*A Mini Project Synopsis on*

# TAILwind :

# Tadpole-based AI and Lidar for Windshield-free Driving

**T.E. - D.S Engineering**


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# CERTIFICATE

This is to certify that the Mini Project report TAILwind : Tadpole-based AI and Lidar for Windshield-free Driving has been submitted by Umesh Pawar (21107014), Dalbirsingh Matharu (21107005), Shreyas Patil (21107061), Vedant Parulekar (21107034) who are Bonafide students of A. P. Shah Institute of Technology, Thane, Mumbai, as a partial fulfillment of the requirement for the degree in **CSE(DATA SCIENCE)**, during the academic year **2023-2024** in a satisfactory manner as per the curriculum laid down by the University of Mumbai.

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# ABSTRACT

This study focuses on developing an autonomous vehicle called TAILwind, emphasizing intelligent object detection, avoidance, and precise steering control. It utilizes a distributed system architecture and innovative tadpole-based design, integrating AI and Lidar technologies. TAILwind incorporates sensors like cameras, ultrasonic arrays, and a precision stepper motor, with the YDLidar enhancing environment mapping and object recognition. Through this approach, TAILwind navigates and comprehensively understands its surroundings, addressing challenges in object recognition and decision-making. This project showcases innovation in robotics and autonomous systems, with TAILwind positioned at the forefront of autonomous vehicle development. It offers a glimpse into future-forward transportation solutions, pushing the boundaries of autonomous driving capabilities.

# Chapter 1

## Introduction

The quest for self-driving cars continues to accelerate, promising increased safety, improved efficiency, and a future where human intervention is no longer necessary behind the wheel. However, current designs often follow a familiar boxy silhouette. This paper introduces a revolutionary contender – the tadpole-shaped self-driving car. Borrowing inspiration from nature, this design challenges the status quo of automotive architecture.

This novel form goes beyond mere aesthetics, leveraging the power of sensor fusion, microcomputing prowess, and precise actuation. The tadpole's sleek exterior embodies aerodynamic efficiency, a crucial factor for extended range and energy conservation. Its low center of gravity ensures unwavering stability, allowing it to navigate uneven terrain and unexpected situations with confidence. Additionally, its inherent maneuverability proves invaluable in navigating tight urban environments, effortlessly negotiating congested parking lots and narrow roadways.

But the true innovation lies beneath its sleek surface. A sophisticated sensory-motor network, orchestrated by the dynamic duo of Raspberry Pi and Arduino, powers the car's autonomous capabilities. Ultrasonic sensors act as vigilant sentinels, creating a detailed picture of the surrounding environment. A camera, akin to a digital eye, meticulously deciphers lane markings, traffic signals, and other visual cues, guiding the car's course. This sensory symphony reaches the processing powerhouse – the Raspberry Pi – where data is interpreted, decisions are made, and the optimal self-driving strategy is formulated. Stepper motors, with unwavering precision, translate these calculated maneuvers into tangible actions, steering and adjusting speed with meticulous control.

While the path to achieving true self-driving functionality is not without challenges, the development of this tadpole car has involved overcoming hurdles such as integrating diverse hardware components, synchronizing sensor data acquisition, and optimizing power consumption. These challenges have been tackled through meticulous hardware integration, robust software architecture, and relentless testing, pushing the boundaries of innovation and resourcefulness.

The future holds exciting possibilities for the tadpole-shaped self-driving car. Advancements in path planning algorithms, robust machine learning for enhanced visual perception, and integration of additional sensors promise even greater autonomy and environmental awareness. This relentless pursuit of improvement aims to refine the car's self-driving capabilities, unlocking its potential for diverse applications beyond personal use. The unique form and nimble maneuverability of the tadpole offer distinct advantages in navigating complex environments, opening doors to a future where self-driving cars operate not just on open highways, but also in intricate urban spaces.

In conclusion, the tadpole-shaped self-driving car embodies a captivating blend of biomimicry, cutting-edge technology, and sensor-driven navigation. It stands as a bold departure from the norm, paving the way for a future where diverse and innovative automotive architectures redefine the landscape of self-driving technology.

## 1.1 Purpose

The development of the tadpole-shaped self-driving car project is driven by a multifaceted purpose. Firstly, it explores the potential of biomimicry in self-driving technology, investigating the advantages of the tadpole's form in terms of efficiency and stability. Secondly, the project seeks to create a cost-effective and accessible platform for self-driving development by utilizing readily available components. This fosters broader experimentation and democratizes access to advancements in the field. Furthermore, the project serves as a platform for integrating various sensors and microcomputing units, pushing the boundaries of sensor fusion and microcomputing capabilities in self-driving cars. Additionally, it aims to assess the versatility of the tadpole design for diverse applications beyond personal use, potentially benefiting logistics, delivery, and specialized operations. Ultimately, the project contributes to the advancement of self-driving technology by exploring novel design concepts, cost-effective solutions, and innovative integration approaches, laying the groundwork for further research and development in this dynamic field.

## 1.2 Problem Statement

Our problem statement is to develop an autonomous driving system capable of navigating diverse road environments safely and efficiently. This solution must accurately perceive surroundings through advanced sensors and make real-time decisions using deep learning algorithms, ensuring reliable autonomous navigation across varied conditions.

## 1.3 Objectives

The tadpole-shaped self-driving car project is driven by a set of ambitious objectives. Firstly, it aims to embrace biomimicry for enhanced performance by leveraging the tadpole's aerodynamic form and low center of gravity to demonstrate its potential for improved efficiency and stability in self-driving technology. Secondly, the project seeks to develop a cost-effective and accessible platform by utilizing readily available components, making self-driving technology more affordable and fostering wider participation. Furthermore, it aims to push the boundaries of sensor fusion and microcomputing integration, exploring the synergy between hardware and software to achieve robust and reliable perception and decision-making systems in self-driving cars. Additionally, the project seeks to evaluate the versatility of the tadpole design for diverse applications beyond personal use, assessing its maneuverability and adaptability in navigating challenging environments and potentially opening doors to applications in logistics, delivery, and specialized operations. Ultimately, all these objectives culminate in the overarching goal of contributing to the advancement of self-driving technology by exploring novel design concepts, cost-effective solutions, and innovative integration approaches, laying the groundwork for further research and development in this rapidly evolving field.

## 1.4 Scope

The tadpole-shaped self-driving car project ventures beyond the realm of conventional car design, driven by a multifaceted vision. It delves into exploring the feasibility of nature-inspired design principles in self-driving technology. By adopting the tadpole's aerodynamic form and low center of gravity, the project aims to demonstrate the potential for improved efficiency, stability, and maneuverability in self-driving cars.

Furthermore, the project champions accessibility and cost-effectiveness. By utilizing readily available components like Raspberry Pi and Arduino, it seeks to create a platform that is more affordable and approachable, fostering wider participation and potentially democratizing access to self-driving technology advancements. This, coupled with the exploration of sensor fusion and microcomputing integration, pushes the boundaries in developing robust and reliable perception and decision-making systems crucial for self-driving functionality.

However, the project's ambition extends beyond its initial prototype. It serves as a springboard for future advancements in several key areas. Building upon the core functionalities, future endeavors could focus on integrating advanced sensors and processing units to enable complex obstacle recognition, real-world traffic navigation, and sophisticated decision-making capabilities. Expanding testing from controlled environments to simulations and real-world scenarios will be crucial for further validation and refinement.

# Chapter 2

## Literature Review

In literature [1], a self driving RC car has been developed, leveraging Artificial Neural Network (ANN) technology. The accompanying thesis explores the integration of ANN in autonomous vehicle systems. The car is constructed using an L298N IC and motor driver, controlled by a microcontroller that communicates instructions to the model car. Grayscale image processing, facilitated by a Convolutional Neural Network (CNN), selectively focuses on pertinent data while disregarding unnecessary information. The system is highly accurate but has a specific scope, primarily detecting lane markings. The input is obtained from an integrated Pi camera, and the neural network processes grayscale images to determine the car's direction, emphasizing lane detection as its sole functionality without additional features.

In literature [2], Aditya Kumar Jain presents an innovative autonomous car model integrating a Raspberry Pi with a Pi camera. The Raspberry Pi and a laptop, interconnected on the same network, collaborate seamlessly. The Pi captures images, processes them in grayscale, and sends them to a Convolutional Neural Network (CNN), predicting outputs: left, right, forward, or stop. This interconnected system showcases the practical application of advanced image processing and neural network techniques in autonomous vehicle navigation. Upon prediction, the model triggers a corresponding Arduino signal, directing the car's movement through its controller. The car undergoes training on various track combinations (straight, curved, mixed), recording 24 videos from which 10,868 images are extracted nd categorized into folders (left, right, straight, stop). The paper thoroughly describes hardware components, software, and neural network configurations. The successful implementation of the model is achieved through Image Processing and Machine Learning, demonstrating its efficacy in design and testing. However, a notable issue is observed as the car slightly deviates from the track, posing potential risks if it encounters nearby obstacles in a real-world scenario.

In Literature [3], conducted by Malay Shah and Prof. Rupal Kapdi, the focus is on object detection using deep neural networks, specifically convolutional neural networks (CNNs). The article addresses the limitations of traditional object detection using a conventional deep CNN. The introduction of a regional based convolutional network enhances accuracy and reduces processing time. Training a neural network from scratch is time consuming and resource intensive, given the challenges of obtaining a sufficiently large dataset with accurate ground truth. The Regional Convolutional Neural Network (RCNN) is proposed to address these challenges. It identifies relevant regions in an image, leading to real time outputs. This deep neural network is particularly valuable in image processing applications, especially in complex medical contexts such as tumor detection, where datasets are intricate and challenging compared to standard road environment models.

In Literature [4], In related works, a distinctive autonomous vehicle platform is introduced, presenting an innovative amalgamation of a Raspberry Pi mini-computer, an Arduino micro-controller, and a Zumo track-driven robot chassis. This platform stands out for its cost-effectiveness and functionality. The Arduino micro-controller facilitates the execution of control laws at hard real-time intervals, ensuring precise and responsive control. Complementing this, the Raspberry Pi Contributes additional computing power, a user-friendly web interface, and supports wireless data-streaming, enabling efficient control tuning and debugging. The paper evaluates the efficacy of this integrated platform, particularly in the realm of controls education. The assessment involves employing the platform for demonstration purposes in a first course on feedback control, showcasing its potential as an effective tool for educational applications.

# Chapter 3

## Proposed System

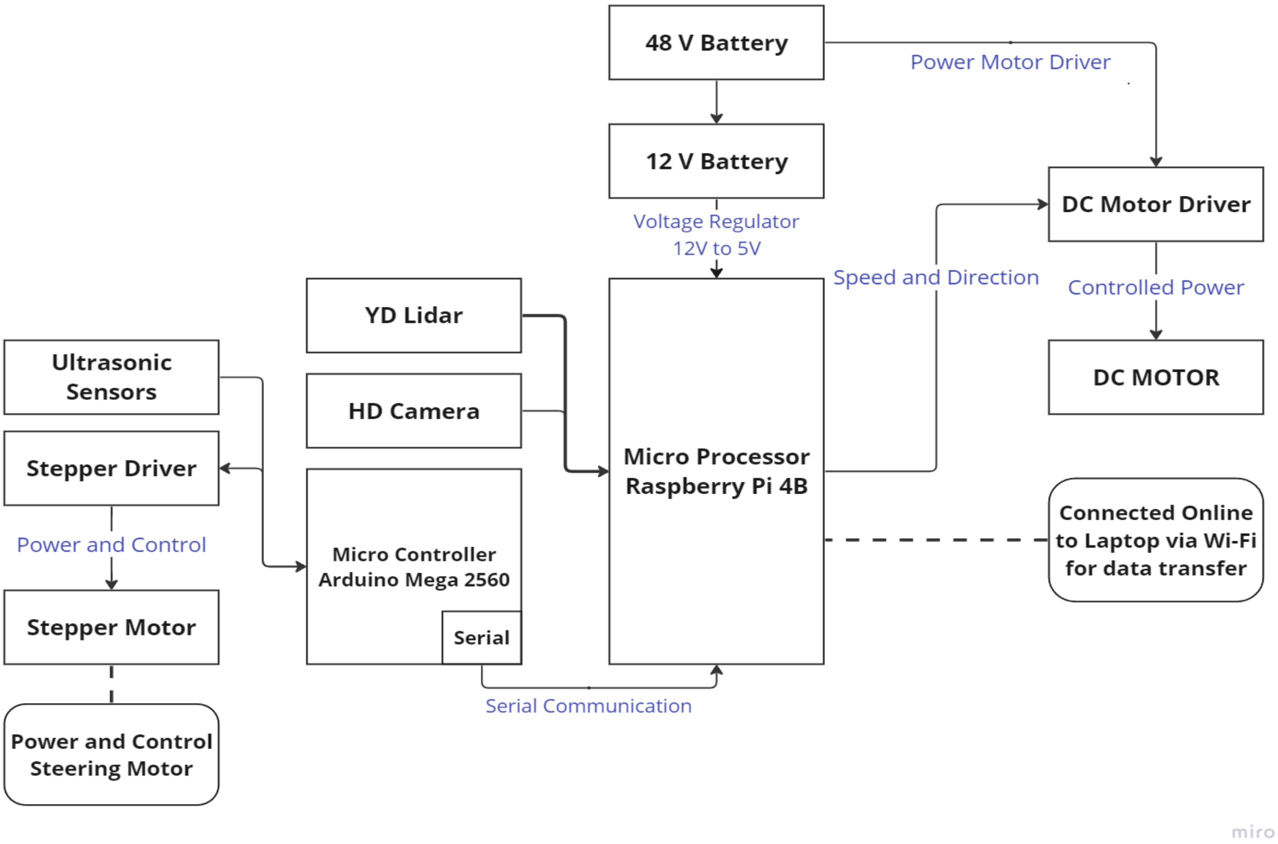


**Fig 3.1: Block Diagram of the Proposed Model**

In the meticulously engineered architecture of our autonomous vehicle model, leveraging a robust 48 V battery as the primary energy reservoir. This high-voltage powerhouse intricately channels its energy into a strategically configured 12 V battery, meticulously calibrated to supply power to pivotal components, notably the Raspberry Pi 4B. Functioning as a central computing hub, the Raspberry Pi orchestrates a symphony of connectivity and control, standing as the nexus for a sophisticated interplay of peripherals that constitute the sensory and control apparatus of our cutting-edge autonomous vehicle.

The sensory capabilities of our model are elevated through the seamless integration of a camera and a Light Detection and Ranging (LiDAR) sensor, both intricately linked directly to the Raspberry Pi. The camera, proficient in object recognition and lane detection, operates as the visual perception module, delivering crucial data for informed decision-making. Simultaneously, the LiDAR sensor introduces a layer of depth perception, enriching the vehicle's spatial awareness and contributing to a comprehensive understanding of the surrounding environment.

To ensure seamless communication and coordination within the system, an Arduino is strategically woven into the architecture, establishing a robust serial communication link with the Raspberry Pi. In its role as a liaison, the Arduino interfaces with ultrasonic sensors responsible for object detection. The ultrasonic readings, serving as pivota environmental input, are relayed to the Arduino. In a sophisticated interplay of data and control, the Arduino utilizes this information to instruct a stepper motor driver, constituting the intricate dance of data and control mechanisms underlying the object avoidance mechanism—a critical facet of our model's safety protocols.

The orchestrated movements of the stepper motor, masterfully conducted by the Arduino, interface with the steering system, executing precise maneuvers to navigate around detected obstacles. This integration of ultrasonic sensors, Arduino, and stepper motor exemplifies our model's advanced approach to real-time object avoidance, ensuring a dynamic and adaptive response to the surrounding environment.

At the core of our autonomous vehicle model is the infusion of machine learning (ML) algorithms, harmoniously converging with hardware components. The Raspberry Pi, acting as the computational nucleus, employs ML techniques to process and analyze data gleaned from the camera, thereby enhancing object recognition and lane detection capabilities. This strategic integration empowers our model to adapt and refine its decision-making processes over time, marking a significant leap in the realm of intelligent vehicle systems.

# Chapter 4

## Requirement Analysis

HD Camera: Hardware Requirements:

- High-definition camera with suitable resolution and frame rate.
- Mounting hardware for secure attachment to the vehicle.

Stepper Motor: Hardware Requirements:

- Stepper motor suitable for precise control of steering or speed.
- Motor driver compatible with Arduino Mega 2560 for control.

Battery (48V & 12V): Hardware Requirements:

- High-capacity batteries with appropriate voltage levels (48V and 12V).
- Charging and power management systems for efficient energy supply.
- Wiring and connectors for connecting batteries to the Raspberry Pi, Arduino Mega 2560, and other components.

Raspberry Pi 4B: Hardware Requirements:

- Raspberry Pi 4B board with sufficient processing power, memory, and I/O capabilities.
- Power supply, cooling system, and storage media (e.g., microSD card) for stable operation.

Arduino Mega 2560: Hardware Requirements:

- Arduino Mega 2560 board with ample digital and analog pins for interfacing with sensors and actuators.
- Power supply and interfacing components for stable operation.
- Compatibility with sensors, motors, and other hardware components

Ultrasonic HC-SR04: Hardware Requirements:

- Ultrasonic sensor module (HC-SR04) for distance measurement and object detection.
- Wiring and connectors for interfacing with Arduino Mega 2560.

ROS (Robot Operating System): Software Requirements:

- Installation of ROS for communication and coordination between hardware components.
- Integration with Python and C++ for software development and scripting.
- Compatibility with Raspberry Pi, Arduino Mega 2560, and other components in the system.

Python: Software Requirements:

- Development of software modules for data processing, decision-making, and system control.
- Integration with OpenCV for image processing and computer vision tasks.
- Compatibility with ROS for communication and coordination with other system components.

C++: Software Requirements:

- Development of firmware code for Arduino Mega 2560 and other microcontroller-based components.
- Integration with ROS for communication and coordination with other system components.

Arduino IDE: Software Requirements:

- Development of firmware code for sensor data acquisition, motor control, and communication with other system components.
- Integration with C++ for firmware development and scripting..

OpenCV: Software Requirements:

- Installation of OpenCV library for image processing and computer vision tasks.
- Development of algorithms for object recognition, lane detection, and traffic sign detection.

# Chapter 5

## Project Design

### 5.1 DFD (Data Flow Diagram)

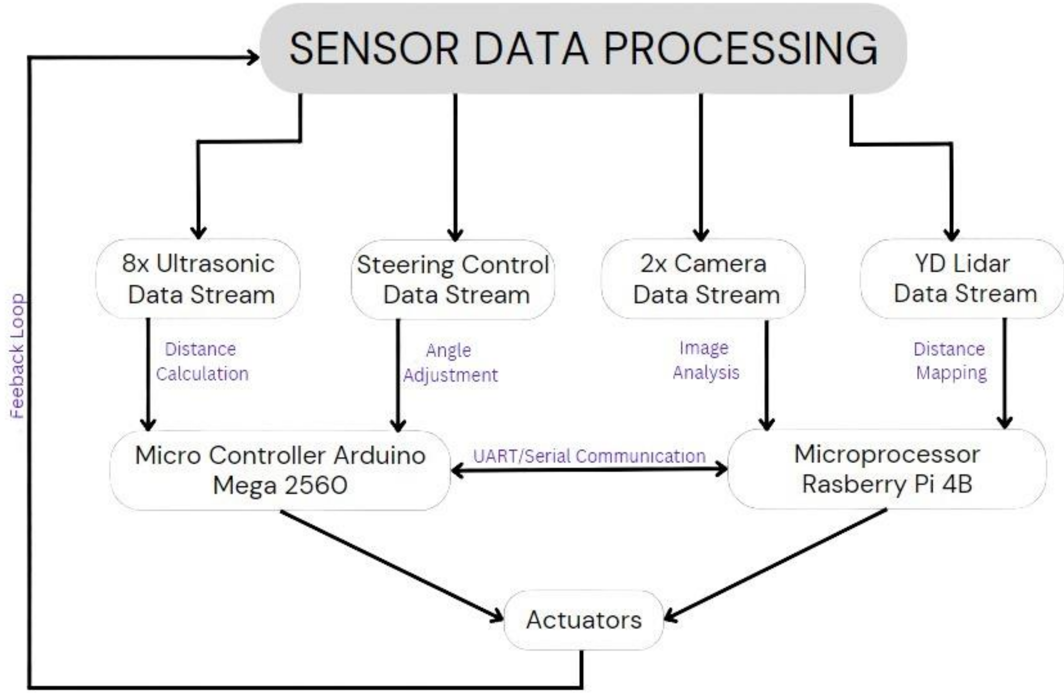


**Fig 5.1: Data Flow Diagram**

The Data Flow integrates eight ultrasonic sensors and a stepper motor, interfacing with the Arduino, while the Raspberry Pi 4 directly connects to two cameras and a LiDAR sensor. Ultrasonic sensor data guides the steering system via the stepper motor. The Arduino processes sensor data and communicates with the Raspberry Pi over serial communication. The Raspberry Pi aggregates data from all sensors, including cameras and LiDAR, for comprehensive environmental perception. Feedback algorithms verify actuator responses, ensuring accurate execution of control commands. This architecture fosters synchronized data flow and robust decision-making within the autonomous vehicle system, enabling seamless integration of sensor inputs and effective control of vehicle dynamics.

## 5.2 System Architecture

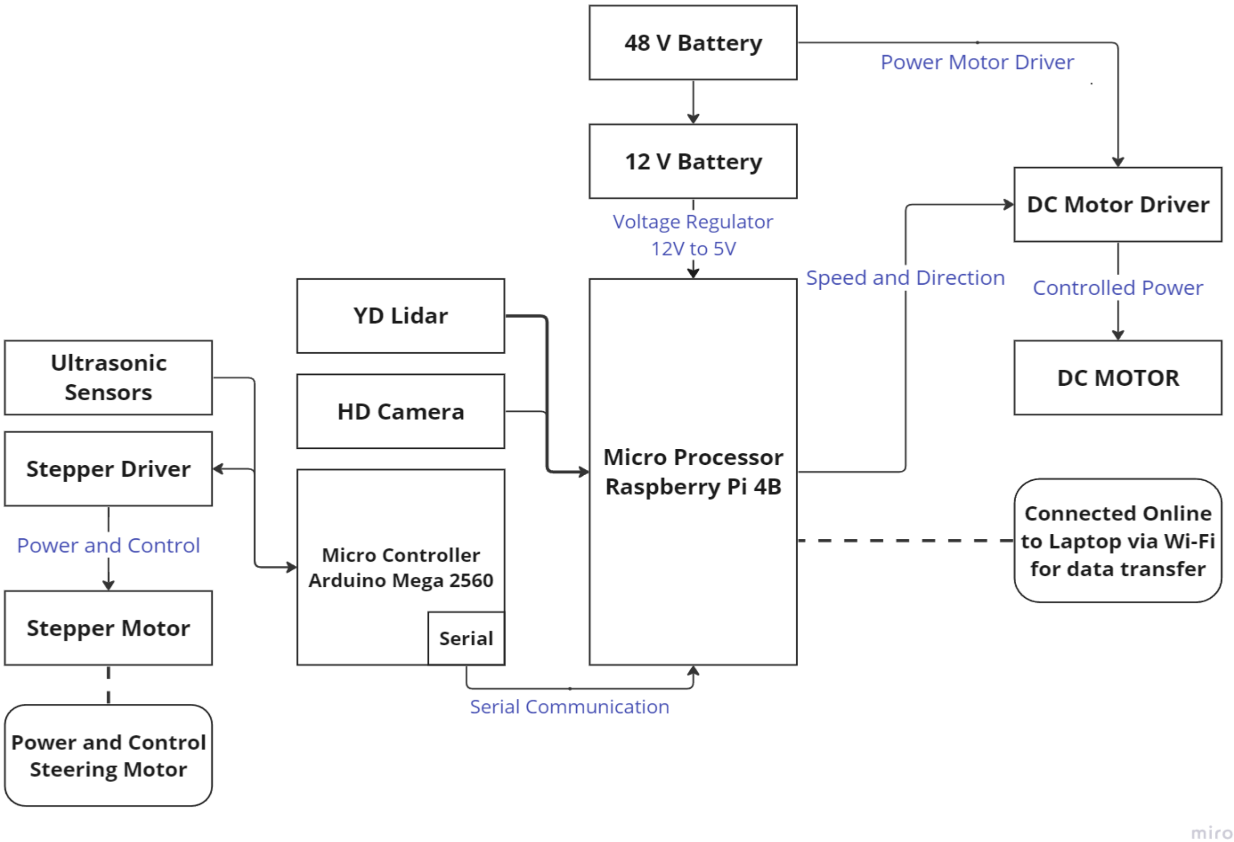


**Fig 5.2: System Architecture**

In our autonomous vehicle architecture, a 48V battery powers essential components, supported by a 12V battery for the Raspberry Pi 4B. The Raspberry Pi coordinates data from a camera and LiDAR sensor, enabling object recognition and depth perception. An Arduino facilitates communication with ultrasonic sensors for object detection, while ML algorithms enhance decision-making. This integrated approach ensures dynamic object avoidance and advanced environmental understanding. The orchestrated movements of the stepper motor, guided by the Arduino, allow precise maneuvers to navigate obstacles. This holistic fusion of hardware and software marks a significant advancement in intelligent vehicle systems, promising safer and more adaptive autonomous driving experiences.

## 5.3 Implementation

During the implementation phase, several crucial tasks were successfully accomplished to ensure the project's functionality and integration of hardware components and software modules. Firstly, meticulous attention was given to establishing a seamless communication link between the Arduino and Raspberry Pi 4B. This involved precise wiring and configuration to enable data exchange between the two platforms. Additionally, the Raspberry Pi's wireless connectivity was meticulously configured, ensuring stable communication over the network. This step was crucial for enabling remote monitoring and control of the autonomous vehicle system.

Furthermore, the integration of ultrasonic sensors with the Arduino platform was executed with precision. Careful circuit connections were made, and firmware code was developed to initialize and read data from the sensors accurately. Signal processing algorithms were then implemented to analyse the ultrasonic data, facilitating precise object detection and obstacle avoidance.

Simultaneously, the camera system was seamlessly integrated with the Raspberry Pi, involving detailed hardware setup and software configuration. Complex computer vision algorithms were implemented to enable real-time object tracking using the camera feed, enhancing the vehicle's perception capabilities. Overall, each achievement during the implementation phase played a crucial role in realizing the project's objectives and ensuring the autonomous vehicle system's functionality and reliability.

# Chapter 6

## Technical Specifications

The autonomous vehicle's technical specifications encompass a comprehensive software ecosystem, integrating various tools and libraries to enable its functionalities. OpenCV serves as a pivotal component for image processing tasks, facilitating object recognition, lane detection, and traffic sign detection through seamless integration with the HD camera. Calibration procedures ensure accurate image capture and processing, with Python enabling the development of tailored software modules and scripts to enhance the camera's functionality.

Steering control is achieved through the integration of the stepper motor system with the Arduino IDE, allowing for firmware code development to ensure precise motor positioning and speed control. Control algorithms and calibration procedures are implemented to guarantee accurate motor movements, supported by firmware development in C++ for custom control logic and algorithms. Efficient power management is ensured through software development of power management algorithms for the battery management system. Integration with ROS enables real-time monitoring of battery status and efficient power consumption management, with Python facilitating the development of software modules for battery monitoring and management tasks.

The Raspberry Pi 4B serves as the central computing hub, with software installation of ROS facilitating communication between the Raspberry Pi and other system components. Python integration enables flexible software development and scripting for data processing, decision-making, and control logic implementation, leveraging the Raspberry Pi's computing power effectively.

Similarly, software development for the Arduino Mega 2560 involves firmware code development using the Arduino IDE, enabling sensor data acquisition, motor control, and communication with other system components. Integration with C++ and ROS allows for seamless communication and integration, ensuring effective coordination within the system. Additionally, OpenCV enhances the system's capabilities, providing tools for image processing and computer vision tasks integrated with Python and C++ for software development and scripting.

# Chapter 7

## Project Scheduling

The group formation and topic selection task was completed by Umesh Pawar, Dalbirsingh Matharu, Vedant Parulekar, Shreyas Patil on 1-30-2024. Functionalities of the project was identified by Shreyas Patil and Vedant Parulekar. Discussion of topic was performed by Umesh Pawar, Dalbirsingh Matharu, Vedant Parulekar, Shreyas Patil on 12-8-2024. Presentation I took place on 3-12-2024 and was performed by Umesh Pawar, Dalbirsingh Matharu, Vedant Parulekar, Shreyas Patil .The System Architecture was designed by Umesh Pawar and Dalbirsingh on 3-12-24 . Sensor testing and Sensor integration was performed by Umesh Pawar, Dalbirsingh Matharu, Vedant Parulekar, Shreyas Patil. Finally, Presentation II was completed on 4-16-2024.

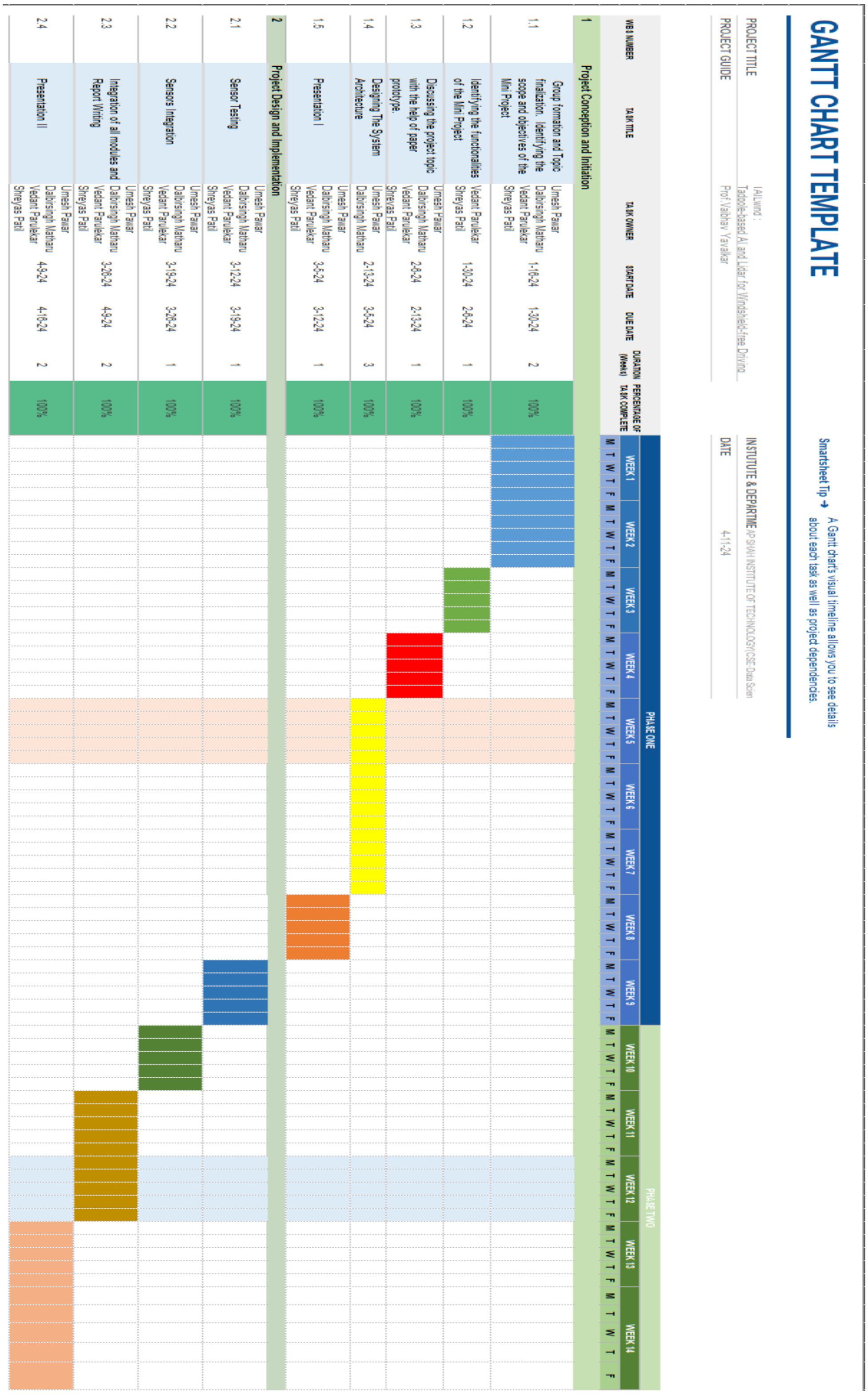


**Fig 7.1: Gantt Chart**

# Chapter 8

## Result

The result of our project, with its successful implementation of object detection, avoidance, tracking, speed control, and steering through sensor technology, heralds a significant milestone in autonomous vehicle development. Firstly, the achievement of reliable object detection means that the vehicle can accurately identify and classify objects in its environment, including other vehicles, pedestrians, and obstacles.

Moreover, the integration of object avoidance ensures that the vehicle can dynamically adjust its path to avoid collisions with detected objects, thereby enhancing safety for passengers and pedestrians alike. Object tracking functionality further enhances the vehicle's situational awareness by continuously monitoring the movement of detected objects, enabling predictive behaviours and proactive responses.

In addition to safety features, the successful implementation of speed control allows the vehicle to adapt its speed based on environmental factors and traffic conditions, promoting smoother and more efficient navigation. Similarly, steering control ensures precise manoeuvrability, enabling the vehicle to navigate complex road geometries and obstacles with accuracy. Overall, the culmination of these achievements signifies a significant advancement in autonomous vehicle technology, with tangible benefits in terms of safety, efficiency, and user experience.

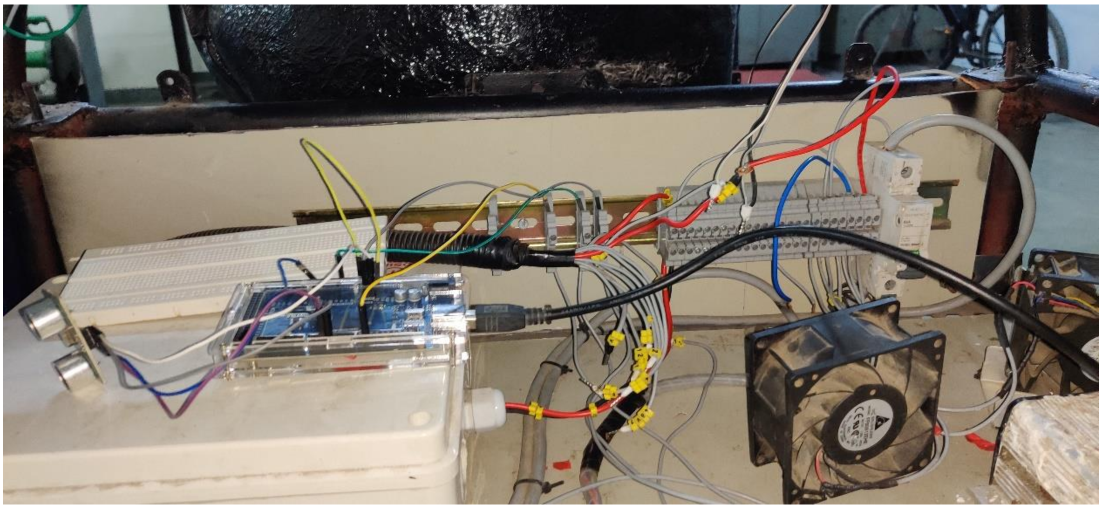

**Fig 8.1: System Image**

In Figure 8.1, the schematic portrays ultrasonic sensors interfaced with an Arduino board. This configuration facilitates precise distance measurements. The connection between the ultrasonics and Arduino underscores the integration of sensor technology with microcontroller.

**Fig 8.2: HD Camera**

In Figure 8.2, a camera system is depicted for pedestrian detection, integrated with ultrasonic sensors. This setup signifies the fusion of visual and proximity sensing technologies.

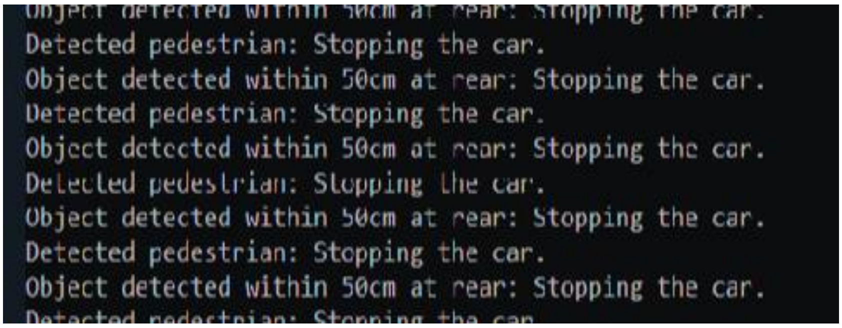


**Fig 8.3: Decision Making**

In Figure 8.3, the output showcases both the detected distance and the presence of pedestrians. The system issues a command to halt the vehicle, utilizing the combined capabilities of ultrasonic sensors, cameras, Raspberry Pi, and Arduino. This fusion of technologies underscores the integration of sensory data for enhanced safety measures.

# Chapter 9

## Conclusion

This project stands as a beacon of progress in the realm of autonomous vehicle development, epitomizing the culmination of meticulous research, rigorous experimentation, and innovative problem-solving endeavours. Through a systematic approach and exhaustive testing, considerable advancements have been achieved in sensor technology, particularly in enhancing perception and environmental understanding.

The seamless integration of disparate components underscores a commitment to cohesive system design, ensuring robust performance across varied driving scenarios. This integration not only enhances operational efficiency but also establishes a solid foundation for future advancements in autonomous vehicle technology. In essence, this project represents a collective endeavour towards advancing autonomous vehicle capabilities, indicative of a steadfast commitment to fostering innovation and driving progress within the field. As methodologies continue to be refined and optimized, the path towards realizing a future where autonomous vehicles play a pivotal role in shaping safer and more efficient transportation ecosystems becomes increasingly clear.

Through meticulous research and methodical experimentation, this project has pushed the boundaries of autonomous vehicle development, yielding significant advancements in sensor technology. By enhancing perception and environmental understanding, these advancements pave the way for safer and more reliable autonomous navigation.

In summary, this project serves as a testament to the collective endeavour towards advancing autonomous vehicle capabilities, reflecting dedication to fostering innovation and driving progress within the field. As methodologies continue to be refined and optimized, the vision of a future where autonomous vehicles play a pivotal role in shaping safer and more efficient transportation ecosystems draws closer.

# Chapter 10

## Future Scope

The future scope of our project encompasses a wide range of potential avenues for further development and application in the field of autonomous vehicle technology. One area of focus is the integration of advanced sensor technologies to enhance the vehicle's perception capabilities. This could involve exploring the incorporation of additional sensors such as radar or LiDAR to improve detection accuracy in various environmental conditions. Furthermore, there is potential for continued refinement and optimization of machine learning algorithms to enhance object detection, pedestrian recognition, and decision-making capabilities. By incorporating deep learning techniques, we can aim for greater accuracy and efficiency in autonomous navigation.

Expanding the project's scope to address challenges in autonomous navigation is another promising direction. This could involve developing robust algorithms and strategies for navigating complex urban environments, adverse weather conditions, or off-road terrains. Additionally, exploring opportunities for integrating the autonomous vehicle system with smart city infrastructure could enable seamless communication and coordination with traffic management systems and other vehicles.

Beyond personal transportation, there is potential to apply autonomous vehicle technology in areas such as fleet management and autonomous delivery services. By extending the project's focus to address evolving needs in logistics and transportation industries, we can explore innovative solutions for improving efficiency and reducing operational costs. Furthermore, research and development efforts can be directed towards enhancing human-machine interaction, ensuring a seamless and user-friendly experience for passengers. This could involve the design of intuitive interfaces and communication methods that facilitate clear and effective interaction between passengers and autonomous vehicles.

Overall, the future scope of our project is characterized by ongoing innovation, adaptation to emerging technologies and trends, and collaboration with stakeholders to realize the full potential of autonomous vehicle technology in shaping the future of transportation.

# References


[1] Hajer Omrane, Mohamed Slim Masmoudi, and Mohamed Masmoudi, “Neural controller of an autonomous driving mobile robot by an embedded camera” in International Conference on Advanced Technologies For Signal and Image Processing - ATSIP, 2018

[2] Aditya Kumar Jain, “Working model of Self-driving car using Convolutional Neural Network, Raspberry Pi and Arduino”, in Proceedings of the 2nd International Conference on Electronics,Communication and Aerospace Technology ICECA 2018.

[3] Malay Shah, Prof, Rupal Kapdi,“Object Detection Using Deep Neural Networks”, in International Conference on Intelligent Computing and Control Systems ICICCS 2017.

[4] Ryan Krauss, "Combining Raspberry Pi and Arduino to Form a Low-Cost, Real-TimeAutonomous Vehicle Platform". in 2016 American Control Conference (ACC)Boston Marriott Copley Place July 6-8, 2016. Boston, MA, USA}

[5] Syed Owais Ali Chishti, Hafiz M. Bilal Zaib, Sana Riaz, "DrivingMatter: An Autonomous RC Carusing Raspberry Pi", in May,2018}

[6] M. Bojarski, D. Del Testa, D. Dworakowski, B. Firner, B. Flepp, P.Goyal, L. D. Jackel, M. Monfort, U. Muller, and J. Zhang, “End toend learning for self-driving cars,”

[7] M. Richardson, and S. Wallace, Getting started with raspberry PI: "O'Reilly Media, Inc.", 2012.

[8] R. Girshick, J. Donahue, T. Darrell, and J. Malik, "Rich featurehierarchies for accurate object detection and semantic segmentation,"in Proceedings of the IEEE conference on computer vision and pattern recognition, 2014, pp. 580-587.

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