Arduino Controllers for Subsystem Coordination in Autonomous Electric Vehicles"

A PROJECT REPORT

Submitted by

NAVEEN B	**211420105069**
PRASHANTH B	**211420105078**
NANDHAKUMAR M	**211420105065**
KAMALESH P	**211420105046**

in partial fulfillment for the award of the degree

of

BACHELOR OF ENGINEERING

in

ELECTRICAL AND ELECTRONICS ENGINEERING

PANIMALAR ENGINEERING COLLEGE

(An Autonomous Institution, Affiliated to Anna University, Chennai)

APRIL 2024

PANIMALAR ENGINEERING COLLEGE

(An Autonomous Institution, Affiliated to Anna University, Chennai)

BONAFIDE CERTIFICATE

Certified that this project report **“AUTONOMOUS SELF DRIVING VEHICLE”**is thebonafideworkof**“KAMALESH.P(211420105046),NAVEEN.B (211420105069), PRASHANTH.B (211420105078),NANDHA KUMAR.M(211402105065)**” who carried out the project work under my supervision.

SIGNATURE **Dr. S. SELVI, M.E, Ph.D.** **HEAD OF THE DEPARTMENT** **PROFESSOR** Department of Electrical and Electronics Engineering, Panimalar Engineering College. Chennai - 600 123	**SIGNATURE** **Mrs. K. DINAKARAN, M.E, Ph.d** **SUPERVISOR** **PROFESSOR** Department of Electrical and Electronics engineering Panimalar Engineering College, Chennai - 600 123

Submitted for End Semester mini Project Viva Voce held on …………………… at Panimalar Engineering College, Chennai.

INTERNAL EXAMINER **EXTERNAL EXAMINER**

ACKNOWLEDGEMENT

Our sincere thanks to our Honourable Founder and Chairman, Dr. JEPPIAAR, M.A., B.L., Ph.D., for his sincere endeavor in educating us in his premier institution.

We would like to express our deep gratitude to our beloved Secretary and correspondent, Dr. P. CHINNADURAI, M.A., M.Phil., Ph.D., for his enthusiastic motivation which inspired us a lot in completing this project and our sincere thanks to our Directors Mrs. C. VIJAYA RAJESWARI, Dr. C. SHAKTHIKUMAR, M.E., Ph.D., and Dr. SARANYASREE SAKTHI KUMAR, B.E., M.B.A., Ph.D., for providing us with necessary facilities for the completion of this project.

We would like to express thanks to our Principal, Dr. K. MANI, M.E., Ph.D., for extending his guidance and cooperation.

We would also like to thank our Head of the Department, Dr. S. SELVI, M.E., Ph.D., Professor and Head, Department of Electrical and Electronics Engineering for her encouragement. Personally, we thank our guide Mr. K.P.DINAKARAN, M.E., Ph.D., Assistant Professor in the Department of Electrical and Electronics Engineering for the persistent motivation and support for this project, who at all times was the mentor of the germination of this project from a small idea.

We express our sincere thanks to the project coordinators Dr. S. DEEPA, M.E., Ph.D., & Dr. N. MANOJ KUMAR, M.E., Ph.D., in the Department of Electrical and Electronics Engineering for the valuable suggestions from time to time at every stage of our project.

Finally, we would like to take this opportunity to thank our family members, faculty, and non-teaching staff members of our department, friends, and well-wishers who have helped us for the successful completion of our project.

ABSTRACT

In this project, an Arduino and Raspberry Pi-based platform is used to create and implement an autonomous vehicle system. The system combines sophisticated deep learning algorithms with a variety of hardware elements, such as proximity sensors, a LiDAR sensor, linear actuators, and a BLDC hub motor, to enable real-time navigation and decision-making.Integration of various technologies to produce a dependable and effective autonomous driving experience is one of the project's main goals. In order to guarantee comfort and stability while operating, the linear actuators and motor control system within the vehicle were carefully designed and calibrated. The system's navigational skills are further improved by the inclusion of Google Maps technology, which gives users access to real-time mapping data for route planning and optimization. The autonomous vehicle system may dynamically modify its path in response to real-time traffic conditions, road closures, and other environmental factors by utilizing the capabilities of Google Maps. This connection increases the overall effectiveness and safety of the autonomous driving experience in addition to improving the navigation system's accuracy . The vehicle's ability to identify nearby obstacles by means of proximity sensors makes navigating through dynamic environments easier. Real-time decision-making relies heavily on deep learning algorithms, which are trained on large datasets to recognize and understand a variety of contextual cues. This lets the car decide on navigation, obstacle avoidance, and course planning with knowledge. The focus was on optimizing control algorithms and fine-tuning parameters to offer agile and smooth driving dynamics, ultimately enhancing user experience and safety.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF ABBREVIATIONS

EV	Electric Vehicle
BEV	Battery Electric Vehicle
PHEV	Plug-in Hybrid Electric Vehicle
HEV	Hybrid Electric Vehicle
FCEV	Fuel Cell Electric Vehicle
CNN	Convolutional Neural Networks
kWh	Kilowatt-Hour
kW	Kilowatt
DCFC	Direct Current Fast Charger
AC	Alternating Current
DC	Direct Current
SOC	State of Charge
BMS	Battery Management System
OBC	On-Board Charger
V2G	Vehicle-to-Grid
V2H	Vehicle-to-Home
NCA	Nickel Cobalt Aluminium
NMC	Nickel Manganese Cobalt
LFP	Lithium Iron Phosphate
MPGE	Miles per Gallon equivalent
TCO	Total Cost of Ownership
ADAS	Advanced Driver Assistance

Unit-1

AUTONOMOUS VEHICLE

1.1INTRODUCTION

The emergence of driverless automobiles is an example of how technical skill, computer intelligence, and technology innovation have come together. In this endeavour, our project represents teamwork and careful preparation with the goal of achieving a reliable and intelligent autonomous driving system. We set out to develop and build a platform that could navigate the complexity of metropolitan surroundings on its own, with an emphasis on practical application.The systematic selection and integration of hardware components, each chosen for its role in enhancing the overall functionality and dependability of the autonomous vehicle system, is essential to our project. By utilizing the processing power of an Arduino and Raspberry Pi platform, we created a flexible computing system that can communicate with a wide range of sensors and actuators. To guarantee peak performance in practical driving situations, proximity sensors, LiDAR technology, linear actuators, and a BLDC hub motor were carefully integrated and calibrated.Our methodology is based on the deliberate integration of cutting-edge deep learning algorithms into the car's decision-making system. Understanding how crucial perceptual intelligence is to autonomous navigation, we developed a multimodal approach that uses Convolutional Neural Networks (CNNs) in conjunction with other deep learning methods. This gave our car the capacity to receive and interpret visual input in real time, giving it the ability to identify and react to environmental cues like traffic signs, cars, and pedestrians.The deep learning models were built on top of large datasets that were carefully selected to cover a broad range of urban driving scenarios. Our models were honed to obtain the necessary accuracy and robustness for implementation in real-world settings through recurrent training and validation. The creation of innovative training approaches and data augmentation strategies to improve the generalisation and flexibility of our deep learning algorithms was essential to this project.The project's clean hardware and software integration was essential to its success. The vehicle's sensor suite and our deep learning algorithms interfaced seamlessly, allowing for dynamic decision-making and real-time sensor data analysis. To ensure smooth and agile navigation through the complexities of urban environments, advanced control algorithms were also created to translate the outputs of our deep learning models into accurate and responsive vehicle actions.

1.2LITERATURE SURVEY

The literature survey delves into two key studies in the field of end-to-end learning for autonomous driving. The first study, authored by Mariusz Bojarski et al. from NVIDIA Corporation, introduces an innovative approach utilizing Convolutional Neural Networks (CNNs) to directly map raw pixels from a single front-facing camera to steering commands. This end-to-end system demonstrates remarkable versatility and effectiveness in navigating diverse driving scenarios, including local roads, highways, parking lots, and unpaved roads. Unlike traditional methods that involve explicit decomposition of the problem into separate tasks such as lane marking detection and path planning, this approach optimizes all processing steps simultaneously, potentially leading to improved performance and smaller system sizes. The study, conducted using an NVIDIA DevBox and Torch 7 for training, achieves real-time operation at 30 frames per second (FPS) on an NVIDIA DRIVETM PX self-driving car computer.

The second study, authored by Anna Choromanaska from New York University, focuses on PilotNet, a neural network-based system developed by NVIDIA for lane keeping in autonomous driving. PilotNet is trained using road images paired with steering angles from human drivers, enabling it to learn domain knowledge directly from observation. The system demonstrates successful lane keeping in various driving conditions, irrespective of lane markings, by recognizing relevant objects on the road. Unlike traditional hand-coded systems, PilotNet learns both obvious and subtle features, such as lane markings, road edges, other vehicles, and even atypical objects like bushes. This study builds upon previous research on end-to-end learning for self-driving cars, highlighting the potential of neural network-based approaches in autonomous driving.

In their groundbreaking research, Lila Huang, Shenlong Wang, Kelvin Wong, Jerry Liu, and Raquel Urtasun introduce an innovative deep compression algorithm meticulously crafted to address the pressing need for reducing the memory footprint of LiDAR point clouds. This pioneering approach capitalizes on the inherent sparsity and structural redundancy inherent within point clouds, offering a transformative solution for bitrate reduction. At the core of their methodology lies the encoding of LiDAR points into an octree, a sophisticated and data-efficient structure well-suited for handling sparse point clouds. Moreover, the authors ingeniously devise a treestructured conditional entropy model aimed at capturing the intricate probabilities associated with octree symbols, thus enabling the seamless encoding of the octree into a compact bitstream.

Through a rigorous validation process utilizing large-scale datasets, Huang et al. provide compelling evidence of the efficacy of their approach. Their findings showcase an impressive reduction in bitrate ranging from 10% to 20% while concurrently upholding reconstruction quality, a feat that outshines existing state-ofthe-art methodologies. Particularly noteworthy is the algorithm's superiority when deployed in downstream 3D segmentation and detection tasks, accentuating its profound relevance and practical utility across diverse domains, notably in the realm of self-driving cars. By pushing the boundaries of compression technology, this research not only offers a promising avenue for optimizing onboard and offboard storage in autonomous vehicles but also paves the way for enhanced efficiency and performance in LiDAR data processing, thereby driving forward the frontier of autonomous driving technology.

In their insightful analysis, Rajasekhar MV and Anil Kumar Jaswal delve into the intricate journey from conventional vehicles to the realm of autonomous cars. Envisioning a future characterized by driverless, efficient, and crash-avoidant vehicles, the authors paint a compelling picture of the transformative potential of autonomous transportation. They meticulously dissect the challenges inherent in this transition, offering a nuanced examination of the adaptation and integration of existing technologies required to unlock the full capabilities of autonomous vehicles.

Drawing parallels and distinctions between the introduction of autonomous vehicles. in the Indian market and their rollout in other global markets, Rajasekhar MV and Anil Kumar Jaswal provide valuable insights into the diverse landscapes shaping the adoption of this disruptive technology. They shed light on the unique dynamics at play, exploring the regulatory frameworks, infrastructural considerations, and consumer attitudes that influence the trajectory of autonomous vehicle adoption.

Furthermore, the authors delve into the intricacies of the acceptance approach for autonomous vehicles within the Indian market context. They navigate through the complex interplay of factors such as consumer perceptions, societal expectations, and governmental policies, offering a comprehensive analysis of the multifaceted landscape surrounding the integration of autonomous technology.

Central to their discourse is the definition of fully autonomous vehicles as entities capable of autonomous perception, decision-making regarding routes, and independent driving. Through this definition, they underscore the transformative potential of autonomous technology, emphasizing its capacity to mitigate accidents, reduce energy consumption, and alleviate pollution, thus heralding a paradigm shift in the transportation ecosystem.

As major Original Equipment Manufacturers (OEMs) gear up to introduce autonomous vehicles to the market, Rajasekhar MV and Anil Kumar Jaswal provide a compelling narrative of the imminent arrival of this disruptive technology. Their analysis serves as a beacon, guiding stakeholders and policymakers alike through the complex terrain of autonomous vehicle integration, paving the way for a future where smart, autonomous transportation reshapes the very fabric of our mobility landscape.

Recent advancements in deep learning algorithms have propelled image classification to unprecedented levels of accuracy, making them indispensable in security-sensitive applications like biometric recognition systems and self-driving cars. However, these very algorithms, while surpassing human performance in many cases, have unveiled a critical vulnerability: susceptibility to adversarial examples. Adversarial examples in computer vision refer to images subtly altered by malicious optimization algorithms to deceive classifiers. To address this pressing issue, numerous defense mechanisms have emerged in recent literature, aiming to bolster the resilience of image classifiers against such attacks.

Despite the growing body of research in this area, devising effective defense mechanisms remains a formidable challenge, as many existing approaches have proven ineffective against adaptive adversaries. In light of this, our article endeavors to furnish readers with a comprehensive review of the latest developments in adversarial machine learning within the realm of image classification, with a particular focus on defense strategies. We propose novel taxonomies for categorizing adversarial attacks and defenses, shedding light on the underlying reasons behind the existence of adversarial examples.

Furthermore, we offer valuable insights and guidance to researchers engaged in the development and evaluation of defense mechanisms. By synthesizing insights from the reviewed literature, we aim to equip researchers with the tools and knowledge necessary to navigate the complex landscape of adversarial machine learning effectively.

Drawing upon the wealth of research findings, our article also delineates promising avenues for future research, identifying key areas where further exploration and innovation are warranted. By charting these potential trajectories, we hope to inspire and guide researchers towards the development of robust, resilient defense mechanisms capable of safeguarding image classification systems against adversarial attacks in an ever-evolving threat landscape.

1.3 EXISTING METHOD

Before the advent of autonomous vehicle technology, transportation systems were primarily reliant on human drivers for navigation and control. Human-driven vehicles operated through manual control, with drivers tasked with interpreting visual cues, making decisions, and executing driving maneuvers based on their perception of the surrounding environment. This traditional approach to transportation, while effective in many cases, was inherently limited by human factors such as fatigue, distraction, and error. Alongside human drivers, automated systems were developed to assist drivers in specific tasks, including cruise control, anti-lock braking systems (ABS), and electronic stability control (ESC). These systems provided partial automation by automating certain aspects of driving, such as maintaining a constant speed or enhancing vehicle stability during braking or cornering.

However, they still required human oversight and intervention, particularly in complex or unexpected situations. Moreover, advancements in vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication technologies paved the way for cooperative intelligent transportation systems (C-ITS). These systems enabled vehicles to communicate with each other and with roadside infrastructure, exchanging information about road conditions, traffic flow, and potential hazards. While not fully autonomous, C-ITS systems represented a significant step towards improving safety and efficiency on the road. Overall, before the emergence of autonomous vehicle technology, transportation systems relied heavily on human drivers supplemented by automated assistance systems and cooperative communication technologies, all of which contributed to enhancing safety and efficiency but were limited in their ability to provide fully autonomous operation.

Fig1.1 Sensor Detection

1.3 PROPOSED SYSTEM

This project details a novel autonomous vehicle (AV) system that leverages deep learning for real-time obstacle detection, navigation, and safe travel, while prioritizing passenger comfort and affordability. Here's a breakdown of the key components and functionalities:

1.Data Acquisition and Localization:

- ➢Google Maps Integration: The system utilizes Google Maps to provide a highlevel understanding of the surrounding environment, including road layout, traffic information, and potential destinations. This serves as a base layer for real-time sensor data processing.

2.Sensor Suite:

- LiDAR Sensor: A LiDAR sensor captures high-resolution 3D point cloud data of the immediate surroundings. This data is crucial for obstacle detection, lane identification, and precise localization within the Google Maps framework.
- Proximity Sensors: These sensors provide short-range obstacle detection, supplementing the LiDAR data and enabling immediate responses to nearby hazards.

3.Deep Learning and Processing Unit:

- Raspberry Pi: This compact and cost-effective platform serves as the central processing unit.
- Deep Learning Framework: Frameworks like TensorFlow or PyTorch will be utilized on the Raspberry Pi to process sensor data and Google Maps information

.

4.Convolutional Neural Network (CNN) Algorithm:

- A CNN algorithm will be implemented for real-time image processing and classification of the LiDAR data. The CNN will be trained on extensive datasets containing labeled objects like vehicles, pedestrians, traffic signs, and lane markings.
- Identify Obstacles: Accurately detect and classify obstacles present in the LiDAR point cloud data.
- Lane Detection: Recognize lane markings and boundaries within the LiDAR data, enabling the AV to stay within its lane.
- Navigation and Control:

- Route Planning: Using Google Maps data and real-time obstacle information from the CNN, the system will plan a safe and efficient route to the desired destination, accounting for traffic conditions and avoiding obstacles.
- Path Following: The planned route will be translated into real-time steering commands for the vehicle.
- Linear Actuators: These actuators will provide precise control over the vehicle's steering mechanism, ensuring it follows the planned path while avoiding detected obstacles

5. **Sensor Fusion:** The system may integrate sensor fusion techniques to combine data from the LiDAR, proximity sensors, and potentially additional sensors like cameras, for a more robust and comprehensive understanding of the environment.
6. **Safety Measures:** Fail-safe mechanisms and emergency protocols will be implemented to ensure passenger safety in unforeseen situations.
7. **Passenger Comfort:** The vehicle design will prioritize passenger comfort through features like comfortable seating and a smooth ride enabled by the precise control of the linear actuators.
8. **Project Significance:**

This project demonstrates the potential of a deep learning-powered AV system using readily available components and open-source software libraries. By integrating Google Maps for high-level navigation and utilizing a CNN for real-time obstacle detection, this approach offers a promising path towards:

1.2 Image segmentation

Unit-2
ARCHITECTUREOFELECTRICVEHICLE

2.1 INTRODUCTION:

In the dynamic landscape of modern transportation, self-driving cars are rapidly gaining traction, promising to reshape our daily commutes and redefine the concept of mobility. Amidst this surge in innovation, existing autonomous driving systems have made remarkable advancements, often relying on proprietary software and intricate hardware configurations.

Our project stands out amidst this backdrop by pioneering a distinct autonomous driving system that prioritizes accessibility, versatility, and user-friendliness. Harnessing an array of cutting-edge technologies, including the Google Maps API, Raspberry Pi, Arduino microcontrollers, BLDC (Brushless DC) hub motors, sophisticated actuators, and machine learning algorithms, we endeavor to create a platform that not only excels in performance but also adapts seamlessly to diverse driving scenarios and user preferences.At the heart of our system lies the Google Maps API, serving as our guiding compass in route planning and navigation. It empowers our vehicle to chart optimal courses and dynamically adjust to real-time changes in traffic and road conditions. Complementing this, the Raspberry Pi assumes the role of our system's central processing unit, seamlessly integrating data from various sensors and leveraging advanced algorithms, including machine learning models, to make informed decisions about the vehicle's movements.

Working in harmony with the Raspberry Pi, Arduino microcontrollers play a pivotal role in orchestrating the intricate coordination of components within our autonomous vehicle. From managing throttle and steering to monitoring battery levels and sensor feedback, Arduino ensures smooth operation and peak performance at every juncture.

Additionally, BLDC hub motors provide efficient propulsion, delivering power reliably to propel our vehicle forward.

A standout feature of our project is its inherent flexibility and user-friendliness. We've engineered our system to seamlessly transition between manual control and autonomous driving modes, empowering users to tailor their driving experience to their preferences. Whether opting for hands-on driving or entrusting the car with control, our system offers a versatile and engaging ride.Moreover, our project aligns with the burgeoning trend towards electric vehicles (EVs), contributing to the shift away from traditional combustion engines towards cleaner, more sustainable transportation solutions. By leveraging BLDC hub motors and integrating energyefficient components, we not only pioneer a smarter driving experience but also reduce our environmental footprint.Ultimately, our overarching ambition is to showcase the transformative potential of accessible technology in ushering in the era of autonomous driving. Through the demonstration of a functional prototype and the integration of diverse components, including machine learning, we aspire to ignite innovation and cultivate curiosity in the ever-evolving landscape of autonomous vehicles.

2.2 TYPES OF ELECTRIC VEHICLES:

BATTERY ELECTRIC VEHICLES (BEVs):

BEVs, also known as All-Electric Vehicles (AEVs), operate solely on a batterypowered electric drivetrain. These vehicles rely entirely on electricity stored in a large battery pack, which can be recharged by connecting to the electricity grid. The charged battery pack then supplies power to one or more electric motors, propelling the vehicle forward.

COMPONENTS OF BEVs:

- Electric Motor
- Inverter
- Battery
- Control Module
- Drivetrain

WORKING:

In a Battery Electric Vehicle (BEV), the electric motor serves as the primary propulsion system, responsible for converting electrical energy from the battery into mechanical motion to drive the vehicle. This process begins when the DC battery supplies power to the electric motor. The motor, typically an alternating current (AC) induction motor or a permanent magnet synchronous motor, then performs the crucial task of converting this electrical energy into rotational mechanical energy.

When the driver presses the accelerator pedal, a signal is transmitted to the vehicle's controller, which acts as the brain of the system. The controller receives input from various sensors and systems within the vehicle and determines the appropriate amount of power needed based on factors such as the position of the accelerator pedal, vehicle speed, and road conditions.

Upon receiving the signal, the controller adjusts the frequency of the AC power output from the inverter to the electric motor. This modulation of the AC power allows for precise control over the speed and torque of the motor, enabling smooth acceleration and deceleration. As a result, the electric motor engages and drives the vehicle's wheels via a cog mechanism or a similar transmission system.

During braking or deceleration, the motor's operation changes. Instead of consuming power to propel the vehicle forward, the motor acts as an alternator, converting the kinetic energy of the moving vehicle back into electrical energy. This generated power is then fed back into the battery pack, effectively recharging it and completing the energy cycle.

This regenerative braking system not only improves the vehicle's overall energy efficiency but also helps extend the driving range of BEVs by recapturing energy that would otherwise be lost as heat during braking. By harnessing this energy and returning it to the battery, BEVs can maximize their efficiency and reduce reliance on external charging sources, contributing to a more sustainable and environmentally friendly mode of transportation.

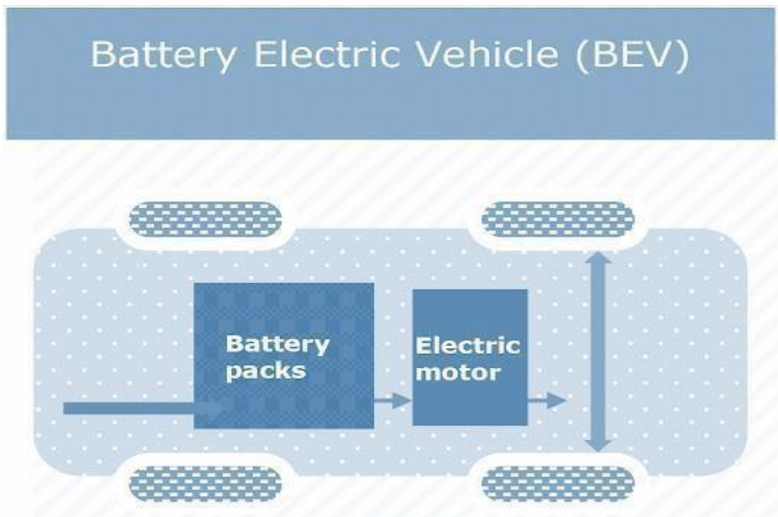


Fig 2.1 Battery ElectricVehicle

2.3 Hub Motor :

The 1200W hub motor, operating at 48V and drawing 32 amps, represents a powerful and efficient propulsion system utilized in electric vehicles and e-bikes. With its high power output and voltage rating, this motor offers substantial torque and acceleration capabilities, making it suitable for a wide range of applications, from urban commuting to off-road adventures.

At 1200W, this hub motor delivers robust performance, enabling vehicles to tackle inclines and challenging terrains with ease. The 48V voltage rating ensures efficient power delivery, maximizing the motor's performance while minimizing energy losses. Additionally, drawing 32 amps allows the motor to unleash its full potential, providing ample power for acceleration and maintaining consistent speeds, even under demanding conditions.

One of the key advantages of the 1200W hub motor is its compact and integrated design, which eliminates the need for external gearing systems and transmission components. This simplifies the vehicle's drivetrain, reducing maintenance requirements and increasing reliability. Moreover, the hub motor's direct drive configuration ensures quiet operation and smooth power delivery, enhancing the overall riding experience for users.

Fig 2.2 Hub Motor 1200W

With its high power output and efficient operation, the 1200W hub motor is wellsuited for a variety of electric vehicles, including e-scooters, e-bikes, and electric motorcycles. Its versatility and performance make it a popular choice among manufacturers and enthusiasts seeking an optimal balance of power, efficiency, and reliability in their electric propulsion systems.

Furthermore, advancements in motor control technology and battery management systems have further enhanced the performance and efficiency of the 1200W hub motor. Intelligent control algorithms optimize power delivery, while regenerative braking systems capture energy during deceleration, extending the vehicle's range and maximizing efficiency.

Overall, the 1200W hub motor represents a cutting-edge solution for electric propulsion, offering high performance, efficiency, and reliability for a wide range of applications in the rapidly evolving electric vehicle market. Whether for daily commuting or recreational use, this motor provides an exhilarating and eco-friendly driving experience while paving the way towards a sustainable transportation future.

2.4 Lead acid Battery :

The utilization of a 48V, 55Ah lead-acid battery pack in conjunction with a hub motor represents a robust and reliable power source for electric vehicles, particularly cars. Lead-acid batteries have long been a staple in the automotive industry due to their proven durability, affordability, and widespread availability. In the context of electric propulsion systems employing hub motors, these batteries offer a balance of performance and cost-effectiveness, making them a viable option for various vehicle applications.

With a voltage rating of 48V and a capacity of 55Ah, this lead-acid battery pack provides ample energy storage for powering the vehicle's electrical systems and driving the hub motor. The 48V voltage rating is well-suited for electric vehicle applications, offering sufficient power to drive the motor while maintaining compatibility with standard charging systems. Additionally, the high capacity of 55Ah ensures extended driving range and sustained performance, allowing for longer trips without the need for frequent recharging.

One of the key advantages of lead-acid batteries is their robust construction and ability to withstand harsh operating conditions. This makes them particularly wellsuited for automotive applications where reliability and durability are paramount. The sealed design of the battery pack ensures minimal maintenance requirements and protection against environmental factors, such as vibration and temperature fluctuations, further enhancing its longevity and performance.

Moreover, lead-acid batteries are known for their cost-effectiveness compared to other battery chemistries, making them an attractive option for budget-conscious consumers and fleet operators. The relatively low upfront cost of lead-acid batteries, combined with their long service life and recyclability, results in a compelling value proposition for electric vehicle manufacturers and end-users alike.

Fig 2.3 Lead Acid Battery

Despite their widespread use and reliability, lead-acid batteries do have some limitations, including higher weight and lower energy density compared to newer lithium-ion alternatives. However, for applications such as electric cars using hub motors, where performance requirements may not be as demanding as in highperformance electric vehicles, lead-acid batteries remain a practical and cost-effective solution.

In summary, the integration of a 48V, 55Ah lead-acid battery pack with a hub motor offers a dependable and economical power train solution for electric cars. With their proven reliability, affordability, and widespread availability, lead-acid batteries continue to play a vital role in enabling sustainable transportation solutions and driving the adoption of electric vehicles in various markets.

2.5 Lead Acid Battery Charger:

A Lead Acid Battery Fast Charger is a crucial component in the electric vehicle ecosystem, offering a rapid and efficient means of recharging lead-acid batteries. Designed to deliver high currents at elevated voltages, these chargers are engineered to replenish the energy reserves of lead-acid batteries swiftly, minimizing downtime and maximizing vehicle availability.

These fast chargers employ advanced charging algorithms and sophisticated power electronics to optimize the charging process while ensuring the safety and longevity of the batteries. By carefully controlling the charging current, voltage, and temperature, these chargers can charge lead-acid batteries at accelerated rates without compromising their performance or reliability.

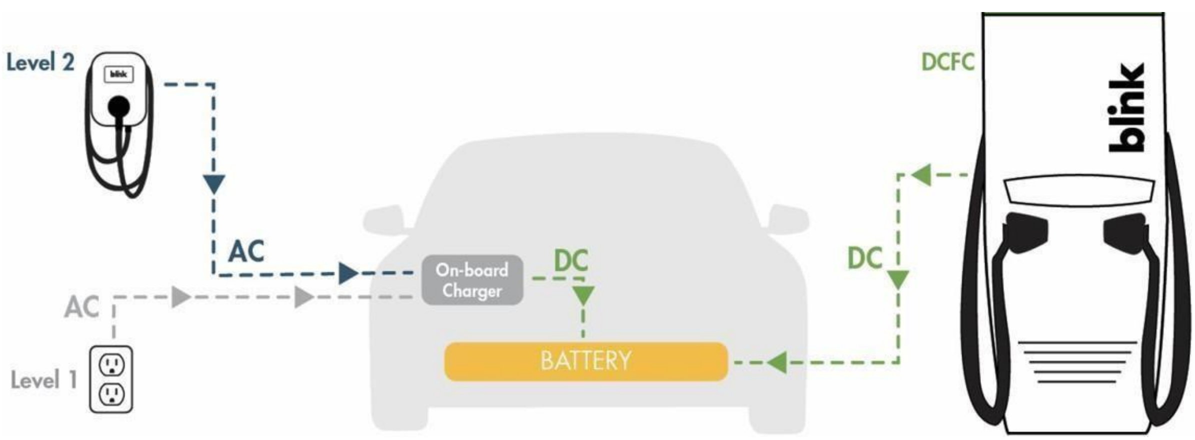


Fig 2.4 Ev car Dc to Dc charger

One of the key features of Lead Acid Battery Fast Chargers is their ability to deliver high charging currents while maintaining optimal battery health. This is achieved through intelligent charging profiles that adjust the charging parameters based on the battery's state of charge, temperature, and chemistry. By dynamically adjusting the charging parameters, these chargers can mitigate the risk of overcharging, overheating, and sulfation, which can degrade battery performance and shorten its lifespan.

Furthermore, Lead Acid Battery Fast Chargers are designed with safety in mind, incorporating built-in protections such as overcurrent protection, overvoltage protection, and short-circuit protection. These safety features help prevent damage to the batteries and ensure reliable operation, even in demanding operating environments.

In addition to their fast-charging capabilities, these chargers are also equipped with advanced monitoring and diagnostics capabilities, allowing users to track the charging process and monitor the health of the batteries in real-time. This enables proactive maintenance and troubleshooting, helping to identify potential issues before they escalate into more significant problems.

Overall, Lead Acid Battery Fast Chargers play a critical role in enabling the widespread adoption of electric vehicles powered by lead-acid batteries. By providing rapid and efficient charging solutions, these chargers help overcome one of the key barriers to electric vehicle adoption – long charging times – while ensuring the reliability and longevity of the batteries.

2.6 Model Autonomous Car:

Incorporating camera-based image processing into the system enhances the functionality of the autonomous car, enabling it to perceive and interpret its surroundings in real-time. Placing cameras at strategic locations, such as the front of the vehicle, allows for comprehensive visual data capture, which is then processed using advanced computer vision algorithms.

The camera captures visual input of the road ahead, including lane markings, traffic signs, pedestrians, and other vehicles. This raw image data is then fed into the onboard processing unit, which employs sophisticated image processing techniques to extract relevant information and make sense of the environment.

Using machine learning and computer vision algorithms, the system can identify and classify various objects and obstacles on the road, such as other vehicles, pedestrians, cyclists, and road signs. It can also detect lane boundaries, road markings, traffic lights, and other essential elements for safe navigation.

By analyzing the camera feed in real-time, the autonomous car can make informed decisions about its driving behavior, such as adjusting speed, changing lanes, yielding to pedestrians, and navigating through intersections. The integration of camera-based image processing enhances the vehicle's perception capabilities, allowing it to adapt to dynamic traffic conditions and navigate complex environments safely and efficiently.

Furthermore, combining camera-based image processing with other sensor modalities, such as LiDAR and radar, creates a robust sensor fusion system that provides redundant and complementary information about the surrounding environment. This multi-sensor approach enhances the reliability and accuracy of the autonomous driving system, enabling it to operate effectively in various weather and lighting conditions.

In summary, integrating camera-based image processing into the autonomous car's sensor suite enhances its perception capabilities, enabling it to navigate autonomously and safely in diverse driving scenarios. By leveraging advanced computer vision algorithms, the system can interpret visual cues from the road and make intelligent decisions in real-time, contributing to the realization of fully autonomous driving technology.

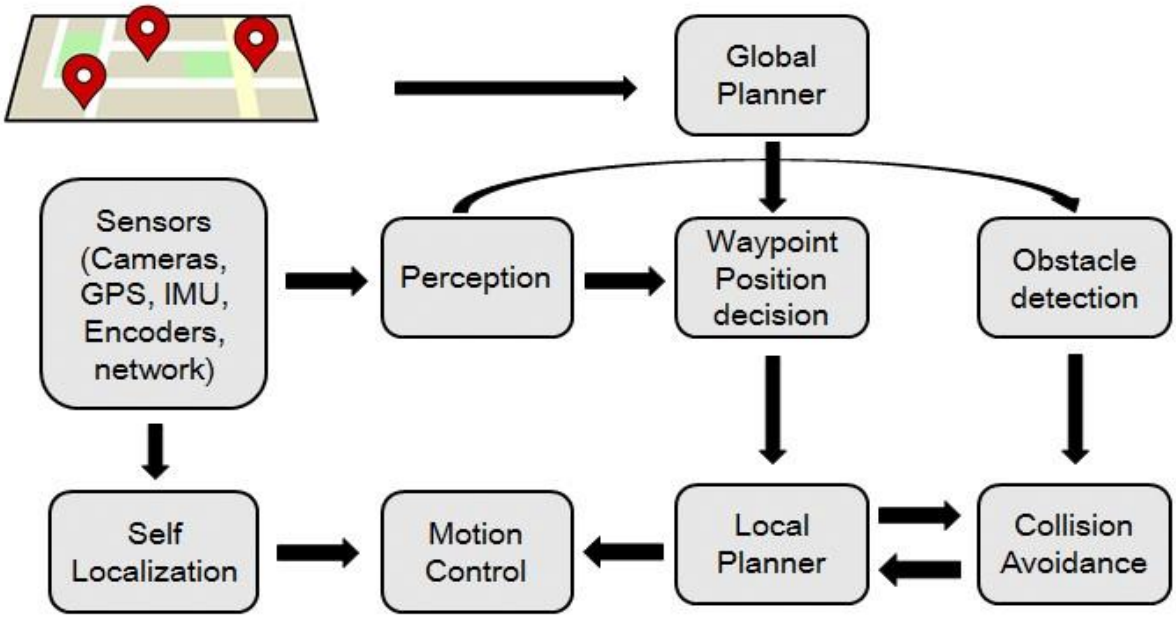


Fig 2.5 location Fetching

UNIT -3

MACHINE AND DEEP LEARNING

3.1 Introduction:

The concept of self-driving cars has been a longstanding aspiration for humanity, reflecting our desire for innovation and progress in transportation. Over the years, this vision has evolved from a distant dream to a tangible reality, with recent technological breakthroughs bringing it within reach, notably exemplified by the commercial availability of Tesla vehicles. These advancements mark a significant milestone in the journey towards autonomous driving, heralding a new era of mobility and safety on our roads.

At the heart of this technological revolution lies deep learning, a versatile and powerful tool that has revolutionized numerous fields, from physics to image classification. Within the realm of autonomous driving, deep learning algorithms, particularly convolutional neural networks (CNN), play a pivotal role in enabling vehicles to navigate and operate independently. By simulating human-like cognitive processes, CNNs empower self-driving cars with the ability to perceive, understand, and respond to their environment in real-time.

In this article, we embark on an exploration of the indispensable role played by deep learning algorithms in the development of autonomous driving technology. We delve into four key aspects: perception, localization, prediction, and decision-making, each representing crucial pillars in the architecture of self-driving systems. Through a comprehensive examination of these components, we gain insight into the intricate mechanisms driving the evolution of autonomous vehicles.

In particular, we examine how companies at the forefront of autonomous driving, such as Tesla, Waymo, and Nvidia, harness CNNs to propel innovation and shape the future of transportation. From enhancing perception through advanced sensor technologies to optimizing decision-making processes with deep reinforcement learning, these companies exemplify the transformative potential of deep learning in revolutionizing the automotive industry.

Join us as we unravel the complexities of autonomous driving and discover the groundbreaking advancements that are reshaping the way we envision transportation. Through our exploration, we aim to provide a comprehensive understanding of the role of deep learning algorithms in realizing the promise of self-driving cars and paving the way towards a safer, more efficient, and sustainable future on our roads.

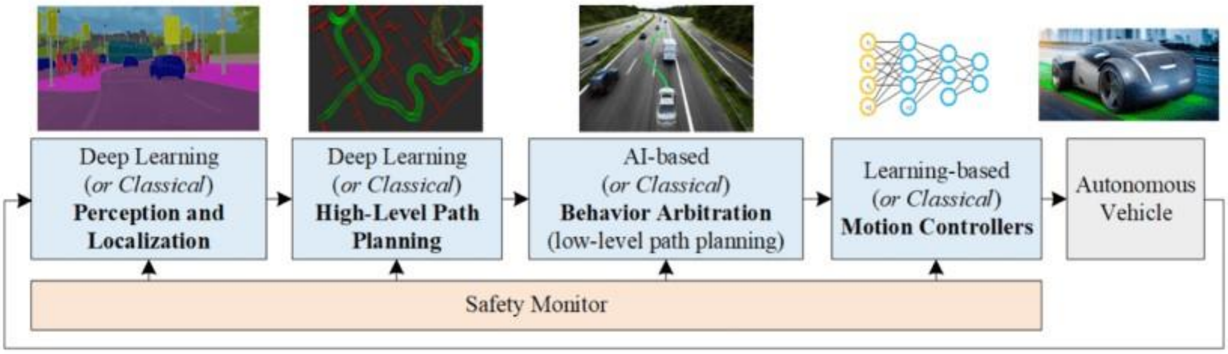


Fig 3.1 Model training process

To understand the workings of self-driving cars, we need to examine the four main parts:

1. Perception
2. Localization
3. Prediction
4. Decision Making

- High-level path planning
- Behaviour Arbitration
- Motion Controllers

3.2 Perception:

Perception serves as the bedrock of autonomous driving, granting vehicles the ability to comprehend and traverse their surroundings with precision and efficacy. Central to this capability is the integration of a diverse array of sensors, including cameras, LiDAR, and RADAR, which collectively enable self-driving cars to achieve real-time object recognition, classification, and spatial awareness.

Cameras play a pivotal role in providing visual input to autonomous vehicles, facilitating tasks such as object classification and segmentation. By capturing highresolution images of the surrounding environment, cameras enable the vehicle's perception system to identify and categorize various objects and obstacles in its vicinity. This visual information forms the foundation for making informed decisions and navigating complex road scenarios.

In addition to cameras, LiDAR (Light Detection and Ranging) technology plays a crucial role in enhancing perception by adding depth to the environment. LiDAR sensors emit laser pulses that bounce off surrounding objects, allowing the vehicle to precisely measure distances and generate detailed 3D maps of its surroundings. This depth information enables self-driving cars to accurately perceive the shape, size, and spatial relationships of objects, thereby enhancing their ability to navigate safely and avoid collisions.

Complementing the capabilities of cameras and LiDAR, RADAR (Radio Detection and Ranging) sensors utilize radio wave signals to calculate distances and detect objects in the vehicle's path. By emitting radio waves and analyzing the reflected signals, RADAR sensors provide valuable data on the position, velocity, and trajectory of objects, including vehicles, pedestrians, and obstacles. This radar-based perception further enhances the vehicle's situational awareness, especially in challenging weather conditions or low-visibility scenarios.

However, the true power of perception in autonomous driving lies not just in the individual capabilities of these sensors, but in their seamless integration and sophisticated fusion techniques. Through the use of advanced algorithms and sensor fusion strategies, self-driving cars are able to combine the rich and complementary information from cameras, LiDAR, and RADAR to create a comprehensive understanding of their environment. This multi-modal perception approach enables vehicles to overcome limitations and uncertainties inherent in any single sensor modality, ensuring robust and reliable perception capabilities critical for safe navigation in diverse driving conditions.

In essence, perception forms the cornerstone of autonomous driving, providing vehicles with the essential sensory input required to interpret and navigate their surroundings effectively. By leveraging a combination of cameras, LiDAR, RADAR, and sophisticated sensor fusion techniques, self-driving cars attain a high level of perception that is indispensable for ensuring safe, efficient, and reliable autonomous transportation.

Fig 3.2 Data collection

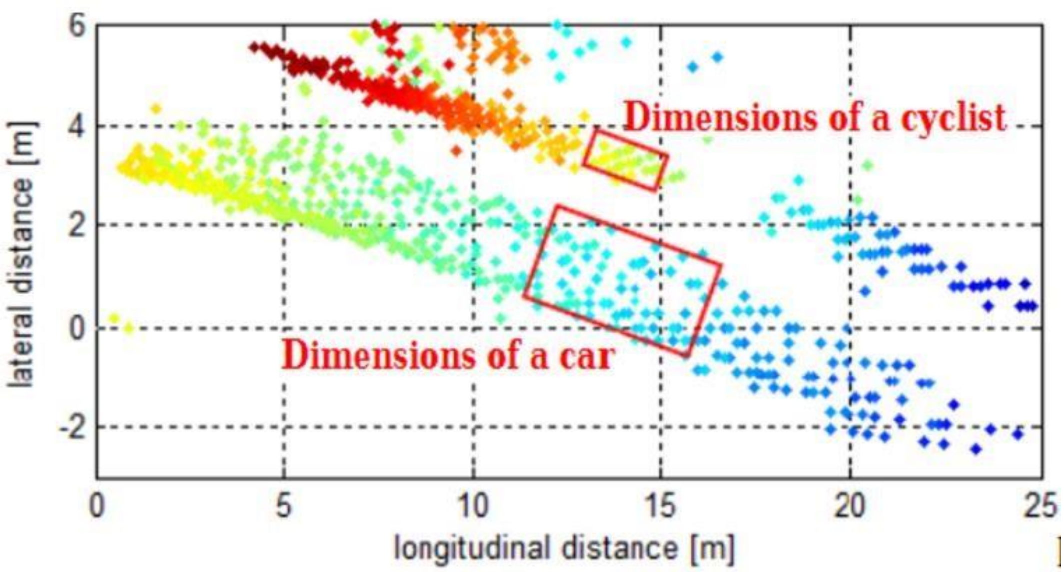


Fig 3.3 Loction graph

3.3 Localization:

Localization is a critical aspect of autonomous driving, allowing self-driving cars to accurately determine their position and orientation as they traverse complex environments. At the core of localization are sophisticated algorithms and techniques that leverage sensor data to precisely pinpoint the vehicle's location relative to its surroundings.

Visual Odometry (VO) techniques, such as Simultaneous Localization and Mapping (SLAM), represent one approach to localization that has proven highly effective in autonomous driving systems. By analyzing key points in consecutive video frames captured by onboard cameras, VO algorithms are able to track the vehicle's movement and compute its position in real-time. Through the simultaneous construction of a map of the environment and estimation of the vehicle's trajectory, SLAM algorithms enable self-driving cars to navigate with remarkable accuracy and reliability.

Furthermore, the integration of deep learning technologies has significantly enhanced the performance of localization algorithms in autonomous driving systems. Neural networks such as PoseNet and VLocNet++ utilize point cloud data from sensors like LiDAR to estimate the vehicle's 3D position and orientation with unprecedented precision. By training on vast amounts of data and learning complex patterns inherent in the sensor data, these deep learning models are able to achieve remarkable levels of accuracy in localization tasks.

The advancements in localization technology have ushered in a new era of autonomy, enabling self-driving cars to navigate with efficiency and confidence in diverse and dynamic environments. By combining the strengths of Visual Odometry, SLAM, and deep learning, autonomous vehicles are able to overcome challenges such as GPS signal loss, dynamic obstacles, and changing road conditions, ensuring safe and reliable navigation on roads around the world.

In summary, localization plays a pivotal role in the autonomy of self-driving cars, providing the crucial spatial awareness required for safe and efficient navigation.

Through the integration of advanced algorithms and deep learning techniques, autonomous vehicles are able to accurately determine their position and orientation in real-time, paving the way for a future of mobility that is safer, more accessible, and more sustainable.

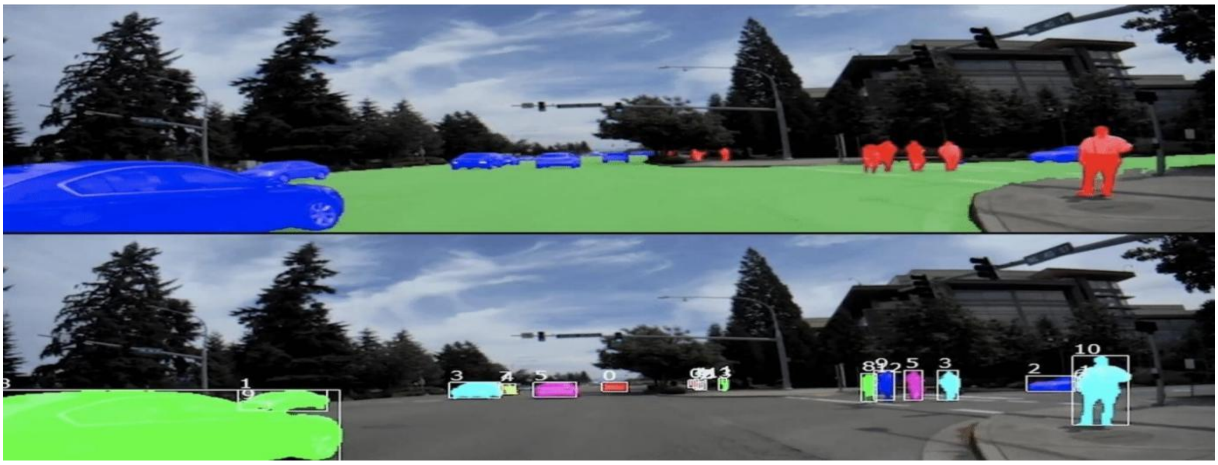


Fig 3.4 Visualization of frames

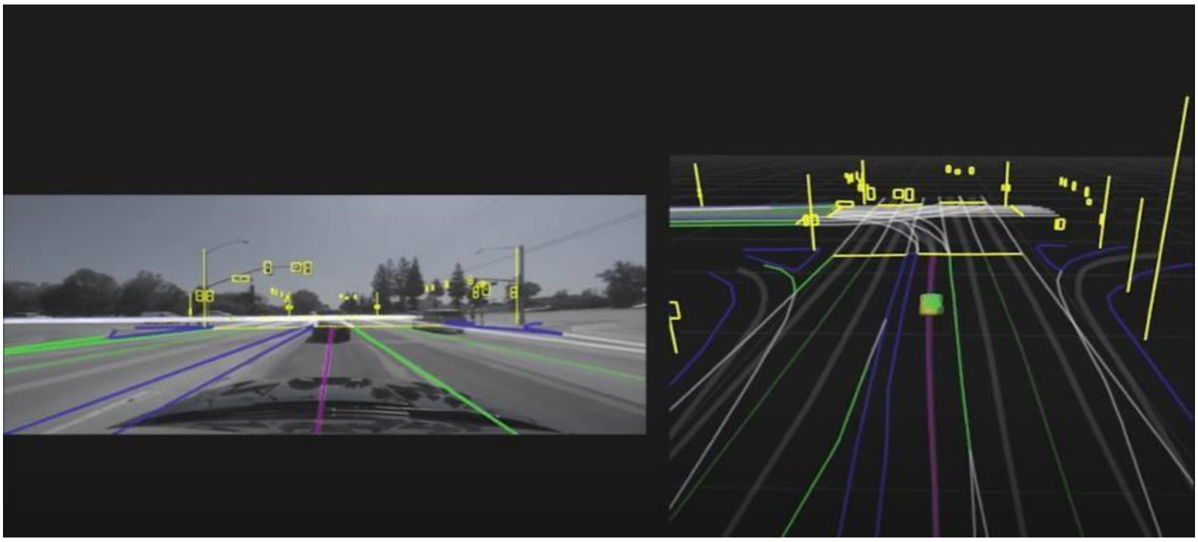


Fig 3.5 Path detection

3.4 Prediction:

Prediction is a critical aspect of autonomous driving, allowing self-driving cars to anticipate the behavior of other road users and navigate safely in complex and dynamic environments. With a comprehensive 360-degree view of the surrounding environment, autonomous vehicles are able to perceive and capture relevant information about the movements and actions of nearby objects and vehicles.

Central to the predictive capabilities of self-driving cars are advanced deep learning algorithms, which process the vast amount of sensor data collected from cameras, LiDAR, RADAR, and other sensors. By modeling complex vision tasks and analyzing various forms of data representation, these deep learning models are able to extract meaningful insights and predict the future trajectories of surrounding objects and vehicles.

Through the utilization of deep learning techniques such as convolutional neural networks (CNNs) and recurrent neural networks (RNNs), self-driving cars can effectively interpret and understand the behavior of other road users. By learning from vast datasets of real-world driving scenarios, these models are trained to recognize patterns and predict the actions of pedestrians, cyclists, vehicles, and other obstacles with remarkable accuracy.

The ability to predict the actions of surrounding objects and vehicles is crucial for enabling proactive decision-making and collision avoidance in autonomous driving systems. By anticipating potential hazards and adjusting their trajectory accordingly, self-driving cars can navigate safely and smoothly through complex traffic situations, minimizing the risk of accidents and ensuring the safety of passengers and pedestrians alike.

In summary, prediction is a fundamental component of autonomous driving technology, allowing self-driving cars to anticipate the behavior of other road users and make informed decisions in real-time. By leveraging advanced deep learning algorithms and sophisticated sensor fusion techniques, autonomous vehicles are able to navigate safely and efficiently in diverse and dynamic environments, paving the way for a future of transportation that is safer, more reliable, and more convenient for all.

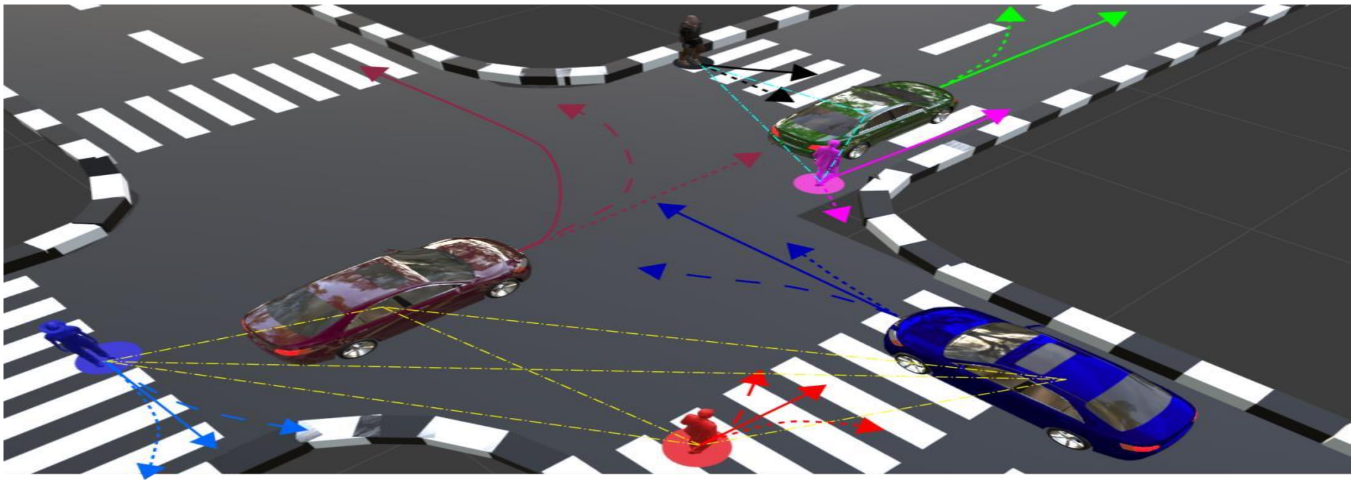


Fig 3.5 Route prediction

3.5 Decision-making:

Decision-making in self-driving cars represents a complex and dynamic process that is essential for navigating through uncertain and constantly changing environments. At the core of this process are sophisticated decision-making frameworks driven by deep reinforcement learning (DRL) algorithms, such as Markov Decision Processes (MDP), which enable autonomous vehicles to make optimal decisions based on their current states and expected rewards.

Markov Decision Processes (MDP) provide a mathematical framework for modeling decision-making problems in uncertain environments. By considering the current state of the environment and the available actions, MDP algorithms enable selfdriving cars to determine the best course of action that maximizes long-term rewards. Through iterative learning and optimization, these algorithms learn to navigate complex road scenarios and adapt to changing conditions in real-time.

Furthermore, decision-making in self-driving cars involves hierarchical components that work together to ensure safe and efficient navigation. Path planning algorithms determine the optimal route for the vehicle based on factors such as traffic conditions, road regulations, and destination preferences. Behavior arbitration mechanisms resolve conflicts and prioritize actions to ensure smooth interaction with other road users.

Motion planning algorithms orchestrate the vehicle's movements, taking into account factors such as speed, acceleration, and lane changes to execute the chosen path safely and efficiently. Finally, vehicle control systems translate the planned trajectories into precise control commands, ensuring smooth and accurate execution of driving maneuvers.

By integrating these hierarchical decision-making components with deep reinforcement learning algorithms, self-driving cars are able to navigate complex environments with confidence and reliability. Through continuous learning and adaptation, autonomous vehicles can respond effectively to dynamic road conditions and unforeseen obstacles, ensuring safe and efficient navigation for passengers and pedestrians alike.

In summary, decision-making in self-driving cars is a multifaceted process that relies on advanced algorithms and sophisticated frameworks to navigate through uncertain environments. By leveraging deep reinforcement learning techniques and hierarchical decision-making components, autonomous vehicles are able to make optimal decisions and safely navigate complex road scenarios, paving the way for a future of transportation that is safer, more efficient, and more accessible for all.

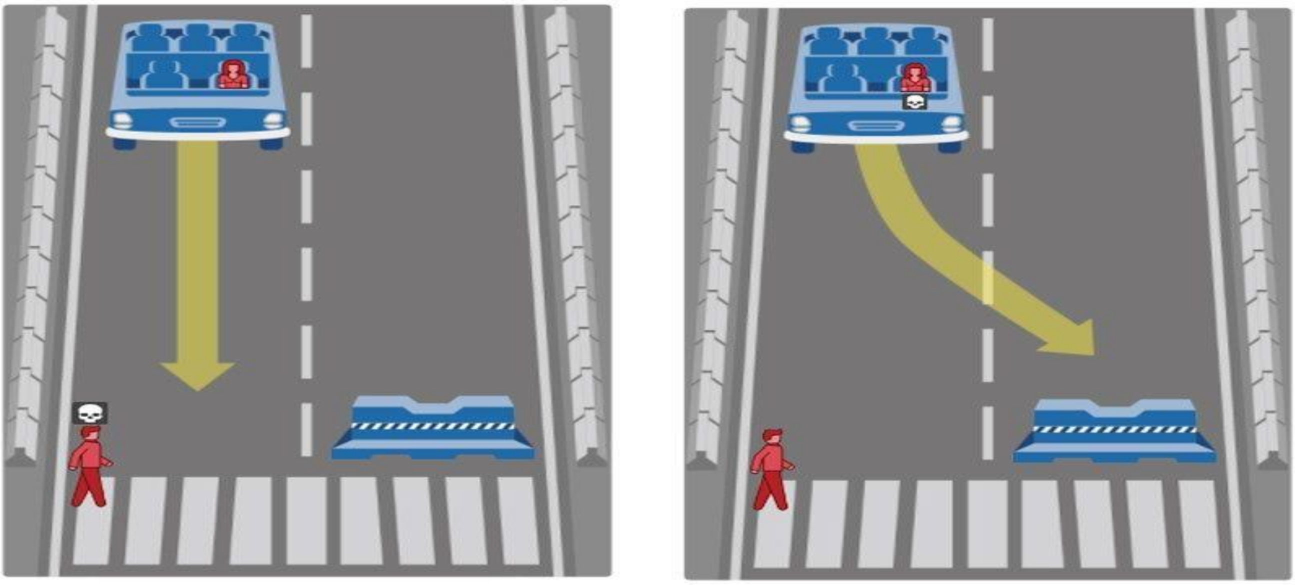


Fig 3.6 Decision-making

3.6 Convolutional Neural Networks:

Convolutional Neural Networks (CNNs) serve as a cornerstone in the realm of autonomous driving, playing a pivotal role in modeling spatial information extracted from sensor data. These sophisticated neural networks are specifically designed to process and analyze visual data, making them invaluable tools for self-driving cars in interpreting their surroundings.

One of the key strengths of CNNs lies in their ability to extract intricate features from images and capture complex patterns present in visual data. By leveraging hierarchical layers of convolutional operations and pooling, CNNs are able to identify relevant features such as edges, textures, and shapes, which are essential for recognizing and classifying objects in the environment.

In the context of autonomous driving, CNNs enable self-driving cars to accurately detect and classify various elements of the road, including vehicles, pedestrians, traffic signs, and lane markings. This capability is crucial for ensuring safe navigation and proactive decision-making on the part of the vehicle's autonomous system.

Companies like Nvidia have embraced CNNs as a fundamental component of their self-driving technology, adopting a minimalist approach that focuses on leveraging these neural networks alongside multiple cameras for comprehensive environmental awareness. By equipping vehicles with a network of cameras positioned strategically around the vehicle, Nvidia's self-driving systems are able to capture a 360-degree view of the surrounding environment, providing rich visual input for CNN-based perception algorithms.

Furthermore, Nvidia's approach to self-driving technology emphasizes end-to-end optimization and deep reinforcement learning, aiming to streamline processing steps and maximize overall system performance. Through iterative learning and optimization, CNN-based systems are able to adapt and improve over time, enhancing their ability to navigate complex road scenarios and make informed decisions in real world driving conditions.

In summary, CNNs represent a fundamental technology in the field of autonomous driving, empowering self-driving cars with the ability to interpret and understand their surroundings through visual data. By harnessing the capabilities of CNNs alongside advanced sensor technologies and deep reinforcement learning algorithms, companies like Nvidia are driving innovation in the development of autonomous vehicles, paving the way for a future of transportation that is safer, more efficient, and more accessible for all.

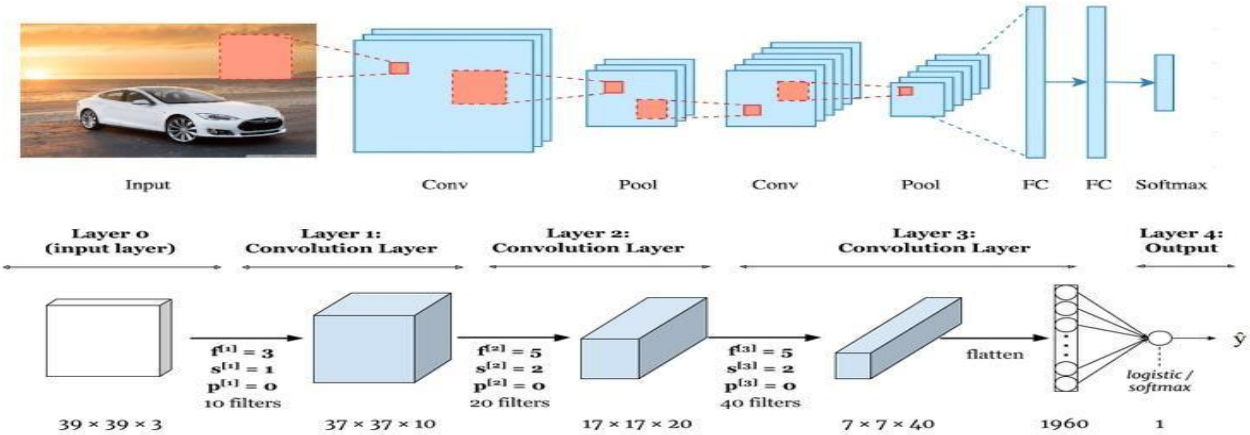


Fig 3.7 CNN Architecture

3.7 Nvidia self-driving car:

Nvidia has adopted a minimalist yet highly effective approach to self-driving technology, leveraging Convolutional Neural Networks (CNNs) as the primary algorithm for its autonomous vehicles. In contrast to Tesla, Nvidia's self-driving cars are equipped with three cameras strategically positioned—one on each side and one at the front—to provide comprehensive environmental awareness.

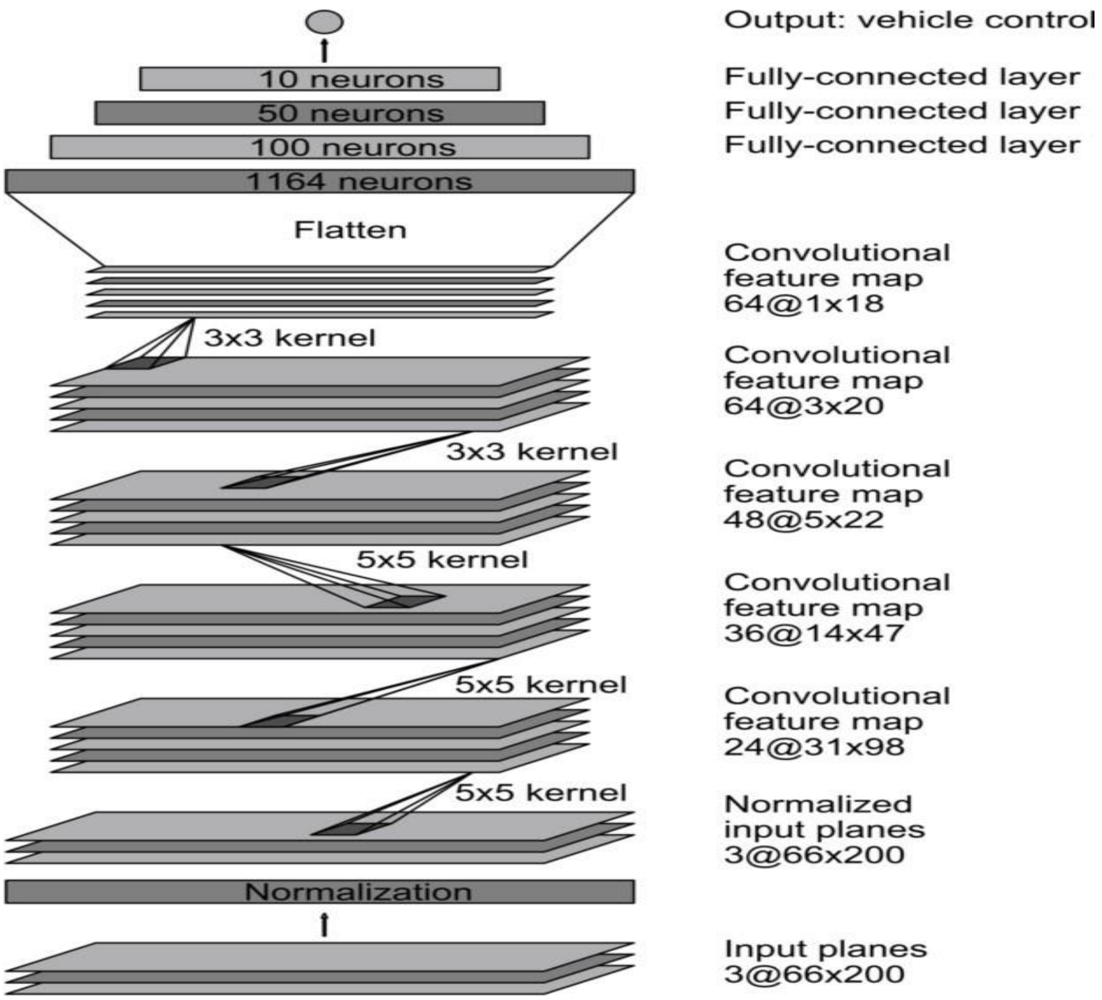
What sets Nvidia's approach apart is its ability to operate in environments where traditional lane markings may be absent, such as parking lots or less structured roadways. The network powering Nvidia's self-driving cars is capable of learning features and representations essential for detecting crucial road features, even in challenging conditions.

A key advantage of Nvidia's end-to-end system is its optimization of all processing steps simultaneously, rather than relying on explicit decomposition of the problem into separate tasks like lane marking detection, path planning, and control. By optimizing processing steps holistically, Nvidia's self-driving system achieves superior performance through internal components that self-optimize to maximize overall system efficiency.

This approach contrasts with traditional methods that rely on human-selected intermediate criteria, such as lane detection, which may not always align with maximizing system performance. By allowing the system to learn and adapt autonomously, Nvidia's self-driving technology can achieve better performance while utilizing smaller networks that require fewer processing steps.

In essence, Nvidia's minimalist approach to self-driving technology represents a paradigm shift in autonomous vehicle development. By harnessing the power of CNNs and optimizing processing steps holistically, Nvidia is paving the way for more efficient, adaptable, and reliable self-driving systems that can operate effectively in diverse real-world environments.

In the evolving landscape of transportation, the integration of mechanical hardware continues to drive innovation, shaping the future of autonomous vehicles. The mechanical frame, or chassis, serves as the structural backbone of the vehicle, providing support for all components. It is engineered for strength and durability, with advanced materials and manufacturing techniques ensuring safety in various driving conditions.



3.8 Layer processing

The development of fully autonomous driving represents a significant technological advancement with the potential to revolutionize transportation. While considerable progress has been achieved, challenges persist, including the optimization of algorithms for diverse road conditions, enhancement of sensing modalities, and improvement of human-machine interaction. Nonetheless, the remarkable strides in self-driving technology highlight its transformative impact on road safety, efficiency, and mobility. With ongoing collaboration and innovation, self-driving systems will continue to evolve to meet the demands of an ever-changing automotive landscape, ushering in a new era of safe, robust, and revolutionary transportation.

Fig 3.9 Dashboard Veiw

3.8 Output Layer:

The output layer produces the final output of the CNN, which depends on the specific task the network is trained to perform. For tasks such as image classification, the output layer typically consists of multiple nodes, each corresponding to a different class label. The output values are often passed through a softmax function to convert them into probabilities, indicating the likelihood of each class.

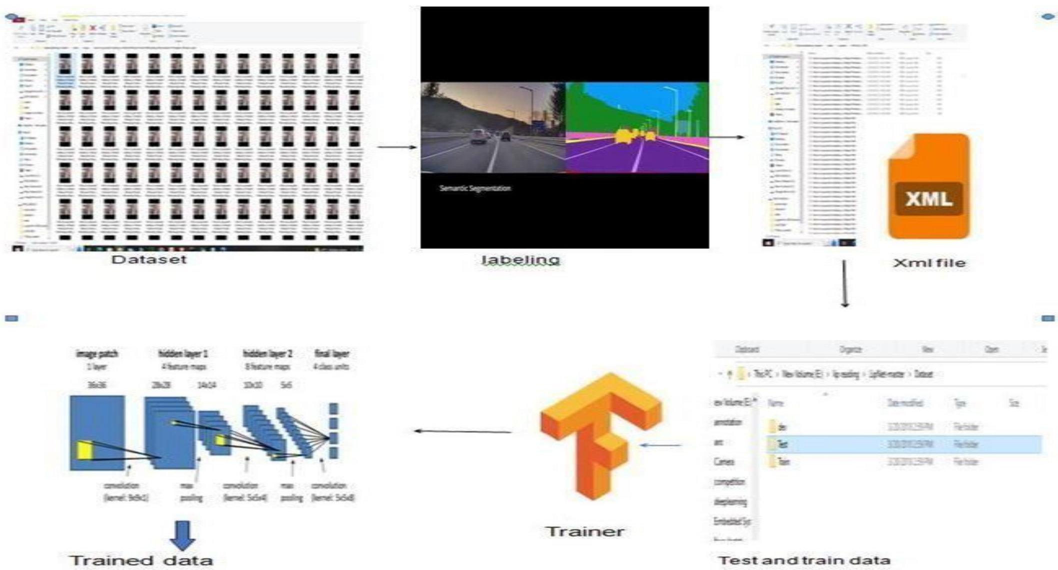


Fig 3.10 Data Set Training

Unit-4

HARDWARECOMPONENTSOFAUTONOMOUSVEHICLE

4.1 MECHANICALHARDWARE:

Autonomous vehicles rely on a sophisticated blend of mechanical hardware to operate safely and efficiently. Actuators, such as servo motors and linear actuators, are instrumental in translating electronic signals into physical motion. Servo motors control steering, ensuring precise navigation, while linear actuators manage throttle and brake inputs, regulating speed and stopping the vehicle when needed. Electric motors, particularly Brushless DC (BLDC) motors, provide propulsion, delivering power to drive the vehicle forward. These actuators work in harmony to enable smooth and responsive movement.

The mechanical frame, or chassis, serves as the structural backbone of the vehicle, providing support for all components. It is engineered for strength and durability, with advanced materials and manufacturing techniques ensuring safety in various driving conditions. Complementing the chassis is the suspension system, which connects the wheels to the frame and absorbs shocks from the road .Springs and dampers work to gether to provide a comfortable ride while maintaining stability and control.

Together, these mechanical components form the foundation of autonomous vehicle technology, enabling safe and reliable operation. Actuators allow for precise control and maneuverability, essential for navigating complex environments. The chassis provides a stable platform for mounting sensors and electronic systems, while the suspension system enhances ride quality and vehicle dynamics. In the evolving landscape of transportation, the integration of mechanical hardware continues to drive innovation, shaping the future of autonomous vehicles.

Fig 4.1 Chase work

4.2 Actuator:

Actuators are essential components in our autonomous vehicle project, serving as the mechanical agents responsible for translating electronic commands into physical motion. In our project, we utilize linear actuators to enable precise control and functionality within various subsystems of the vehicle.

Linear actuators operate on the principle of converting rotary motion into linear motion, allowing them to push, pull, lift, or position objects along a straight pathwith accuracy and reliability.These actuators are equipped with motors that generate rotational motion,which is then translated into linear motion through mechanisms such as lead screws or belt drives.

In our project,linear actuators play a vital role in controlling throttle and brake inputs, regulating the vehicle's speed and stopping power with precision. By integrating linear actuators into these systems, we can achieve smooth and responsive modulation of vehicle acceleration and deceleration, ensuring safe and efficient operation on the road.

Additionally, linear actuators are utilized in steering mechanisms to enable autonomous steering control. By incorporating linear actuators into the steering system, we can adjust the vehicle's direction autonomously based on sensor inputs and navigation algorithms. This functionality is crucial for navigating complex environments and executing precise maneuvers with confidence and reliability.

Furthermore, linear actuators contribute to the overall performance and functionality of our autonomous vehicle by providing reliable and precise linear motion capabilities. Their versatility and adaptability make them ideal for a wide range of applications, allowing us to tailor their usage to meet the specific requirements of our project.

Fig 4.2 Actuator

4.3 ELECTRICAL HARDWARE:

In our autonomous vehicle project, an array of electrical hardware components is meticulously selected to empower diverse functionalities and operations. At the core of our system lies the Raspberry Pi 4 Model B with 4GB of RAM, serving as the central processing unit and the brain of the vehicle. The Raspberry Pi harnesses significant computational power, enabling the execution of complex algorithms, processing sensor data, and making real-time decisions imperative for autonomous driving. In addition to the Raspberry Pi, Arduino microcontrollers are strategically employed to interface with sensors, actuators, and other peripherals. These microcontrollers play a pivotal role in integrating hardware components and executing precise control logic for tasks such as steering, throttle modulation, and braking.

To augment the vehicle's perception capabilities, a camera module is seamlessly integrated into the system, capturing comprehensive visual data from the vehicle's surroundings. This camera module serves as the eyes of the autonomous vehicle, providing vital inputs for object detection, lane tracking, and obstacle avoidance algorithms, thereby enhancing situational awareness and navigation capabilities.

Furthermore, a touch panel interface is thoughtfully incorporated into the vehicle's dashboard, offering an intuitive and user-friendly interaction platform with the autonomous driving system. The touch panel interface empowers users to input destination coordinates, select driving modes, and monitor vehicle status and diagnostics in real-time, enhancing the overall user experience.

Collectively, these meticulously selected electrical hardware components form the robust backbone of our autonomous vehicle platform, enabling intelligent decisionmaking, precise control, and a seamless user experience across a wide range of driving scenarios.

4.4 Raspberry Pi Module:

The Raspberry Pi 5 is not merely a standalone computer but a versatile and highly customizable single-board computer system. Unlike traditional desktop computers, the Pi 5 consolidates essential components like the CPU, RAM, and graphics onto a single circuit board, facilitating compact and efficient design. However, its true power lies in its expandability and flexibility.

At the heart of the Pi 5 lies a potent 2.4 GHz quad-core, 64-bit Arm Cortex-A76 CPU, capable of effortlessly handling everyday tasks and even accommodating light programming projects. This processing prowess is complemented by either 4GB or 8GB of LPDDR4X RAM, offering ample capacity to multitask smoothly and efficiently. While not strictly modular, the RAM options provide users with the flexibility to tailor the computing experience to their specific requirements.

Storage on the Pi 5 is accommodated through a Micro-SD card slot, offering unparalleled flexibility. Users can select the appropriate card size and speed based on their needs, whether it's for basic operating system storage or extensive media archives.

The Pi 5's connectivity options are where its true magic unfolds. Dual HDMI ports allow for stunning 4Kp60 visuals on two displays simultaneously, making it ideal for multimedia applications. Built-in Wi-Fi and Gigabit Ethernet ensure seamless internet connectivity, making the Pi 5 well-suited for projects requiring online access and network connectivity.

Fig 4.3 Raspberry pi 5 Module

4.5 Arduino Module:

The Arduino Uno module stands as a cornerstone of our autonomous vehicle project, offering unparalleled versatility, reliability, and ease of integration. Renowned for its compact form factor and robust features, the Arduino Uno serves as a vital component for interfacing with sensors, actuators, and other peripherals essential to the vehicle system.

Powered by the Atmega328 micro-controller, the Arduino Uno provides a flexible platform for executing control logic, processing sensor data, and interfacing with external devices. Its extensive array of digital and analog input/output pins enables seamless integration with a diverse range of sensors, including ultrasonic sensors for precise distance measurement, gyroscopes for accurate orientation sensing, and encoders for monitoring wheel speed.

Within our project, the Arduino Uno assumes a pivotal role in orchestrating and managing various subsystems of the autonomous vehicle. From regulating throttle and brake control via linear actuators to dynamically adjusting steering angles based on real-time sensor inputs, the Arduino Uno serves as the nerve center, ensuring smooth operation and precise control.

Furthermore, the Arduino Uno boasts real-time processing capabilities, guaranteeing swift execution of control algorithms and rapid responses to dynamic environmental conditions. Its straightforward design and dependable performance make it an ideal choice for executing critical tasks necessitating high precision and accuracy, such as maintaining vehicle stability, navigating obstacles, and executing complex autonomous driving maneuvers.

Beyond its technical prowess, the Arduino Uno's open-source nature and extensive community support foster a collaborative ecosystem of developers, enthusiasts, and professionals. This vibrant community provides a wealth of resources, libraries, and tutorials, empowering individuals to expedite development, troubleshoot issues, and explore new frontiers in autonomous vehicle technology. Such accessibility not only accelerates innovation but also encourages knowledge sharing and collaboration, propelling the advancement of autonomous vehicle technology into the future.

Fig 4.4 Arduino Module

4.6 Camera Module:

For our autonomous vehicle project, we require a camera module with specific specifications tailored to our needs. The camera should feature a high resolution, ideally above 1080p (1920 x 1080 pixels), to ensure detailed image capture for accurate perception and object recognition. Additionally, a high frame rate of at least 30 frames per second (fps) is desirable for capturing fast-moving objects and enabling smooth video footage in real-time applications. A wide field of view (FOV), preferably at least 120 degrees horizontal, is essential to provide comprehensive coverage of the vehicle's surroundings and minimizeblind spots. Excellent low-light performance is crucial for visibility in challenging lighting conditions, such as nighttime driving or low-visibility environments. Moreover, a wide dynamic range (WDR) is necessary to capture details in both bright and dark areas of the scene, maintaining image clarity and contrast.

The camera module should feature a compatibleinterface, suchasUSB,MIPICSI2orEthernet,forseamlessintegrationwiththe vehicle's onboard computer system. Furthermore, compatibility with various mounting options is essential for flexible placement and optimal positioning within the vehicle's architecture.

Overall, a camera module meeting these specifications would provide the necessary capabilities for visual perception, object recognition, and environment sensing, enabling safe and efficient navigation in diverse driving scenarios.

4.5 Camera Module

4.7 Touch Panel:

The touch panel integrated into our autonomous vehicle project features a spacious 10- inch diagonal screen size, offering users an expansive and immersive interface for interacting with the vehicle's systems and functionalities. This generous size ensures that users have ample space to view maps, access menus, and control various vehicle functions without feeling constrained by limited screen real estate. Whether navigating through complex menus or interacting with detailed maps, the 10-inch touch panel provides a comfortable and intuitive user experience.

Further more, the touch panel boastsa high-resolution display, typically with a resolution of at least 800 x 480 pixels or higher. This ensures that graphics and text are rendered with crispness and clarity, enhancing visibility and readability for users. Whether displaying intricate maps with fine details or presenting informative menus with legible text, the high- resolution display ensures that users can easily discern information at a glance.

In terms of touch sensitivity, the touch panel utilizes advanced capacitive touchscreen technology. This technology enables responsive and accurate touch input detection, allowing users to interact with the interface effortlessly through gestures such as tapping, swiping, and pinching. Whether selecting menu options, zooming in on maps, or scrolling through lists, users can expect smooth and precise touch responses from the 10-inch touch panel.

Additionally, the touch panel may feature advanced functionalities such as multi touch support and gesture recognition. Multi-touch support enables users to perform simultaneous touch gestures, such as pinch-to-zoom or two-finger scrolling, enhancing navigation and interaction capabilities. Gesture recognition technology allows users to execute commands and actions through intuitive hand gestures, further streamlining the user experience and reducing the need for manual input.

Fig 4.6 Touch Panel

4.8 SENSOR MODULE:

1.Proximity Sensor:

In our autonomous vehicle project, the HC-SR04 Ultrasonic Sensor serves as a critical component for ensuring the safety and efficiency of our vehicle's navigation system. This sensor operates based on ultrasonic technology, emitting high-frequency sound waves and measuring the time it takes for the waves to bounce off nearby objects and return to the sensor. By analyzing these time-of-flight measurements, the sensor can accurately determine the distance between the vehicle and surrounding obstacles.

One of the key advantages of the HC-SR04 sensor is its impressive detection range, whichspans fromapproximately2centimetersto4meters. This wide range allows the sensor to detect objects both in close proximity to the vehicle and at a distance, enabling comprehensive coverage of the vehicle's surroundings. Whether navigating through tight spaces or traveling at higher speeds, the HC-SR04 sensor provides reliable obstacle detection capabilities to help the vehicle navigate safely and efficiently.

Furthermore, the HC-SR04 sensor features a wide detection angle of around 15 degrees, providing a broad field of view that minimizes blind spots and ensures thorough coverage of the environment. This wide-angle detection capability enhances the vehicle's situational awareness, allowing it to detect obstacles from multiple directions and make informed decisions about navigation and maneuvering.

In terms of integration, the HC-SR04 sensor interfaces seamlessly with our vehicle's onboard computer system. Its simple digital interface makes it compatible with popular micro-controllers such as Arduino and Raspberry Pi, allowing for easy integration into our vehicle's sensor suite. Additionally, the sensor's compact size and low power consumption make it well-suited for installation in the vehicle without imposing significant weight or power requirements.

Overall, the HC-SR04 Ultrasonic Sensor is a versatile and reliable solution for obstacle detection in our autonomous vehicle project. With its wide detection range, broad field of view, and seamless integration capabilities,this sensor playsavital role in ensuring hesafety and efficiency of our vehicle's navigation system in diverse driving environments.

Fig 4.6 ProximitySensor

2.LiDAR sensor:

The LiDAR (Light Detection and Ranging) sensor serves as a cornerstone of our environmental perception system, offering precise and detailed 3D mapping of the vehicle's surroundings. With a range spanning several tens to hundreds of meters, the LiDAR sensor detects objects at considerable distances, providing essential data for obstacle detection, localization, and path planning. Its wide field of view, typically ranging from 90 to 360 degrees horizontally and 30 to 40 degrees vertically, ensures comprehensive coverage of the environment, minimizing blind spots and enabling thorough environmental perception. Moreover, the sensor delivers high-resolution 3D point cloud maps with sub-centimeter accuracy in distance measurements, facilitating

Fig 4.8 LiDAR Sensor

precise object detection and ranging. Operating at scan rates ranging from a few thousand to millions of pulses per second, the LiDAR sensor rapidly scans the environment, capturing detailed information about the surroundings in real time. Despite its advanced capabilities, the LiDAR sensor is available in various form factors, ranging from compact, lightweight units suitable for integration into vehicles to larger, more robust units for industrial applications. By leveraging thespecifications and capabilities of the LiDAR sensor, our autonomous vehicle can navigate complex environments safely and reliably, detecting obstacles, localizing itself within its surroundings, and planning optimal paths for navigation

4.9 CONTROLLER:

The DC-to-DC converter controller serves as a vital component responsible for managing thepowerdistribution within thevehicle's electrical system. Thiscontroller plays a crucial role in converting the high-voltage DC power from the vehicle's main battery orpower source to the lower-voltage DC power required to operate various electronic systems and components within the vehicle.

One of the primary functions of the DC-to-DC converter controller is to regulate the voltage outputtoensurethatitremainswithin the acceptableoperatingrangeforthe vehicle's electrical components. This is essential for preventing damage to sensitive electronics and ensuring reliable performance of critical systems such as the vehicle's onboard computer, sensors, actuators, and communication modules.

Moreover, the DC-to-DC converter controller may incorporate features such as over- voltage protection, under-voltage protection, and short-circuit protection to safeguard against potential electrical faults or anomalies. These protection mechanisms help to prevent damage to the vehicle's electrical system and ensure the safety of both the vehicle and its occupants.

Additionally, the DC-to-DC converter controller may include efficiency optimization algorithms to maximize the efficiency of the power conversion process. By minimizing energy losses during conversion, these algorithms help to optimize the vehicle's energy usage and extend its operating range on a single charge.

Furthermore, the DC-to-DC converter controller may support various power management modes to adapt to different driving conditions and power requirements. For example, it may dynamically adjust the voltage output based on the load demand or switch between different voltage levels to meet the needs of different electrical subsystems.

The controller is a 24-tube sine wave type controller. The controller in an electric car is to manage the flow of electrical energy from the battery to the motor, ensuring efficient use of the battery's energy and controlling the motor's speed and torque.The controller used for the controlling operation of the electric car. It provides controlling operations like forward motoring, reverse motoring.The DC-TO-DC converter is built in with the controller unit.

This controller is sealed type unit.

Fig4.9 ControllerDC-DCConverter

Unit-5

Conclusion

5.1 Output and Performance:

Our project focusing on the development of an autonomous self-driving car represents a remarkable advancement in the landscape of modern transportation. By opting for iron rods in constructing both the chassis and body of the vehicle, we emphasize our dedication to durability and structural robustness. This choice not only enhances the overall safety of the vehicle but also ensures the protection of passengers and pedestrians alike in various driving conditions and scenarios. The utilization of the Google Maps API for route planning and navigation further amplifies the efficiency and reliability of our autonomous vehicle. This integration empowers our car to embark on journeys from point A to point B with unparalleled precision and accuracy. Leveraging the vast database and real-time updates provided by Google Maps, our vehicle can navigate through complex road networks, adapt to traffic conditions, and calculate optimal routes swiftly and seamlessly.

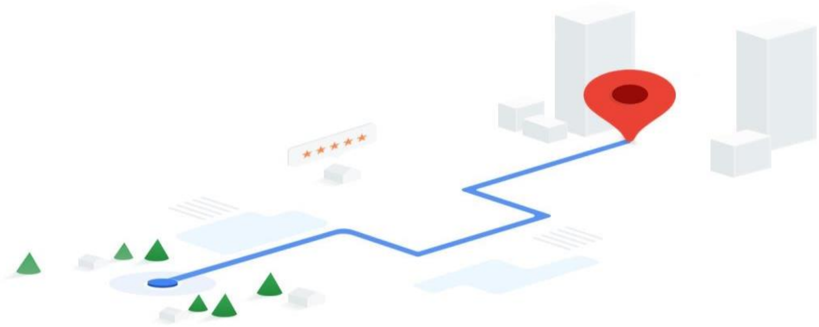


Fig 5.1 Google Map API

Moreover, by harnessing the power of the Google Maps API, our autonomous car gains access to a plethora of features and functionalities that streamline the navigation process. From identifying the shortest and fastest routes to avoiding congestion and road closures, our vehicle leverages the wealth of data provided by Google Maps to optimize its journey and ensure timely arrivals at destinations.

Overall, the incorporation of iron rods for structural integrity and the integration of the Google Maps API for route planning and navigation collectively elevate the capabilities and performance of our autonomous self-driving car. This combination of robust construction materials and cutting-edge technology underscores our commitment to safety, reliability, and innovation in modern transportation solutions.

Fig 5.2 Model Output

The integration of the Google Maps API into our autonomous vehicle's navigation system represents a pivotal advancement in enhancing its efficiency and reliability. By tapping into the extensive database and real-time updates offered by Google Maps, our car is equipped to embark on journeys from point A to point B with unparalleled precision and accuracy.

Through the Google Maps API, our autonomous vehicle gains access to a wealth of geographic information, including detailed maps, traffic patterns, and points of interest. This comprehensive dataset enables our car to navigate through intricate road networks, adapt to changing traffic conditions, and calculate optimal routes swiftly and seamlessly.

One of the key advantages of leveraging the Google Maps API is its ability to provide real-time updates on traffic congestion, accidents, and road closures. By continuously monitoring these factors, our autonomous car can dynamically adjust its route to avoid delays and obstacles, ensuring smooth and efficient travel for passengers.

Furthermore, the Google Maps API offers a range of features and functionalities that streamline the navigation process. Our vehicle can identify the shortest and fastest routes to its destination, taking into account factors such as distance, traffic flow, and road conditions. Additionally, the API enables our car to incorporate user preferences, such as avoiding toll roads or highways, into its route planning algorithms.

Overall, the integration of the Google Maps API empowers our autonomous vehicle with the intelligence and adaptability needed to navigate complex urban environments with ease. By harnessing the power of real-time data and advanced mapping technologies, our car ensures timely arrivals and enhances the overall passenger experience.

Appendix:

Specification:

1.Motor Type: BLDC Hub Motor with Permanent Magnets

2. Motor design: Double axle output with 10-inch rim

3. Rim size and material: 2.15-10 Iron rim

4. Matching Tire: 3.0-10, 3.5-10

5. Magnet Height: 35mm

6. Pole Pairs: 23 pairs

7. Rated Power: 1200W

8. Max Power: 2000W

9. Rated Voltage: 72V

10. Speed: 45-50 km/hr

11. Max No-load RPM: 620-650 RPM

12. Max Torque: SON M (Please provide the correct value)

13. Max Efficiency: 89-90%

14. Rated current: 234A (Please specify the unit)

15. Max current: 4A (Please specify the unit)

16. Brake type: Drum brake

17. Rear Fork with for installation: 200mm (Please specify the unit)

18. Cross Section of Phase wire: 32 (Please specify the unit)

19. Axle Thread: M12 (Please specify the correct term)

20. Hall sensor phasing angle: 123 degrees

21. Type of Sensor :3pc

Coding:

```
from datetime import datetime
import html
import re
import googlemaps

def get_formatted_directions(api_key, start_lat_long, end_lat_long):
# Define a nested function to replace direction phrases
def replace_direction(instruction):
# Replace specific direction phrases
if "head west" in instruction.lower() or "head east" in instruction.lower() \
or "head south" in instruction.lower() or "head north" in instruction.lower():
return "Go straight"
else:
return instruction

# Define a nested function to clean HTML tags
def clean_html(raw_html):
# Remove HTML tags
clean_text = re.sub('<.*?>', ", raw_html)
```

```
return clean_text

# Initialize the Google Maps client
gmaps = googlemaps.Client(key=api_key)

# Request directions
directions_result = gmaps.directions(start_lat_long,
end_lat_long,
mode="walking",
departure_time=datetime.now())

# Extract steps
steps = directions_result[0]['legs'][0]['steps']

# Parse and clean the steps
formatted_directions = [
{"instruction": '
'.join(clean_html(html.unescape(step['html_instructions'])).split()[:2]),
"distance": step['distance']['text'].split()[0]}
for step in steps
]

# Replace directions
formatted_directions = [{"instruction": replace_direction(step["instruction"]),
"distance": step["distance"]} for
step in formatted_directions]

return formatted_directions

# Replace with your API key, start and end coordinates
api_key = "AIzaSyC8CiFxInsH6F_NKbCJuNIX9_aWca3AISs"
start_lat_long = "13.050884229166712, 80.0765312947763"
end_lat_long = "13.051018232680292, 80.07485376051997"
```

```
# Get formatted directions using the single function
formatted_directions = get_formatted_directions(api_key, start_lat_long, end_lat_long)

# Print the formatted_directions variable to verify the contents
print(formatted_directions)
```