COLLISION AVOIDANCE SYSTEM BASED ON AUTO ZONE-DIMMING HEADLIGHTS:

PREVENTING TROXLER EFFECT

Capstone Project Report

Final Evaluation

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Dec-2023

ABSTRACT

Night-time driving poses significant challenges due to reduced visibility, especially when facing the glare from oncoming headlights. This project presents a pioneering solution – the "Collision Avoidance System Based on Auto Zone-Dimming Headlights." By leveraging cutting-edge technology, including advanced camera sensors, computer vision algorithms, and adaptive lighting control, the system addresses the Troxler effect-induced temporary blindness, aiming to enhance both driver safety and overall road safety.

Through real-time video data captured by high-resolution cameras, the system employs sophisticated algorithms to identify oncoming vehicles, and dynamically adjust the headlight dimming zones. This precise response optimizes visibility for the driver while minimizing glare for other road users. The project's multi-faceted approach encompasses software development, sensor integration, hardware interaction, and user interface design.

The journey was not without challenges, including accurate distance calculation, compatibility across diverse vehicle profiles, and ensuring driver acceptance. These obstacles were surmounted through meticulous calibration, adaptive algorithms, and user-centric design principles.

The implications of this project extend beyond technological advancement. It envisions a safer future where collisions are prevented, accidents are minimized, and night-time driving becomes more secure and comfortable. The project underscores the synergy between innovation and road safety, demonstrating the transformative potential of technology in illuminating not only the roads but also the lives of countless drivers.

This project contributes to the evolving landscape of automotive safety and sets a precedent for future developments in collision avoidance technology, emphasizing the importance of merging technical excellence with societal impact.

DECLARATION

We hereby declare that the design principles and working prototype model of the project entitled Auto-zone dimming headlights is an authentic record of our own work carried out in the Computer Science and Engineering Department, TIET, Patiala, under the guidance of Dr. Shalini Batra and Dr. Harpreet Singh during 7th semester (2023).

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ACKNOWLEDGEMENT

We would like to express our thanks to our mentor Dr. Harpreet Singh. He has been of great help in our venture, and an indispensable resource of technical knowledge. He is truly an amazing mentor to have.

We are also thankful to Dr. Shalini Batra, Head, Computer Science and Engineering Department, entire faculty and staff of Computer Science and Engineering Department, and also our friends who devoted their valuable time and helped us in all possible ways towards successful completion of this project. We thank all those who have contributed either directly or indirectly towards this project.

Lastly, we would also like to thank our families for their unyielding love and encouragement. They always wanted the best for us and we admire their determination and sacrifice.

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INTRODUCTION

1.1 PROJECT OVERVIEW

Night-time accidents cast a long shadow on road safety, with their potential to cause serious harm and loss of life. Startling statistics from Pitchipoo[11] reveal that over 60% of accidents occur during the night, underscoring the urgency of addressing this issue. According to Global status report published by the (WHO) World Health Organization on the road safety, the eighth leading cause of death is the road traffic injuries [1]. Current research suggests that by 2030, it will become the fifth leading cause of death [1]. A combination of factors, including poor visibility, driver fatigue, and compromised performance, contribute to the elevated risk of accidents after sunset. Among these factors, poor visibility, often stemming from the blinding effect of oncoming vehicle headlights, stands out as a prominent cause. Research cited in (Sk)[12] highlights the temporary blindness induced by such headlights, which can lead to a loss of vehicle control.

Compounding the issue of blinding glare is the Troxler effect, a physiological quirk of human vision that exacerbates the hazards associated with intense illumination. This medical phenomenon is elicited by exposure to exceedingly luminous light sources, and its repercussions are far-reaching. The Troxler effect leads to a momentary state of visual impairment, akin to a fleeting eclipse of sight. However, the implications are far from transient—a driver's reaction time can be elongated by a consequential 1.4 seconds. This seemingly minuscule increment in reaction time can indelibly tip the balance between safety and catastrophe on the precarious tightrope of road navigation. Whether a driver swerves out of harm's way or collides with an obstacle can pivot on this seemingly imperceptible time delay.

The gravity of the Troxler effect lies in its ability to alter the dynamics of decision-making and responsiveness during the critical moments when swift reactions are paramount. This ephemeral lapse in sight can lead to potentially catastrophic outcomes, transforming what could have been averted accidents into life-altering incidents. In the continuum of events that unfold on the asphalt stage, these fractions of seconds unfurl as chapters that chronicle the difference between serendipitous escape and unfortunate collision.

In response to these grave concerns, a forward-looking solution emerges—a system for automatic headlight dimming, strategically proposed to combat night-time accidents. This innovative system harnesses modern technology, particularly camera-based detection, to identify incoming vehicles. Upon detection, the system calculates the distance and angle of the oncoming vehicle, establishing localized dimming zones accordingly. These zones enable the system to automatically reduce the brightness of specific segments of a vehicle's headlights when an oncoming vehicle is detected. This intelligent dimming minimizes the blinding effect on other drivers while still providing adequate road illumination.

Implementing this automatic headlight dimming system holds the potential to be a significant stride toward enhancing night-time road safety. By addressing the core issue of impaired visibility and the subsequent Troxler effect, the system could substantially mitigate the risks associated with night-time driving. The complexity of the underlying technology notwithstanding, this solution aligns with the broader trajectory of automotive safety, where intelligent systems are increasingly leveraged to foster safer driving environments.

In conclusion, the menace of night-time accidents casts a somber light on road safety, exacerbated by factors such as poor visibility and the blinding glare of oncoming vehicle headlights. The Troxler effect compounds these dangers, contributing to delayed driver responses and potential accidents. The proposal of an automated headlight dimming system offers a ray of hope, utilizing cutting-edge camera-based technology to identify and respond to oncoming vehicles. By intelligently adjusting headlight intensity, this solution holds the promise of substantially curbing accidents, reinforcing its role in fostering safer nocturnal journeys for all road users.

1.2 NEED ANALYSIS

Driving on Indian roads has been no less than a bumpy ride since the last few decades, owing to a lack of active road safety strategy in place. As per a report published in 2019, over 1.35 million people die in road crashes across the globe each year, of which India accounts for more than 11% of those deaths. (ArriveSafe) [7].

A significant portion of accidents in the city are caused by high beams and decorative lighting in vehicles. First off, a lot of individuals, especially rookie drivers, aren't well-informed about how low and high beams actually work or when to use either of them. Second, most city roads and state highways lack working street lights, with the exception of well-travelled motorways and six-lane highways. Because of this, drivers are forced to continue utilizing only their high beams. (T.)[6].

According to representatives of the Road Accident Action Forum, the improper use of high-beam lights was directly responsible for 33% of incidents that occurred at night. An organization called Arrive Safe performed a survey of the drivers in Punjab and Haryana. According to this report, 73.83 percent of drivers use their high beams while driving at night. Among these drivers, 48.3% continue to use high beams when driving. (Reporter, S) [8].

The team's planned work addresses the aforementioned issues and benefits the driver in the ways listed below.

1. Increased visibility: By automatically altering dimming zones in accordance with lighting conditions and traffic flow, glare is reduced and the driver's visibility is enhanced.

2. Increased safety: Auto zone-dimming headlights lessen glare, lowering driver weariness and distraction, which can raise the risk of collisions.

3. Comfort: By lessening eye strain and discomfort brought on by bright lighting from approaching vehicles, auto zone-dimming headlights offer a more comfortable driving experience.

4. Convenience: The automatic headlights eliminate the need for drivers to manually adjust their headlights, which adds to their convenience

1.3 RESEARCH GAPS

Research gaps refer to areas within a specific field of study where there is a lack of sufficient research or where existing research is incomplete, inconclusive, or outdated. Identifying research gaps is crucial for guiding future research efforts and addressing unanswered questions or unresolved issues. In the context of our project, here are potential research gaps we could consider exploring:

1. Optimal Zone-Dimming Strategies:

   While the proposed system involves creating local dimming zones, there could be a need to investigate the most effective and efficient strategies for creating these zones. Research could delve into determining the optimal number, size, and placement of dimming zones to achieve the best balance between reducing glare for oncoming vehicles and maintaining visibility for the driver.

2. Adverse Weather Conditions:

   The system's performance might be affected by adverse weather conditions such as rain, fog, or snow. Research could focus on how these conditions impact the accuracy of the camera-based detection and distance calculation, as well as how the dimming zones should be adjusted to accommodate such scenarios without compromising safety.

3. Human Factors and Acceptance:

   Understanding the human factors involved is crucial. Research could explore how drivers perceive and react to the dimming of their headlights' zones, especially if they are used to a particular level of illumination. Additionally, studying the acceptance of this system among drivers and potential challenges in adaptation could provide insights into its real-world feasibility.

4. Impact of Dimming on Surroundings:

   The dimming of headlights not only affects oncoming drivers but also the overall road environment. Research could study the potential impact on road visibility, signage legibility, and overall ambient lighting conditions. Striking a balance between reduced glare and maintaining sufficient visibility for all stakeholders is important.

5. Nighttime Wildlife Detection:
   Collisions with wildlife can also be a significant concern during nighttime driving. Research could explore the feasibility of extending the system's capabilities to detect and respond to the presence of wildlife on the road, reducing the risk of collisions with animals.

6. Interaction with Non-Motorized Objects:
   In addition to vehicles, pedestrians, and animals, the system should consider the presence of non-motorized objects like road signs, barriers, and debris. How can the system differentiate between relevant objects and those that don't require dimming? Research could address the challenges of object recognition and classification.

Addressing these research gaps can contribute to the advancement of our project. By conducting targeted research in these areas, we can provide valuable insights and inform practical solutions.

1.4 PROBLEM DEFINITION AND SCOPE

Problem Definition:

The problem statement pertains to the development of an innovative and technologically advanced automatic nighttime headlight dimming system for vehicles. In contemporary road transportation, the prevalence of high-intensity headlights has inadvertently led to increased glare and visual discomfort for drivers of oncoming vehicles, subsequently diminishing road safety. Addressing this issue requires the creation of a cutting-edge solution that seamlessly adjusts headlight intensity based on real-time environmental conditions, enhancing both driver comfort and road safety.

Scope:

The scope of the automatic nighttime headlight dimming system includes the following components:

1. Environmental Sensors: Integration of light sensors, ambient light detectors, and potentially camera-based systems to detect lighting conditions and surrounding vehicle movement.

2. Data Processing: Development of algorithms to analyze data and determine appropriate dimming levels based on factors such as the presence of oncoming vehicles, street lighting, and road curvature.

3. Headlight Control Mechanism: Implementation of mechanisms to control the headlight beam's intensity, direction, and coverage area. This may involve motorized adjustment systems or adaptive optics.

4. Testing and Validation: Rigorous testing under various driving conditions, including different road types, weather conditions, and lighting scenarios, to ensure accurate detection and reliable performance.

5. Compliance and Regulations: Ensuring that the system complies with relevant safety regulations and standards governing vehicle lighting systems.

6. Integration: Collaboration with vehicle manufacturers to seamlessly integrate the automatic nighttime headlight dimming system into new and existing vehicle models.

Ultimately, the successful development and deployment of this automatic nighttime headlight dimming system hold the potential to revolutionize nighttime driving safety, reduce accidents caused by glare, and contribute to an overall enhancement of road safety standards. By mitigating the adverse effects of intense headlights, this system aims to create a safer and more comfortable driving experience for all road users, exemplifying the intersection of technology and safety in the modern automotive landscape.

It's important to note that the system's scope may vary based on technical feasibility, budget constraints, and the intended market. The ultimate goal is to create a reliable and effective solution that enhances road safety by intelligently managing headlight intensity during nighttime driving.

1.5 ASSUMPTIONS AND CONSTRAINTS

S. No.	ASSUMPTIONS
1.	No Heating Limitations
2.	Functional Headlights:
3.	No External Factors
4.	Obstacle-Free Roads
5.	Absence of Pedestrians and Bicyclists
6.	Neglecting Glare from Surrounding Lights

Assumptions

1. **No Heating Limitations:** The experiment assumes that the headlights can function without heating limitations, ensuring consistent performance regardless of extended usage. In practical scenarios, excessive usage might lead to overheating and degradation of performance.
2. **Functional Headlights:** The headlights used in the experiment are in good condition and operate without any faults, damages, or malfunctions. This ensures that the experiment accurately assesses the impact of the automatic headlight dimming system without extraneous variables.
3. **No External Factors:** The experiment excludes external factors, such as adverse weather conditions (e.g., rain, fog) and other environmental elements (e.g., glare from surrounding lights). This streamlined approach allows for a focused evaluation of the system's core functionality.
4. **Obstacle-Free Roads:** The experiment assumes obstacle-free roads, devoid of any hindrances or obstructions, including animals like cows or other livestock. Such obstacles could influence the experiment's results by necessitating sudden changes in vehicle speed or direction.
5. **Absence of Pedestrians and Bicyclists:** The absence of pedestrians and bicyclists on the road eliminates their interactions with the system, even though their presence often poses challenges for headlight adjustments and safety.

6. **Neglecting Glare from Surrounding Lights:** The exclusion of glare from surrounding lights, such as street lamps and signs, could impact the system's performance as it fails to consider instances where the system might dim headlights unnecessarily.

1.6 STANDARDS

Following are the IEEE standards of various components used in development of our project.

1. IEEE Standards for Arduino Uno R3: Arduino is a specific open-source hardware and software platform for building digital devices and interactive objects. Arduino boards are designed to comply with various electronic and safety standards, such as CE marking and RoHS compliance, but these are not specific to IEEE standards. Arduino follows its own design and development practices, guided by the principles of open-source hardware and the Arduino community.

2. IEEE Standards for Web Camera: The web camera, a crucial visual input source for our project, is governed by several IEEE standards. IEEE 1394, also known as FireWire, empowers the camera with high-speed data transfer capabilities, ensuring real-time transmission of stereo images. IEEE 1588, the Precision Time Protocol, synchronizes network clocks, an essential aspect for accurate stereo image processing and alignment. Moreover, IEEE 802.3af standards come into play, as they facilitate Power over Ethernet (PoE), providing power to the camera and simplifying its setup by eliminating the need for separate power cables.

3. IEEE Standards for Resistors: Even seemingly humble resistors adhere to IEEE standards that contribute to their reliability and functionality. IEEE 315, also known as the Resistor Color Code standard, plays a significant role by providing a standardized color-coding system. This system ensures that resistors' values are easily identifiable, facilitating consistency and accuracy in design and assembly processes.

5. IEEE Standards for LEDs: The efficient and effective operation of our LEDs is influenced by specific IEEE standards. IEEE 1696, which pertains to LED life and reliability, guides the selection of LEDs that offer longevity and consistent performance. IEEE 802.3bt, in the context of Power over Ethernet (PoE), shapes LED integration, contributing to power-efficient design practices and minimizing energy consumption.

6. IEEE Standards for Jumper Wires: Even the seemingly straightforward jumper wires adhere to relevant IEEE standards. IEEE 315, in particular, ensures the quality and specifications of these wires, supporting stable connections and reliable data transmission within the project's electronic components.

By embracing these IEEE standards for each component, our project development gains a solid foundation that prioritizes compatibility, reliability, and adherence to established industry norms. This approach guarantees that our auto zone-dimming headlights system is not only innovative but also aligned with best practices that ensure its seamless integration and robust performance.

7. **IEEE Standards for 4-channel Relay module:** Relay modules, such as the 4-channel variants, are designed to control multiple electrical circuits by using electromagnetic relays. While the IEEE (Institute of Electrical and Electronics Engineers) doesn't typically produce standards specific to individual commercial modules, the development and use of these devices necessitate adherence to various electrical and safety standards. General standards applicable to relay modules include IEC 61810, defining requirements for electromechanical elementary relays, and IEC 60947, which covers low-voltage switchgear and controlgear assemblies. Additionally, compliance with safety standards such as those from Underwriters Laboratories (UL) may be essential for products entering specific markets, particularly in North America. For global markets, CE marking ensures conformity with European Union directives. Manufacturers and designers should consult product documentation and adhere to relevant regional electrical and safety standards to ensure the reliability, safety, and regulatory compliance of 4-channel relay modules.

1.7 APPROVED OBJECTIVES

Objectives for implementing a AUTO ZONE-DIMMING HEADLIGHTS System are:

1. **Literature Survey and System Analysis:** Conducting a comprehensive literature survey is fundamental to gaining a deep understanding of the existing research and

developments in the field of auto zone-dimming headlights systems. This objective aims to identify previous work, understand the methodologies employed, and draw insights from their successes and limitations. Analyzing existing systems provides a foundation for designing an efficient and effective solution.

2. **Vehicle Detection and creation of localised dimming zones:** This objective centers on the critical task of accurately identifying and localizing vehicles within a video stream. This step lays the groundwork for subsequent actions, enabling the system to make informed decisions regarding the application of localized dimming. Building upon the data obtained from vehicle detection, the system's focus is to intelligently create localized dimming zones. These zones are strategically determined areas on the host vehicle's headlights that need dimming to prevent glare for oncoming drivers. The objective involves calculating the dimensions, angles, and locations of these zones to maximize the reduction of glare while preserving optimal illumination for road visibility.

3. **Circuit Design and Hardware Deployment:** To design a circuit to control LED matrix for an auto-zone dimming headlight system. Further, to deploy the detection and control system on a hardware device, such as a Raspberry Pi and enable real-time inference for detecting objects in images.

1.8 METHODLOGY

1. To study the literature of identifying the incoming vehicle through real-time video or image sensing using machine learning technique, calculating the distance and angle from the incoming vehicle and achieving a local dimming zone.

2. Implement sensors to detect oncoming vehicles: The first step in achieving the objectives of auto zone-dimming headlights is to install a system that can detect the presence of other vehicles on the road and the ambient brightness levels. This can be achieved through web camera which needs to be positioned to have a clear view of the road ahead and can detect oncoming vehicles with high accuracy.

3. The determination of positional estimates on a computer screen involves segmenting the screen into four distinct regions through the strategic implementation of vertical grids. These regions are defined and identified based on the coordinates derived from the YOLOv8 algorithm, specifically targeting object recognition and localization.
4. Calibrate the headlight system to switch the particular LEDs off automatically based on sensor inputs creating a local dimming zone: Next, the headlight control module needs to be calibrated to make the right decisions based on the information from the sensors. This involves setting up suitable thresholds to switch the particular LEDs off and fine-tuning the system to minimizec the risk of false positives or false negatives. The calibration process should consider factors such as the distance, angle and direction of the oncoming vehicle.

By following this methodology, it is possible to achieve the objectives of auto zone-dimming headlights, increasing safety on the road, providing convenience for drivers, and promoting driver comfort.

1.9 PROJECT OUTCOMES AND DELIVERABLES

Our Project will provide the following functionalities:

1. **Detection of Oncoming Vehicles:**

A pivotal feature of our project is its capability to detect oncoming vehicles within the driver's visual field. Through cutting-edge computer vision techniques, the system identifies vehicles approaching from the opposite direction in real-time. This detection serves as the foundation for subsequent intelligent actions that mitigate potential hazards posed by glaring headlights.

2. **Automatic Creation of Local Dimming Zones:**

The project boasts an advanced capacity to automatically generate localized dimming zones on the vehicle's headlights. These zones are meticulously calculated based on the angle and distance of the detected oncoming vehicle. By selectively dimming only the specific region where the oncoming vehicle is present, the system strikes an equilibrium between ensuring the driver's visibility and eliminating the discomforting glare that can compromise road safety.

3. **Reduction of Night-Time Accidents:**

One of the primary objectives of our project is to make a substantial dent in the prevalence of night-time accidents. By efficiently managing headlight glare through the automatic creation of localized dimming zones, the system minimizes the Troxler effect and its subsequent impact on driver reaction time. This reduction in glare-induced impairment translates to safer road conditions, reduced collision risks, and ultimately, a significant drop in night-time accidents.

4. **Inclusive Low-Cost Implementation:**

Notably, our project's ambition transcends technological advancements—it strives for accessibility. Our system can be integrated into vehicles across the spectrum, including lower-end cars. This low-cost implementation democratizes the benefits of safer night-time driving, ensuring that a broader segment of the population can benefit from reduced glare, enhanced visibility, and increased road safety.

1.10 NOVELTY OF WORK

Our work is distinguished by its unique blend of advanced technology, practicality, and the profound impact it promises to have on road safety and driver comfort. Several novel aspects define the ingenuity of our project:

1. **Precision in Localized Dimming:** The hallmark of our project lies in its ability to create localized dimming zones with unparalleled precision. By leveraging intricate calculations based on the angle and distance of oncoming vehicles, our system goes beyond mere glare reduction. It ensures that dimming is applied only to the specific regions that require it, optimizing visibility for both drivers and fellow road users.

2. **Real-Time Responsiveness:** The real-time responsiveness of our system marks a significant breakthrough. In a matter of moments, it detects oncoming vehicles, calculates dimming parameters, and adjusts headlight brightness. This instantaneous responsiveness transforms the driving experience, mitigating the Troxler effect and enhancing reaction times precisely when they matter the most.

3. **Inclusive Accessibility:** Our work is distinct for its inclusive approach. While advanced automotive technologies often find their niche in high-end vehicles, we break this mold. Our solution is engineered for affordability, enabling integration even in lower-end cars. This democratization of safer night-time driving expands the project's impact across diverse socioeconomic segments.

4. **Holistic Road Safety Enhancement:** While many innovations target specific facets of road safety, our project addresses a comprehensive spectrum of challenges associated with night-time driving. By harmonizing vehicle detection, intelligent dimming, and driver comfort, we offer a holistic solution that proactively reduces accidents, elevates visibility, and fosters a secure driving environment.

5. **Eco-Friendly and Sustainable:** The novelty of our work extends to its eco-conscious design. By focusing on LED matrix control for dimming, we optimize energy usage and contribute to sustainable driving practices. This synergy of technological advancement and environmental responsibility embodies a modern approach to automotive innovation.

2.1 LITERATURE SURVEY

The following section deals with the survey of the existing systems, tools, and technologies used for Auto-Zone dimming headlights.

2.1.1 RELATED WORK

Night-time accidents are a major concern for road safety and can result in serious injuries and fatalities. According to Pitchipoo[11], more than 60% accidents occur during night time. Poor visibility, driver's visual fatigue & performance etc were identified as prime factors for more accidents during night time. One of the key causes of night-time accidents is poor visibility due to the headlights of oncoming vehicles. (Sk)[12] shows that this can result in drivers being momentarily blinded, causing them to lose control of their vehicle. Drivers face a huge problem due to high beam light which falls directly into their eyes when driving at night. There is medical effect called Troxler effect associated with this phenomenon. The Troxler effect refers to temporary blindness caused by exposure to a very bright light source, such as the headlights of oncoming vehicles during night-time. This effect can increase a driver's reaction time by 1.4 seconds, which is a significant difference on the road and can lead to accidents.

2.1.2 RESEARCH GAPS OF EXISTING LITERATURE

1. One of the methodology used is using Gabor filters for feature extraction and Support Vector Machines (SVMs) for vehicle detection. Gabor filters are orientation and scale tunable edge and line detectors that provide selectivity in scale and orientation, making them suitable for extracting statistics from features such as edges and lines in images. The extracted features are then collected from sub-images obtained by subdividing the original image into sub-windows, providing robustness to errors in the hypothesis generation step. After feature extraction, a SVM classifier is trained using the extracted features. SVMs are two-class classifiers that

perform structural risk minimization to maximize generalization on novel data. The proposed approach is then tested using real data, and the results are compared with other schemes such as using PCA features or neural network classifiers.

2. The proposed methodology in the research paper aims to develop a real-time vehicle detection system using a monocular camera. The system consists of two main steps: Hypothesis Generation (HG) and Hypothesis Verification (HV). In HG, the system identifies potential vehicles by analyzing the shadows underneath them, which are significant features on the road. By extracting shadow areas using adaptive thresholding and enhancing their visibility through morphological operations, bounding boxes representing hypothetical vehicle areas are generated. In HV, gradient information is used to verify the hypotheses. Modified Histogram of Oriented Gradient (HOG) descriptors are employed to extract features, focusing on horizontal and vertical gradients. These features are combined into a lower-dimensional vector, and AdaBoost and Support Vector Machine (SVM) classifiers are trained to classify the hypotheses as vehicles or non-vehicles. The methodology involves training the classifiers with a vehicle dataset and evaluating the system's real-time performance and detection accuracy on real traffic scenes. Overall, the methodology leverages shadow analysis and gradient information, introducing modifications to the HOG descriptor for real-time detection while maintaining high accuracy.

3. The research focuses on optimizing the YOLOv3-tiny algorithm for embedded devices. The YOLO series algorithm converts the target detection problem into a regression problem and utilizes a single neural network for regression, making the network structure simple and efficient. The YOLOv3-tiny algorithm divides the input image into grids and generates bounding boxes for target detection. The paper proposes optimizing the network structure, specifically the shallow layers and downsampling process. The shallow layers are optimized by widening the network layer and adding a 5x5 receptive field convolutional layer. The downsampling process is modified to preserve more feature information. The network is further optimized by sparseness and quantization, reducing the number of parameters and utilizing an onboard NPU module for calculation acceleration.

4. The proposed methodology for real-time vehicle detection involves three steps. Firstly, the Vehicle Cueing stage identifies potential vehicle candidates using shadows and road width. In

the Vehicle Detection step, a modified Integral Channel Feature is used for feature extraction, and Adaboost with a cascade method is employed for classification. Finally, the Vehicle Validation step utilizes a deep learning model to validate the detections obtained through Adaboost. This methodology aims to achieve efficient and accurate real-time vehicle detection.

5. The algorithm involves the conversion of captured videos from the RGB color format to the HSV format to segment vehicle colors accurately. The HSV format image is then split into separate channels and processed individually to segment vehicle colors and filter out environmental colors. Chain codes are used for contour detection to localize vehicle regions, and convex hulls are employed to define the shape of each object. Centroid positions are calculated and tracked using Kalman filters, and data association is used to associate centroid points with the appropriate filters. The Kalman filter model predicts and updates the state of the system based on measurements.

6. The main strategy includes two steps: vehicle candidate generation and vehicle candidate verification. The first step chooses vehicle tail light information to extract vehicle candidates from text images; and in the second step, BP neural network is used to identify vehicle candidates. (Gabor feautres, BPNN)

Table 2. Research Findings for Existing Literature

TITLE	AUTHOR	METHODOLOGY	OUTCOME
Vehicle detection using tail light segmentation	Qing Ming Kang-Hyun Jo [15]	The main strategy includes two steps. The first step chooses vehicle tail light information to extract vehicle candidates from text images and in the second step, BP neural network is used to identify vehicle candidates. (Gabor features, BPNN)	It presents an effective ideal way for detecting vehicles in parking area and common road.
Intelligent LED Matrix Lighting Systems on modern vehicles	Andrija VELIČKOVIĆ Miloš MILOŠEVIĆ Maša MILOŠEVIĆ Aleksandra CVETKOVIĆ [19]	DLP technology utilizes tiny mirrors on a chip to produce high-resolution images through a lens or heat sink, and TI's 1.3M-mirror device has fast switching and response times.	These headlights are characterized by arrays of diodes in the form of matrices that emit light individually and that can be controlled in terms of controlling the amount of light they emit depending on current needs and driving conditions

GaN-based mini-LED matrix applied to multi-functional forward lighting	Quang-Khoi Nguyen, Yi-Jou Lin, Ching Sun [5]	The article presents a single reflector that uses a mini-LED matrix to project both low and high beams, with flexible and adjustable illumination patterns.	Adjustable illumination patterns
Hardware-in-the-Loop-Simulation of the light distribution of automotive Matrix-LED-Headlights	Mirko Waldner1, Maximilian Krämer1 and Torsten Bertram1 [18]	In this approach a camera system digitizes the beam pattern and the image processing calculates the luminous intensity distribution.	Find the optimal balance between the maximization of the viewing area of the driver and the minimization of the dazzling of other traffic participants.
A Review of Recent Developments in Vision-Based Vehicle Detection	Sayanan Sivaraman and Mohan M. Trivedi [25]	The methods used to detect vehicle are HOG, Haar-like features for the detection of horizontal, vertical, and symmetric structures, SIFT features were used to detect the rear faces of vehicles, Gabor features. SVM and Adaboost is used for classification.	As monocular images lack direct depth measurements, appearance-based methods are more common in the monocular vehicle detection literature.
A Real-Time Vision System for Nighttime Vehicle Detection and Traffic Surveillance	Yen-Lin Chen, Bing-Fei Wu, Hao-Yu Huang, and Chung-Jui Fan [21]	Various techniques used are virtual loop detectors, frame differencing, model-and feature-based techniques, and color and edge features to detect and recognize vehicles in traffic images	The proposed system is able to avoid most of the reflected glares and appropriately detect, classify, and track most cars and motorbikes.
Automatic Light Beam Controller for driver assistance	Selma Music, Haris Balihodzic [3]	Adaptive thresholding is used to detect bright blobs. An automatic multilevel thresholding method is applied to grey-intensity images obtained by converting RGB images. Multilevel segmentation is then used to extract bright objects from the images.	Reduced glare for oncoming drivers, improved visibility for the driver, tested successfully in real-world scenarios
Real-time automotive night-vision system for drivers to inhibit headlight glare of the oncoming vehicles and enhance road visibility	Gouranga Mandal, Diptendu Bhattachary & Parthasarathi De [24]	The frame is split into three parts: Region 1 has oncoming high-beam light tackled by Canny Edge-Detector. Seeded Region-Growing removes the glare in Region 2. Region 3 is enhanced for better road and environment visibility.	Proper enhancement was seen in most observations by reducing luminance in Regions 1 and 2 and increasing it in Region 3. Improper enhancement was observed in some frames due to atmospheric light fluctuations, imperfect segmentation, or lack of Region 3.

Night Time Vehicle Detection for Driving Assistance Light Beam Controller	P.F. Alcantarilla, L.M. Bergasa, P. Jimenez, M.A. Sotelo, I. Parra, D. Fernandez, S.S. Mayoral [20]	B&W camera captures input images for the vision system. Adaptive thresholding identifies bright blobs in the images, which are segmented and clustered based on geometric characteristics. Multi-frame clustering is done using Kalman Filter, and tracked objects are classified by SVM.	The system can detect both headlights and tail lights, but at different distances: 300m-500m for headlights and 50m-80m for tail lights. Although headlight detection performance is good, tail light detection needs improvement.
Vehicle Detection in the Autonomous Vehicle Environment for Potential Collision Warning	Mario Gluhaković, Marijan Herceg, Miroslav Popović, Jelena Kovačević [23]	Object detection using ROS, YOLO, CNN.	The algorithm YOLO v2 does not perform well when the distances are over 50 meters. This can be improved bt increasing the training data.
Vision-based Vehicle Detection and Inter-Vehicle Distance Estimation	Giseok Kim, Jae-Soo Cho [16]	The authors detects and tracks vehicles using image processing and machine learning techniques, and it estimates inter-vehicle distance using a geometrical method. A well-known calibration item is used to calibrate the camera. Real-world driving situations are used to evaluate the system, demonstrating its efficacy in real-time.	The proposed algorithm achieves 94.9%of accuracy in daytime detection of vehicles and it is fast enough to process 32.2 frames per second.
Pedestrians' perception and response towards vehicles during road-crossing at nighttime	Venkatesh Balasubramanian, Rahul Bhardwaj [22]	Real time detection of vehicles and time to identify them with or without using LED strips.	Mounting an LED strip between the headlights of a low beam car improved vehicle recognition accuracy from 90% to 93.33%. For high beam cars, recognition accuracy was only 56.67%, but increased to 86.67% when an LED strip was added.
Front and Rear Vehicle Detection and Tracking in the Day and Night Times Using Vision and Sonar Sensor Fusion	SamYong Kim, Se-Young Oh, JeongKwan Kang and YoungWoo Ryu, Sang-Cheol Park and KyongHa Park [1]	A real-time vehicle detection and tracking system that uses computer vision and sonar sensors to detect vehicles during both day and night. It uses a pre-processing module, vehicle candidate extraction module, validation module, and fusion module to process both image and sonar data.	It is a vehicle detection system for day and night conditions. Techniques such as symmetry scanning and inverse perspective transform ensure accuracy. False positives due to shadow patterns are eliminated
Night-time Vehicle Detection for Automatic	Pushkar Sevekar (Student), S. B. Dhonde	The survey discusses the state-of-the-art methods and relevant systems developed by automobile	The survey covers the development of headlight control systems like multi-beam LED, Smart Beam, and AHC, as

Headlight Beam Control	(Associate Professor) [4]	manufacturers, including the multibeam LED system by Mercedes Benz, Smart Beam by Gentex Corporation, and Adaptive Headlight Control (AHC) by Mobil-Eye. It selects an ideal beam to reduce accidents caused by temporary blindness.	well as the implementation of ADAS. It emphasizes the need for a simple and reliable solution to be implemented in every vehicle to reduce accidents caused by temporary blindness.
Vehicle detection using tail light segmentation	Qing Ming Kang-Hyun Jo [15]	The main strategy includes two steps. The first step chooses vehicle tail light information to extract vehicle candidates from text images and in the second step, BP neural network is used to identify vehicle candidates. (Gabor features, BPNN)	It presents an effective ideal way for detecting vehicles in parking area and common road.
Intelligent LED Matrix Lighting Systems on modern vehicles	Andrija VELIČKOVIĆ Miloš MILOŠEVIĆ Maša MILOŠEVIĆ Aleksandra CVETKOVIĆ [19]	DLP technology utilizes tiny mirrors on a chip to produce high-resolution images through a lens or heat sink, and TI's 1.3M-mirror device has fast switching and response times.	These headlights are characterized by arrays of diodes in the form of matrices that emit light individually and that can be controlled in terms of controlling the amount of light they emit depending on current needs and driving conditions
GaN-based mini-LED matrix applied to multi-functional forward lighting	Quang-Khoi Nguyen, Yi-Jou Lin, Ching Sun [5]	The article presents a single reflector that uses a mini-LED matrix to project both low and high beams, with flexible and adjustable illumination patterns.	Adjustable illumination patterns
Hardware-in-the-Loop-Simulation of the light distribution of automotive Matrix-LED-Headlights	Mirko Waldner1, Maximilian Krämer1 and Torsten Bertram1 [18]	In this approach a camera system digitizes the beam pattern and the image processing calculates the luminous intensity distribution.	Find the optimal balance between the maximization of the viewing area of the driver and the minimization of the dazzling of other traffic participants.
A Review of Recent Developments in Vision-Based Vehicle Detection	Sayanan Sivaraman and Mohan M. Trivedi [25]	The methods used to detect vehicle are HOG, Haar-like features for the detection of horizontal, vertical, and symmetric structures, SIFT features were used to detect the rear faces of vehicles, Gabor features. SVM and Adaboost is used for classification.	As monocular images lack direct depth measurements, appearance-based methods are more common in the monocular vehicle detection literature.

A Real-Time Vision System for Nighttime Vehicle Detection and Traffic Surveillance	Yen-Lin Chen, Bing-Fei Wu, Hao-Yu Huang, and Chung-Jui Fan [21]	Various techniques used are virtual loop detectors, frame differencing, model-and feature-based techniques, and color and edge features to detect and recognize vehicles in traffic images	The proposed system is able to avoid most of the reflected glares and appropriately detect, classify, and track most cars and motorbikes.
Automatic Light Beam Controller for driver assistance	Selma Music, Haris Balihodzic [3]	Adaptive thresholding is used to detect bright blobs. An automatic multilevel thresholding method is applied to grey-intensity images obtained by converting RGB images. Multilevel segmentation is then used to extract bright objects from the images.	Reduced glare for oncoming drivers, improved visibility for the driver, tested successfully in real-world scenarios
Real-time automotive night-vision system for drivers to inhibit headlight glare of the oncoming vehicles and enhance road visibility	Gouranga Mandal, Diptendu Bhattachary & Parthasarathi De [24]	The frame is split into three parts: Region 1 has oncoming high-beam light tackled by Canny Edge-Detector. Seeded Region-Growing removes the glare in Region 2. Region 3 is enhanced for better road and environment visibility.	Proper enhancement was seen in most observations by reducing luminance in Regions 1 and 2 and increasing it in Region 3. Improper enhancement was observed in some frames due to atmospheric light fluctuations, imperfect segmentation, or lack of Region 3.
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2.1.3 DETAILED PROBLEM ANALYSIS

Real-Time Processing: The real-time processing of camera data and subsequent adjustments to headlight dimming zones must be executed within tight time constraints to ensure timely and effective collision avoidance. Delays in processing could reduce the system's responsiveness and compromise its ability to prevent accidents.

Varying Vehicle Profiles: Different vehicle models have distinct headlight designs and characteristics. Adapting the system to accommodate various vehicle profiles while maintaining optimal dimming effectiveness might pose a challenge, particularly in scenarios involving vehicles with significantly different shapes and sizes.

Driver Acceptance and Interaction: A potential challenge is ensuring that drivers accept and trust the automatic headlight dimming system's actions. Some drivers may prefer manual control over the dimming settings and might resist or misunderstand the system's interventions.

Compatibility with Existing Infrastructure: Integrating the collision avoidance system with a diverse range of vehicle makes and models, each with unique hardware and software configurations, could present compatibility issues. Ensuring seamless integration with existing vehicle infrastructure might require substantial adaptation.

False Positives and Negatives: Detecting oncoming vehicles accurately is crucial. However, the system must avoid false positives (detecting vehicles that are not oncoming) and false negatives (failing to detect oncoming vehicles). Factors such as varying lighting conditions and unexpected road scenarios might contribute to these challenges.

Regulatory Compliance: The collision avoidance system needs to adhere to safety and regulatory standards within the automotive industry. Ensuring that the system meets relevant regulations while maintaining its effectiveness is a complex task.

Maintenance and Calibration: Over time, camera sensors might require maintenance and recalibration to sustain accurate detection and calculation capabilities. Ensuring that the system remains effective throughout its lifespan requires addressing potential sensor degradation and calibration issues.

System Complexity: As an advanced technology, the system could become complex in terms of software algorithms, sensor integration, and interaction with existing vehicle systems. Managing this complexity to deliver a reliable, user-friendly system might be challenging.

Interference from External Sources: External light sources, such as streetlights, other vehicles' headlights, and reflective surfaces, could interfere with accurate vehicle detection and headlight dimming calculations. Addressing these potential sources of interference is crucial for maintaining the system's reliability.

2.1.4 SURVEY OF TOOLS AND TECHNOLOGIES USED

1. Computer Vision and Image Processing:

OpenCV: Widely used computer vision library for image and video processing.

TensorFlow and PyTorch: Popular machine learning frameworks for implementing image processing and object detection algorithms.

Haar Cascade Classifiers: For detecting features and patterns in images, such as vehicle tail lights or headlights.

2. Machine Learning and Neural Networks:

Convolutional Neural Networks (CNN): For object detection and classification tasks, such as identifying vehicle candidates.

Support Vector Machines (SVM) and Adaboost: For classification of detected objects (e.g., vehicles).

YOLO (You Only Look Once): For training object detection models to identify vehicles and their features.

3. Embedded Systems and Microcontrollers:

Arduino: For controlling hardware interfaces and integration with vehicle systems.

4. User Interface Development:

Qt: Cross-platform UI framework for creating intuitive user interfaces for driver interaction and system status display.

Android Studio: For developing mobile applications that interface with the collision avoidance system.

5. Simulation and Prototyping:

CARLA: Open-source simulator for testing and validating the collision avoidance system in various driving scenarios.
Unity: For creating interactive and realistic simulations of real-world driving situations.

6. Communication Protocols:

Controller Area Network (CAN): Standard protocol for communication between microcontrollers and electronic control units (ECUs) in vehicles.
FlexRay: High-speed protocol for real-time communication in automotive applications.

7. Hardware Testing and Compliance

ISO 26262 Compliance Tools: For ensuring that the collision avoidance system adheres to automotive safety standards.
Vehicle Hardware Integration Platforms: Such as Autoware and ROS, to integrate the collision avoidance system with vehicle hardware.

8. Testing and Evaluation:

Real-world Driving Data: Gather real-world driving data to evaluate the system's efficacy in various conditions.
Calibration Tools: For calibrating camera sensors and ensuring accurate distance and angle calculations.

9. Adaptive Lighting Control:

LED Matrix Technology: Implement adaptive LED matrix lighting systems that adjust the amount and direction of emitted light based on driving conditions.

10. Data Processing and Algorithms:

Signal Processing Libraries: For processing camera data and sensor inputs to calculate distance, angle, and luminous intensity distribution.
Geometric Algorithms: For estimating inter-vehicle distance and optimizing headlight dimming zones.

2.3 SOFTWARE REQUIREMENT SPECIFICATION

2.3.1 INTRODUCTION

2.3.1.1 PURPOSE

The overarching purpose of the project "Collision Avoidance System Based on Auto Zone-Dimming Headlights: Preventing Troxler Effect" is to develop an innovative and technologically advanced solution that addresses the critical issue of night-time accidents caused by the Troxler effect. The project seeks to enhance road safety by designing and implementing an automatic headlight dimming system that intelligently mitigates the Troxler effect, thereby minimizing driver discomfort, enhancing visibility, and ultimately preventing accidents during night-time driving scenarios.

Key Objectives:

1. To conduct a literature survey regarding the various work that has been done in the same direction and to study the already existing systems.

2. To identify and locate vehicles in a video stream and create localized dimming zones to automatically reduce the brightness of specific portions of the vehicle's headlights.

3. To design a circuit to control LED matrix for an auto-zone dimming headlight system. Further, to deploy the detection and control system on a hardware device, such as a Arduino or Raspberry Pi and enable real-time inference for detecting objects in images.

In essence, the purpose of this project is to develop a cutting-edge collision avoidance system that not only eliminates the Troxler effect but also revolutionizes night-time driving safety. By creating an intelligent system that dynamically adapts headlight illumination, the project aims to enhance driver comfort, minimize accidents, and set new standards for road safety during nocturnal conditions.

2.3.1.2 INTENDED AUDIENCE AND READING SUGGESTIONS

This section identifies the specific groups of individuals for whom the project "Collision Avoidance System Based on Auto Zone-Dimming Headlights: Preventing Troxler Effect" is intended, along with recommended resources for deeper comprehension of the project's complexities and objectives.

Intended Audience:

1. Research and Development Professionals: Researchers and professionals engaged in the fields of vehicular safety, intelligent transportation systems, and software engineering will find this project highly relevant. They will gain insights into cutting-edge technological applications for improving road safety.

2. Automotive Engineers and Technologists: Professionals specializing in automotive electronics, safety mechanisms, and lighting technologies will benefit from understanding the integration of software-driven systems to enhance vehicle safety and driver experience.

3. Academic Researchers and Students: Scholars and students in the domains of computer science, electrical engineering, and automotive engineering will find the project intellectually stimulating. It offers real-world applications for their theoretical knowledge.

4. Safety Advocates and Regulatory Authorities: Individuals advocating for road safety and those involved in setting automotive safety standards will appreciate the project's potential impact on reducing accidents and enhancing driving safety.

5. User Experience Designers: Professionals focused on crafting user-friendly interfaces and positive experiences will be interested in understanding how the automatic headlight dimming system interacts with drivers and contributes to overall road safety.

Reading Suggestions:

For a comprehensive understanding of the project, consider exploring the following resources:

1. Research Papers and Journals: Delve into academic research papers and journals related to automotive safety, human factors, and intelligent transportation systems. Look for studies on the Troxler effect, night-time accidents, and collision avoidance technologies.

2. Conference Proceedings: Attend or review proceedings from conferences and symposiums focused on automotive safety, intelligent transportation, and road safety technologies. These events often feature discussions on cutting-edge advancements.

3. Webinars and Online Seminars: Participate in webinars and online seminars conducted by experts in the fields of vehicular safety and software-driven solutions. These platforms offer insights into practical implementations and challenges.

4. Industry Whitepapers: Explore industry whitepapers published by automotive manufacturers, safety organizations, and technology providers. These documents often outline trends, challenges, and potential solutions in road safety.

5. Case Studies and Success Stories: Investigate case studies and success stories of similar collision avoidance systems implemented in real-world scenarios. Analyze their effectiveness, challenges faced, and lessons learned.

6. Regulatory Guidelines: Familiarize yourself with safety regulations and guidelines set by relevant authorities in the automotive industry. Understand how the project aligns with and contributes to road safety standards.

7. Technical Web Resources: Visit websites, forums, and online communities dedicated to automotive safety, software engineering, and vehicular technology. Engage in discussions and learn from the experiences of professionals in these domains.

2.3.1.3 PROJECT SCOPE

The scope of the automatic nighttime headlight dimming system includes the following components:

1. Data Processing: Development of algorithms to analyze sensor data and determine appropriate dimming levels based on factors such as the presence of oncoming vehicles, street lighting, and road curvature.

2. Headlight Control Mechanism: Implementation of mechanisms to control the headlight beam's intensity, direction, and coverage area. This may involve motorized adjustment systems or adaptive optics.

3. Testing and Validation: Rigorous testing under various driving conditions, including different road types, weather conditions, and lighting scenarios, to ensure accurate detection and reliable performance.

4. Compliance and Regulations: Ensuring that the system complies with relevant safety regulations and standards governing vehicle lighting systems.

5. Integration: Collaboration with vehicle manufacturers to seamlessly integrate the automatic nighttime headlight dimming system into new and existing vehicle models.

Ultimately, the successful development and deployment of this automatic nighttime headlight dimming system hold the potential to revolutionize nighttime driving safety, reduce accidents caused by glare, and contribute to an overall enhancement of road safety standards. By mitigating the adverse effects of intense headlights, this system aims to create a safer and more comfortable driving experience for all road users, exemplifying the intersection of technology and safety in the modern automotive landscape.

It's important to note that the system's scope may vary based on technical feasibility, budget constraints, and the intended market. The ultimate goal is to create a reliable and effective solution that enhances road safety by intelligently managing headlight intensity during nighttime driving.

2.2.2 OVERALL DESCRIPTION

2.2.2.1 PRODUCT PERSPECTIVE

The "Collision Avoidance System Based on Auto Zone-Dimming Headlights: Preventing Troxler Effect" is designed to integrate seamlessly with modern vehicles, augmenting their safety systems with intelligent collision avoidance technology. The system acts as an enhancement to the existing vehicle lighting system, specifically the headlights, and does not require extensive modifications to the vehicle's hardware or structure. It operates autonomously and collaboratively with the host vehicle's lighting controls to enhance night-time road safety.

The collision avoidance system functions as an intelligent software solution that interfaces with the vehicle's camera sensors, processing unit, and lighting control mechanisms. It operates independently of other vehicle systems while being designed to complement and enhance the overall driver experience.

2.2.2.2 PRODUCT FEATURES

The "Collision Avoidance System" encompasses a range of product features that collectively contribute to the enhancement of night-time driving safety:

1. Automatic Vehicle Detection: The system utilizes advanced camera sensors to detect oncoming vehicles in the vicinity. This detection process is dynamic and real-time, allowing for proactive response to changing traffic scenarios.

2. Position Estimation: Upon detecting an oncoming vehicle, the system determines the region in which vehicle lies. This data forms the basis for determining the extent of headlight dimming required.

3. Dynamic Zone-Dimming: Based on calculated region, the system creates localized dimming zones within the host vehicle's headlights. These zones are strategically positioned to minimize glare for oncoming vehicles while maintaining optimal illumination for the host vehicle.

4. Adaptive Brightness Adjustment: The system intelligently adjusts the brightness of the dimming zones in real-time. This adaptation ensures that the dimming is precise, responsive, and aligned with the presence and position of oncoming vehicles.

5. Collision Avoidance Logic: The collision avoidance system's core logic is designed to prevent the Troxler effect and optimize driver reaction times. By seamlessly dimming headlight zones, the system reduces the likelihood of temporary blindness and enhances the driver's ability to navigate safely.

6. Compatibility with Existing Systems: The system is engineered to integrate with the vehicle's existing lighting control mechanisms and safety systems. It operates harmoniously with other Advanced Driver Assistance Systems (ADAS) to provide a holistic approach to road safety.

These product features collectively form a cohesive solution that is designed to prevent the Troxler effect, enhance night-time visibility, and contribute to the broader goal of improving road safety.

2.2.3 EXTERNAL INTERFACE REQUIREMENTS

2.2.3.1 USER INTERFACES

2.2.3.2 HARDWARE INTERFACES

The collision avoidance system interfaces with specific hardware components within the vehicle to function effectively:

Camera Sensors: The system interfaces with camera sensors strategically positioned on the vehicle. These sensors provide real-time video input that is crucial for detecting oncoming vehicles and calculating distances and angles.

Lighting Control Mechanisms: The system interfaces with the vehicle's existing lighting control mechanisms to adjust the brightness of the headlight dimming zones. This integration ensures seamless collaboration between the collision avoidance system and the vehicle's lighting systems.

2.2.3.3 SOFTWARE INTERFACES

The collision avoidance system interfaces with software systems to process data and communicate information:

Camera Data Processing: The system interfaces with software algorithms responsible for processing data from camera sensors. These algorithms extract relevant information, such as vehicle presence and position, to inform the dimming calculations.

Vehicle Control Interface: The system interfaces with the vehicle's central control unit to initiate headlight dimming adjustments. This interface ensures coordinated control over the dimming zones and the overall lighting system.

2.2.4 OTHER NON-FUNCTIONAL REQUIREMENTS

2.2.4.1 PERFORMANCE REQUIREMENTS

1. **Vehicle Detection Accuracy:**

   The system must achieve a minimum detection accuracy of 95% for identifying oncoming vehicles within the driver's field of view.

2. **Real-Time Responsiveness:**

   The system should respond to detected oncoming vehicles and adjust the localized dimming zones within milliseconds to effectively mitigate glare.

3. **Dimming Accuracy:**

   The system's calculation of dimming zones' dimensions, angles, and positions must be accurate to within 5 degrees and 5% of the vehicle's actual dimensions.

4. **Troxler Effect Reduction:**

   The auto zone-dimming process must result in a Troxler effect delay reduction of at least 1.4 seconds, enhancing driver reaction times.

5. **Energy Efficiency:**

   The system should operate within energy-efficient parameters, ensuring minimal impact on the vehicle's battery life and overall energy consumption.

6. **Data Processing Time:**

   The time taken to process the video stream, detect oncoming vehicles, and calculate dimming parameters should not exceed 100 milliseconds per frame.

7. **Reliability and Availability:**

   The system should operate with a minimum uptime of 99.5%, ensuring consistent performance and availability for drivers during night-time journeys.

8. **System Latency:**

   The overall system latency, including data transmission and processing, should not exceed 200 milliseconds to maintain real-time responsiveness.

9. **Adaptive Brightness Adjustment:**

   The system's automatic dimming should achieve an optimal balance between glare reduction and maintaining driver visibility, preventing under- or over-dimming scenarios.

10. **Minimum False Positives and Negatives:**

The system must maintain a low rate of false positives (incorrectly identifying objects as vehicles) and false negatives (missing actual oncoming vehicles) in vehicle detection.

2.2.4.2 SAFETY REQUIREMENTS

1. Real-Time Responsiveness:

The system must exhibit real-time responsiveness in detecting oncoming vehicles and adjusting headlight brightness within milliseconds to prevent any delay in glare reduction.

2. Fail-Safe Mechanism:

Implement a fail-safe mechanism that defaults the system to standard headlight mode in case of technical failures or malfunctions to ensure continuous vehicle operation.

3. Redundancy and Reliability:

Incorporate redundant sensors and components to ensure that the system maintains its functionality even in the event of sensor failure or communication breakdown.

4. Manual Override:

Enable a manual override feature that allows drivers to manually adjust the headlight brightness and disable the auto zone-dimming feature, providing control in unexpected scenarios.

5. Adverse Conditions Handling:

The system must account for adverse weather conditions (e.g., heavy rain, fog) and adapt dimming parameters accordingly to maintain optimal road visibility.

6. Visibility Maintenance:

The system should not compromise the driver's visibility of road signs, markings, pedestrians, or obstacles even during the dimming process.

7. Dynamic Environment Adaptation:

Design the system to adapt to dynamic road environments, including varying road geometries, curves, and inclines, to ensure accurate adjustments in localized dimming zones.

8. Pedestrian and Bicyclist Safety:

Ensure that the system's dimming zones do not affect the visibility of pedestrians and bicyclists, ensuring their safety and visibility at night.

9. Power Management:

Design the system with efficient power management to prevent draining the vehicle's battery excessively and ensuring continuous operation without compromising vehicle functionality.

10. Regular Maintenance Alerts:

Provide users with alerts and notifications for regular maintenance of the system components to ensure consistent performance and safety.

2.3 COST ANALYSIS

S No.	Item	Quantity	Price	Total Price
1	Arduino UNO	1	2740	2740
2	LEDs	4	168	672
3	5V 4 Channel Relay Module	1	800	800
4	Web Camera	1	1400	1400
5	Pack of Jumper wires, Adapter, Serial Cable	-	500	500
6	DC Buck Module	1	150	150
7	Tower Pro MG 995 Motor	1	700	700
	Total			6962

Table 3: Cost Analysis

2.4 RISK ANALYSIS

Here's a risk analysis for the project "Collision Avoidance System Based on Auto Zone-Dimming Headlights: Preventing Troxler Effect":

1. Technical Challenges and Failures:

- **Risk:** The algorithms for vehicle detection, distance calculation, and zone dimming might not work accurately in all scenarios, leading to false positives or negatives. Technical failures in camera sensors or computing systems could also impact the system's reliability.
- **Mitigation:** Thorough testing and validation under a wide range of conditions are crucial. Implement redundancy and fail-safe mechanisms to minimize the impact of technical failures.

2. Adverse Weather and Lighting Conditions:

- Risk: Poor weather conditions (rain, snow, fog) and inadequate lighting might affect the camera's ability to accurately detect oncoming vehicles or calculate distances.

- Mitigation: Develop algorithms that can adapt to various lighting and weather conditions. Include additional sensors (such as radar) that are less affected by visual impairments caused by weather.

3. Driver Perception and Acceptance:

- Risk: Drivers might resist the dimming of their headlights' zones or find the changes in illumination uncomfortable or distracting.

- Mitigation: Conduct thorough user studies and human factors research to design a system that is intuitive, comfortable, and non-intrusive. Provide clear communication to the driver about the system's functionality and benefits.

5. Interaction with Existing Vehicle Systems:

- Risk: Integration with other Advanced Driver Assistance Systems (ADAS) could lead to conflicts or unintended interactions between different safety features.

- Mitigation: Conduct thorough testing of the integrated system to identify and address any conflicts. Implement seamless coordination between the collision avoidance system and other ADAS technologies.

6. Legal and Regulatory Hurdles:

- Risk: Deployment of a novel collision avoidance system could encounter legal and regulatory obstacles that delay or prevent implementation.

- Mitigation: Work closely with regulatory authorities to understand and address any compliance requirements. Advocate for necessary changes in regulations to accommodate innovative safety technologies.

7. Cost and Affordability:

- Risk: The implementation of such a system might significantly increase the cost of vehicles, limiting its adoption.

- Mitigation: Explore cost-effective sensor and computing solutions without compromising safety. Highlight the potential long-term benefits, such as reduced accidents and associated costs.

8. Maintenance and Calibration:

- Risk: Over time, cameras and sensors might require maintenance or recalibration, affecting the system's accuracy.

- Mitigation: Develop self-monitoring mechanisms that alert users or maintenance personnel when recalibration or maintenance is needed. Provide clear guidelines for maintenance routines.

9. Unintended Consequences:

- Risk: While the system aims to prevent accidents, there could be unforeseen consequences, such as drivers becoming overly reliant on the technology or changing their behavior in unexpected ways.

- Mitigation: Continuously monitor driver behavior and system effectiveness to identify any unintended consequences. Provide driver education about the system's limitations and proper use.

Effective risk management is critical to the success of the project. By identifying potential risks and implementing appropriate mitigation strategies, the project can increase its chances of delivering a safe and reliable collision avoidance system.

3.1 INVESTIGATIVE TECHNIQUES

1. **Experimental Testing:** Conduct controlled experiments in a controlled environment to assess the system's accuracy and efficiency. Vary factors like lighting conditions and angles of approach are used to gauge how reliably the system detects vehicles. Record and analyze the system's response time and false negative rates to evaluate its performance comprehensively.
2. **Field Trials:** Organize field trials in actual traffic settings to observe the system's behavior in real-world scenarios. Monitor its ability to detect various vehicle types (cars, bikes, trucks). Evaluate its response to unpredictable variables like weather conditions and vehicle movement patterns. This technique provides valuable insights into the system's effectiveness under practical conditions.
3. **User Surveys and Feedback:** Engage drivers who have used the system in surveys or interviews. Inquire about their experiences, challenges faced, and benefits gained from the system. Collect feedback on usability, accuracy, and user interface design. This technique helps identify user preferences, pain points, and areas for improvement.
4. **Comparative Analysis:** Compare the headlight system with similar methods like dimming using LDR. Assess factors such as cost-effectiveness, ease of installation, maintenance requirements, and overall efficacy in reducing glare. This technique helps identify the system's competitive advantages and areas for enhancement.
5. **Performance Benchmarking:** Benchmark the headlight system's technical capabilities against industry standards and best practices. Evaluate its performance in terms of data processing speed, real-time responsiveness, accuracy of detection, and creation of dimming zones. This technique ensures that the system meets or exceeds established benchmarks.
6. **Continuous Monitoring:** Implement continuous monitoring mechanisms within the system's architecture. Set up metrics and alerts that monitor the system's performance in real time. Regularly review these metrics to identify anomalies, performance

degradation, or potential improvements. This technique ensures that the system remains practical and operational over time.

In conclusion, the suite of investigative techniques outlined above forms a robust framework for the thorough evaluation, enhancement, and validation of the zone-dimming headlight system. By employing experimental testing, field trials, user surveys, comparative assessment, performance benchmarking, and continuous monitoring, the system can be subjected to comprehensive and multidimensional scrutiny. This approach ensures not only the accuracy and efficiency of the vehicle detection and zone-dimming mechanisms but also validates the system's real-world applicability and user satisfaction. As a result, the auto zone-dimming system can confidently fulfill its mission of reducing glare-induced Troxler's effect and improving the comfort and safety of drivers.

3.2 PROPOSED SOLUTION

The inception of the methodology involved conducting an extensive literature review to comprehend the diverse methods, techniques, and technologies employed for detecting oncoming vehicles using real-time video or image sensing with machine learning algorithms. This review served as the bedrock for understanding the complexities and nuances of oncoming vehicle identification. The following are the components of the proposed solution, together forming an auto zone-dimming headlight.

3.2.1 VEHICLE DETECTION MODEL

Our proposed solution is built around the critical Vehicle Detection Model, which is powered by the cutting-edge YOLOv8 neural network architecture. Our project depends on this strong framework, which is made to quickly and correctly find vehicles in a variety of settings. The unique YOLOv8, which is an update to the "You Only Look Once" series, is great at finding objects in real time and is very accurate. It is important because it can process whole photos at once, which makes it a great choice for our adaptive auto zone-dimming headlight system. The deep neural network design and carefully tuned anchor boxes in the model are key to getting accurate results and reliable feature extraction for vehicles of different sizes and aspect ratios.

Figuring out how YOLOv8 works helps you understand what it can do. For this method to work, an image is split into a grid, and each grid cell is like a small detector that has to guess what items are in its own area. Using a convolutional neural network (CNN) to extract features, YOLOv8 gradually pulls out high-level features that are necessary for accurate object recognition. The model projects the confidence score, bounding box, and class likelihood for each grid cell. This makes sure that detection is accurate and quick. It is faster and more accurate because of the unified structure, anchor boxes, focus mechanism, and features like PANet in the YOLOv8-Panet variant. This makes it an important part of our project.

Our thorough method of collecting data, annotating it, and preparing it not only shows how advanced YOLOv8 is, but it also makes it possible for it to be used in different situations. This careful process makes sure that the model can handle a wide range of situations, which adds to its usefulness in real life. Our thorough data processing method and YOLOv8 principles work together to create a strong framework for our Vehicle Detection Model. This framework is in line with the goals of our adaptive auto zone-dimming headlight system.

3.2.2 POSITION ESTIMATION:

The determination of positional estimates on a computer screen involves segmenting the screen into four distinct regions through the strategic implementation of vertical grids. These regions are defined and identified based on the coordinates derived from the YOLOv8 algorithm, specifically targeting object recognition and localization. By utilizing the x coordinates of both the bottom-left and top-right corners of the bounding boxes generated through this algorithm, the software discerns and maps the regions wherein these coordinates fall. This methodological approach ensures precise region allocation for each object detected, contributing significantly to accurate spatial localization and subsequent computational analyses.

3.2.3 HEADLIGHT CONTROL MODULE INTEGRATION:

The integration of the data with the headlight control module, the central intelligence of the system, is pivotal. The module processes the data from the sensors to discern the ideal locations for establishing dimming zones. This intricate interaction forms the core of the system's dynamic adaptation to changing driving scenarios.

Calibrating the headlight system represents a critical phase that demands meticulous attention. During this process, well-defined thresholds are established within the headlight control module to ascertain the precise locations when specific LEDs are to be automatically extinguished, forming the dimming zones. This fine-tuning minimizes the occurrence of false positives and false negatives, ensuring optimal performance.

3.2.4 VALIDATION AND TESTING:

To validate the effectiveness and robustness of the auto zone-dimming headlight system, a comprehensive testing regimen is conducted. This encompasses simulated scenarios and real-world tests across varying road conditions and ambient lighting levels. The validation process guarantees that the system operates reliably across a spectrum of driving situations and lighting environments.

The detailed methodology presented here offers a comprehensive guide for the development of an auto zone-dimming headlight system that redefines nighttime driving safety and convenience. By fusing machine learning, sensor integration, advanced image processing, intricate calibration, rigorous validation, and a future-oriented perspective, this technology promises a new era of road safety by mitigating glare for oncoming drivers. As the automotive landscape evolves, auto zone-dimming headlights stand as a testament to innovation's potential to enhance safety and elevate the nocturnal driving experience.

3.3 WORK BREAKDOWN STRUCTURE

The breakdown structure is shown as follows:

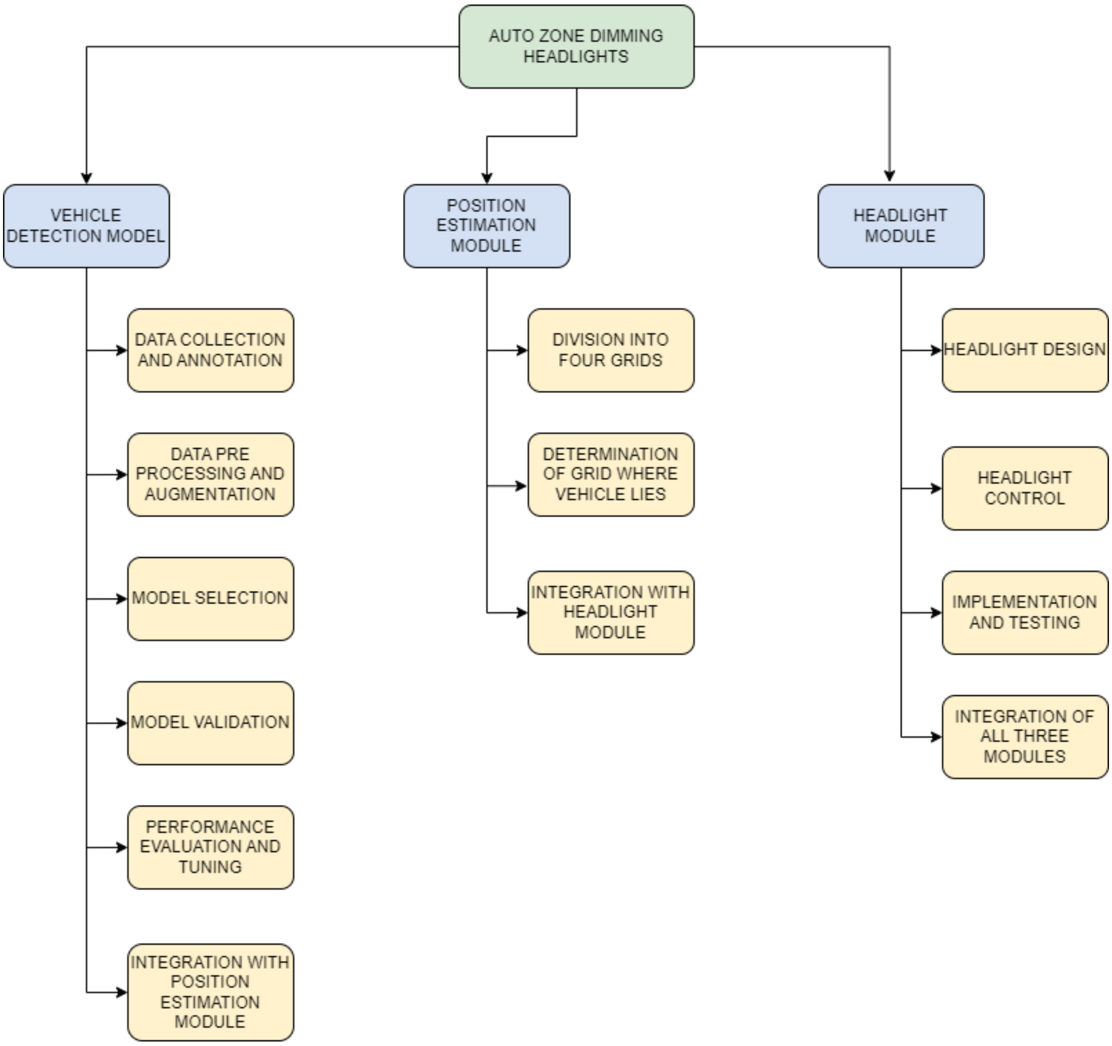


Fig 1 : Work Breakdown Structure

COMPONENT 1: VEHICLE DETECTION MODEL

MODULE 1.1: Data Collection And Annotation

Collect and curate a diverse dataset of vehicle images.

Annotate the dataset with bounding boxes around vehicles.

MODULE 1.2: Data Preprocessing And Augmentation

Resize and normalize images to a consistent format.

Apply data augmentation techniques to increase dataset diversity.

MODULE 1.3: Model Selection

Research and select appropriate vehicle detection algorithms (YOLO, SSD, Faster R-CNN, etc.).

Design the neural network architecture and layers for vehicle detection.

MODULE 1.4: Model Validation

Train the selected model using the annotated dataset.

Validate the model's performance on a separate test dataset.

MODULE 1.5: Performance Evaluation And Tuning

Measure detection accuracy, precision, recall, and computational efficiency.

Fine-tune hyperparameters to achieve optimal performance.

MODULE 1.6: Integration With Position Estimation System

Develop APIs or interfaces to connect the vehicle detection model with the position estimation system.

Ensure seamless communication between the two components.

COMPONENT 2: POSITION ESTIMATION SYSTEM

MODULE 2.1: Web Camera Integration

Integrate sensors like cameras or LIDAR to capture data.

Set up a system to acquire real-time images or distance measurements.

MODULE 2.2: Position Estimation Algorithm Design

Develop an algorithm to estimate the position and direction of oncoming vehicles.

Incorporate vehicle angle data for accurate position prediction.

Process sensor data to extract relevant information about the position and distance of detected vehicles.

Calculate the angle at which the vehicles are approaching.

MODULE 2.3: Performance Testing And Calibration

Test the accuracy of position estimation under various driving scenarios.

Calibrate the system to ensure precise alignment between vehicle position and headlight adjustment.

MODULE 2.4: Integration With Headlight Control

Establish communication between the position estimation system and the headlight control module.

Transmit relevant data for adaptive light adjustment.

COMPONENT 3: HEADLIGHT

MODULE 3.1: Headlight Design

Design headlights consisting of two specialized arrays: one explicitly designed for low-beam functionality and another tailored for high-beam projection.

The process commences with defining detailed specifications for each LED array, encompassing factors like luminance, beam pattern, color temperature, and energy efficiency while differentiating their attributes based on their designated low and high beam roles.

The physical arrangement of the arrays is thoughtfully designed to ensure efficient light distribution.

MODULE 3.2: Control Algorithm Design

Design an algorithm that processes input from the vehicle detection and position estimation systems.

Calculate the appropriate areas to dim the headlights based on vehicle positions and angles.

Ensure that the dimming zones effectively prevent glare for other drivers.

Determine how the headlight beams should be adjusted based on vehicle positions and directions.

MODULE 3.3: Implementation And Testing

Implement the control algorithm within the headlight system.

Test the system in various scenarios to verify its performance and accuracy.

MODULE 3.4: Integration With Vehicle Detection Model And Position Estimation Module

Integrate with the outputs of the vehicle detection model and position estimation system.

Use the processed data to inform the headlight adjustment decisions.

MODULE 3.5: User Interface

Design a user interface that allows drivers to adjust settings and preferences.

Implement comfort features like adaptive brightness and auto-dimming based on ambient lighting.

3.4 TOOLS AND TECHNOLOGY

3.4.1 PYTHON

Python has established itself as a dominant programming language in the fields of Computer Vision and Machine Learning due to its versatility, extensive libraries, and user-friendly syntax. Its rich ecosystem of libraries, frameworks, and tools has significantly accelerated the development and implementation of complex algorithms and models in these domains. Here's a detailed description of Python's role in Computer Vision and Machine Learning

Key Features:

Ease of Use and Readability:

Python's clean and readable syntax makes it an ideal choice for beginners and experienced programmers. Its human-friendly code style simplifies the implementation of intricate Computer Vision and Machine Learning algorithms, enhancing the collaborative and exploratory nature of these fields.

Abundance of Libraries and Frameworks:

Python boasts an extensive array of libraries and frameworks that cater specifically to Computer Vision and Machine Learning tasks. Libraries such as OpenCV, scikit-image, and Pillow provide a variety of tools for image processing, manipulation, and feature extraction, while machine learning libraries like TensorFlow, PyTorch, and scikit-learn offer a wealth of pre-built models and functions.

Deep Learning Frameworks:

Python's strength in Machine Learning lies in its support for deep learning frameworks like TensorFlow and PyTorch. These frameworks have revolutionized the way researchers and practitioners build complex neural networks for tasks such as image classification, object detection, segmentation, and style transfer.

Jupyter Notebooks for Interactive Exploration:

Python's integration with Jupyter Notebooks facilitates interactive exploration and experimentation. Researchers can seamlessly combine code, visualizations, and explanatory text, making it an excellent platform for documenting and sharing findings in Computer Vision and Machine Learning projects.

3.4.2 TENSORFLOW

TensorFlow is an open-source machine learning framework developed by Google that has revolutionized the field of artificial intelligence and deep learning. It provides a comprehensive platform for building, training, and deploying machine learning models, mainly focusing on neural networks and deep learning architectures. TensorFlow's versatility, scalability, and extensive library of tools have made it a cornerstone in the development of AI applications across a wide range of industries.

Key Features:

Graph Computation:

TensorFlow employs a unique approach called a computational graph, where operations are represented as nodes and data as edges. This allows for optimized execution and efficient use of resources, making it well-suited for complex neural network architectures.

Keras Integration:

TensorFlow integrates seamlessly with the Keras high-level neural network API. Keras provides an intuitive and user-friendly interface for building and training neural networks, making it easier for newcomers to enter the field.

Deployment Options:

TensorFlow provides multiple deployment options, including TensorFlow Serving for deploying models in production, TensorFlow Lite for mobile and embedded devices, and TensorFlow.js for browser-based applications.

3.4.3 ARDUINO UNO R3

The Arduino platform has brought about a significant technological revolution in the fields of electronics and prototyping. Arduino boards, which were created with an emphasis on simplicity and accessibility, have become indispensable for both novice and experienced enthusiasts in the do-it-yourself electronics industry.

Key Features:

Open-Source Characteristics:

Arduino operates under the principles of open-source, granting users unrestricted access to its hardware and software designs. The inclusive atmosphere promotes a dynamic community, stimulating cooperation, the exchange of thoughts and concepts, and ongoing ingenuity.

Adjustable Hardware:

There are numerous models of Arduino boards, each with a unique set of capabilities to accommodate specific requirements. These boards, ranging from the Arduino Uno to the Mega and beyond, provide users with an extensive selection of inputs, outputs, and connectivity choices, thereby facilitating the development of a vast array of projects.

Facilitating Programming:

An outstanding characteristic of Arduino is its intuitive Integrated Development Environment (IDE), which streamlines the process of coding. Because of its syntax resembling that of C/C++, even novices can easily comprehend it, enabling them to implement their ideas rapidly.

Exceptional support for sensors and shields:

The broad capabilities of Arduino are enhanced by its compatibility with a multitude of sensors, modules, and shields. These supplementary components enhance the operational capabilities of projects by integrating sensors that detect and quantify factors such as temperature, humidity, motion, and more.

Accessibility and Affordability:

Due to their affordable price, Arduino boards are accessible to a wide range of individuals. This financial feasibility promotes learning and experimentation without causing undue financial strain, rendering it an optimal selection for prototyping and educational objectives.

3.4.4 YOLOV8

YOLOv8, also known as "You Only Look Once Version 8," is a cutting-edge object detection algorithm that represents a significant advancement in the field of computer vision. YOLOv8 builds upon the success of its predecessors, aiming to achieve a remarkable balance between accuracy and real-time inference speed. This algorithm is part of the YOLO (You Only Look Once) family of models, known for their ability to perform object detection tasks in a single forward pass, making them exceptionally fast and efficient.

Key Features:

Real-Time Inference:

YOLOv8 continues the YOLO tradition of real-time object detection. Its architecture is designed for rapid inference, making it suitable for applications that require quick and responsive detection of objects in images or video streams.

Single Pass Processing:

YOLOv8 follows the YOLO concept of processing the entire image in a single pass through the neural network. This approach eliminates the need for complex multi-stage pipelines, leading to faster inference speeds.

Scale Detection:

YOLOv8 employs a multi-scale approach to object detection. It operates on various scales within an image, enabling the detection of objects of different sizes, which is particularly important for real-world scenarios.

Compatibility:

YOLOv8 can be integrated with various deep learning frameworks such as TensorFlow and PyTorch, making it accessible to a broad audience of researchers and developers.

3.4.5 OPENCV

OpenCV (Open Source Computer Vision Library) is a widely used open-source computer vision and machine learning software library. It offers an extensive set of tools, functions, and algorithms designed to enable developers, researchers, and enthusiasts to build and deploy computer vision applications with ease. OpenCV has become an essential resource in the field of computer vision, empowering a wide range of industries with its versatile capabilities.

Key Features:

Wide Range of Functions:

OpenCV provides a comprehensive suite of functions for tasks such as image and video manipulation, object detection, facial recognition, feature extraction, camera calibration, and more. Its vast collection of tools simplifies the development of complex computer vision algorithms.

Real-Time Processing:

OpenCV is optimized for real-time image and video processing. Its efficient algorithms allow for fast and responsive computer vision tasks, making it suitable for applications that require rapid analysis.

Image and Video I/O:

OpenCV supports a wide range of image and video formats, making it a valuable tool for reading, writing, and manipulating multimedia data. This functionality is essential for preprocessing and data augmentation in machine learning pipelines.

Computer Vision Algorithms:

OpenCV includes a rich collection of algorithms for image processing, feature detection, object tracking, optical flow estimation, and more. These algorithms serve as building blocks for creating sophisticated computer vision applications.

Machine Learning Integration:

OpenCV integrates with machine learning frameworks like TensorFlow and PyTorch, allowing developers to combine traditional computer vision techniques with advanced deep learning models.

4.1 SYSTEM ARCHITECTURE

The presented block diagram fig 2 offers a graphical overview of our project's software architecture. It showcases key modules as interconnected blocks, illustrating the flow of data and control between them. As we advance, this diagram will be pivotal for discussions, adjustments, and maintaining a robust software framework.

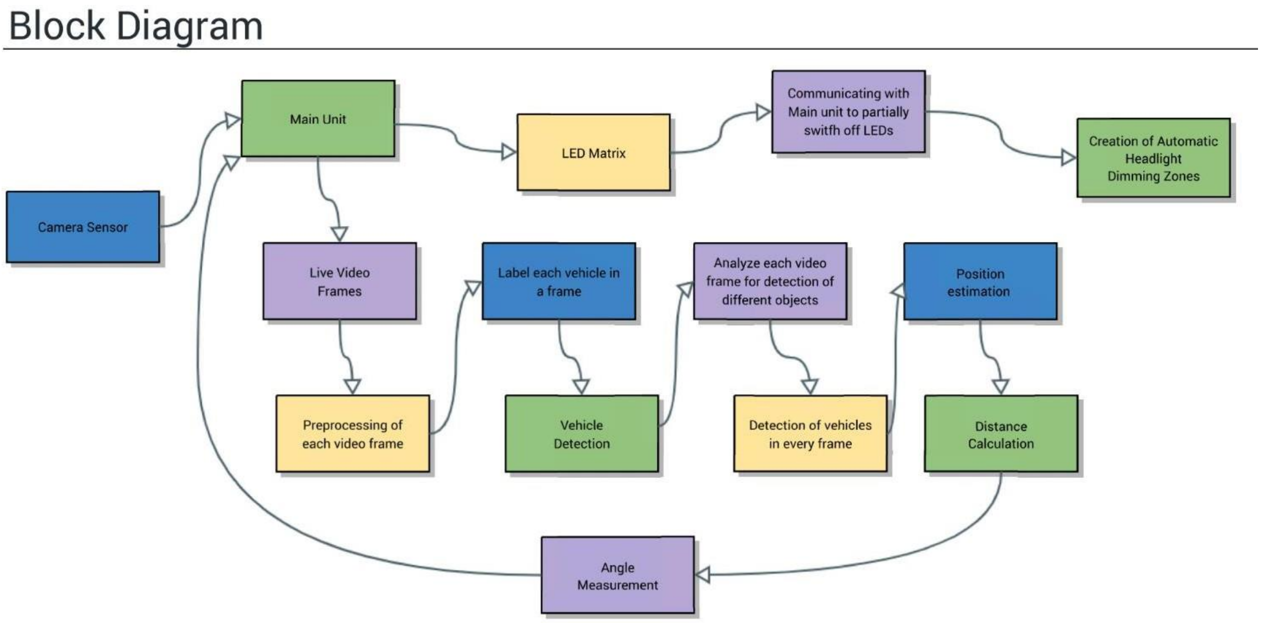


Fig 2: Block Diagram

The MVC architecture diagram as shown below outlines our project's structure using the Model-View-Controller paradigm. It visually represents the Model for data and logic, the View for user interface, and the Controller for managing user input and system behavior. As we move forward, this diagram will be crucial for discussions, improvements, and maintaining a robust MVC framework.

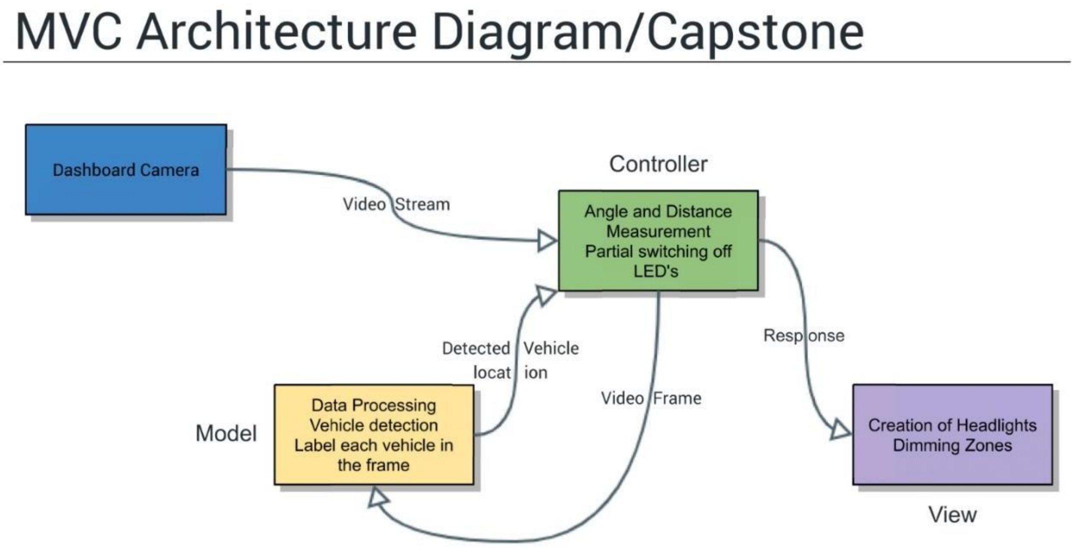


Fig 3: MVC Architecture Diagram

4.2 DESIGN LEVEL DIAGRAMS

The class level diagram offers a detailed snapshot of our project's structure, focusing on classes, attributes, methods, and their interconnections. As development unfolds, this diagram will be invaluable for discussions, code optimization, and maintaining a well-organized and efficient class hierarchy.

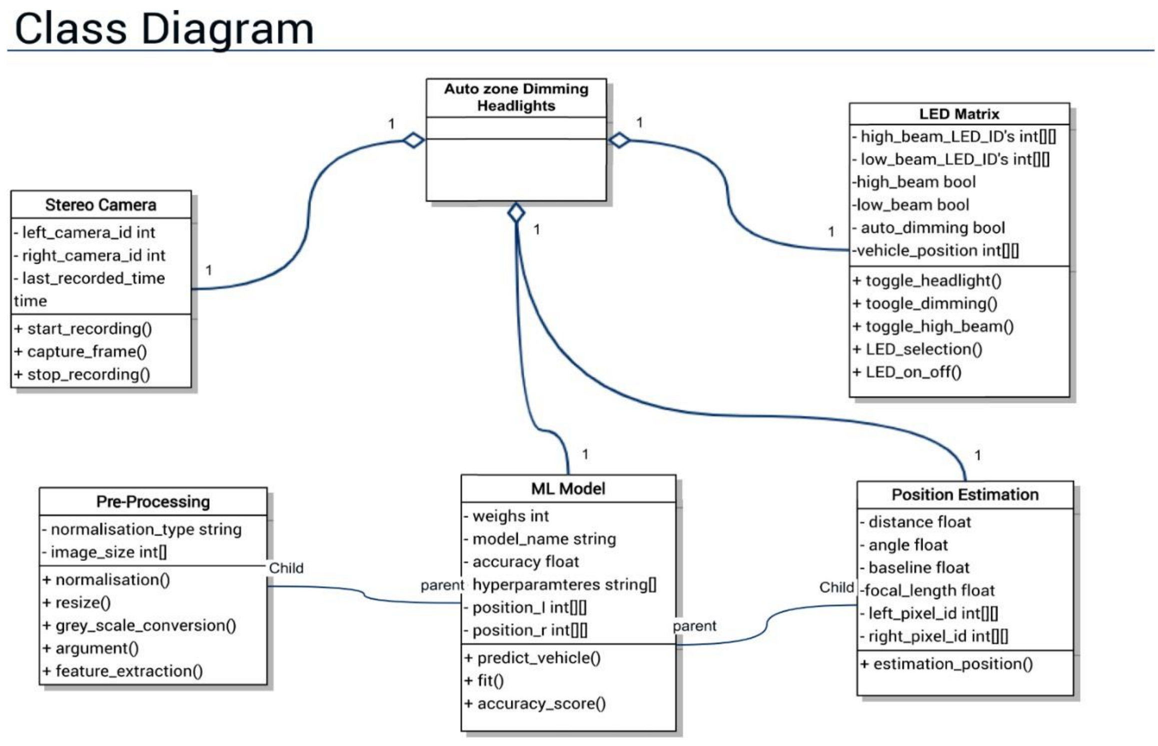


Fig 4: Class Diagram

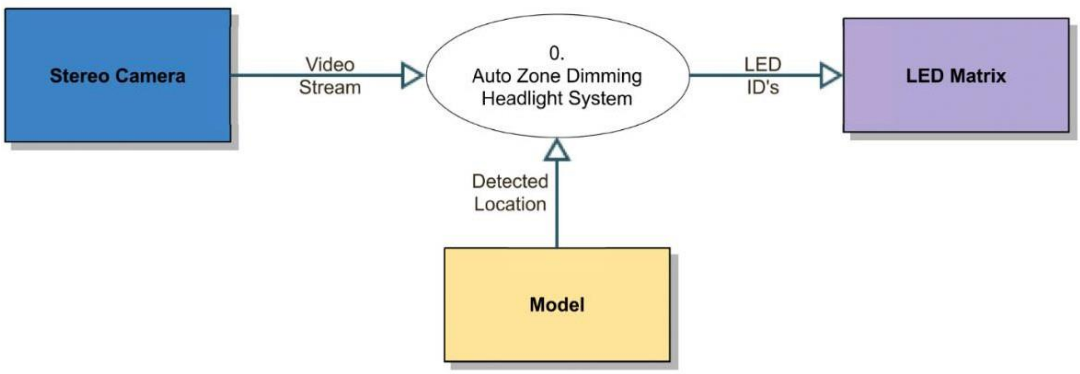


Fig 5: Level 0 DFD

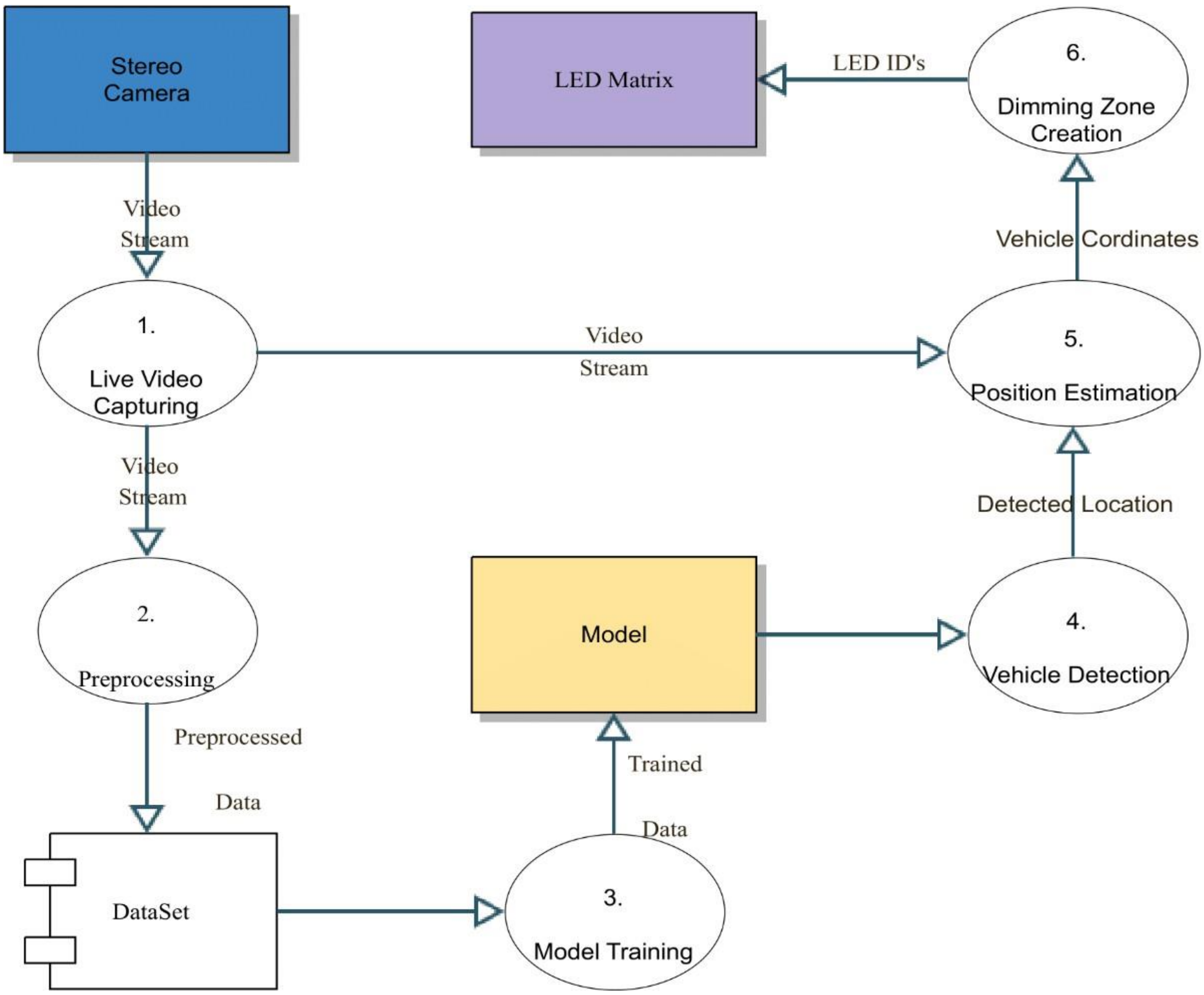


Fig 6: Level 1 DFD

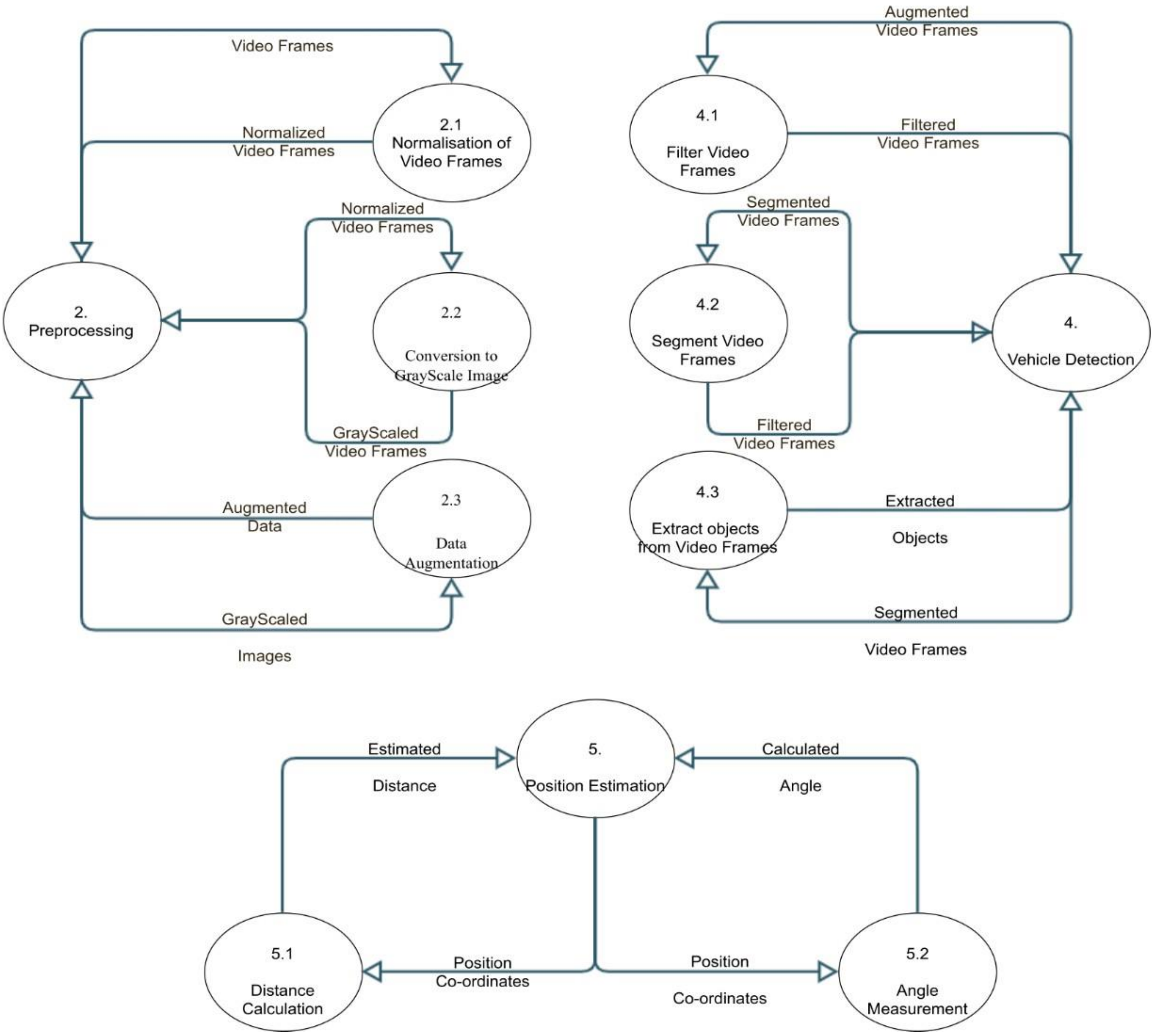


Fig 7 : Level 2 DFD

4.3 USER INTERFACE DIAGRAMS

The use case diagram visually encapsulates our project's functional requirements by illustrating various use cases and their relationships. It provides a high-level view of how users interact with the system. Using standardized UML symbols, this diagram fosters team-wide understanding, aiding effective communication about user-system interactions. As our project advances, this diagram will prove indispensable for discussions, feature refinements, and ensuring alignment with user needs.

Use case diagram is as follows:

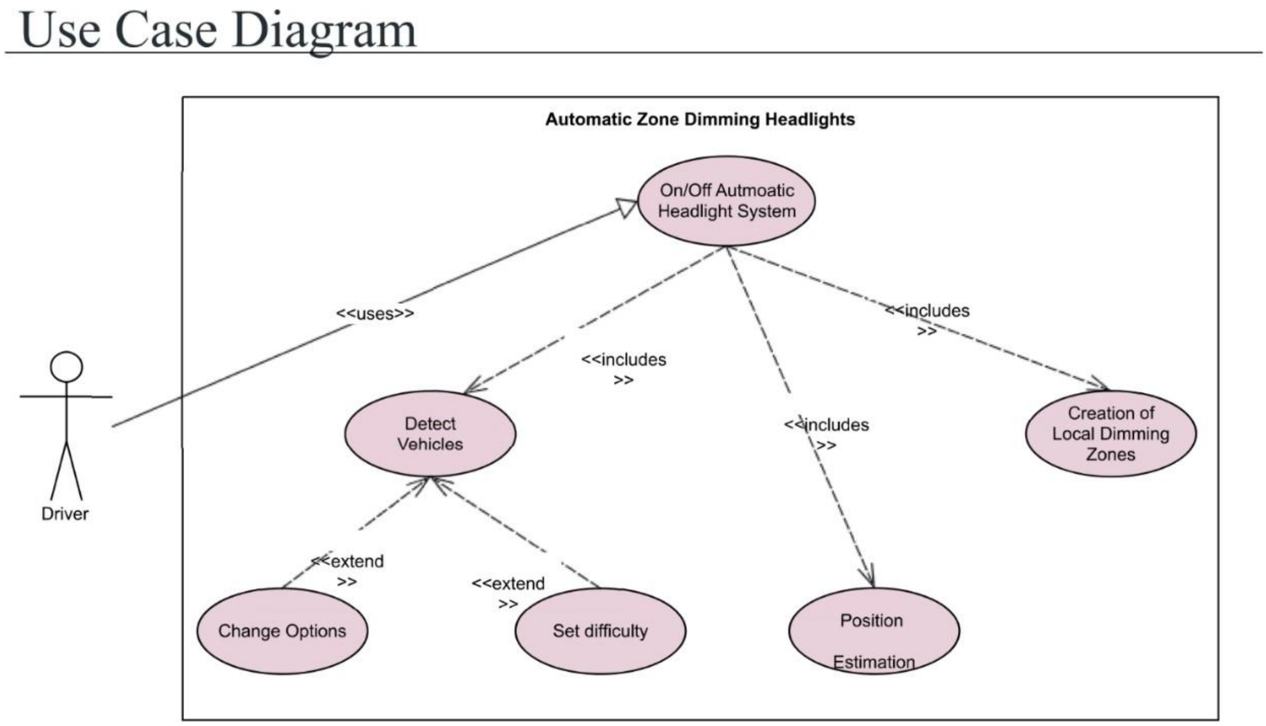


Fig 8 : Use Case Diagram

5.1 EXPERIMENTAL SETUP

The experimental setup consists of the following hardware components:

1. Arduino
2. LED matrix for headlights
3. Motor
4. Relay Module
5. Web Camera
6. DC Buck module

The system is powered using an adapter. The computer is connected to Arduino with a serial cable, and a web camera provides real-time feed input. The YOLOv8 model processes this feed and precisely determines vehicle position coordinates for vehicles detected.

The computer screen is divided into four regions using vertical grids, enabling the system to calculate the regions where the oncoming vehicles lie. This information is transmitted to the Arduino, which communicates with the relay module, instructing it to turn off particular LEDs corresponding to the region where the vehicle is located. If the detected vehicles necessitate turning off all LEDs, a signal is relayed to the motor, triggering the rotation of the LED matrix system from its initial position of 110 degrees to 150 degrees.

Our hardware setup is as follows:

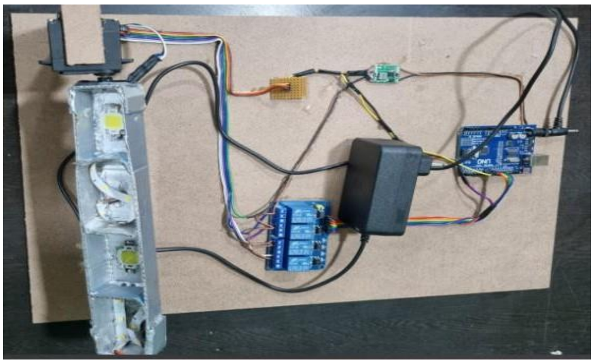


Fig 9 : Experimental Setup

5.2 EXPERIMENTAL ANALYSIS

5.2.1 DATA

The data for the entire training was gathered through self-collection methods. The data is collected by recording videos while driving a car at night. To make this data usable for training the model, a Python script was used, which extracted images from the videos and saved them into a folder on our computer. Our dataset contained around 500 images.

5.2.2 PERFORMANCE PARAMETERS

ROC Curve is as follows

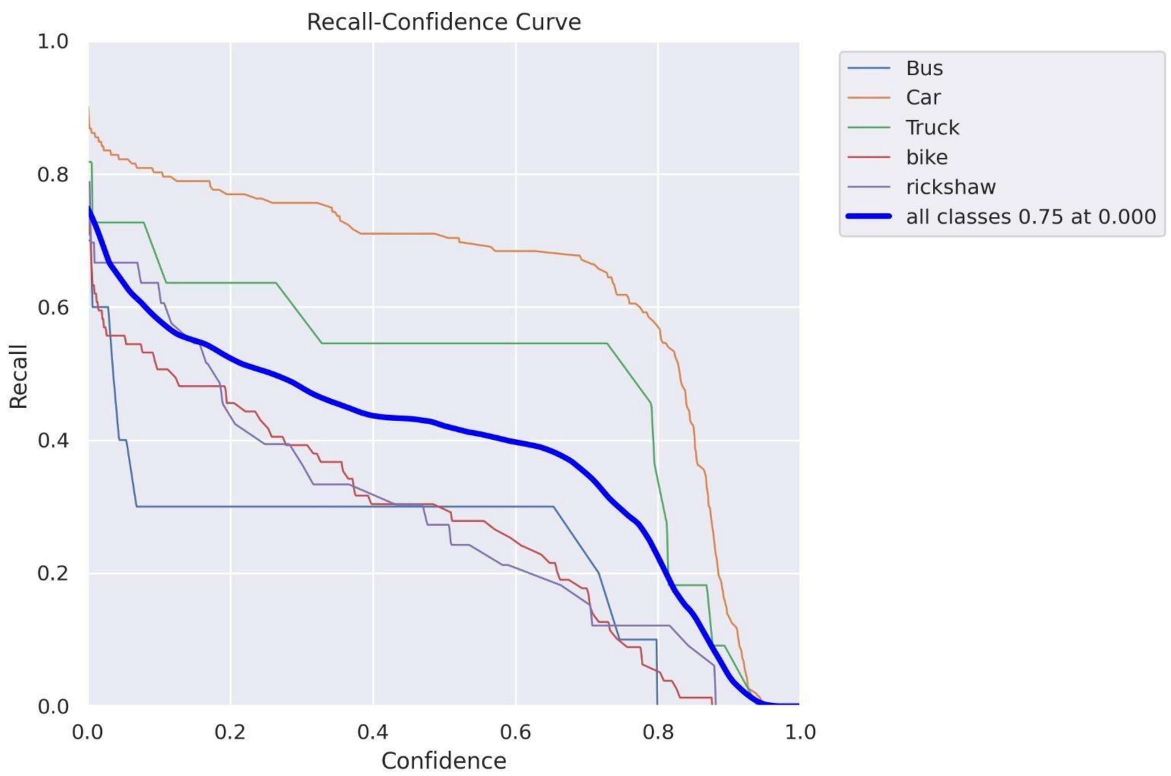


Fig 10 : ROC Curve

The recall-confidence curve provides a visual depiction of how recall varies concerning different confidence levels. The car demonstrates the highest accuracy compared to other vehicles, as its curve positioning is closer to the upper corner of the graph. At a confidence value of 0, the recall stands at 0.75. Confusion matrix is as shown below.

Confusion Matrix

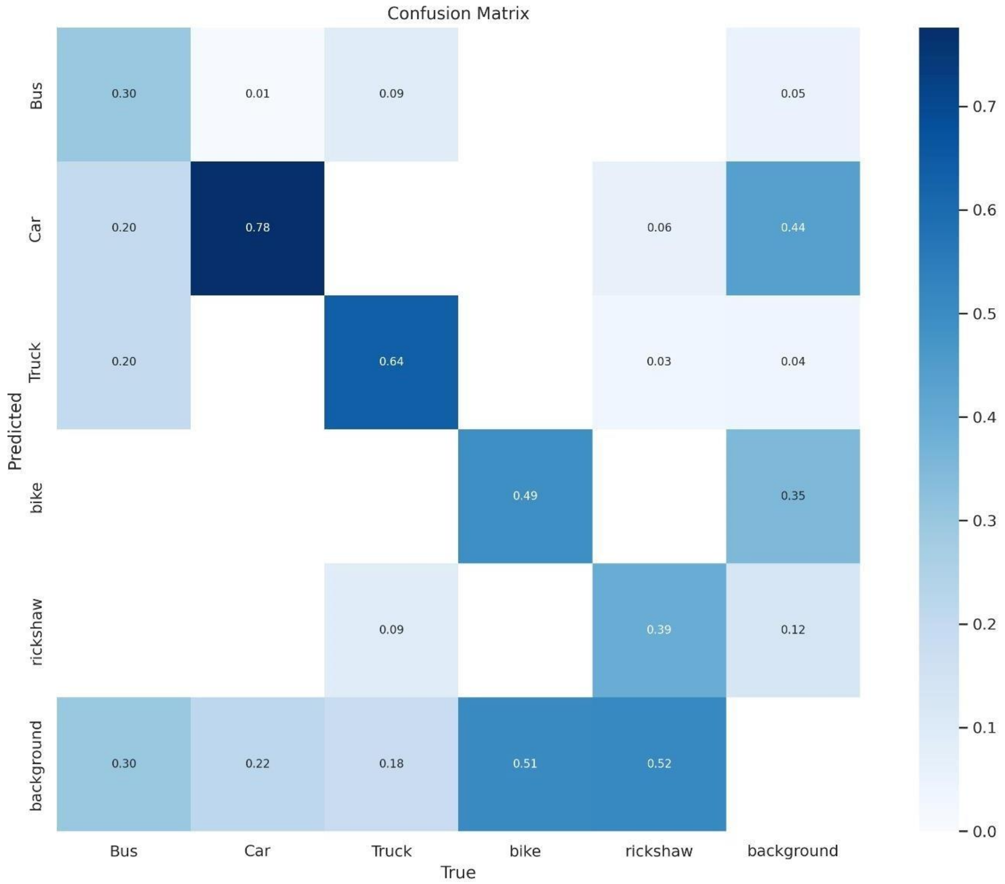


Fig 11: Confusion matrix

The number of correct and incorrect predictions are summarized and broken down by each class. This Confusion matrix shows that for cars and truck, cell corresponding to predicted and true have high intensity indicating higher accuracy.

5.3 WORKING OF PROJECT

5.3.1 PROCEDURAL WORK FLOW

Following is the workflow:

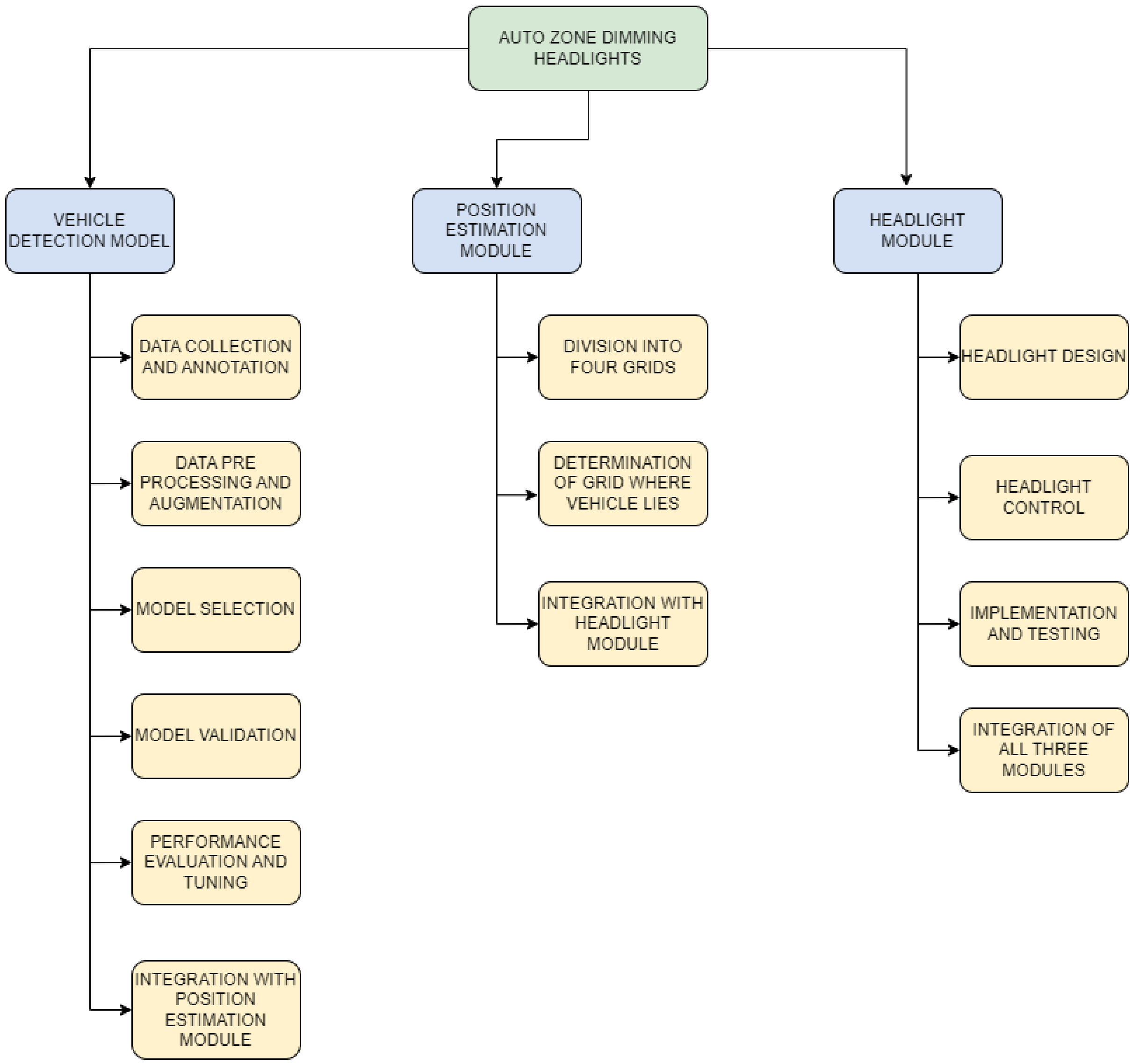


Fig 12: Procedural Work Flow

Literature Survey: We did extensive Literature review as shown in below figure by reading around 50 research papers. This was done to gather knowledge about the concerned domain and to study about the already existing methods and approaches.

Title	Authors	Methodology Used	Evaluation Metrics	No of Approaches for Comparison	No of features used in experiment	Dataset on which applied	References used	Outcome	Link
Combining Monocular and Stereo-Vision for Real-Time Vehicle Ranging and Tracking on Multilane Highways	Sayanan Sivaraman and Mohan M. Trivedi	STEREO-MONOCULAR VISION FUSION	True Positive Rate vs. False Positives per Frame	3	7	data has been captured using a calibrated stereo rig, mounted on a vehicle platform, looking forward.Video is captured at an image resolution of 500×312	32	The fully implemented system processes a single frame in 46ms.	https://ieeexplore.ieee 30b5ZhGJ5VSkgdion
Multiple Scale Aggregation with Patch Multiplexing for High-speed Inter-vehicle Distance Estimation	Masahiro Hirano1 , Yuji Yamakawa1 , Taku Senoo2 , Norimasa Kishi1 and Masatoshi Ishikawa3	HIGH-SPEED STEREO VISION AND PATCH MULTIPLEXING, Correlation filter based – MOSSE / A-MOSSE (Alternating MOSSE) for Vehicle Tracking	Mean Absolute Error	4	NA	NA	18	The accuracy of the proposed approach is found to be comparable to that of LRFs (laser rangefinder), and the system is capable of estimating relative velocity and acceleration of the preceding vehicle	https://ieeexplore.ieee
Vehicle-to-vehicle distance estimation using artificial neural network and a toe-in-style stereo camera	Ozgur Duran,* , Bulent Turan	TOE-IN-STYLE STEREO-VISION-BASED METHOD WITH ANN MODEL	MAPE, RMSE, NRMSE, MSE	2	7	The images taken from the ego-vehicle at 1-m intervals along an overall distance of 1–	68	Estimates the distance without the need for camera calibration.	https://www.sciencedi TcMMSljKHCJo5AFa

Fig 13: Literature Survey

Dataset Creation: Creating the dataset was a very important part of our project, especially for finding vehicles in real time. We did this by recording videos of ourselves driving the car on Indian roads at night. These videos show a variety of situations that we wanted our Vehicle Detection Model to be able to handle.

Then, we used a Python script to carefully take screenshots from the recorded movies, following our overall method. This fits with our promise of a full process of gathering data, annotating it, and preparing it. After that, we made our dataset more accurate and useful by adding notes to each extracted picture on Roboflow. This step made sure that our information was perfectly suited to the needs of driving at night on Indian roads.

The labelled dataset was used to train our YOLOv8 model in a way that was unique to us. This customized training helped our model get used to the specific needs and changing characteristics of Indian roads, which made sure it could work smoothly and efficiently. YOLOv8 concepts were easily combined with our careful data processing method to create a strong foundation for our Vehicle Detection Model. This scheme fits perfectly with the goals of our adaptive auto zone-dimming headlight system. It shows how important accuracy and flexibility are for dealing with the complicated situations that happen on Indian roads at night.

Below are the screenshots of python script used:

```python
import cv2
import time
import os
```

```python
# Replace 'video_path' with the path to your video file
video_path = 'Dashcam2.mp4'

# Create the output folder if it doesn't exist
output_folder = 'Dashcam2_frames/'
if not os.path.exists(output_folder):
    os.makedirs(output_folder)

# Open the video file
cap = cv2.VideoCapture(video_path)

# Check if the video file was opened successfully
if not cap.isOpened():
    print("Error: Could not open video file.")
    exit()

frame_number = 0
frame_interval = 5  # Interval in seconds
last_capture_time = time.time()

while True:
    ret, frame = cap.read()

    if not ret:
        print("End of video.")
        break
```

```
        current_time = time.time()
        elapsed_time = current_time - last_capture_time

        if elapsed_time >= frame_interval:
            frame_number += 1
            frame_filename = f'frame_{frame_number:04d}.jpg'
            frame_path = os.path.join(output_folder, frame_filename)
            cv2.imwrite(frame_path, frame)
            last_capture_time = current_time
            print(f"Saved {frame_filename}")

        cv2.imshow('Video Frame', frame)

        if cv2.waitKey(1) & 0xFF == ord('q'):
            break

    cap.release()
    cv2.destroyAllWindows()
```

```
Saved frame_0001.jpg
Saved frame_0002.jpg
Saved frame_0003.jpg
Saved frame_0004.jpg
Saved frame_0005.jpg
Saved frame_0006.jpg
Saved frame_0007.jpg
Saved frame_0008.jpg
Saved frame_0009.jpg
Saved frame_0010.jpg
Saved frame_0011.jpg
```

Pictures in dataset show different views of driving scenarios, like other types of vehicles and different lighting conditions. It included a variety of scenes to help our model learn how to recognize vehicles in all sorts of situations. These pictures were then annotated with bounding boxes around vehicles and labelled manually using Roboflow. The dataset was classified into five categories: AutoRickshaw, Car, Truck, Bus and Bike.

Choosing the vehicle detection algorithm: Next step was to decide among the different detection algorithms. We tried different algorithms like RNN, CNN and YOLO v5. Best results were given by YOLO v5, therefore we proceeded with that.

Training and Testing the Model: We trained the model for multiple vehicle detection using the created dataset and then tested it with some test images.

Train set:

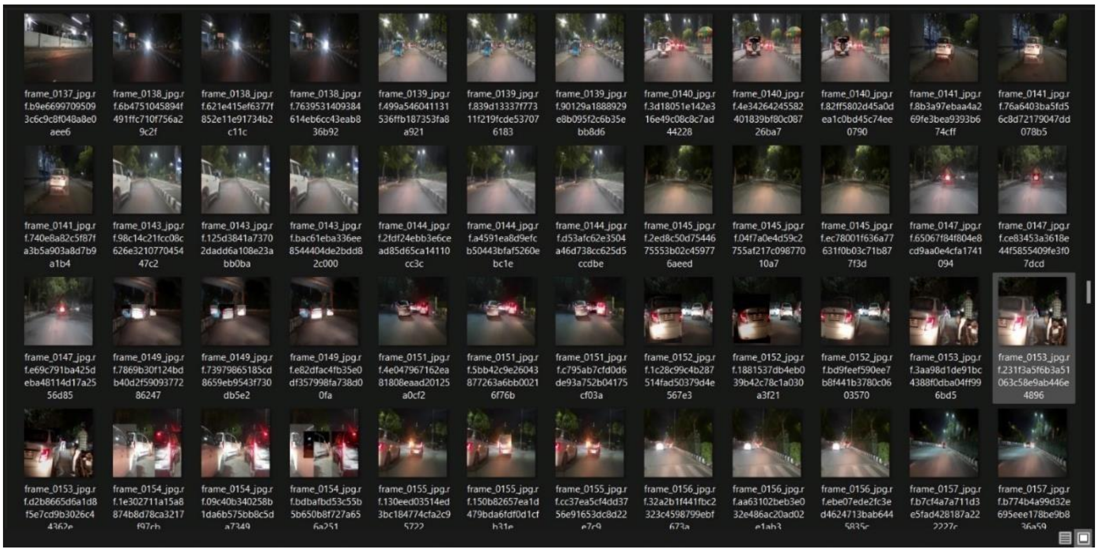


Fig 14: Train Set

Test set:

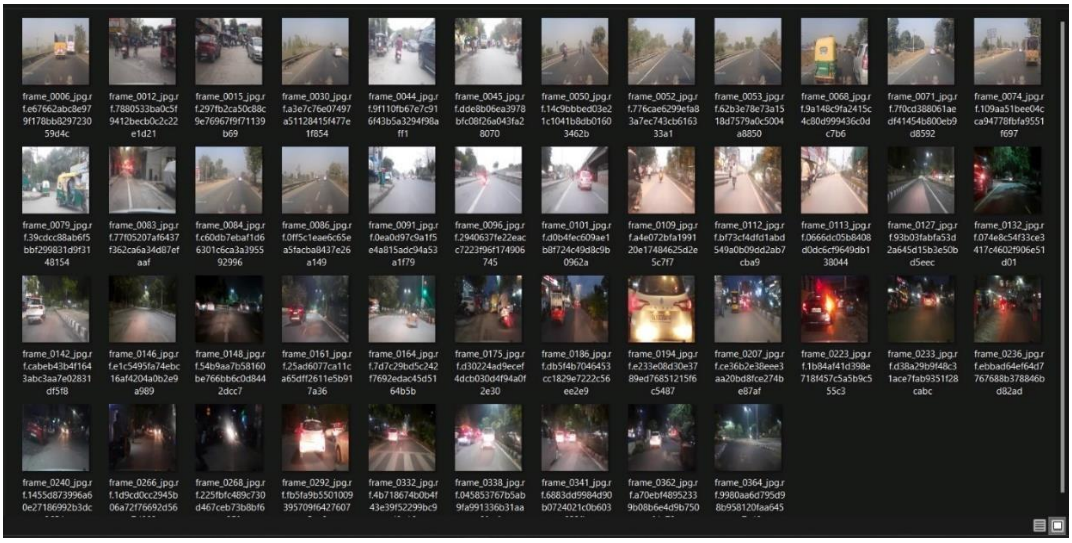


Fig 15: Test Set

Validation set:

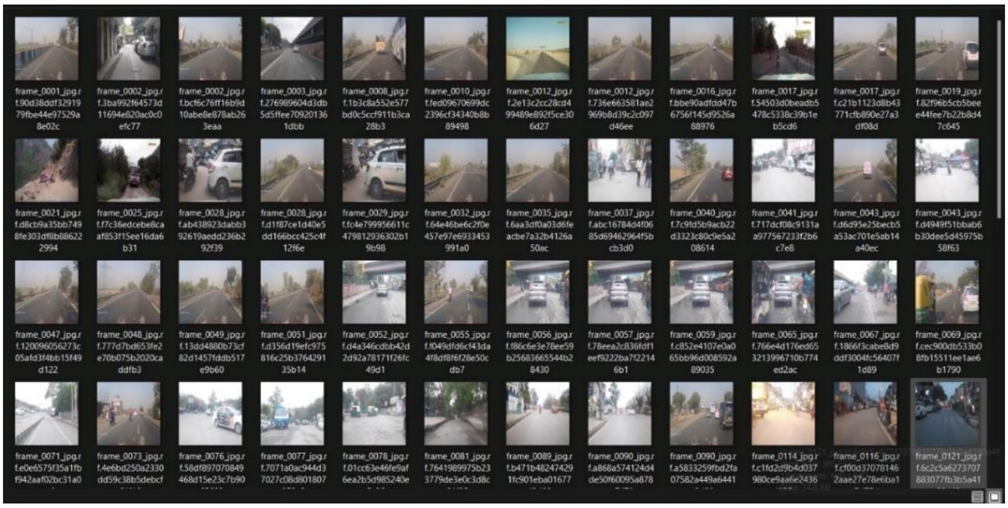


Fig 16: Validation Set

Position Estimation: The vehicle detection part was over till here. Next, we divided the screen into four grids and determined in which grid the detected vehicles lies.

Below figure shows the position estimation

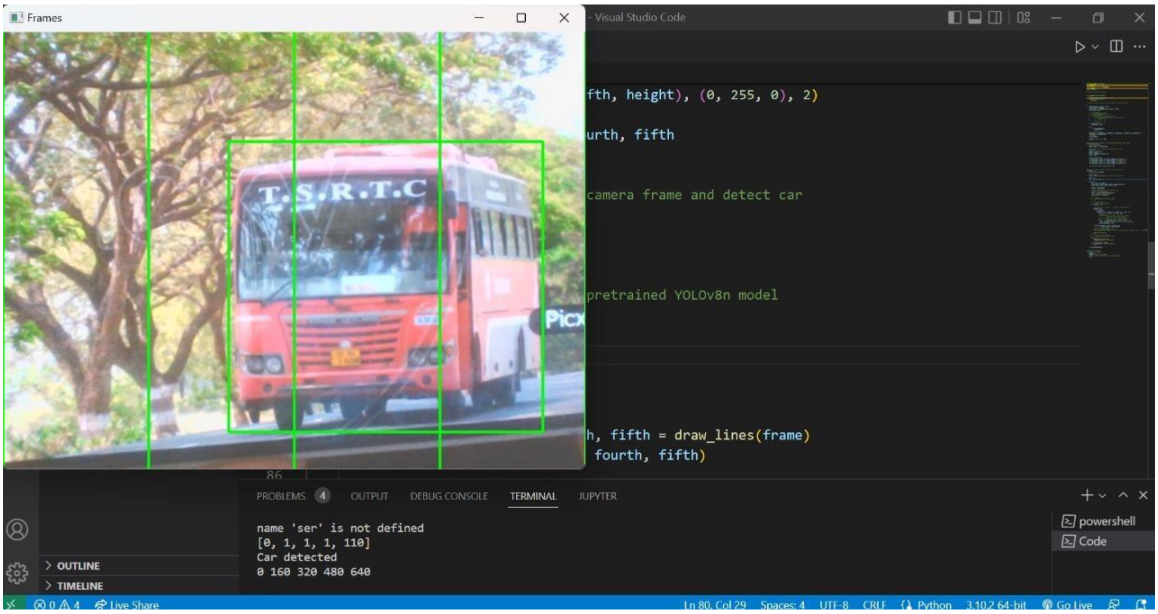


Fig 17: Position Estimation

LED Matrix System: We used four LED's to form a headlight. When we turn our system on, All four LED's are on. Then, as vehicle is detected, we turn off the LED of all the frames where vehicle was detected. If the vehicle is in all the frames, then we do not turn off all the LED's as that can be more dangerous so we simply turn the low beam on by rotating the LED's by an appropriate angle using a motor.

This is the LED matrix we created

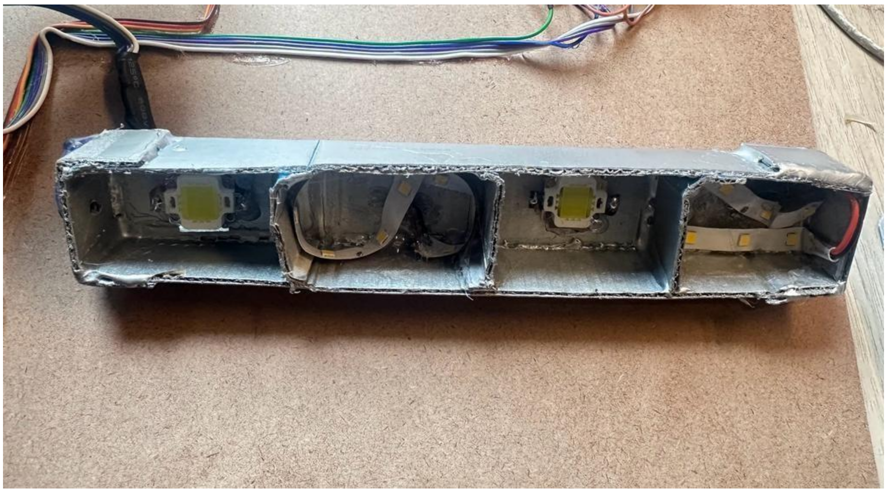


Fig 18: LED Matrix System

Hardware integration: Next Step was to integrate this whole system with hardware. We used 5V 4 channel relay module to control the switching of LED's. Serial input is sent to relay module through Arduino as discussed in 5.1.

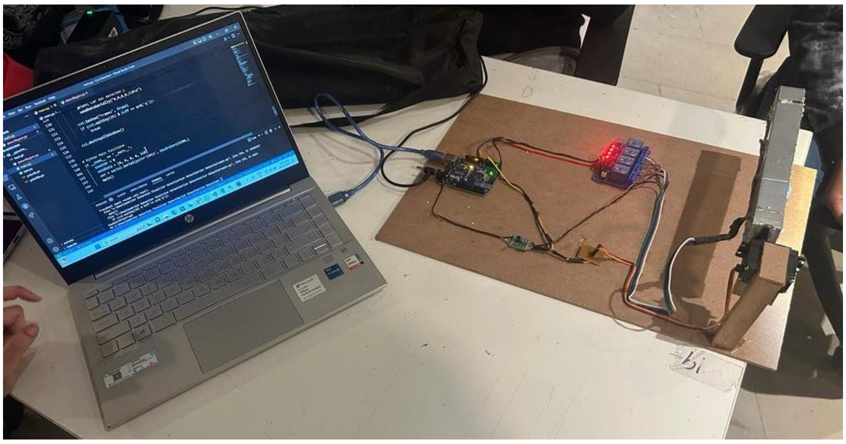


Fig 19: Hardware Integration

5.3.2 ALGORITHMIC APPROACHES USED

YOLO V8 for vehicle detection:

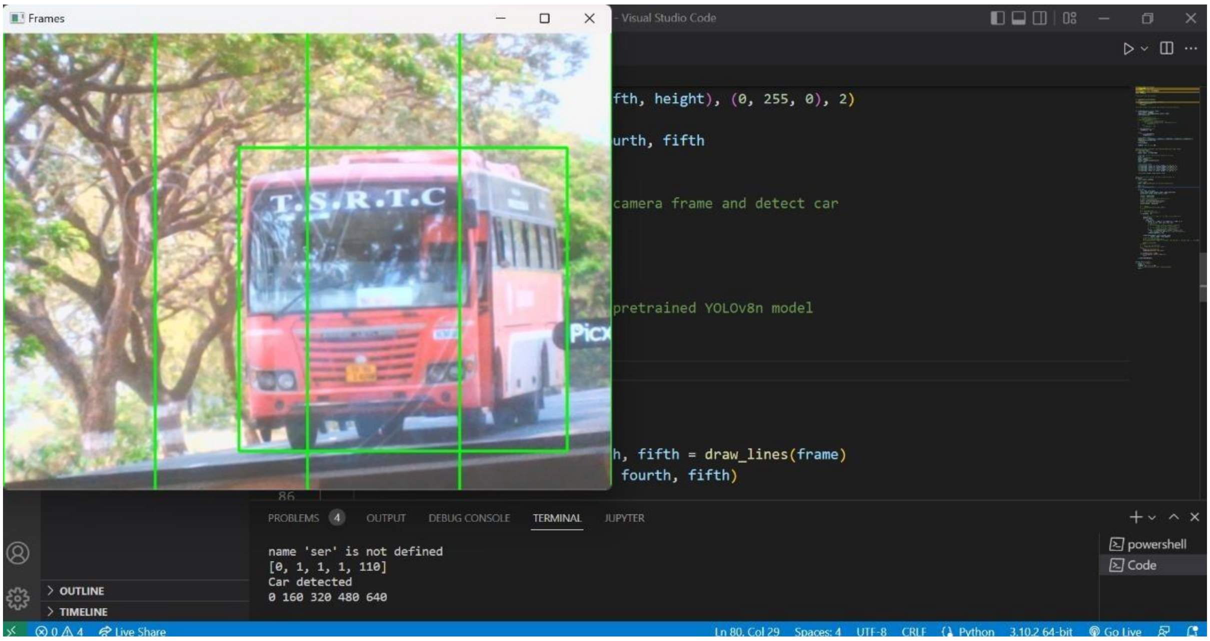
Popular object detection algorithm YOLO (You Only Look Once) is renowned for its speed and precision in real-time object detection. YOLO v8 is a promising option for vehicle detection in our project because it offers improvements in detection speed and accuracy. It keeps up its real-time performance, which enables our system to quickly and precisely detect vehicles without reducing speed. Because of its capacity to use larger training datasets, it can learn more thoroughly, which improves generalization and detection performance for a variety of vehicle types and situations. Five vehicle classes can be identified by our YOLO v8 model: cars, autos, cycles, bikes, and buses. Our automatic zone-dimming headlight system can distinguish between various vehicle types by using YOLO v8's features that are specific to these classes. This allows us to effectively adjust headlight intensities based on the type of vehicle that is detected. This improvement makes a big difference in overall road safety when driving at night.

This is the vehicle detection screenshot.

Fig 20: YOLO v8

Position Estimation Algorithm:

The determination of positional estimates on a computer screen involves segmenting the screen into four distinct regions through the strategic implementation of vertical grids. These regions are defined and identified based on the coordinates derived from the YOLOv8 algorithm, specifically targeting object recognition and localization. By utilizing the x coordinates of both the bottom-left and top-right corners of the bounding boxes generated through this algorithm, the software discerns and maps the regions wherein these coordinates fall. This methodological approach ensures precise region allocation for each object detected, contributing significantly to accurate spatial localization and subsequent computational analyses.



5.3.3 PROJECT DEPLOYMENT

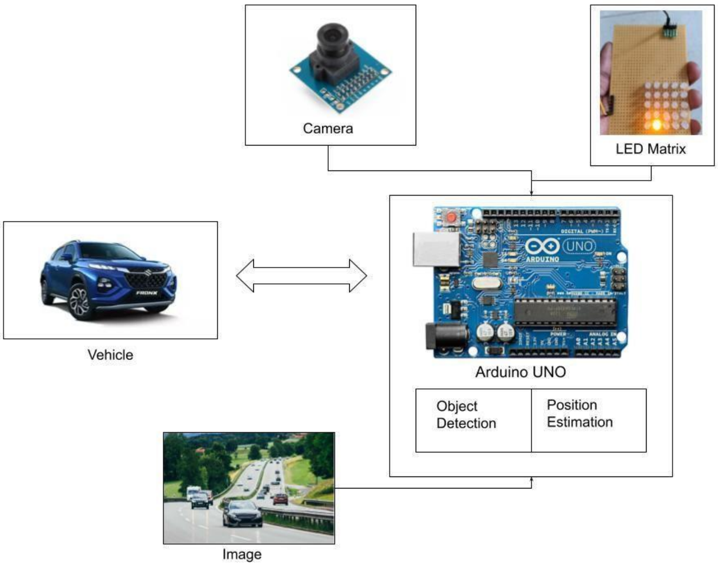


Fig 21: Project Deployment

The final step in configuring an adaptive headlight system for vehicles involves meticulously connecting all of the various components. This entails mounting the LEDs, control unit, relay module, and camera on the car. Subsequently, we link all the cables and ensure that electricity is delivered to all components. After that, we make the necessary modifications and adjustments to the system to ensure the highest possible efficiency. We test it in numerous settings, such as driving at varying speeds, on different types of roads, and in all kinds of weather. We also test its ability to decrease glare, adjust the illumination, and detect automobiles. All of this is contrasted with conventional headlight systems. In addition to the technical aspects, we also take user feedback into account, follow ethical guidelines, and weigh costs to ensure that the new system actually improves things.

5.3.4 SYSTEM SCREENSHOTS

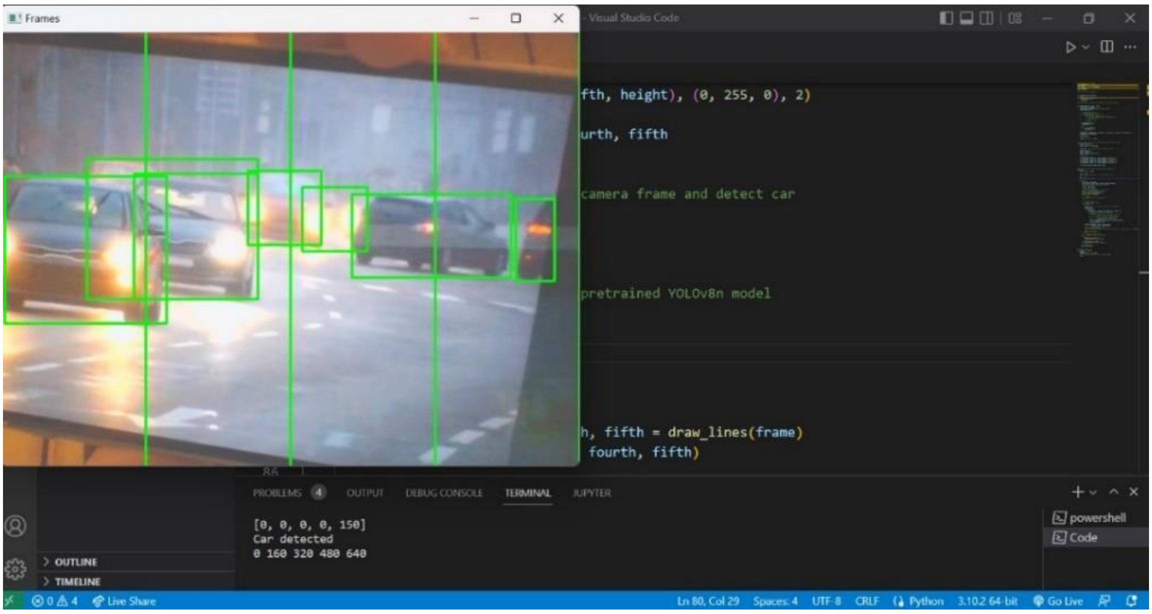


Fig 22 a: System Screenshots

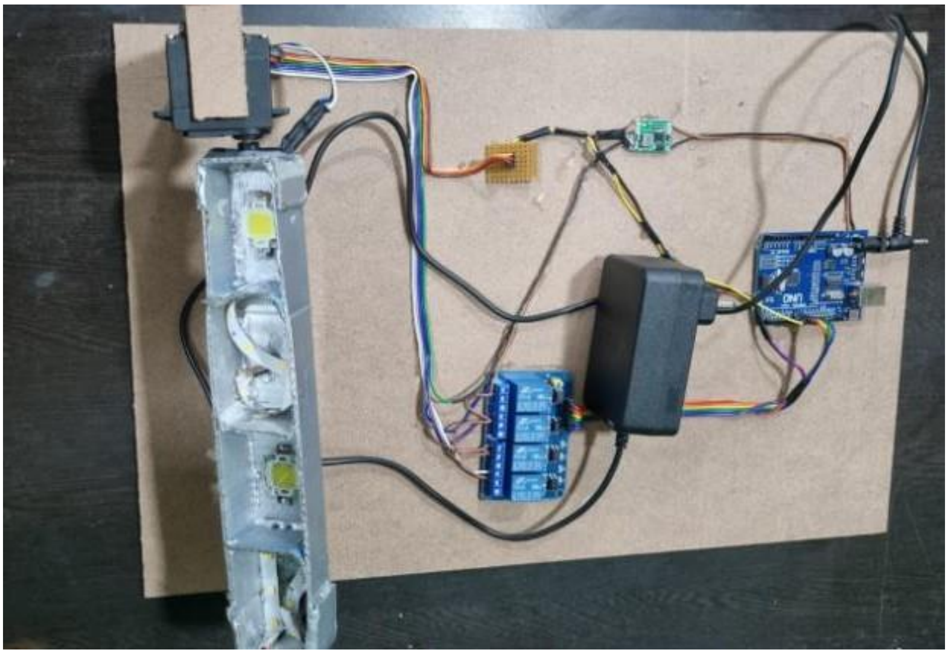


Fig 22 b: System Screenshots

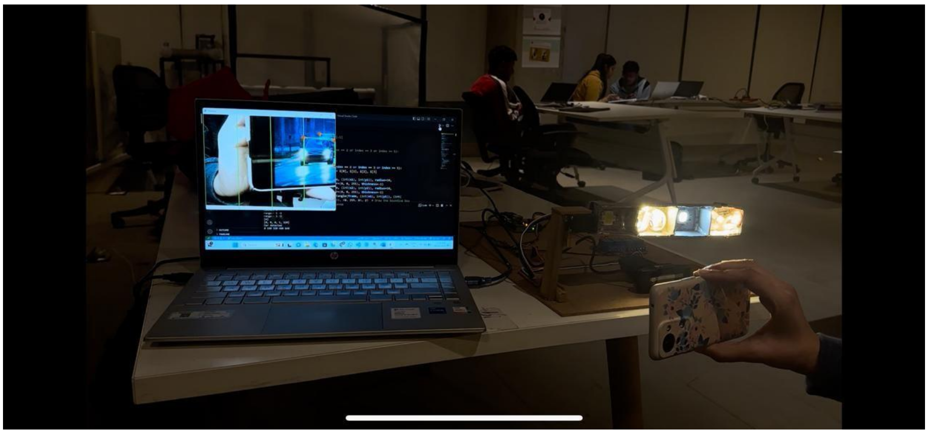


Fig 22 c: System Screenshots

5.4 TESTING PROCESS

5.4.1 Test Plan

5.4.2 Features to be tested

Module to be Tested	Test Applied	Functionality Tested
Vehicle Detection System	Accuracy Testing	Detection precision for cars, autos, cycles, bikes, buses
	Real-time Performance	System's ability to detect vehicles in real-time
	Multi-Vehicle Detection	Ability to detect and differentiate multiple vehicles simultaneously
Adaptive Lighting System	Dimming Zone Accuracy	Accuracy in adjusting headlight intensities in specific zones
	Responsiveness Testing	Speed and effectiveness in dynamically adjusting light settings

Table 4: Features to be tested

5.4.3 Test Strategy

First, unit testing was done for each separate module of the project – Vehicle Detection, Position Estimation and LED Matrix control. Then, we performed SIT (System Integration Testing) to make sure that all modules work in coordination with each other in real time. Finally, beta testing is performed to measure the performance of the product in a live environment. The product is evaluated in terms of reliability, usability, Realtime factor, and delay. Table shows the testing environments used for testing.

S. No.	Environment Name	Description	Network	Usage
1	LOCAL	This environment is used to perform unit testing of each separate module on the local machine. All other modules instead of the one being tested are mocked.	Local Machine	Unit Testing
2	SIT	It stands for System Integration Testing. In this, all modules are connected in a controlled environment to ensure coordination between modules and data integrity.	Local Area Network(LAN)	System Integration Testing
3	**UAT**	It stands for User Acceptance Testing. This is an uncontrolled environment where the product is tested from a user point-of-view.	Public Network (the Internet)	Beta Testing

Table 5: Test Strategy

5.4.4 Test Techniques

Mentioned below are the techniques used for the testing of this project:

1. Unit Testing: This type of testing is done to test the functionality of a single module or a single piece of code, typically in a disconnected environment. In this, we separately tested all the modules i.e.

Vehicle Detection: We tested if the vehicle are accurately detected in realtime at night, multiple vehicles are detected, Also, all types of vehicles are detected such as car, truck, rickshaw, bike etc.

position estimation: We checked if correct grids are calculated according to the vehicle detected

LED matrix control: We tested if correct LED's are switched off according to the estimated grids. If vehicle is detected in more than three grids, then headlight is switched to low beam i.e it is rotated by an angle.

2. System Integration Testing: This type of testing is done to test the coordination between different software modules, i.e., to make sure that they work together correctly, portraying desired behavior, and maintaining data integrity. This was done after integration of all the modules. We checked for accuracy, reliability, real-time factor was considered.

3. Beta/Acceptance Testing: This type of testing is done in a live environment. It is done to test and evaluate the system from a user point-of-view, to make sure that the desired business functionality is satisfied. We performed it on road with moving vehicle to check if it works when real life factors come in.

5.4.5 Test Cases

Test case 1:

Name:	Vehicle Detection
Purpose:	Working of Vehicle Detection System under different circumstances
Input:	Realtime video stream from web cam
Expected Result:	All types of vehicles are detected accurately. Also, multiple vehicles in a single frame is detected.

Table 6: Test Case 1

Test case 2:

Name:	Position Estimation

Purpose:	To check if correct grids are being identified according to the detected vehicles
Input:	Coordinates of detected vehicles
Expected Result:	Correct grids are identified (If vehicle is in grid no 2 and 3 so it should output 2 and 3)

Table 7: Test Case 2

Test case 3:

Name:	LED Control
Purpose:	To check if correct LED's are switched off according to estimated position
Input:	Grid numbers where vehicles are detected
Expected Result:	Correct LED's are turned off. In case there are 4 no. of grids where vehicle is detected, then we change the angle of headlight.

Table 8: Test Case 3

5.4.6 Test Results

Test case 1: Vehicle detection

Conditions	Expected Outcome	Pass/Fail
Accurate vehicle detection	System works perfectly fine	Pass
Multiple vehicles detection	System works perfectly fine	Pass
Different type of vehicles detected	System works perfectly fine	Pass

Table 9: Test Result 1 Vehicle Detection

Test case 2: Position Estimation

Conditions	Expected Outcome	Pass/Fail
Both x coordinates in single grid	System works perfectly fine	Pass
Both x coordinates in different grids	System works perfectly fine	Pass

Table 10: Test Result 2 Position Estimation

Test case 3: LED matrix control

Conditions	Expected Outcome	Pass/Fail
Single grid	System works perfectly fine	Pass
Two grids	System works perfectly fine	Pass
Three grids	System works perfectly fine	Pass
Four grids	System works perfectly fine	Pass

Table 11: Test Result 3 LED matrix control

5.5 Results and Discussions

In the rigorous evaluation of YOLOv8 for vehicle detection, several key performance metrics were considered. YOLOv8 displayed remarkable accuracy and precision, showcasing its ability to accurately identify and classify vehicles, which is critical in ensuring safety. Additionally, the model's high recall value demonstrated its proficiency in reducing false negatives, thereby effectively detecting the majority of vehicles in various environments. This was reflected in the competitive F1-score. The mean average precision (mAP) metric provided a comprehensive assessment, and YOLOv8 achieved a commendable mAP score, affirming its efficiency in object localization and class prediction.

The feasibility of implementing the model hinges on the availability of sufficient computational resources, as its demands must align with the onboard processing capabilities of these vehicles. Moreover, compliance with safety standards is non-negotiable. YOLOv8's robustness and accuracy are crucial to ensuring the proper working of headlights.

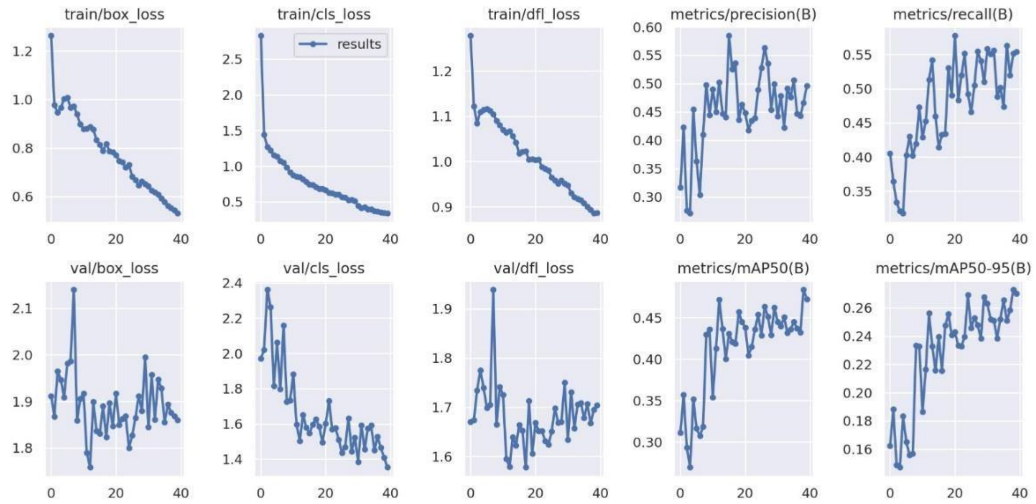


Fig 23 a: Results and Discussions

Fig 23 b: Results and Discussions

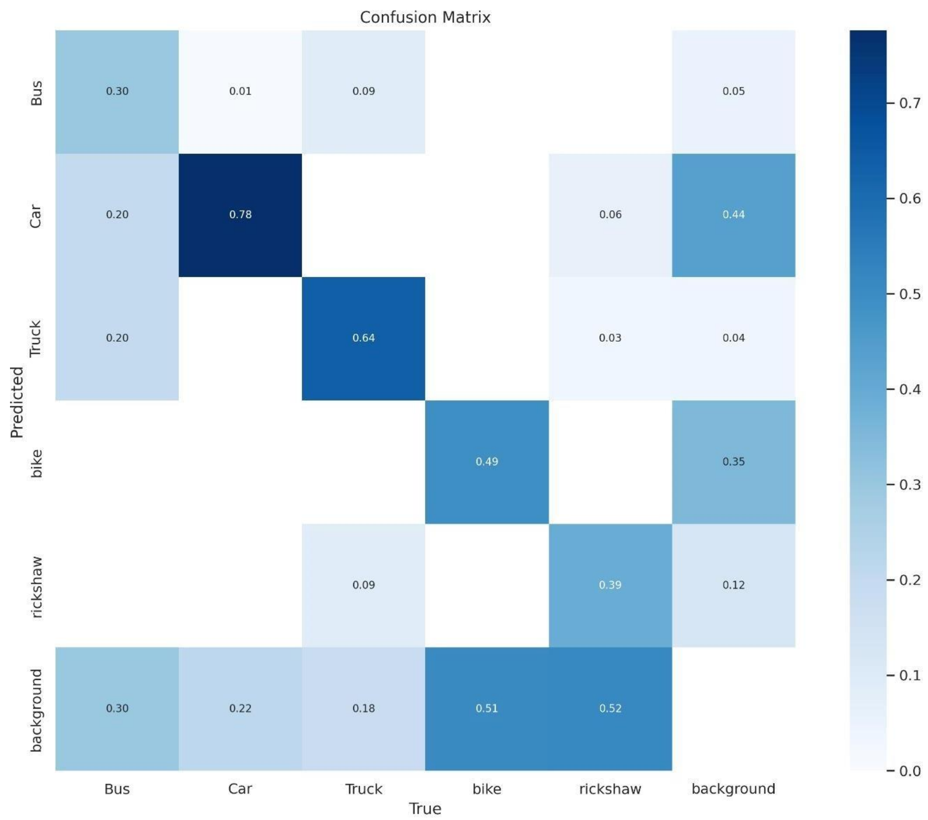


Fig 23 c: Results and Discussions

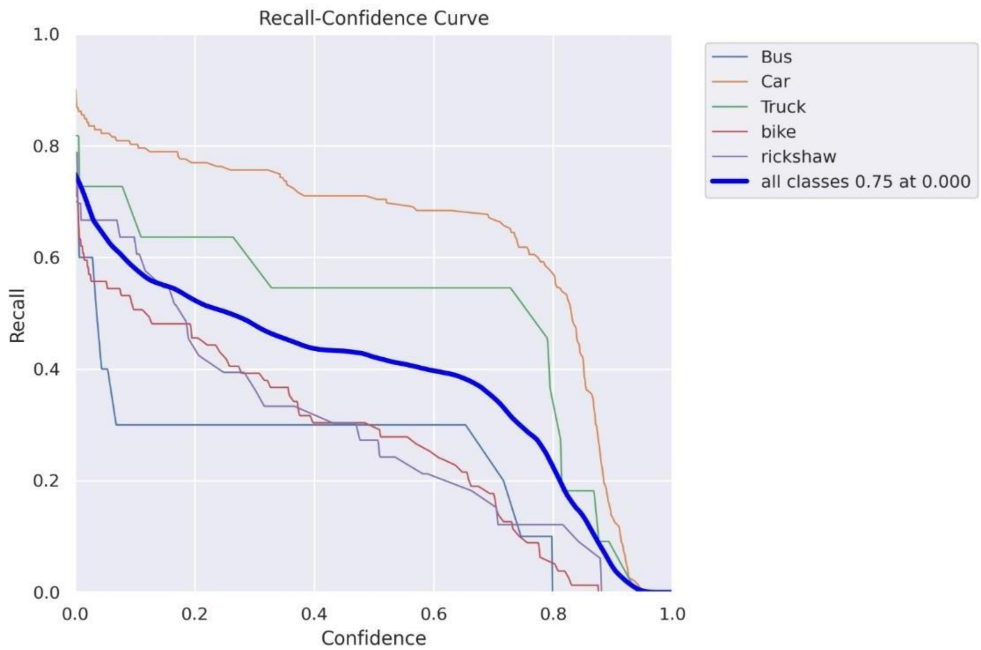


Fig 23 d: Results and Discussions

5.6 Inferences Drawn

The car demonstrates the highest accuracy compared to other vehicles, as its Recall Confidence curve positioning is closer to the upper corner of the graph. At a confidence value of 0, the recall stands at 0.75. This Confusion matrix shows that for cars and truck, cell corresponding to predicted and true have high intensity indicating higher accuracy.

5.7 Validation of Objectives

Sr No	Objective	Status
1	Conduct a literature survey to study the already existing systems	**Successful**
2	Creation of localized dimming zones	**Successful**
3	LED matrix creation and its integration with hardware	**Successful**

Table 12: Validation of Objectives

6.1 CONCLUSIONS

"To conclude, the 'Preventing Troxler Effect with Auto Zone-Dimming Headlights' project represents a noteworthy progress in nighttime driving safety. The convergence of state-of-the-art technology, thorough investigation, and real-world application marks a new era in traffic safety, particularly in the context of nighttime operations. By using video sensors (camera) and innovative algorithms, the system counteracts the Troxler effect and makes it possible to accurately identify oncoming vehicles, calculate angles and distances, and dynamically modulate headlight dimming zones. This discovery holds significant promise for furthering vehicular security technologies, even beyond its direct impact on driver safety.

The project's technical intricacy is highlighted by the combination of complex computer vision algorithms like YOLO v8, accurate sensor synchronization, and flexible lighting systems. Accurate vehicle identification is made possible by real-time video data capture processed by sophisticated algorithms, which also serves as the foundation for angle and distance calculations and the best possible dimming zone arrangement.

To achieve our conduct a literature survey regarding the various work that has been done in the same direction and to study the already existing systems, we divided our screen into four frames. The system deactivates LED lights in the corresponding frames when it detects a vehicle. Moreover, when three or four frames identify a vehicle, the system automatically modifies headlight angles to low beams. This flexibility, along with real-time reactivity, demonstrates the system's adaptability and preparedness to function well in a range of traffic situations."

6.2 ENVIRONMENTAL, ECONOMIC AND SOCIAL BENEFITS

Environmental Benefits:

Less Light Pollution: Zone-dimming headlights reduce the amount of light that is emitted into the surrounding area, which helps to reduce light pollution.

Energy Efficiency: These headlights might potentially save energy by altering various zones as opposed to continuously using high-intensity lighting, which will help with overall energy conservation efforts.

Economic Benefits:

Decreased Accident costs: Dimming headlights may help to lessen the frequency and impact of collisions, which might save medical expenses, insurance claims, and automotive repair costs.

Enhanced Lighting System Longevity: Adaptive dimming may increase the life of headlights and related parts, saving car owners money on replacement and maintenance.

Benefits to Society:

Enhanced Road Safety: This technology reduces the risk of accidents, injuries, and fatalities on the roads by decreasing the blinding effect of headlights on other drivers, particularly at night.

Improved Comfort for Drivers: Less glare makes driving more comfortable, which could reduce stress and fatigue in drivers and enhance their general mental health.

Using Cutting-Edge Safety Technologies: By putting these systems into place, one is demonstrating a dedication to using cutting-edge technologies for public safety and establishing a standard for the incorporation of intelligent systems into cars to encourage safer driving habits.

6.3 REFLECTIONS

Despite our extensive investigation and implementation, some obstacles point to shortcomings that prevent its broad acceptance as a standard approach to improve driving safety at night. The main issues are with how complicated the setup is; even simple tasks like changing the lighting for approaching cars require a significant time commitment. Another significant drawback is the considerable amount of time needed for successful execution in different scenarios, such as real-time detection and hardware integration.

Beyond the technical aspects, working with a variety of electronic components—from simple LEDs to Arduino and relay modules—was part of our project. We learned the value of cooperation, strong leadership, meeting deadlines, and using technology more broadly for the good of the public throughout this project. We were able to determine the best options for our system by weighing the benefits and limitations of each component.

6.4 FUTURE WORK

Improvement of Accuracy:

Investigate cutting-edge algorithms or sensor technologies to increase the precision of distance measurement and vehicle detection while lowering false positives and negatives. Look into AI- or machine-learning-based methods for more accurate and dependable real-time detection.

Extension of the Dataset:

To improve the system's ability to adapt to different lighting, weather, and road conditions, expand the size and diversity of the dataset used for testing and training.

To guarantee reliable performance in a variety of situations, incorporate data from a larger range of scenarios and driving environments.

Multiple Car Recognition:

Enhance the system's ability to recognize and react to numerous vehicles at once, so that it can manage intricate traffic situations involving numerous approaching vehicles.

Extension Concerning Animals and Pedestrians:

Increase the system's capacity to recognize and react to vehicles carrying people and animals, and add sophisticated sensors or algorithms to recognize and modify lighting conditions for improved safety. Examine the incorporation of extra sensors or technologies designed to identify and reduce hazards related to pedestrians and animals.

7.1 CHALLENGES FACED

Since the project includes a large amount of hardware implementation, there were number of difficulties during the development phase.

1) Real-time Detection: Computational efficiency is required to implement a real-time detection algorithm. The complexity of analyzing real-time video data from a camera to quickly identify cars without sacrificing accuracy was a significant obstacle. Iterative testing and improvement of the detection method was necessary to optimize it for fast decision-making while retaining precision.
2) Multiple vehicles: Creating a solid algorithm that can manage scenarios in which multiple cars are present at once was the problem. Thorough thought and testing were necessary to make sure the system prioritizes and reacts to each approaching vehicles in a clear and timely manner.
3) Hardware Integration: For the system to work as a whole, smooth connection between hardware components must be established. It took a lot of effort to debug hardware connectivity problems, make sure the power supply was steady, and fix possible problems with Arduino boards and motors. The development process became more complex due to the requirement for thorough testing to find and fix integration problems.
4) Outcomes and dependability: An essential part of the research was testing the dependability and durability of electronic components. It took several testing cycles to make sure the system consistently gave reliable results in a range of scenarios. Careful attention to detail was necessary when addressing problems with possible wear and tear and the brittleness of electrical components.

7.2 RELEVANT SUBJECTS

1) Machine learning

2) Data science

3) Electrical engineering

4) Edge AI

5) Software Engineering

7.3 Interdisciplinary Knowledge Sharing

As students specializing in Computer Science and Engineering, our proficiency in machine learning models, detection algorithms, and a fundamental understanding of hardware components has paved the way for a comprehensive solution. Our collaboration has not only fostered efficient communication within the team but has also yielded innovative solutions. This fusion of insights from diverse domains has not only enriched our project with a multi-disciplinary viewpoint but has also showcased the educational impact, enabling us to apply theoretical concepts learned in academic settings to real-world challenges. In essence, our project underscores the transformative potential that emerges when knowledge from different fields converges, confirming that true innovation frequently occurs at the junction of multiple viewpoints and skills.

7.4 Peer Assessment Matrix

EVALUATION OF:						
EVALUATION BY:		PARTH	RIDHIMA	NANDINI	MUDRIKA	ADITYA ROY
	PARTH		5	5	5	5
	RIDHIMA	5		5	5	5
	NANDINI	5	5		5	5
	MUDRIKA	5	5	5		5
	ADITYA ROY	5	5	5	5	

Table 13: Peer Assessment Matrix

7.5 Role Playing and Work Schedule

PARTH	Documentation, Vehicle Detection, Testing, Hardware Implementation, Integration
RIDHIMA	Documentation, Vehicle Detection, Testing, Hardware Implementation, Integration
NANDINI	Documentation, Vehicle Detection, Testing, Position Estimation, Integration
MUDRIKA	Documentation, Vehicle Detection, Testing, Position Estimation, Integration
ADITYA ROY	Documentation, Vehicle Detection, Testing, Hardware Implementation, Integration

Table 14: Individual Role

7.6 Student Outcomes Description and Performance Indicators (A-K Mapping)

SO	Description	Outcome
A1	Applying mathematical concepts to obtain analytical and numerical solutions.	Grid calculation for position estimation
A2	Applying basic principles of science towards solving engineering problems.	Understanding the Troxler effect
A3	Applying engineering techniques for solving computing problems.	Various techniques
B1	Identify the constraints, assumptions and models for the problems.	The project assumed there are no pedestrians and animals on road
B2	Use appropriate methods, tools and techniques for data collection.	Data was self collected using camera and then annotated and labelled manually

B3	Analyse and interpret results with respect to assumptions, constraints and theory.	We could extend the project for pedestrians and animals
C1	Design software system to address desired needs in different problem domains.	ML model has been trained and tested for analysis and detection of vehicles
C2	Can understand scope and constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability and sustainability.	There are economic constraints associated with this project as infrared cameras are very expensive
D1	Fulfill assigned responsibility in multidisciplinary teams.	Success
D2	Can play different roles as a team player.	While working with a team for over an year now, we have learnt the importance of team work
E1	Identify engineering problems.	Just like this project was intended to avoid night-time accidents, we can identify problems and solve them with engineering
E2	Develop appropriate models to formulate solutions.	This model was appropriate
E3	Use analytical and computational methods to obtain solutions.	Yolo v8 was used for analysing
F1	Showcase professional responsibility while interacting with peers and professional communities.	We were professional with our peers and mentors
F2	Able to evaluate the ethical dimensions of a problem.	We stayed ethical
G1	Produce a variety of documents such as laboratory or project reports using appropriate formats.	All submissions have been made on time and as per guidelines
G2	Deliver well organised and effective oral presentation.	On point presentations have been delivered
H1	Aware of environmental and societal impact of engineering solutions.	Like this project helps society, we are aware of social impacts of engineering
H2	Examine economic tradeoffs in computing systems.	Cost of hardware and system implementation have been evaluated

I1	Able to explore and utilize resources to enhance self-learning.	Information of Internet and Research Papers was helpful

Table 15 – Student Outcomes Description

7.7 Brief Analytical Assessment

This capstone project assigned made us learn values and facts on academic area as well as psychological level. As we chose a topic we never studied before, it helped us to learn more in Computer Science. Also it helped us to gain confidence to think about and execute new things to solve various problems of society. Various values as team work, time management, multi-tasking etc were inculcated on personal level. On the academic level, we got to polish our skills on report writing, poster making, presentation etc, quite well. All the submissions were done before the deadlines without any delay.

1. What sources of information did your team explore to arrive at the list of possible Project Problems?

Ans:

The scope of project revolves around the field of Road Safety and accidents avoidance and thus to implement such an amalgamated outcome of these two fields we had to refer to some research papers in these fields as well as consult our mentors. The reason we decided to go for this project is because of the number of accidents happening daily which are usually shown on television and newspapers and the loss of closed ones and the helpness of not doing anything had shaken us, thus we had to devise a solution for the same.

2. What analytical, computational and/or experimental methods did your project team use to obtain solutions to the problems in the project?

Ans:

The experimental method we adopted was the creation of dimming zones on detection of oncoming vehicles in the headlight and switching off the LED's of that particular portion. In terms of computation and analytical topics, YOLO v8 for detection and Arduino, motor, relay module were used to process and switching on/off the LED's of the regions in which the vehicles are lying and assist in all computations.

3. Did the project demand demonstration of knowledge of fundamentals, scientific and or engineering principles? If yes, how did you apply?

Ans:

Yes it did. No such solution to a problem exists without prior knowledge of the engineering fundamentals and basic scientific knowledge. We as Computer Science Engineers used our expertise in coding and machine learning algorithms in order to train our own YOLO v8 model for detection and hardware integration and implementation and for accuracy various testing techniques were implemented. Our knowledge of software engineering was also used in creation of UML diagrams and report making.

4. How did your team shares responsibility and communicate the information of schedule with others in team to coordinate design and manufacturing dependencies?

Ans:

In my view, no project can be achieved solo. Practically it can be but it will take a long time as no person can be expected to do every task efficiently. Each member of the group brings something unique to the table and helps in contributing to the success of the project. We as the members of our team have learned the importance of teamwork and leadership values through this small venture of ours and we achieved this so by realising the strengths and weaknesses of each member and assigning him/her the tasks of strength in accordance resulting in succession of every task within the deadline and maximum efficiency.

5. What resources did you use to learn new materials not taught in class for the course of the project?

Ans:

Google is the only resource you need in order to learn something you don't know about. For the successful completion of our project we had to refer to many research appears on night time accidents and auto dimming headlights and refer to the online documentation for the same in order to learn about this newly and very fast developing field of study. Also, youtube videos were of great help to leam about the various hardware and their implementation since this integration part was never been taught to us in class. Also help and guidance from seniors, mentors and our friends in understanding a new topic have also been used.

6. Does the project make you appreciate the need to solve problems in real life using engineering and could the project development make you proficient with software development tools and environments?

Ans:

Yes it did, seeing as how many people died because of direct light of headlights of oncoming vehicles and lakhs and thousands of road accidents happening every night and realising that we could use our engineering knowledge and made something to improve the life of people have been highly appreciated by the entire team. Through our venture we aim to provide a small ray of hope in improving their livelihood and yes throughout the course of this project development what we learnt is the practical implementation of knowledge and therefore helped us in becoming a better engineer.

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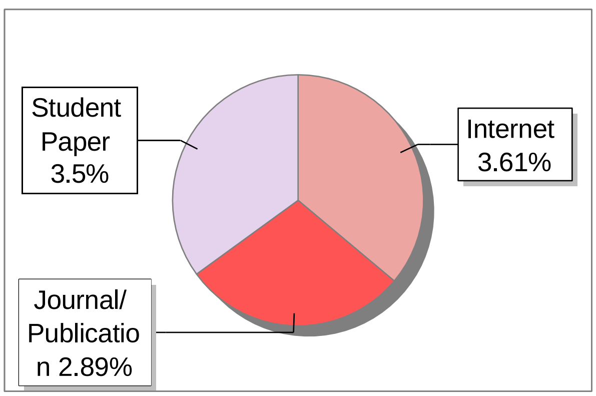

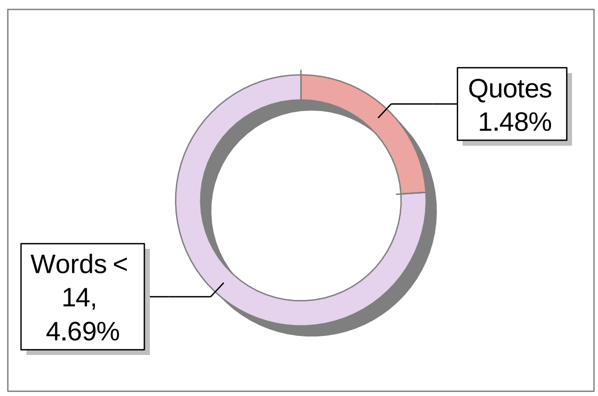

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