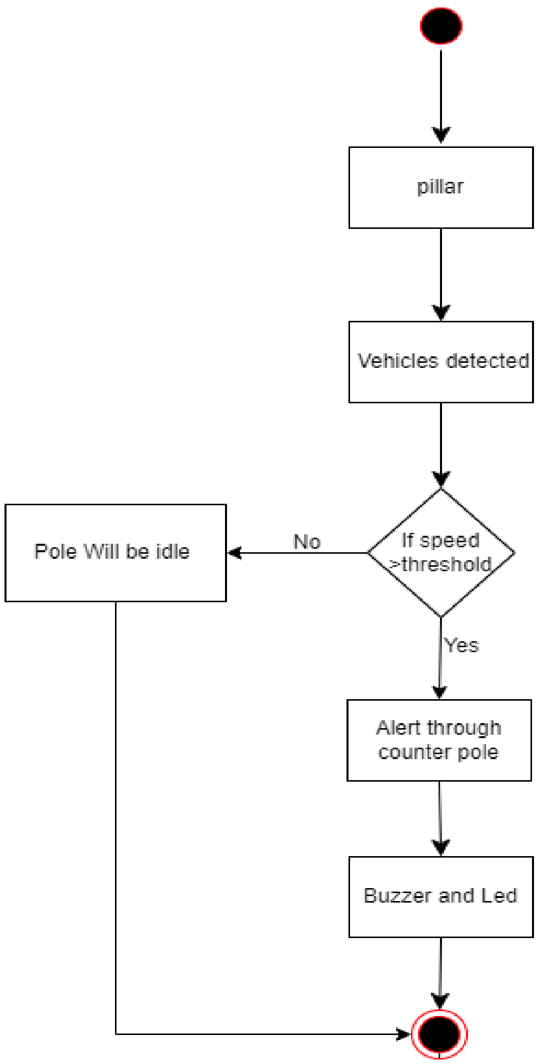


Figure 4.7: Activity Diagram

The figure 4.7 describes about activity diagram for the given scenario depicts the sequential flow of actions within the system. It begins with the initialization process, where pins are set up for sensors, LED, and serial communication. The main operating cycle, represented by the loop function, involves measuring distances using two ultrasonic sensors, calculating the vehicle speed based on the time difference between sensor readings, and checking if the speed exceeds a predefined threshold. If the speed is above or equal to 60 km/h, the LED is turned on to indicate a potential speeding vehicle. The calculated speed is also outputted to the serial monitor for debugging purposes. Error handling is incorporated to address division by zero errors during speed calculation. A delay of 500 milliseconds is introduced for stability before the loop repeats, ensuring continuous operation of the system.

4.3 Algorithm & Pseudo Code

4.3.1 Speed Alerting Algorithm

1. Pin Configuration: Define the pins for the ultrasonic sensors (trigPin1, echoPin1, trigPin2, echoPin2) and the LED pin (ledPin).

2. Variable Declaration: Declare variables for storing duration (duration1, duration2), distance (distance1, distance2), and speed.

3. Setup Function:

   - Set the pinMode for all pins as either OUTPUT or INPUT.
   - Initialize serial communication with a baud rate of 9600 for debugging purposes.

4. Loop Function:

   - Call the measureDistance function for both sensors to measure the distance.
   - Calculate the time difference between the two sensor readings and convert it to seconds.
   - Define the distance between the sensors.
   - Calculate the speed using the formula: speed = distanceBetweenSensors / timeDifference * 3.6 (to convert m/s to km/h).
   - Output the speed to the serial monitor.
   - If the speed is greater than or equal to 60 km/h, turn on the LED; otherwise, turn it off.

5. Measure Distance Function:

   - Trigger the ultrasonic sensor by setting the trigPin to LOW for 2 microseconds and then HIGH for 10 microseconds.
   - Measure the duration of the echo pulse using pulseIn function.
   - Calculate the distance based on the duration and the speed of sound (0.034 cm/s).
   - Print the raw distance readings for debugging purposes.
   - Store the duration in the appropriate variable based on the trigPin used.
   - Return the calculated distance.

4.3.2 Pseudo Code

```
DEFINE CONSTANTS:
  trigPin1 = 2  // First sensor trigger pin
  echoPin1 = 3  // First sensor echo pin
  trigPin2 = 4  // Second sensor trigger pin
  echoPin2 = 5  // Second sensor echo pin
  ledPin = 7    // LED pin

DEFINE VARIABLES:
  duration1     // Duration variable for first sensor reading
  duration2     // Duration variable for second sensor reading
  distance1     // Distance variable for first sensor reading
  distance2     // Distance variable for second sensor reading
  speed         // Variable to store calculated speed

SETUP:
  Set trigPin1 as output
  Set echoPin1 as input
  Set trigPin2 as output
  Set echoPin2 as input
  Set ledPin as output
  Initialize serial communication at 9600 baud rate

LOOP:
  Measure distance for first sensor using measureDistance
  function
  Measure distance for second sensor using measureDistance
  function
  Calculate time difference between sensor readings
  Calculate distance between sensors
  Check for division by zero
  If timeDifference is not equal to zero:
    Calculate speed in km/h
    Output speed to serial monitor
```

```
    Control LED based on speed (if speed >= 60 km/h, turn on
   LED; else, turn off LED)
  Else:
    Print "Error: Division by zero" to serial monitor
  Delay for stability (500 ms)

MEASURE DISTANCE FUNCTION:
  Send 10  s  pulse to trigger the sensor
  Read duration of echo pulse
  Calculate distance based on duration
  Print raw distance readings for debugging
  Store duration for speed calculation
  Return calculated distance
```

4.4 Module Description

4.4.1 Speed Detection Algorithm(Doppler Shift)

The speed detection process using the Doppler effect involves using radar or lidar devices that emit waves (radio or light waves, respectively) toward a moving vehicle and then measure the changes in the frequency of the waves as they bounce back from the vehicle.

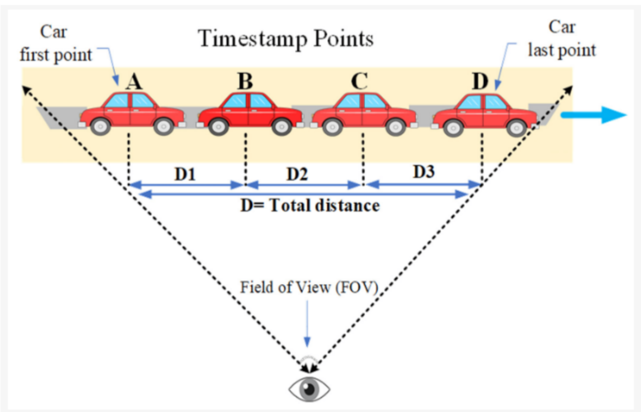


Figure 4.8: Speed detection Algorithm

This change in frequency is used to calculate the speed of the vehicle, based on the principles of the Doppler effect. Here are the steps:

1. Wave Emission: In order to detect a target, the system generates waves, most commonly acoustic (sonar) or electromagnetic (radar). In radar systems, this released wave can be a radio wave, and in sonar systems, it can be a sound wave.

2. Interaction with Target: The wave makes contact with the object it is aiming toward, such a car or an airplane. The Doppler effect causes the wave's frequency to vary as the target moves. The wave's frequency rises as the target gets closer to the emitter. The frequency drops when the target moves away.

3. Frequency Analysis: Following an interaction with the target, the system measures the frequency of the wave that returns. The Doppler shift, which is directly related to the target's speed in relation to the emitter, can be found by the system by comparing the frequency of the emitted wave with the frequency of the returning wave.

4. Speed Calculation: The system determines the target's speed by using the Doppler shift data. The established connection between Doppler shift and relative velocity serves as the foundation for this computation.

5. Display or Action: The computed speed can be recorded for additional study, shown on a screen for the operator, or used to start an action like squelching traffic or sending a speeding penalty.

4.4.2 Alerting Algorithm

1. Monitoring: The algorithm keeps an eye on certain system events, data streams, or parameters on a constant basis. Depending on the application domain, these characteristics may include sensor readings, network traffic, user activity, system performance measurements, or any other pertinent data sources.

2. Rules and Thresholds: The algorithm establishes rules or thresholds that, when met or exceeded, cause warnings to sound. Usually, the specified criteria or thresholds are determined by the particular needs of the application or the intended system behavior. They may be established using statistical research, domain knowledge, historical facts, or legal requirements.

3. Detection: The alerting system picks up on abnormalities or departures from typical behavior when the monitored parameters or events surpass the predetermined thresholds or break the set criteria. Simple threshold comparisons, pattern

recognition, anomaly detection methods, machine learning models, or a combination of these approaches may be the basis for this detection.

4. Alert Generation: The algorithm sends out an alert or notification to pertinent parties, including system administrators, operators, or end users, when it notices a noteworthy occurrence or circumstance. Depending on the urgency and seriousness of the situation, the warning may appear as a visual notification, an auditory alarm, an email alert, an SMS message, or a series of automated activities that trigger system responses.

5. Escalation and Response: To make sure that alarms are properly handled and answered promptly, the alerting algorithm may occasionally incorporate escalation methods. This might be assigning warnings to staff members at different levels according to their significance or severity, putting automatic response.

4.5 Steps to run the project

4.5.1 Installation and Configuration:

1. Place Smart Pillars in the appropriate places along the roads to provide stability and correct alignment.

2. As specified in the design, connect the Arduino microcontrollers, communication modules, and ultrasonic sensors.

3. To ensure precise speed detection and communication, calibrate the sensors and adjust the system settings.

4.5.2 Integration with Traffic Management Systems:

1. Connect data from Smart Pillars to current traffic management systems to enable smooth reaction and coordination.

2. Create procedures for informing the appropriate authorities and stakeholders about traffic information and alarms in real time.

4.5.3 Monitoring and Maintenance:

1. Establish a routine monitoring program to guarantee continued system performance and operation.

2. Regular maintenance checks should be performed to examine hardware parts, update software, and quickly resolve any problems.
3. In order to maximize the Smart Pillar system's performance over time, pay attention to input and make the required modifications.

Chapter 5

IMPLEMENTATION AND TESTING

5.1 Input and Output

5.1.1 Smart Pillar Design

Each smart pillar will be equipped with ultrasonic sensors and an Arduino microcontroller. The ultrasonic sensors are responsible for detecting the speed of passing vehicles by measuring the time interval between the emission and reception of sound waves bounced off the moving vehicles. This data is then processed by the Arduino to calculate the actual speed. The Arduino should also be configured to receive GPS coordinates to accurately determine the location of each incident of overspeeding. For communication between pillars, a module will be incorporated into each pillar to transmit real-time speed data and alerts to adjacent pillars. This setup allows for immediate communication and response, helping to alert incoming traffic about potential dangers ahead due to speeding vehicles, thereby enhancing preventive measures and overall road safety.

5.1.2 Alert Process

In order to tackle the issue of traffic accidents resulting from inadequate visibility and communication, the suggested output design integrates intelligent pillars positioned on both sides of the road. These pillars are outfitted with Arduino controllers and ultrasonic sensors to track passing cars' speeds continually. The smart pillar uses a wireless link to instantaneously transmit its detection of a car violating the speed limit to its counterpart across the road. The opposing pillar then turns on warning signals to advise oncoming motorists of the rushing car ahead, like flashing lights and alarm sounds. This device greatly improves road safety in low-visibility situations by actively preventing accidents by alerting drivers in real time, in addition to detecting and recording speed infractions for law enforcement.

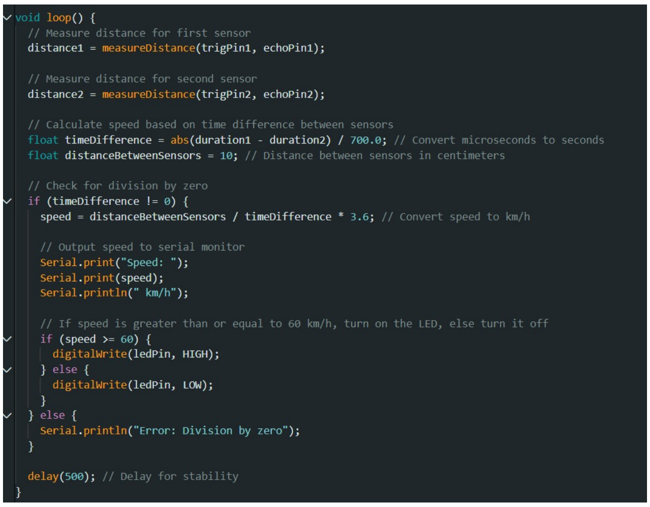
5.2 Testing

5.3 Types of Testing

5.3.1 Unit testing

Unit testing for the Smart Pillar using Ultrasonic Sensor and Arduino involves testing individual units of code, such as functions and modules, in isolation to ensure they perform as expected.

Input



```
void loop() {
  // Measure distance for first sensor
  distance1 = measureDistance(trigPin1, echoPin1);

  // Measure distance for second sensor
  distance2 = measureDistance(trigPin2, echoPin2);

  // Calculate speed based on time difference between sensors
  float timeDifference = abs(duration1 - duration2) / 700.0; // Convert microseconds to seconds
  float distanceBetweenSensors = 10; // Distance between sensors in centimeters

  // Check for division by zero
  if (timeDifference != 0) {
    speed = distanceBetweenSensors / timeDifference * 3.6; // Convert speed to km/h

    // Output speed to serial monitor
    Serial.print("Speed: ");
    Serial.print(speed);
    Serial.println(" km/h");

    // If speed is greater than or equal to 60 km/h, turn on the LED, else turn it off
    if (speed >= 60) {
      digitalWrite(ledPin, HIGH);
    } else {
      digitalWrite(ledPin, LOW);
    }
  } else {
    Serial.println("Error: Division by zero");
  }

  delay(500); // Delay for stability
}
```

Figure 5.1: Unit Testing

Test result

```
Output    Serial Monitor ×
Message (Enter to send message to 'Arduino Uno' on 'COM9')
Speed: 77.54 km/h
Speed: 39.62 km/h
Speed: 77.54 km/h
Speed: 60.87 km/h
Speed: 2.10 km/h
Speed: 1.91 km/h
Speed: 1.90 km/h
Speed: 1.91 km/h
Speed: 19.73 km/h
```

Figure 5.2: Unit testing output

5.3.2 Integration testing

Integration testing for our project includes the testing of the sensor endpoints to check if the sensors is up and running and sensing the correct values of speed and sending alerts to the counterpart pillar

Input

```
void setup() {
  pinMode(trigPin1, OUTPUT);
  pinMode(echoPin1, INPUT);
  pinMode(trigPin2, OUTPUT);
  pinMode(echoPin2, INPUT);
  pinMode(ledPin, OUTPUT);
  Serial.begin(9600);
}
void loop() {
  distance1 = measureDistance(trigPin1, echoPin1);
  distance2 = measureDistance(trigPin2, echoPin2);
  float timeDifference = abs(duration1 - duration2) / 700.0;
  float distanceBetweenSensors = 10;
  if (timeDifference != 0) {
    speed = distanceBetweenSensors / timeDifference * 3.6;
    Serial.print("Speed: ");
    Serial.print(speed);
    Serial.println(" km/h");
    if (speed >= 60) {
      digitalWrite(ledPin, HIGH);
    } else {
      digitalWrite(ledPin, LOW);
    }
  } else {
    Serial.println("Error: Division by zero");
  }
  delay(500);
}
int measureDistance(int trigPin, int echoPin) {
  digitalWrite(trigPin, LOW);
  delayMicroseconds(2);
  digitalWrite(trigPin, HIGH);
  delayMicroseconds(10);
```

Figure 5.3: Integration Test

Test result

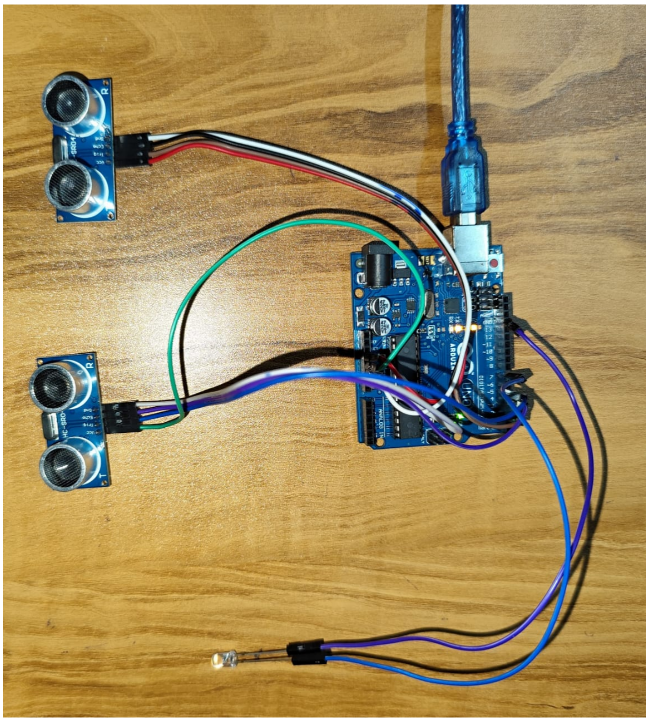
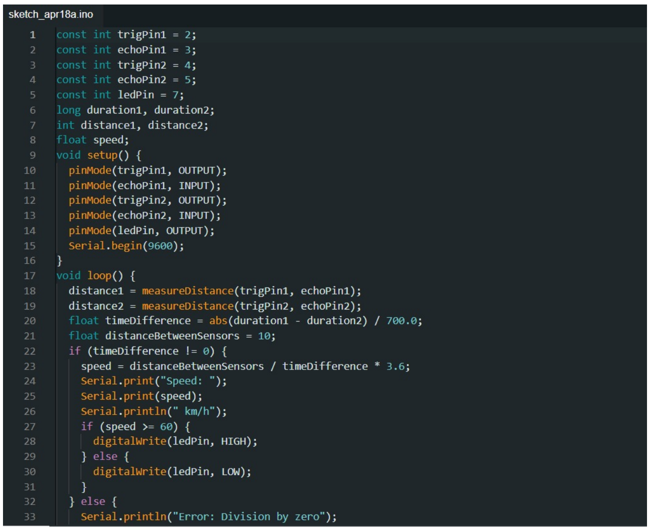


Figure 5.4: Integration Test output

5.3.3 System testing

The goal of system testing is to ensure that all components of a software application work together seamlessly to achieve the specified requirements and functionality. All the modules present in this project are tested together.

Input



```
sketch_apr18a.ino
const int trigPin1 = 2;
const int echoPin1 = 3;
const int trigPin2 = 4;
const int echoPin2 = 5;
const int ledPin = 7;
long duration1, duration2;
int distance1, distance2;
float speed;
void setup() {
  pinMode(trigPin1, OUTPUT);
  pinMode(echoPin1, INPUT);
  pinMode(trigPin2, OUTPUT);
  pinMode(echoPin2, INPUT);
  pinMode(ledPin, OUTPUT);
  Serial.begin(9600);
}
void loop() {
  distance1 = measureDistance(trigPin1, echoPin1);
  distance2 = measureDistance(trigPin2, echoPin2);
  float timeDifference = abs(duration1 - duration2) / 700.0;
  float distanceBetweenSensors = 10;
  if (timeDifference != 0) {
    speed = distanceBetweenSensors / timeDifference * 3.6;
    Serial.print("Speed: ");
    Serial.print(speed);
    Serial.println(" km/h");
    if (speed >= 60) {
      digitalWrite(ledPin, HIGH);
    } else {
      digitalWrite(ledPin, LOW);
    }
  } else {
    Serial.println("Error: Division by zero");
```

Figure 5.5: System Testing

Test Result

```
Output   Serial Monitor ×
Message (Enter to send message to 'Arduino Uno' on 'COM9')
Speed: 77.54 km/h
Speed: 39.62 km/h
Speed: 77.54 km/h
Speed: 60.87 km/h
Speed: 2.10 km/h
Speed: 1.91 km/h
Speed: 1.90 km/h
Speed: 1.91 km/h
Speed: 19.73 km/h
```

Figure 5.6: System testing output

5.3.4 Test Result

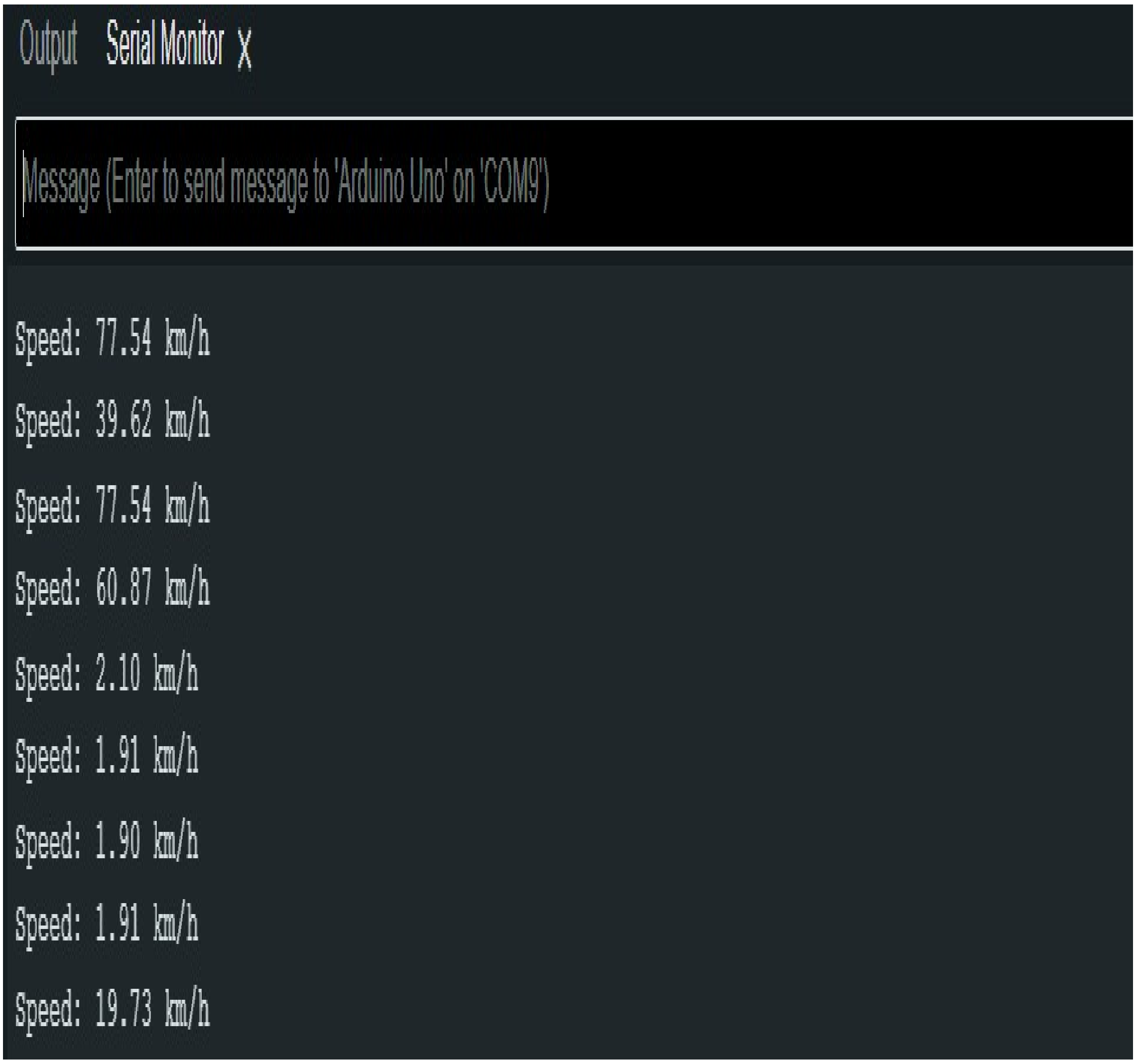


Figure 5.7: Speed Test Result

Chapter 6

RESULTS AND DISCUSSIONS

6.1 Efficiency of the Proposed System

One effective technique to improve two-way traffic safety is through the incorporation of Smart Pillar that has been suggested. Through the strategic placement of Arduino microcontrollers and ultrasonic sensors, the system guarantees accurate vehicle speed detection, allowing for quick reactions to possible threats. Proactive actions are made easier by real-time warnings that are sent between Smart Pillars, alerting drivers and pedestrians to dangerous situations and speeding offenses. In addition to lowering the risk of accidents, this proactive strategy maximizes traffic flow, reducing congestion and improving overall road efficiency.

The system's effectiveness and usefulness are further enhanced by its user-friendly interfaces and interaction with current traffic management systems. Efficiency is further improved by ongoing assessment and improvement processes, which provide adaptability to changing traffic conditions and safety regulations. Essentially, the suggested Smart Pillar integration represents a thorough and effective solution.

6.2 Comparison of Existing and Proposed System

Existing system:

The suggested Smart The enforcement of traffic laws and speed detection are the main components of the current road safety system. Usually, speed cameras or radar equipment are used to track vehicle speeds and penalize drivers who go over the speed limit. Nevertheless, because fines are only applied following speeding infractions, this system is essentially reactive. It is not equipped with real-time intervention features to stop accidents or quickly reduce possible risks. Additionally, the current system might not always be able to handle issues with poor visibility or communication breakdowns, both of which can lead to traffic accidents. All things considered, the current system does a great job of enforcing traffic laws, but it is not as good at taking preventative action to improve road safety and efficiently reduce risks in real time.

Proposed system:

A major step forward in improving two-way traffic safety is the incorporation of Smart Pillars into the proposed road safety system. Because of their Arduino technology and ultrasonic sensors, these Smart Pillars can accurately detect vehicle speeds and provide notifications for any threats in real time. The suggested system has a proactive stance by giving drivers and pedestrians immediate warnings, in contrast to the current system, which is mostly reactive. The purpose of this proactive intervention is to improve overall road safety by preventing accidents and rapidly mitigating dangers. The effectiveness of the suggested system is further increased by its integration with the current infrastructure, which guarantees smooth data interchange and communication.All things considered, the suggested system is a revolutionary approach to road safety that turns the focus from reactive enforcement to proactive prevention, greatly lowering the risk of collisions and enhancing the security of two-way road systems.All things considered, the suggested system is a revolutionary approach to road safety that turns the focus from reactive enforcement to proactive prevention, greatly lowering the risk of collisions and enhancing the security of two-way road systems.

6.3 Sample Code

```
const int trigPin1 = 2;
const int echoPin1 = 3;
const int trigPin2 = 4;
const int echoPin2 = 5;
const int ledPin = 7;
long duration1, duration2;
int distance1, distance2;
float speed;
void setup() {
  pinMode(trigPin1, OUTPUT);
  pinMode(echoPin1, INPUT);
  pinMode(trigPin2, OUTPUT);
  pinMode(echoPin2, INPUT);
```

```
  pinMode(ledPin, OUTPUT);
  Serial.begin(9600);
}
void loop() {
  distance1 = measureDistance(trigPin1, echoPin1);
  distance2 = measureDistance(trigPin2, echoPin2);
  float timeDifference = abs(duration1 - duration2) / 700.0;
  float distanceBetweenSensors = 10;
  if (timeDifference != 0) {
    speed = distanceBetweenSensors / timeDifference * 3.6;
    Serial.print("Speed: ");
    Serial.print(speed);
    Serial.println(" km/h");
    if (speed >= 60) {      digitalWrite(ledPin, HIGH);
    } else {
      digitalWrite(ledPin, LOW);
    }
  } else {
    Serial.println("Error: Division by zero");
  }

  delay(500);
}

int measureDistance(int trigPin, int echoPin) {
  digitalWrite(trigPin, LOW);
  delayMicroseconds(2);
  digitalWrite(trigPin, HIGH);
  delayMicroseconds(10);
  digitalWrite(trigPin, LOW);
  long duration = pulseIn(echoPin, HIGH);
  int distance = duration * 0.034 / 2;
  Serial.print("Distance: ");
  Serial.println(distance);
  if (trigPin == trigPin1) {
```

```
    duration1 = duration;
  } else if (trigPin == trigPin2) {
    duration2 = duration;
  }
  return distance;
}
```

Output

Figure 6.1: Speeds of the vehicles observed

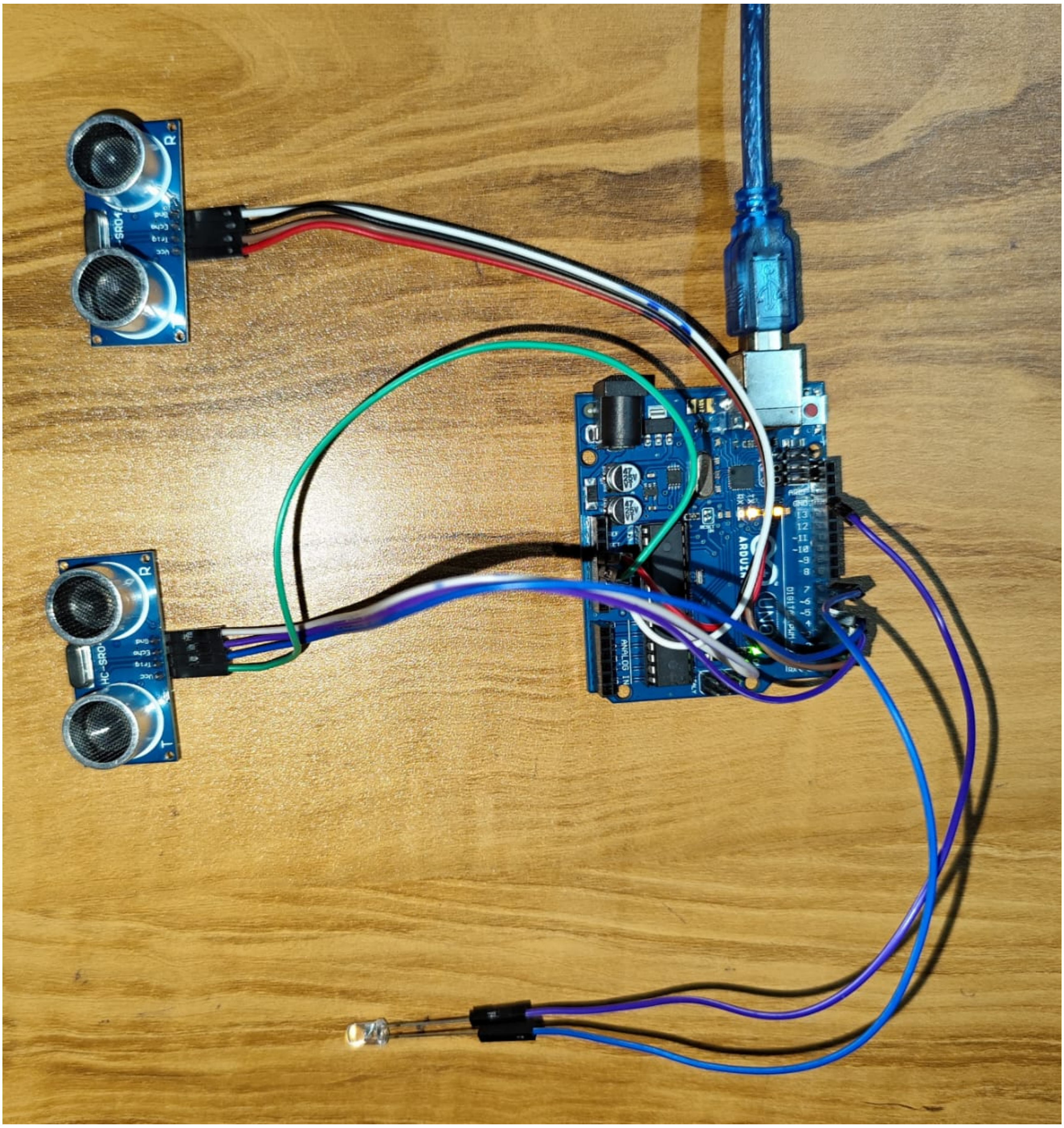


Figure 6.2: Internal connections of the smart pillar

Chapter 7

CONCLUSION AND FUTURE ENHANCEMENTS

7.1 Conclusion

To sum up, integrating Smart Pillars is a ground-breaking technique to improve two-way road safety. These pillars provide real-time vehicle speed detection and timely alert delivery by utilizing ultrasonic sensors and Arduino technology, allowing for proactive accident prevention measures. In contrast to conventional systems, the incorporation of Smart Pillar enables prompt responses to possible risks, thereby decreasing the probability of accidents and improving road safety in general.

Moreover, the suggested system's adaptability and efficacy in a variety of road settings are guaranteed by its compatibility with current infrastructure and ongoing evaluation processes. In addition to enhancing pedestrian and vehicle safety, Smart Pillar integration optimizes traffic flow and lowers the number of accidents on our roads because to its proactive approach and seamless integration.We are getting closer to a future where road safety is given priority and accidents are reduced, resulting in safer and more effective transportation networks for everybody, as we adopt these creative ideas.

7.2 Future Enhancements

Future improvements to the Smart Pillar integration could potentially improve road safety and efficiency even more. Using cutting-edge artificial intelligence systems that can analyze real-time traffic data to anticipate and prevent accidents before they happen is one way to make improvements. Smart Pillars could be able to foresee possible risks based on past data, weather patterns, and other pertinent aspects by utilizing AI-driven predictive analytics. This would allow for even more proactive intervention tactics.

Furthermore, the combination of communication technologies between vehicles and infrastructure and vehicles and vehicles may improve the capabilities of Smart Pillars.Anticipating ahead, more improvements to the Smart Pillar integration could increase road safety and effectiveness even more. Improving traffic data analysis through the use of sophisticated artificial intelligence algorithms that can anticipate and stop accidents before they happen is one way to make improvements. Through the utilization of AI-powered predictive analytics, Smart Pillars have the ability to identify possible risks by analyzing past data, meteorological conditions, and other pertinent variables. This allows for even more preemptive approaches to intervention.

Chapter 8

PLAGIARISM REPORT

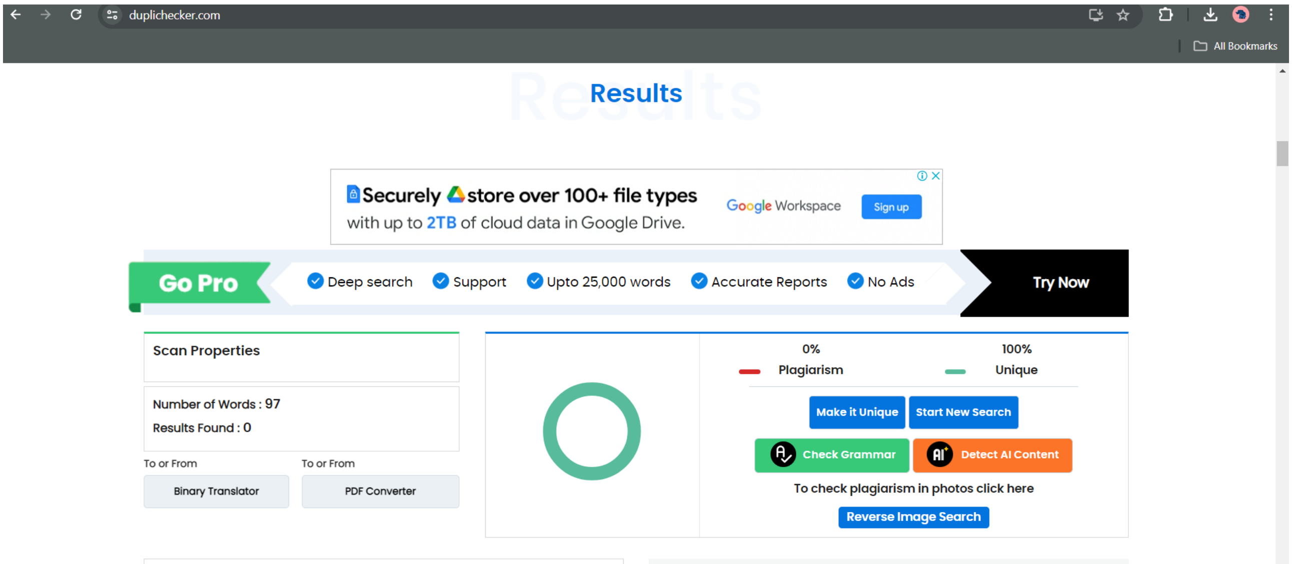


Figure 8.1: Plagiarism Report

Chapter 9

SOURCE CODE & POSTER PRESENTATION

9.1 Source Code

```
const int trigPin1 = 2;
const int echoPin1 = 3;
const int trigPin2 = 4;
const int echoPin2 = 5;
const int ledPin = 7;
long duration1, duration2;
int distance1, distance2;
float speed;
void setup() {
  pinMode(trigPin1, OUTPUT);
  pinMode(echoPin1, INPUT);
  pinMode(trigPin2, OUTPUT);
  pinMode(echoPin2, INPUT);
  pinMode(ledPin, OUTPUT);
  Serial.begin(9600);
}
void loop() {
  distance1 = measureDistance(trigPin1, echoPin1);
  distance2 = measureDistance(trigPin2, echoPin2);
  float timeDifference = abs(duration1 - duration2) / 700.0;
  float distanceBetweenSensors = 10;
  if (timeDifference != 0) {
    speed = distanceBetweenSensors / timeDifference * 3.6;
```

```
    Serial.print(”Speed: ”);
    Serial.print(speed);
    Serial.println(” km/h”);
    if (speed >= 60) {      digitalWrite(ledPin, HIGH);
    } else {
      digitalWrite(ledPin, LOW);
    }
  } else {
    Serial.println(”Error: Division by zero”);
  }

  delay(500);
}

int measureDistance(int trigPin, int echoPin) {
  digitalWrite(trigPin, LOW);
  delayMicroseconds(2);
  digitalWrite(trigPin, HIGH);
  delayMicroseconds(10);
  digitalWrite(trigPin, LOW);
  long duration = pulseIn(echoPin, HIGH);
  int distance = duration * 0.034 / 2;
  Serial.print(”Distance: ”);
  Serial.println(distance);
  if (trigPin == trigPin1) {
    duration1 = duration;
  } else if (trigPin == trigPin2) {
    duration2 = duration;
  }
  return distance;
}
```

9.2 Poster Presentation

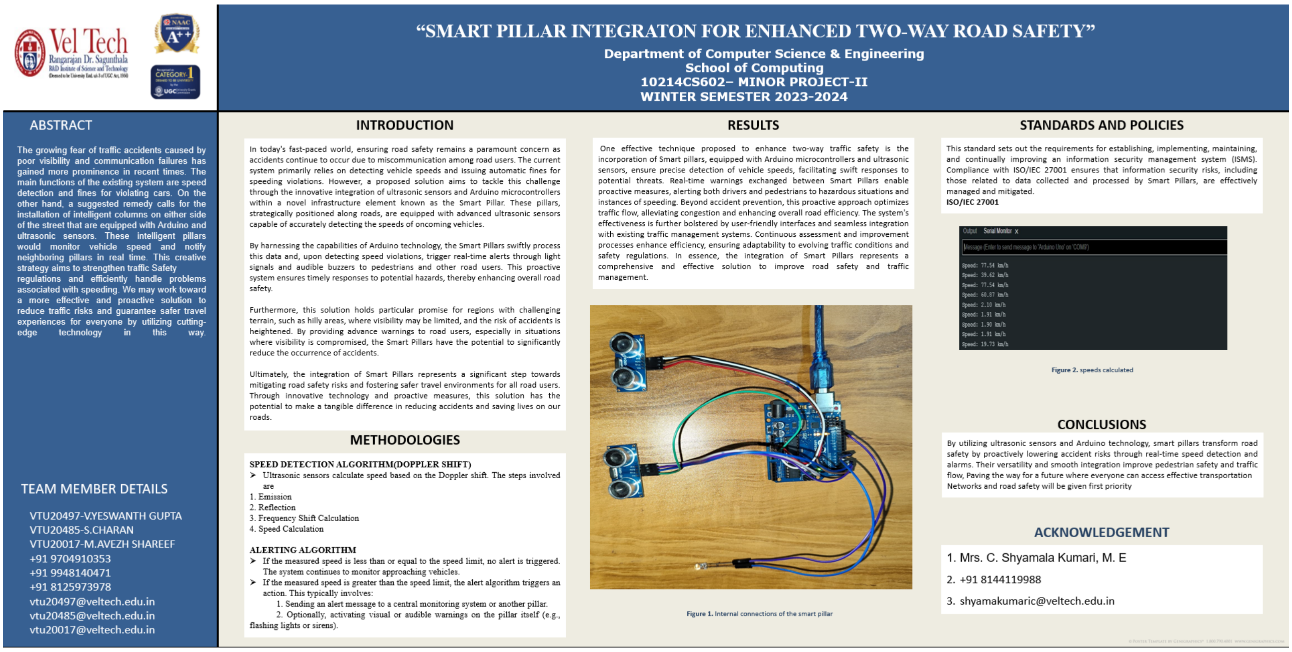


Figure 9.1: Poster

References

[1] Rithik, M. and Chokkalingam, S., ”Image Based Classification for Vehicle Accident Detection and Insurance Claim Using Artificial Intelligence,” in 2024 International Conference on Emerging Systems and Intelligent Computing (ESIC), pp. 521-525, February 2024.
[2] Ramya Devi, M. and Lokesh, S., ”Intelligent accident detection system by emergency response and disaster management using vehicular fog computing,” Automatika, vol. 65, no. 1, pp. 117-129, Jan. 2024.
[3] Kayser Mehbub Siam, S.M., Islam Sumaiya, K., Rakib Al-Amin, M., Hasan Turjo, T., Islam, A., Rahim, A.H.M.A. and Rakibul Hasan, M., ”Real-time accident detection and physiological signal monitoring to enhance motorbike safety and emergency response,” arXiv e-prints, pp. arXiv-2403, Mar. 2024.
[4]Podda, A.S., Balia, R., Pompianu, L., Carta, S., Fenu, G. and Saia, R., ”CARgram: CNN-based Accident Recognition from Road Sounds through Intensity-Projected Spectrogram Analysis,” Digital Signal Processing, p. 104431, 2024.
[5] Matsui, T., Oda, T., Wakabayashi, K., Nagai, Y., Yukawa, C., and Barolli, L., ”An Accident Detection System for Private Lavatories Using Fuzzy Control and Thermal Camera,” in International Conference on Emerging Internet, Data Web Technologies, pp. 452-459, Feb. 2024.
[6] Ariani, L., Winjaya, F., and Rachman, N.F., ”Detection of Railways Through Axle Detection Patterns Using Inductive Proximity Sensors,” in 2nd International Conference on Railway and Transportation 2023 (ICORT 2023), pp. 204-212, Feb. 2024, Atlantis Press.
[7] Chen, J., Pu, J., Yin, B., Zhang, R., and Wu, J.J., ”TA-NET: Empowering Highly Efficient Traffic Anomaly Detection Through Multi-Head Local Self-Attention and Adaptive Hierarchical Feature Reconstruction,” IEEE Transactions on Intelligent Transportation Systems, 2024.
[8] Khatavakar, V., Mahajan, A., and Kalebere, C., ”Advanced Helmet Detection System using Deep Learning for Road Safety Enhancement,” International Journal of Multidisciplinary Innovation and Research Methodology, vol. 3, no. 1, pp. 16-22, 2024.
[9] Gkioka, G., Dominguez, M., Tympakianaki, A., and Mentzas, G., ”AI-Driven Real-Time Incident Detection for Intelligent Transportation Systems,” in Emerging

Cutting-Edge Developments in Intelligent Traffic and Transportation Systems, pp. 56-68, 2024, IOS Press.
[10] Lakshmi, A.B., Ragunath, C., Yeswanth, R., and Rajkumar, M., ”Smart Helmet for Riders to Avoid Accidents Using IoT,” in 2024 2nd International Conference on Computer, Communication and Control (IC4), pp. 1-4, Feb. 2024.