ZAGAZIG UNIVERSITY
FACULTY OF ENGINEERING
MECHATRONICS DEPARTMENT

Modified And Creative Features For Advanced Driver-Assistance System (ADAS)

Graduation Project 2024

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Acknowledgment

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Abstract

Advanced driver-assistance systems (ADAS) are one of the fastest-growing safety application areas due to the desire to reduce vehicular accidents and fatalities. Beyond passive safety systems, active safety systems play a major role in reducing traffic fatalities and the monetary impact of vehicular accidents. ADAS systems include long- and medium-range radar and vision systems. Developing an ADAS system requires state-of-the-art yet cost-effective RF technology that can be embedded in the vehicle for exterior object detection and classification. A state-of-the-art radar system can tell a vehicle from a pedestrian, from a wall, and know the location and potential corrective path. Extraordinary computation power is needed to make the system efficient, but to become more prevalent in the marketplace the cost must be very low.

Active safety systems include adaptive cruise control (ACC) and collision-warning systems with automatic steering and braking intervention. In a collision-warning system, a microcontroller-controlled 77 GHz transmitter emits signals reflected from objects ahead, to the side and to the rear of the vehicle, which are captured by multiple receivers integrated throughout the vehicle. Using a high-performance 32-bit single- or dual-core microcontroller with embedded flash and RAM, the radar system can detect and track objects in the frequency domain, triggering a driver warning of an imminent collision and initiating ESC emergency intervention.

Camera systems in ADAS can display what is behind or beside the vehicle, even at night on screen. They can also analyze the video content for automatic lane-departure warning systems and high/low-beam headlight control. An image sensor interface provides incoming video frames to a single- or dual-core architecture optimized with DSP extensions for image improvement filtering and edge or spot detection. Additional system requirements include an appropriate communication interface, an integrated DRAM interface for fast access to external memory and embedded flash for low system cost.

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Chapter 1: Introduction

1.1. Executive Summary

Our project centers on advancing safety features for electric vehicles through an integrated Advanced Driver Assistance System (ADAS). Key components include Adaptive Cruise Control, Traffic Sign Recognition, and a Driver Monitoring System, all tailored to the specific needs of electric cars. These systems enhance energy efficiency, intelligent driving decisions, and driver awareness.

An Internal Hydraulic wheel jack is introduced to address emergency scenarios, providing a unique solution for the safe removal of damaged tires in electric vehicles. This innovation contributes not only to overall vehicle safety but also addresses the specific challenges posed by electric cars.

At the revolution of electric vehicle (EV), our project takes a pioneering approach by not only developing an electric car but also by the integration of a comprehensive safety solution rooted in Advanced Driver Assistance Systems (ADAS).

Our team, driven by a mission to reduce accidents and elevate road safety, has meticulously crafted an electric vehicle with advanced features, including Adaptive Cruise Control, Traffic Sign Recognition, and a Driver Monitoring System each tailored to the unique dynamics of our bespoke EV.

Beyond conventional safety measures, our project introduces a creative Internal Hydraulic wheel jack, enhancing emergency response by facilitating the easy removal of damaged tires. This innovation not only addresses the distinct challenges faced by EVs but also contributes to the broader goal of promoting safety on the roads.

So, we redefine safety standards for electric vehicles. Our project not only showcases the potential of a fully developed electric car but also emphasizes our commitment to a future where accidents are minimized, and roadways become safer for all, underlined by the expertise of building our own electric vehicle.

1.2.Main Features

1.2.1.Electric Vehicle (EV)

We'll create a remarkable electric car with advanced safety features, shaping the future of sustainable transportation. Our project revolves around the transformative integration of electric vehicles (EVs), redefining the future of driving. Emphasizing sustainability and efficiency, EVs serve as the cornerstone of our innovation. By moving away from traditional fuel sources, we not only mitigate environmental impact but also address key challenges in the automotive industry. This introduction sets the stage for a journey into our Advanced Driver Assistance System (ADAS), where electric mobility becomes the driving force for a cleaner, greener, and technologically advanced transportation experience.

1.2.2 Adaptive Cruise Control (ACC)

Adaptive Cruise Control is an advanced driver assistance system (ADAS) designed to enhance vehicle safety and convenience. Unlike traditional cruise control, which maintains a constant speed set by the driver, ACC uses Camera to monitor the distance and relative speed of the vehicle ahead. It automatically adjusts the vehicle's speed to maintain a safe following distance, even in changing traffic conditions

1.2.3.Traffic Sign Recognition (TSR)

Traffic Sign Recognition (TSR) is a crucial feature of ADAS that contributes to safer and more efficient driving by detecting and interpreting traffic signs. Traffic Sign Recognition is a key component of ADAS due to its potential to Improve Safety, Enhance Traffic Flow and Increase Comfort and Convenience.

1.2.4 Internal Hydraulic wheel jack

The idea of Internal Hydraulic wheel jack is to balance the car on three wheels using hydraulic cylinders subjected under each of the four tires of the car. This allows the customer to easily removal of the broken tire and replaces it with the new one. This totally new feature will be a good replacement of the normal jack.

1.2.5.Driver monitoring system

The driver monitoring system is a new sensor-based technology to track driver alertness. The system not only recognizes the driver, it also checks his or her level of heart pulse in order to increase safety for passengers and other road user

1.3. Problem Statements and Project Goal

1.3.1 Addressing Automotive Challenges with Electric Vehicles:

Electric vehicles (EVs) offer a compelling solution to diverse automotive challenges. By significantly reducing greenhouse gas emissions, enhancing energy efficiency, and promoting renewable energy adoption, EVs address environmental concerns and contribute to a sustainable energy landscape. Furthermore, their quiet operation counters noise pollution, fostering quieter and more tranquil urban spaces.

1.3.2. Adaptive Cruise Control in Complex Traffic:

While Adaptive Cruise Control (ACC) has proven effective in standard traffic conditions, its performance in more complex and unpredictable scenarios, such as heavy congestion or sudden lane changes, remains a challenge. Developing algorithms that enhance ACC adaptability to diverse traffic situations is vital for maximizing its utility in real-world driving scenarios.

1.3.3. Traffic Sign Recognition Accuracy:

The accuracy of Traffic Sign Recognition (TSR) systems remains a pertinent challenge. Variability in sign designs, environmental conditions, and real-time processing constraints can lead to instances of misinterpretation or delayed recognition. Enhancing the precision of TSR algorithms is imperative to ensure reliable communication between the vehicle and the driver.

1.3.4. Streamlining Tire Maintenance for Damaged Tires:

One persistent challenge in the automotive landscape involves the hassle associated with changing damaged tires. Traditional methods often demand physical effort, making the process cumbersome for drivers, particularly in adverse conditions. The integration of the Internal Hydraulic wheel jack in our project addresses this issue effectively. By providing a user-friendly mechanism controlled by a simple button press, the Piston System significantly simplifies tire changes. This feature not only enhances user convenience but also mitigates the physical exertion typically associated with tire maintenance, offering a practical solution to a common problem faced by drivers.

1.3.5.Driver Health Monitoring Reliability:

Achieving consistent and accurate driver health monitoring poses challenges due to individual variations in physiological responses and potential interferences from external factors. Ensuring the reliability of health assessments, especially in dynamic driving conditions, is crucial for timely intervention and maintaining a high level of safety.

1.4.Market survey

1.4.1.Advanced Driver Assistance systems Industry Segmentation

The Advanced Driver Assistance Systems Market report covers the growing demand for passenger cars and commercial vehicles across the globe and the penetration of ADAS features in these vehicles, Investments done by component manufacturers and software providers to establish their presence, and market shares players operating in the market. The scope of the report includes:

The Advanced Driver Assistance Systems Market is segmented by Type, Technology, Vehicle Type, and Geography. By Type, the market is segmented as Parking Assist System, Adaptive Front-lighting, Night Vision System, Blind Spot Detection, Advanced Automatic Emergency Braking System, Collision Warning, Driver Drowsiness Alert, Traffic Sign Recognition, Lane Departure Warning, and Adaptive Cruise Control.

By Technology, the market is segmented as Radar, LiDAR, and Camera. By Vehicle Type, the market is segmented as Passenger Cars and Commercial Vehicles and by Geography, the market is segmented as North America, Europe, Asia-Pacific, and Rest of the World. For each segment, market sizing and forecast have been done on basis of value (USD billion).

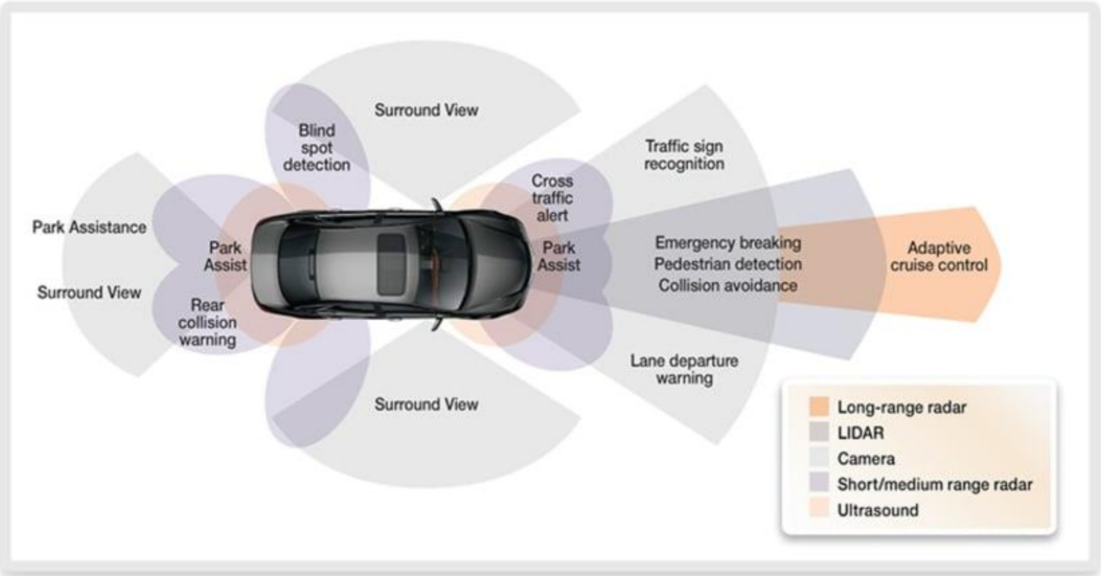


Figure 1:ADAS Segmentation

- **By Type**

1. Parking Assist System
2. Adaptive Front Lightening
3. Night Vision System
4. Blind Spot Detection
5. Advanced Automatic Emergency Braking System
6. Collision Warning
7. Driver Drowsiness Alert
8. Traffic Sign Recognition
9. Adaptive Cruise Control
10. Lane Departure Warning

- **By Technology**
  1. Radar
  2. LiDAR
  3. Camera

1.4.2.Tesla - Statistics & Facts

After years of anticipation, the first Cybertruck models produced by Tesla reached customers in the third quarter of 2023, only for deliveries to be postponed again in April 2024. These delays in early 2024 happened around the same time as reported layoffs among Tesla's global workforce. In 2023, Tesla employed nearly 140,500 people worldwide.

The company ranked within the fifteen most valuable brands across all industries in 2023. Tesla continued to break records in 2023, with its vehicle deliveries reaching a record 1.8 million units in 2023. This global presence contributes to the company's financial performance, though Tesla remains reliant on its domestic market.

Financial performance boosted by the U.S. market

Tesla recorded a net income in 2020 and has reported considerable year-over-year growth since then, despite an increasing cost of revenues. At over 78.5 billion U.S. dollars in revenue, Tesla's automotive sales represent the core of Tesla's business activities. The manufacturer has been steadily increasing its research and development expenses, investing in fields such as artificial intelligence and connected vehicles.

To round up its 2023 performance, Tesla also became the North American Charging Standard as many of its competitors committed to using its fast-charging connectors. The company has been incrementing its Supercharger network, which should soon be open to a wider range of electric vehicles and therefore a broader range of customers. This is not the only way in which the United States remained Tesla's most important target market: Tesla was also among the ten manufacturers with the largest market share of the U.S. automotive market.

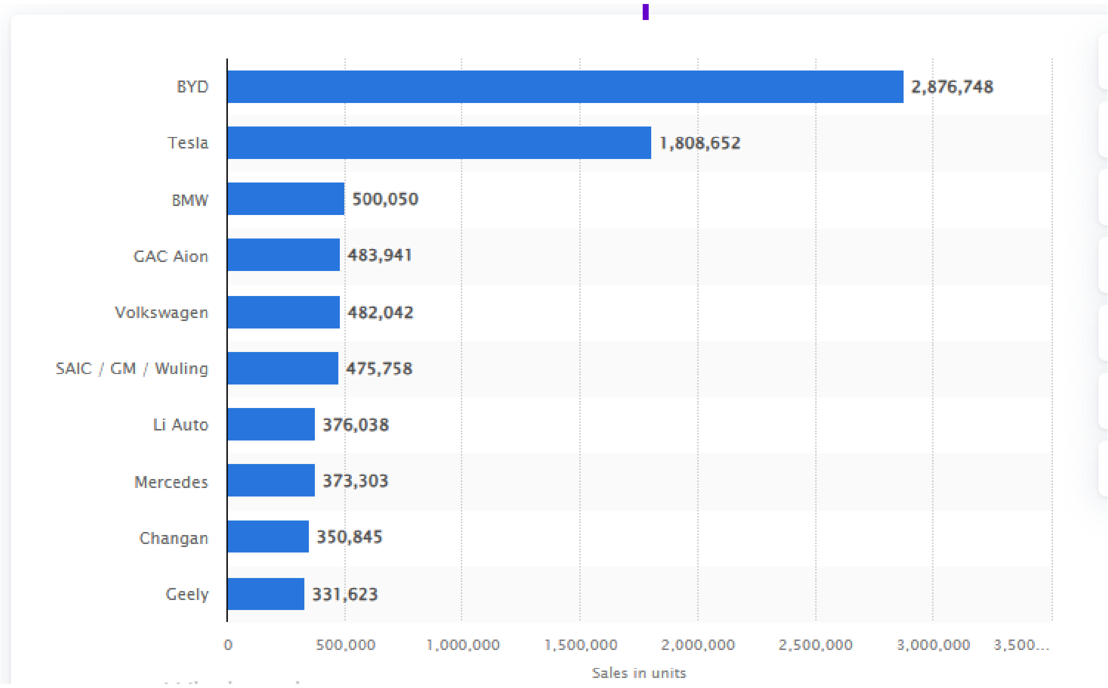


Figure 2:Estimated Plug In Electric Vehicle sales Worldwide in 2023

1.4.3.Plug-in electric vehicle sales worldwide by brand 2023

BYD overtook Tesla as the best-selling electric vehicle brand in 2022 and maintained its position in the ranking through 2023. That year, BYD sold nearly 2.88 million plug-in electric vehicles globally. Tesla and BMW completed the top three brands that year, with Tesla reporting some 1.81 million sales. BYD is also the leading manufacturer of electric vehicles in China, based on sales.

1.4.4.European brands charge ahead in electric car sales

With Europe-based brands Volkswagen, BMW, and Mercedes all impressively ranked in the plug-in electric vehicle (PEV) market, there is no doubt that Europe's incumbent automakers are ready to zoom past rivals when it comes to electric mobility. Volatility in the market has, however, come to light in 2020 following the coronavirus outbreak, as international auto sales contracted by around 15 percent and plummeted to around 64 million units. The global automotive chip shortage, accelerated by the pandemic, further contributed to challenges in the market throughout 2021 and 2022. The European electric vehicle market has been growing through these challenges, with plug-in electric vehicle sales representing over 23 percent of the 2023 European passenger car sales.

Fueling a green future

With climate change still a hot topic of conversation across the globe, the adoption of fuel-cell electric vehicles (FCEV), which emit only water vapor into the environment, as well as hybrids, plug-in hybrids, and battery electric vehicles is becoming ever more enticing. Green transportation-related patent applications worldwide represented close to a quarter of all green patents filed in 2020.

1.4.5.Electric vehicles in the United States - statistics & facts

The electric vehicle (EV) market in the United States broke records in 2022, estimated at just under 918,500 light electric vehicle sales. This was over two and a half times more than in 2018—the year which marked the beginning of a strong demand for Tesla's Model 3. The sedan is one of the best-selling electric vehicles on the U.S. market.

1.4.6.New players are yet to reach profitability

Tesla continues to dominate the U.S. EV market, with an estimated 536,100 electric vehicles sold in the United States in 2022. However, competition is beginning to gain momentum, and manufacturers such as General Motors are continuing to add new EV models into their range of vehicles offered. Ford's Mustang Mach-E and Chevrolet's Bolt made it into the list of best-selling battery-electric vehicle models in 2022. Nearly 20,800 and 22,100 Chevrolet Bolts were sold in the United States in 2020 and 2021, respectively. The model is manufactured by a subsidiary of General Motors, which will end its Bolt production at the end of 2023 to focus on building electric pickup trucks. 2022 Chevrolet Bolt sales dropped to their lowest point since 2017. General Motors intends to only sell zero-emission vehicles by 2035.

Despite more American brands ranking high among the best-selling battery-electric vehicle (BEV) brands in the United States, the U.S. electric vehicle market heavily depends on Tesla's sales. In 2022, the company reported over five times as many BEV sales as Ford, which ranked second. This contrasts with the global BEV market, where the gap between Tesla and other manufacturers is not as steep.

Tesla's success and the increasing popularity of electric vehicles have attracted growing investments in EVs, charging infrastructure, and battery manufacturing. Manufacturers are looking to increase their research and development expenditure, with electric mobility at the forefront of their investments. This is partly motivated by the U.S. government's commitment to decarbonizing its fleet, with many states pledging to ban the sale of fossil fuel vehicles by 2035. However, despite this success, new market players still struggle to attain profitability. Despite the R1T being among the ten best-selling battery-electric cars in the U.S., Rivian reported its largest net loss in the 2022 fiscal year. Lucid Motors fared better, decreasing its net loss that same year, but has yet to become profitable.

1.4.7.Market challenges discourage consumers

Increasing retail gasoline prices could contribute to consumer interest in EVs. However, the market still faces various challenges which can act as disincentives for prospective car buyers. In an October 2022 survey, U.S. respondents highlighted EVs' cost, driving range, and the time necessary to charge their batteries as the leading concerns regarding battery-electric vehicles. According to an October 2022 survey, 47 percent of U.S. participants expected an EV to have a driving range of 400 miles or above, including 19 percent expecting an EV to have a driving range of 600 miles or more. As of April 2023, the 2022 Lucid Air Dream Edition Range was the EV model with the longest range on the market at 520 miles. Tesla's 2021 Model 3 with all-wheel drive, second in this ranking, had a driving range of around 353 miles, fitting or exceeding the expectations of 53 percent of U.S. consumers.

However, while consumers' range anxiety might not match market reality, price inflation has been heavily impacting the automotive market due in part to market uncertainties linked with the semiconductor shortage and rising raw material prices. While electric vehicles were not as affected by this uncertainty, their price point was still prohibitive for many consumers. In December 2022, the average selling price for electric cars was the third highest across all vehicle types. It remained relatively stable compared to December 2021—down 397 U.S. dollars to nearly 61,500 U.S. dollars.

When it comes to electric vehicle charging infrastructure, the United States boasts the third-largest public charger network worldwide. However, 77 percent of U.S. consumers surveyed in October 2022 reported intending to charge their electric vehicles most often at home, highlighting prohibitive installation costs as one of the main reasons they could not access charging at home. In 2022, the U.S. recorded over 136,500 public chargers installed in the country, over six times the size of its private charger network. These various challenges leaves space for new opportunities in the U.S. EV market, with the government supporting EV adoption by enacting various laws and incentives to promote the sector—608 electric vehicle laws and incentives were recorded in 2022.

1.4.8.Current Market In Electric Vehicles

The Electrifying Rise: Unveiling the Current Electric Vehicle Market

The electric vehicle (EV) market is experiencing a period of phenomenal growth, rapidly shifting gears from a niche segment to a mainstream contender. Driven by environmental concerns, technological advancements, and government incentives, this transformation is redefining the automotive landscape. Let's delve into the current state of the EV market, exploring its key players, trends, challenges, and the road ahead.

- **Market Growth and Dynamics**

Global EV sales are surging. In 2022, electric vehicles captured a significant 14% market share for new car sales, with China leading the charge. This translates to millions of EVs hitting the roads, displacing their gasoline-powered counterparts. This growth is projected to continue, with forecasts suggesting that EVs could account for half of all new car sales by 2030 [source needed].

Several factors contribute to this surge. Environmental anxieties surrounding climate change are pushing consumers towards cleaner transportation options. Governments worldwide are enacting policies that promote EV adoption, offering tax breaks, subsidies, and charging infrastructure investments. Additionally, technological advancements are leading to longer ranges, faster charging times, and more affordable EVs.

- **Major Players and Competition**

The EV market is a battleground for established automakers and innovative startups. Traditional giants like Tesla, General Motors, Ford, and Volkswagen are heavily investing in EV development, launching new models and expanding production capacities. Tesla remains a dominant force, known for its luxurious performance EVs, while legacy automakers are striving to catch up with a wider range of offerings catering to diverse consumer needs.

Disruptive startups like Rivian and Lucid Motors are also making waves with their innovative designs and focus on luxury electric vehicles. This influx of players has intensified competition, leading to a wider variety of EVs at different price points, further accelerating market growth.

➢ Market Segmentation and Trends

The EV market isn't monolithic. It encompasses various segments catering to diverse consumer preferences. Here's a breakdown of some key trends:

- **Battery Electric Vehicles (BEVs):** These are the most common type of EV, powered solely by electricity stored in a battery pack. BEVs offer the greatest environmental benefits but require access to charging infrastructure. Manufacturers are focusing on extending ranges and reducing charging times.
- **Plug-in Hybrid Electric Vehicles (PHEVs):** These vehicles combine an electric motor with a gasoline engine, offering both electric and gasoline-powered driving modes. PHEVs are a good choice for those with range anxiety or limited access to charging stations.
- **Luxury EVs:** High-end automakers are capitalizing on the growing demand for luxury EVs, offering premium features, extended ranges, and cutting-edge technology. Tesla has carved a niche in this segment, while established brands like Porsche and Audi are entering the fray with their own luxurious offerings.
- **Mass-Market EVs:** As battery costs decrease and production scales up, automakers are introducing more affordable EVs for the mainstream consumer. This segment is crucial for wider adoption and will likely witness significant growth in the coming years.

Challenges and Opportunities

Despite its rapid growth, the EV market faces some significant challenges.

- **Range Anxiety:** Concerns about running out of power before reaching a charging station remain a barrier for some potential EV buyers.
- **Charging Infrastructure:** The current charging infrastructure is inadequate, especially in remote areas. Expanding and improving the charging network is crucial for broader EV adoption.
- **Battery Costs:** Battery technology has advanced, but costs remain a hurdle for some EV models. Continued advancements in battery technology are vital to bring down prices and make EVs more accessible.

On the other hand, these challenges present exciting opportunities. Investments in battery research, development, and recycling are accelerating. Governments are prioritizing the expansion of charging infrastructure. As these concerns are addressed, EV adoption is poised to accelerate even further.

The Road Ahead: A Sustainable Future

The electric vehicle market is at a tipping point. With growing consumer interest, technological advancements, and government support, EVs are poised to become the dominant mode of transportation in the coming decades. This shift towards EVs will have a profound impact on the environment, reducing greenhouse gas emissions and contributing to a more sustainable future.

However, the success of this transition hinges on overcoming the existing challenges. Collaborative efforts from governments, automakers, energy companies, and infrastructure developers are essential to create a robust ecosystem that supports widespread EV adoption. As these challenges are tackled and the market matures, the electric vehicle revolution promises a cleaner, more sustainable future for transportation.

This overview provides a glimpse into the dynamic and ever-evolving world of electric vehicles. As the market continues to evolve, one thing is certain: the future of transportation is electric.

Delving Deeper into the Electric Vehicle Market

Building upon the foundational aspects of the EV market, let's delve deeper into some intriguing aspects that are shaping its future:

Geographical Variations and Regional Leaders

The EV market isn't uniform across the globe. Here's a closer look at some key regional trends:

- **China:** The undisputed leader in EV sales, China boasts a robust EV ecosystem with strong government support, a focus on domestic production, and a rapidly expanding charging network. This dominance is likely to continue in the near future.
- **Europe:** European countries like Norway, Germany, and the United Kingdom are experiencing significant EV adoption, driven by stringent emissions regulations and generous incentives. Europe is expected to be a major battleground for EV manufacturers in the coming years.
- **The United States:** While lagging behind China and Europe, the US EV market is experiencing healthy growth. Increased consumer interest, coupled with federal tax credits and state-level incentives, is driving this expansion. Tesla remains a dominant force, but major US automakers are ramping up their EV offerings.
- **Developing Markets:** The EV market in developing countries is still nascent. However, there's growing interest, particularly in countries with high fuel prices and concerns about air pollution. Affordability and access to charging infrastructure will be key factors for growth in these regions.

The Battery Conundrum

Battery technology is a central theme in the EV story. While range anxiety is a major concern, other factors related to batteries deserve attention:

- **Battery Degradation:** Batteries lose capacity over time, impacting an EV's range. Understanding and mitigating degradation is crucial for long-term EV ownership. Developments in battery management systems and thermal control are key areas of focus.
- **Ethical Sourcing of Battery Materials:** Concerns exist regarding the environmental and social impact of mining materials like lithium and cobalt used in batteries. Sustainable sourcing practices and responsible recycling are becoming increasingly important.
- **Second Life Batteries:** Used EV batteries still hold significant capacity. Repurposing them for stationary energy storage applications can extend their life cycle and improve overall resource utilization.

The Charging Landscape: Beyond Infrastructure

The charging infrastructure is vital for EV adoption, but it's not just about the number of charging stations. Here are some additional considerations:

- **Charging Speed:** While slow Level 2 chargers are convenient for home charging, faster DC fast chargers are essential for long-distance travel. Investments in ultra-fast charging technology will further enhance user experience.
- **Standardization:** A lack of standardization in charging connectors can be inconvenient for EV owners. Universal charging standards are crucial for seamless charging experiences across different brands and models.
- **Smart Charging:** Integrating EVs with the smart grid can optimize charging times and reduce strain on the electricity grid. Technologies like vehicle-to-grid (V2G) charging can even allow EVs to feed power back into the grid during peak demand periods.

The Future of Mobility

The EV revolution extends beyond passenger cars. Let's explore some emerging trends:

- **Electric Buses and Trucks:** Electrification of public transportation and commercial vehicles is gaining traction. This can significantly reduce emissions in urban areas and contribute to cleaner transportation overall.
- **Electric Scooters and Motorcycles:** Electric two-wheelers are becoming increasingly popular in urban areas, offering a convenient and eco-friendly mode of transportation for short commutes. Sharing models and battery swapping technologies are further accelerating their adoption.
- **Autonomous Electric Vehicles:** The convergence of EV technology with autonomous driving holds immense potential. Self-driving electric vehicles could revolutionize transportation, leading to increased efficiency and safety.

Chapter 2: Our Project

2.1.Electrical Car (EC)

2.1.1. Executive Summary

This project involves converting an empty vehicle frame into a sophisticated electric car, incorporating an electric power system and Advanced Driver Assistance Systems (ADAS) to significantly enhance safety and efficiency. This initiative represents a step towards sustainable and technologically advanced transportation solutions.

2.1.2.Introduction

This transformative project revolves around converting a basic vehicle chassis into an eco-friendly, intelligent electric vehicle. It extends beyond simply replacing an engine; it entails a thorough redesign to integrate cutting-edge electric and safety technologies, bringing an old chassis back to life. This process involves detailed modifications to accommodate modern electric components, aiming to produce a vehicle that is not only environmentally friendly but also equipped with the latest in automotive technology. This pioneering approach emphasizes the innovative integration of ADAS, setting new standards for vehicle intelligence and safety in the realm of sustainable transportation.

2.1.3.Design and Functionality

I. Materials

I. Mechanical Parts

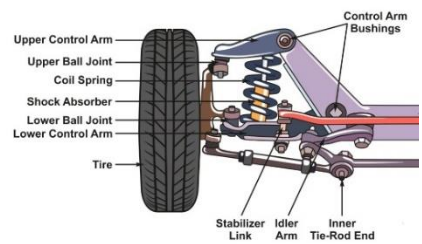
➔ **Chassis:** Serving as the vehicle's foundational structure, the chassis is meticulously modified to support essential components such as the motor, battery, and passenger seating. It is engineered to handle the additional weight and structural shifts associated with electric vehicle components, ensuring both safety and performance efficiency.

- In our Vehicle, an old chassis of (UTV) is used shown in figure (4) Car and modified it to be suitable for our Design .

Figure 3:old chassis of (UTV)

➔ **Suspension system :**

Critical for providing a comfortable ride and effective handling, the suspension system from an old UTV is carefully adapted and integrated into the modified chassis. This system is re-engineered to align with the altered dynamics of the electric vehicle, ensuring optimal stability and shock absorption.



- A suspension system from an old (UTV) car was bought and made our trusty chassis ready for the upgrade.

II. Electrical Parts

➔ **Electric Motor:** The vehicle is powered by a state-of-the-art brushless DC motor shown in figure (4). known for its efficiency and durability. This motor is selected for its superior performance characteristics, including high torque and low maintenance demands.

- **Features**: Exceptional efficiency, broad operational range, and quiet operation.
- **Technical Parameters**: 2000W power, 48V DC, 10 Nm holding torque, and a top speed of 2000 rpm.

Figure 4:BLDC Motor 2000W

➔ **Motor Driver :** This component is crucial for precise control over the motor's functions, adjusting speed and torque in response to driving conditions. It acts as the interface between the motor and the vehicle's control systems, facilitating responsive and smooth vehicular operations.

- **Features**: Enhanced safety and adaptability to various driving conditions.
- **Technical Parameters**: 1500W power, 48V DC voltage.

We bought a brushless DC Motor Speed Driver shown in figure (5).

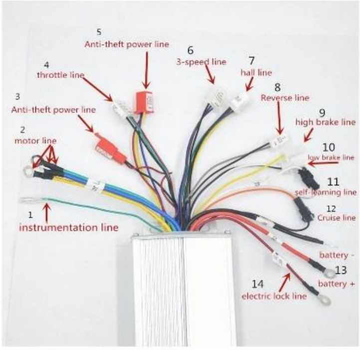


Figure 5:Brushless DC Motor

- **Power supply**: The power supply unit is designed to convert and regulate electrical power from the grid to suit the specific needs of the electric vehicle, ensuring efficient energy consumption and constant performance under varying operational demands.

- 2000W/48V Power Supply was used shown in figure (6).
- Power supply as a charger was used to charge the batteries and to test the electric motor without the batteries.

Figure 6:Power Supply

- **Batteries:** A robust array of lead-acid batteries provides the necessary power for the vehicle. These batteries are chosen for their reliability, cost-effectiveness, and ease of maintenance.

Figure 7: Batteries

- **Cost-Effectiveness:** They are more affordable than lithium-ion batteries, making them a cost-effective choice for budget-conscious projects**.**
- **Familiar Technology:** Lead-acid batteries have long been in use and are well-understood, which simplifies handling and maintenance**.**
- **Durability:** These batteries are robust and can endure various environmental conditions without damage from overcharging or over-discharging.
- **Simple Charging System:** Lead-acid batteries use straightforward charging systems, eliminating the need for complex algorithms and facilitating easier infrastructure setup.
- **Availability:** They are widely available, ensuring easy maintenance and replacement

2.1.4.Methodogy

I. Phase 1 Chassis Modification

- The chassis have been into some phases:
  - Phase 1: Welding and modification
  - Phase 2: Sanding The chassis to get of the rust and make it suitable for painting Shown in figure (9).
  - Phase 3: Painting shown in figure (8).

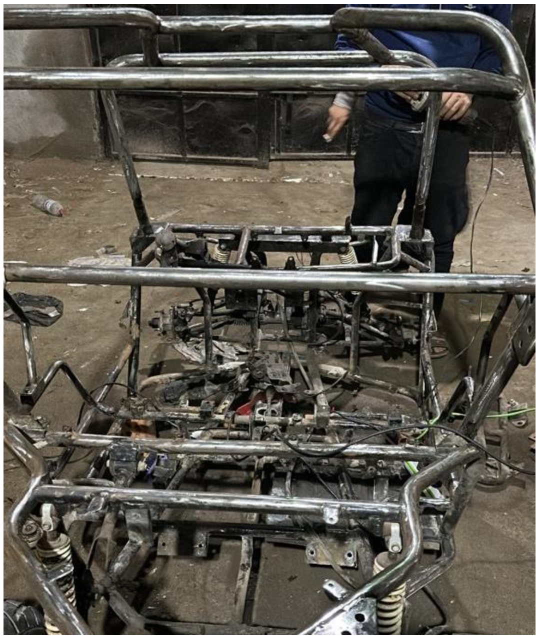


Figure 9:Welding process

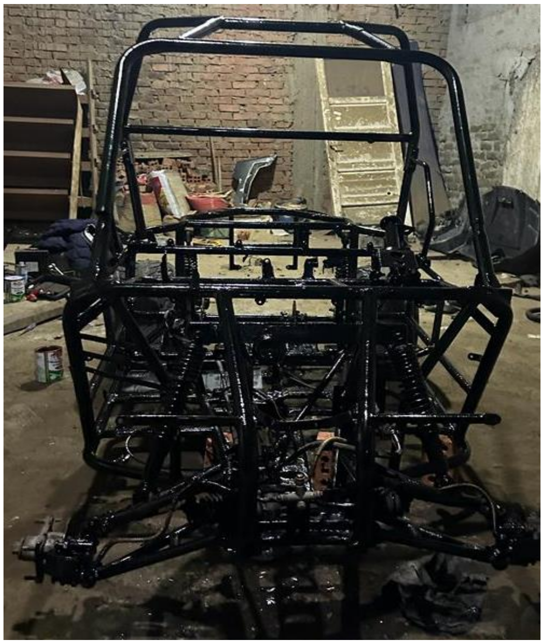


Figure 8:Pinting process

II. Phase 2 Motor Attachment

- The chassis and base of the motor were modified to make it fit our electric motor.
- The electric motor was attached to the chassis as shown in figure (10) and figure (11).

Figure 10:Motor Attachment

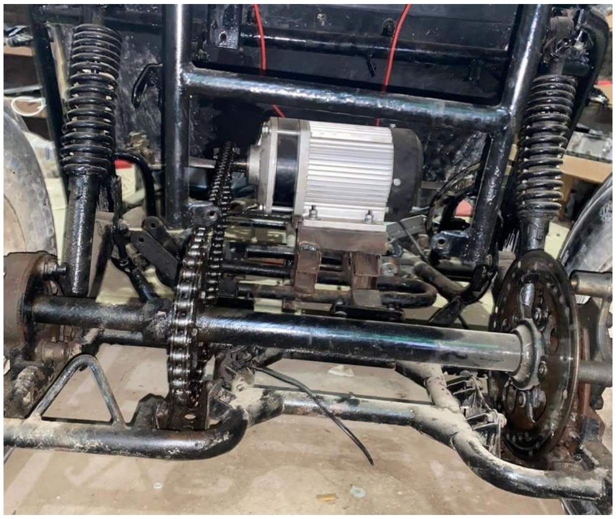


Figure 11:Motor Attachment

- After the successful attachment of the electric motor to the chassis, the connections were rechecked to ensure that the motor fit and works perfectly.
- The next step involved linking the motor to the motor controller. This was achieved with precision, following the guidelines depicted in figure (12). The power supply, capable of producing (52 V - 30 A), was then connected, setting the stage for our first trial run.

Figure 12:The power supply

III. Phase 3 Battery Integration

- In Phase 3 of the project, the team focused on selecting the optimal batteries to power the electric vehicle system. They conducted extensive research on various battery types and capacities, engaging in workshops, online courses, and consultations with experts to deepen their understanding of battery technology. This comprehensive study led to the choice of a robust power setup comprising five 12V batteries, each with an 80A capacity, culminating in a powerful 48V and 80A supply Shown in figure (13). This phase not only secured an efficient power solution but also demonstrated the importance of perseverance and systematic research in overcoming technical challenges.

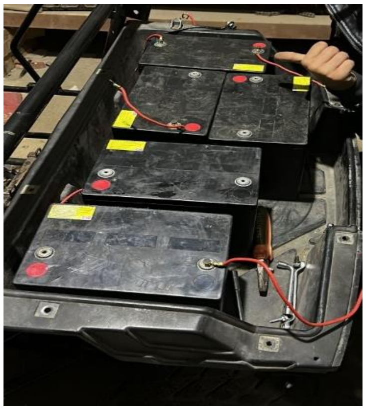


Figure 13:Battery Integration

2.1.5.Conclusion

⇨ This chapter detailed the meticulous process of converting an empty chassis into a fully functional and advanced electric car, emphasizing the integration of a powerful electric power system and sophisticated ADAS. The project not only showcases an innovative approach to vehicle design but also contributes to the broader goals of environmental sustainability and technological advancement in the automotive industry. The successful execution of this project demonstrates a significant leap forward in transforming traditional automotive frameworks into modern, efficient, and safe electric vehicles.

2.2.ECU

2.2.1.Circuit

I. Power Circuit

The power circuit in this system aims to manage the 60-volt output from the Lead Acid battery effectively. Given the diverse components requiring power, two circuits have been implemented:

a. Low Power Circuit

This circuit is designed to generate a maximum of 0.8 Amps, for powering all sensors and the MCU utilized. The XL7015 DC-DC Step-down converter (BUCK converter) is employed to reduce the battery bank's 60 volts to 12 volts. From there, the voltage needs to be further reduced to 5 volts and 3.3 volts to accommodate the various sensors and actuators in the system. For this purpose, voltage regulators are utilized. The LD1117V33 voltage regulator produces 3.3 volts, while the L7805CV voltage regulator produces 5 volts. Figure (14) illustrates the connection of the Low Power Circuit.

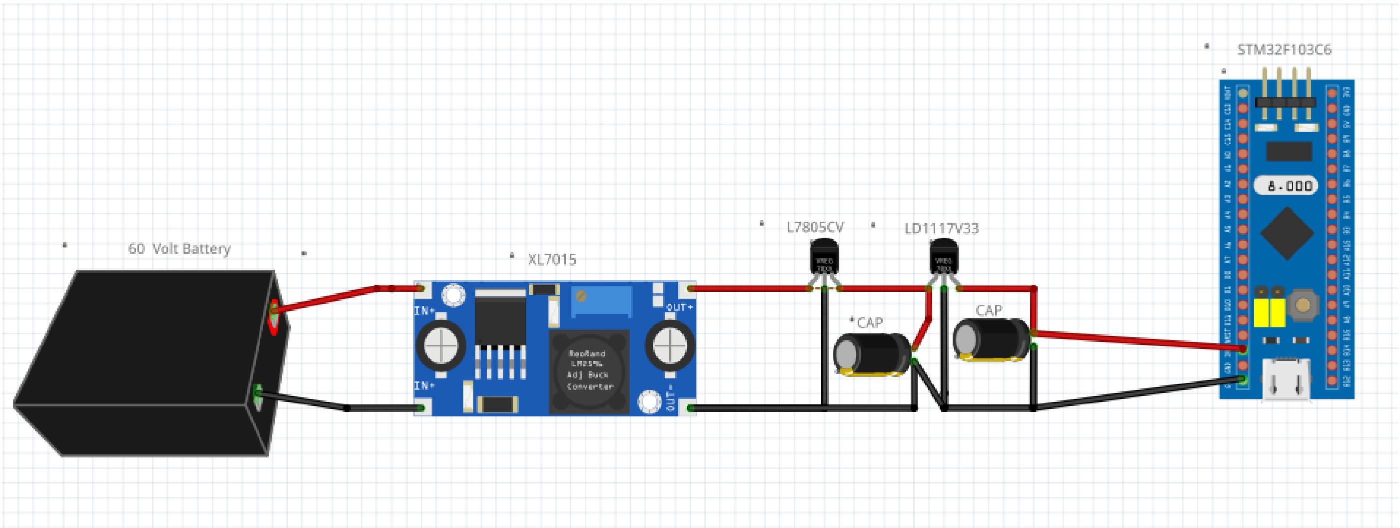


Figure 14:Low Power Circuit

b. High Power Circuit

The High Power Circuit is tasked with generating a maximum of 15 Amps, sufficient to power all actuators. Similar to the Low Power Circuit, the XL7015 DC-DC Step-down converter (BUCK converter) is employed to lower the battery bank's 60 volts to 12 volts. However, in this circuit, the TIP3055 BJT (Bipolar Junction Transistor) is utilized to amplify the current. It will be configured in a common emitter configuration. Equation (2.1) illustrates the forward current gain of this configuration.

$$\beta_F = h_{FE} = \frac{I_C}{I_B} \tag{2.1}$$

Where:

- β_F is the forward current gain
- I_C is the collector current
- I_B is the base current

The emitter current is the combination of collector & base current. It can be calculated using any of these equations (2.2).

$$\begin{gathered} \boldsymbol{I_E = I_C + I_B} \\ \boldsymbol{I_E = \frac{I_C}{\alpha}} \\ \boldsymbol{I_E = I_B(1 + \beta)} \end{gathered} \tag{2.2}$$

And equation (2.3) shows Collector-to-Emitter Voltage:

$$\boldsymbol{VCE = VCB + VBE} \tag{2.3}$$

Where:

- $\boldsymbol{VCE}$ is the collector-to-emitter voltage
- $\boldsymbol{VCB}$ is the collector-to-base voltage
- $\boldsymbol{VBE}$ is the base-to-emitter voltage

And figure (15) shows the simulation of TIP3055 BJT

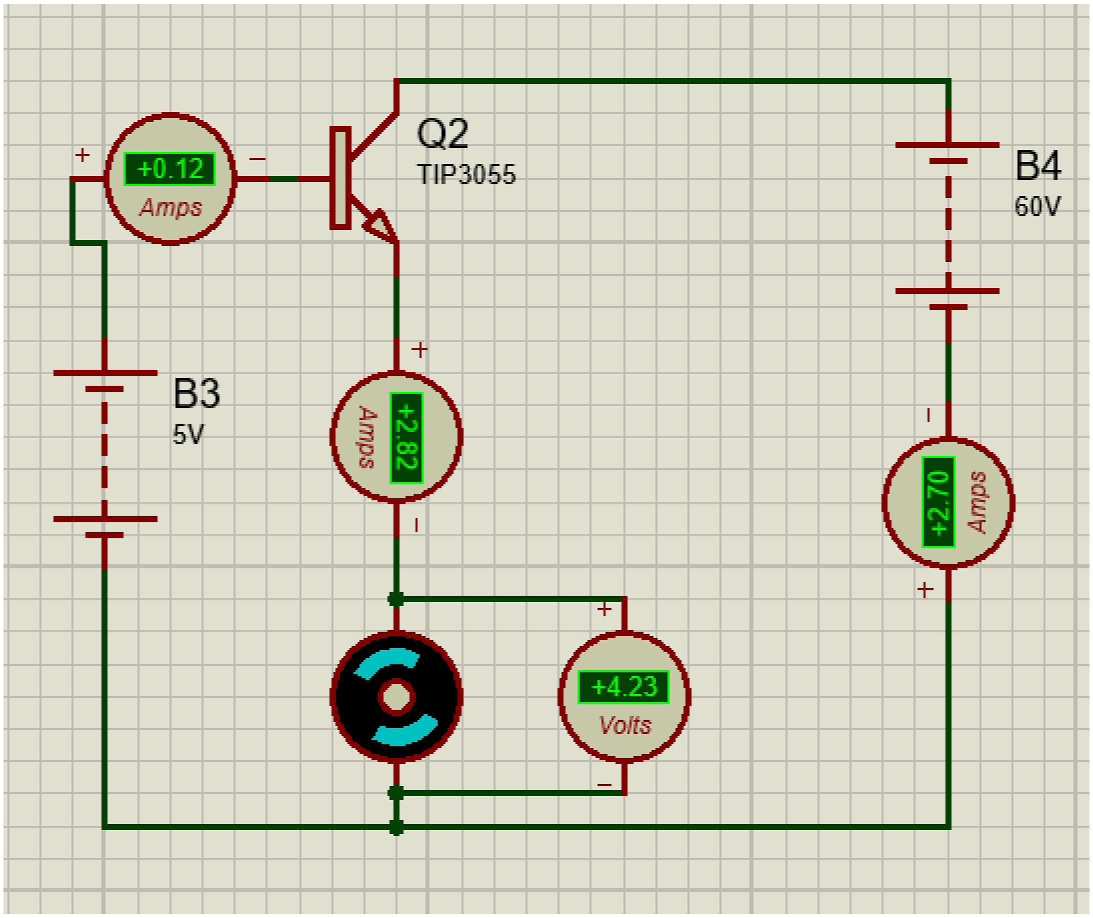


Figure 15 TIP3055

c. MCU

The STM32F103C6 microcontroller, based on ARM architecture, operates within a 2.0 to 3.6 V power supply range and is available in extended temperature ranges. It offers extensive power-saving modes, making it suitable for various applications such as motor drives, medical equipment, and industrial control systems. Key features include a 32-bit Cortex™-M3 CPU core operating at up to 72 MHz, 128 Kbytes of Flash memory, and 20 Kbytes of SRAM. It supports multiple communication interfaces, including I2C, USART, SPI, CAN, and USB. Additionally, it features A/D converters, DMA support, timers, and a CRC calculation unit.

d. .DAC Design

The R-2R DAC (Resistor-2-Resistor Digital-to-Analog Converter) is widely used in electronics for converting digital signals to analog voltages. It employs a network of precision resistors arranged in a ladder-like configuration, with two types of resistors: R and 2R. Each bit of the digital input corresponds to a specific resistor; when a bit is 1, the corresponding resistor (usually of value R) is connected to the reference voltage, and when it's 0, it's not connected. The output voltage is the sum of the voltages across the connected resistors, which is then filtered for a smooth analog signal.

Advantages of the R-2R DAC include simplicity, good linearity, and low glitch energy, but it requires precision resistors, increasing costs. The output voltage ($Vout$) of an R-2R DAC can be calculated using a specific equation (2.4).

$$Vout = Vref \times \left(\frac{D}{2^N}\right) \tag{2.4}$$

Where:

- $Vout$ is the output voltage.
- $Vref$ is the reference voltage applied to the DAC.
- D is the decimal equivalent of the binary input code.
- N is the number of bits in the digital input code.

In this equation, $\frac{D}{2^N}$ represents the fraction of the reference voltage corresponding to the input digital code. Multiplying it by the reference voltage ($Vref$) gives us the actual output voltage ($Vout$), Figure (16) shows the connection of the physical DAC with STM32F103C6.

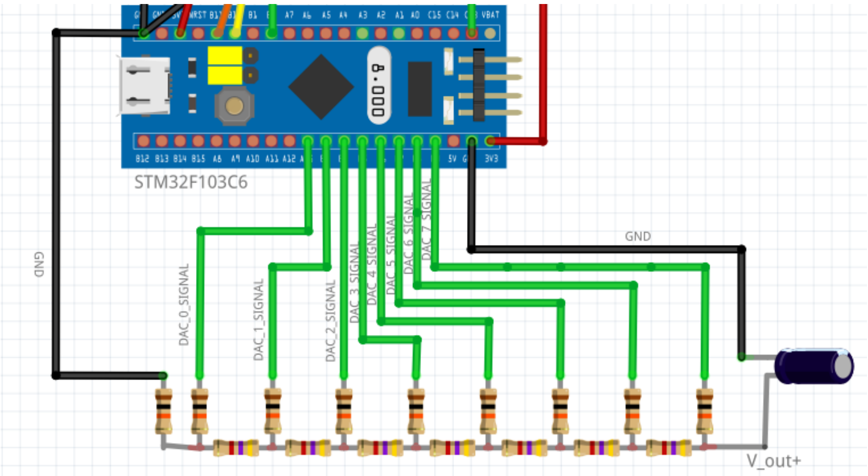


Figure 16 DAC with STM32F103C6

e. .Adaptive Cruise Control

After the DAC is designed now we can control the BLDC Motor by sending analog voltage to the motor drive so we can control its speed and this is the time that Adaptive Cruise Control can be designed the TF-Luna Lidar is responsible for measuring the distance between the vehicle and obstacle, The BLDC motor HALL EFFECT SENSOR used to measure the speed of the vehicle and to make the Cruise Control the SPDT switch used to control the state of Cruise Control (ON, OFF), Figure (17) shows the connection of Adaptive Cruise Control (ACC).

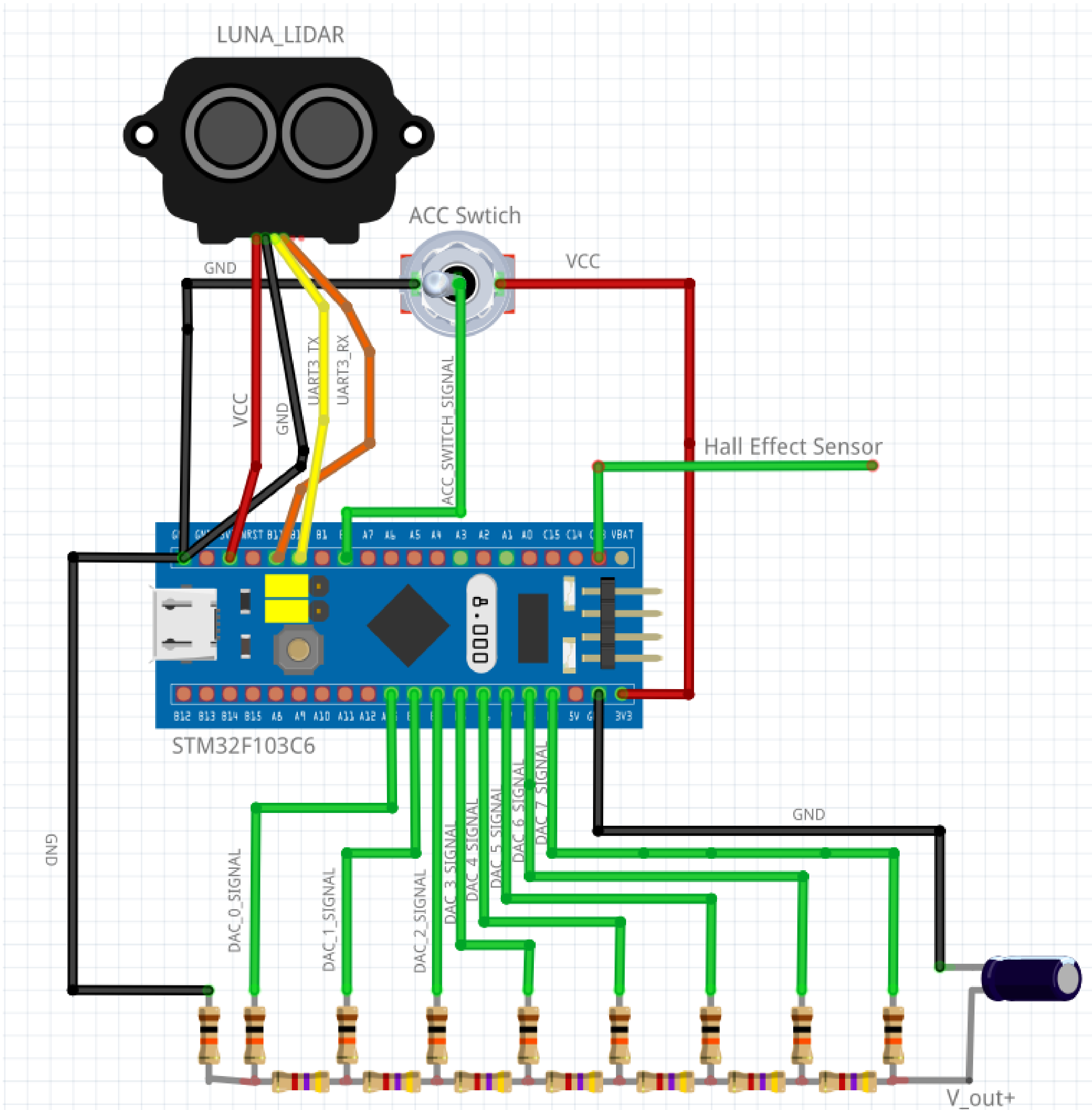


Figure 17 Connection of Adaptive Cruise Control

f. AI Systems Connection

The sub-systems that work with AI algorithms are Traffic Sign Recognition, Face Recognition, and Driver Monitoring System and all of them interact with the MCU in the same way using the FTDI that allows it to connect to a USB port and convert the data to UART protocol then data passed to the MCU to make processing to it and take action according to the results of the process and Figure (18) shows the connection of FTDI with MCU.

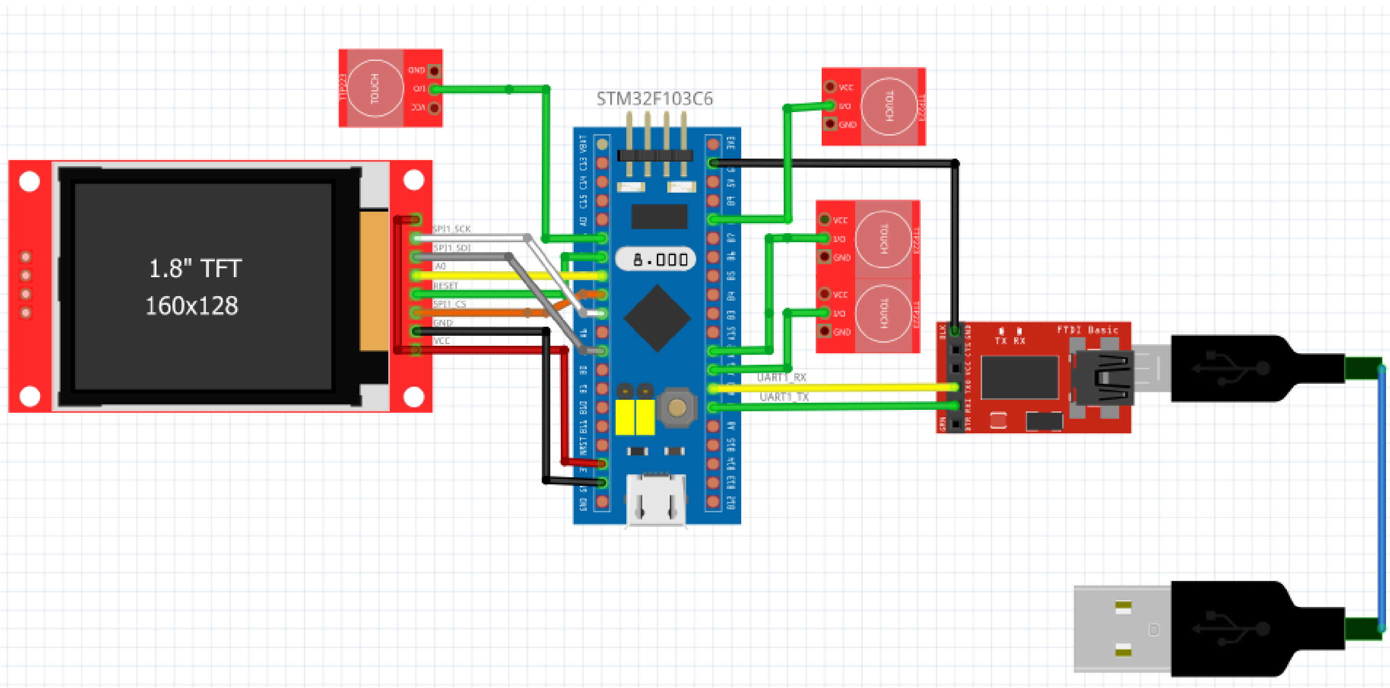


Figure 18 Connection of systems working with AI

g. Internal Wheel jack Circuit

The Internal Wheel jack circuit is very simple and can control the motor of the wheel jack using a DPDT switches with feedback from the contact pin to ensure that the motor will not work if the contact pin is pulled up (has a High-level voltage) and Figure (19) shows the connection of the IWJ circuit.

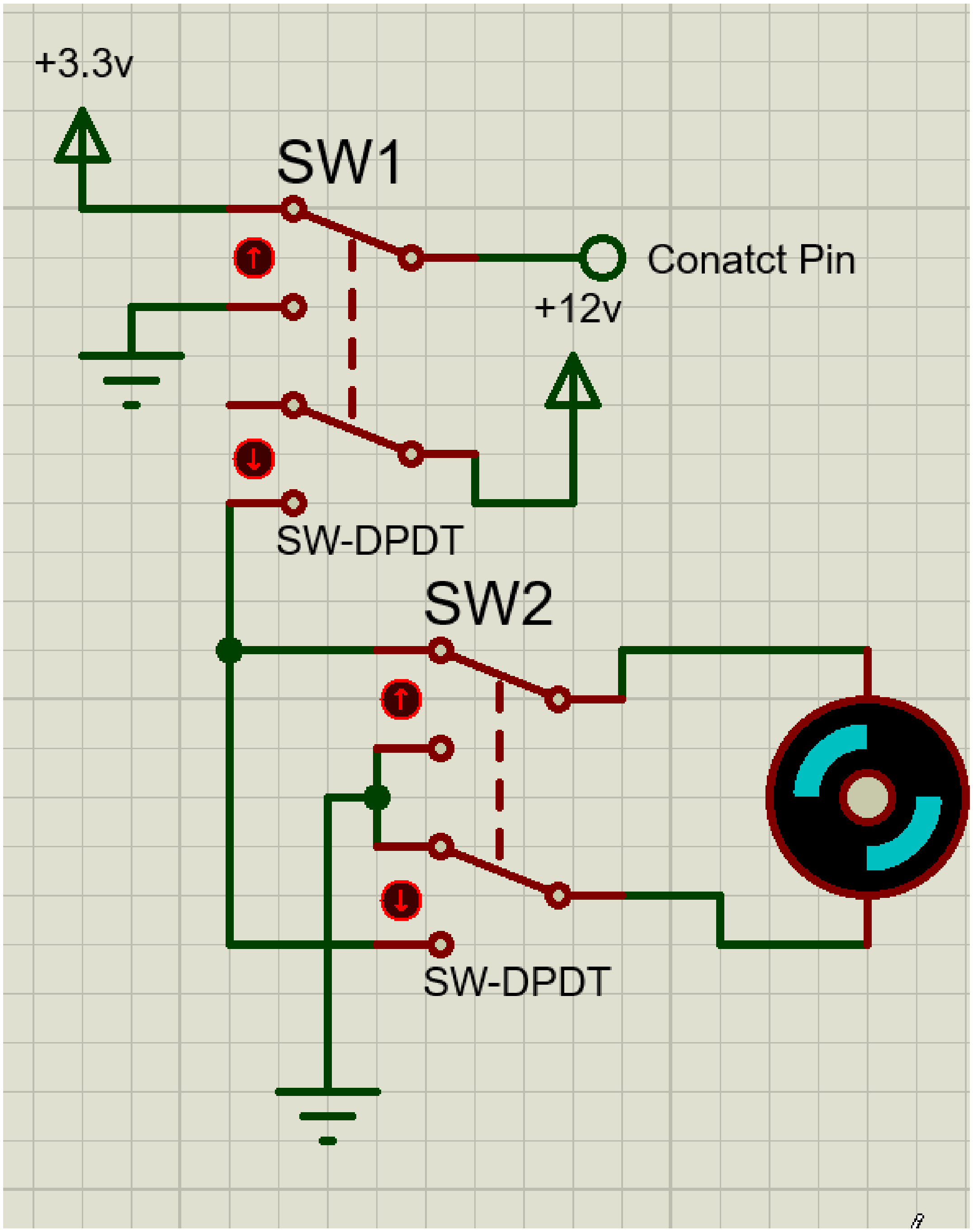


Figure 19 Connection of the IWJ circuit

2.2.2.Coding

I. Adaptive Cruise Control

The adaptive cruise control is made by taking the feedback from the LUNA lidar and Hall Effect Sensor and sending the action to the DAC to send it to the motor drive so to make adaptive cruise control it is required to know how to take the distance from the Lidar.

a. LUNA Lidar

After choosing the hardware component it is required to program it to take the distance from it and this lidar can work with UART protocol and configure its baud rate by 115200bits/sec, figure (20) shows the frame of Luna lidar

Byte	0	1	2	3	4	5	6	7	8
Description	0x59	0x59	Dist_L	Dist_H	Amp_L	Amp_H	Temp_L	Temp_H	Check_sum

Figure 20 Frame of Luna lidar

After initializing the UART baud rate by 115200bits/sec,1 start bit, no parity bits, and 1 stop bit now the 16-bit distance can be received from the lidar.

b. DAC

The DAC can be controlled through the GPIO of the MCU where the IO pins can hold 1 or 0 and the coding of the 8-bit DAC will only happen by controlling the GPIO driver and figure (21) shows simulation for R-2R DAC

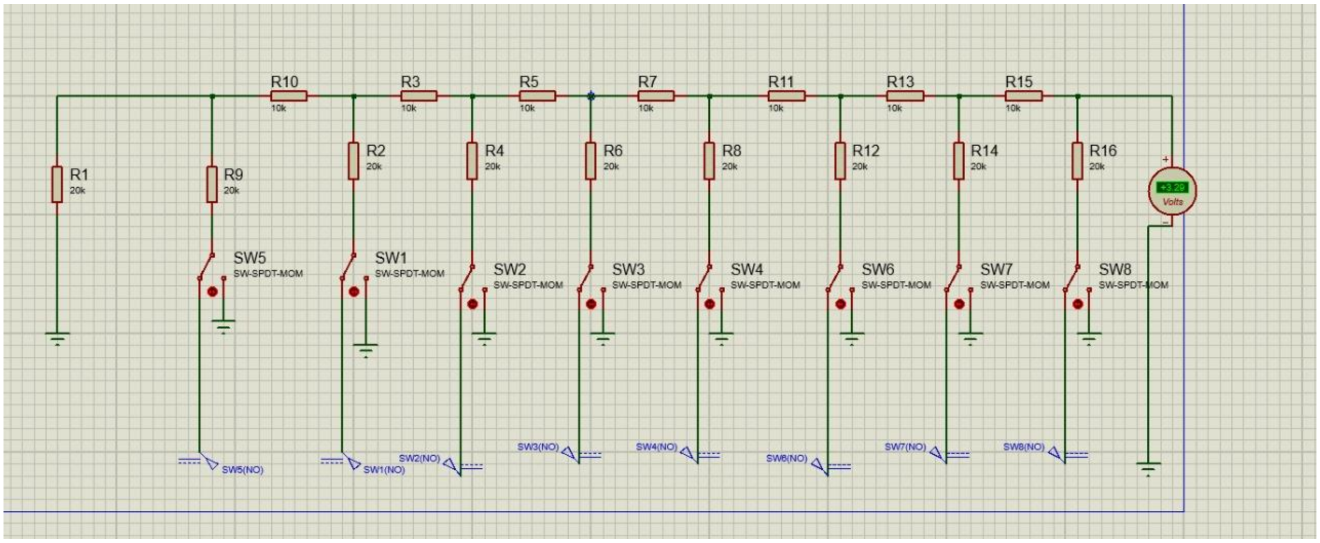


Figure 21 Simulation for R-2R DAC

c. Hall Effect Sensor (HFS)

The Hall effect sensor detects a magnetic field perpendicular to a current-carrying conductor, generating a voltage known as Hall voltage. It's used in automotive, industrial, and consumer electronics for tasks like position sensing, and proximity detection, from figure (22) the HFS gives 28 pulses for every revolution

Figure 22 Pulses /rev

So, from equation (2.5) the speed (KM/H) can be calculated if the HFS gives x Pulses in 1 sec:

$$N_{(rps)} = \frac{x}{28}$$

$$N_{(rpm)} = \frac{N_{(rps)}}{60}$$

$$\mathrm{v}_{(m.s^{-1})} = r * \omega_{(rad.s^{-1})} = r \times \left(2 * \frac{\pi}{60}\right) \times N_{(rpm)}$$

$$\mathrm{v}_{(km.h^{-1})} = 3.6 \times \mathrm{v}_{(m.s^{-1})}$$

$$\mathrm{v}_{(km.h^{-1})} = \frac{3}{25} \times \pi \times r \times N_{(rpm)} \qquad (2.5)$$

Where :

- x is the number of HFS pulses per 1sec
- $N_{(rps)}$ is the number of revolutions per 1sec
- $N_{(rpm)}$ is the number of revolutions per 1 minute
- $\mathrm{v}_{(m.s^{-1})}$ is the Speed meter per sec
- $\mathrm{v}_{(km.h^{-1})}$ is Speed kilometer per hour
- r is the radius of the motor shaft

II. Traffic Sign Recognition

Traffic sign recognition is designed by detecting the sign using an AI algorithm and then sending a frame using UART from Laptop to MCU this frame consists of 3 main parts

a) Start of frame: this frame has a unique ID that indicates what the data that this frame is for.
b) Data frame: this frame contains n number of data frames and all of them contain important data.
c) End of frame: this frame indicates that this is the end of the frame and ready to send another frame

So, the AI algorithm sends the frame mentioned before to send a flag to the MCU then the MCU makes a processing to this flag and starts to print this Sign in the TFT screen.

III. Driver Monitoring System

The design of the driver monitoring system is handled in two ways :

a) Touch Sensor: using 4 touch sensors on the steering wheel and if at least only one touch sensor has a logic one this means that the driver touches the steering wheel.
b) AI algorithm: using an AI algorithm to detect the eyes of the driver and if the eyes are closed for more than a specific period a frame like the mentioned frame is sent to the MCU to take action on the MOTOR.

IV. Face Recognition

At first, the Driver turns on the car through a switch when this switch turns on the frame like mentioned before is sent to the laptop and alerts it that the system should be turned on then the camera opens and detects if the person who trying opens the car in the database or not and if the person verified the laptop send a frame to the MCU tell it that this person verified and start the whole system, the MCU starts to suspend the Face ID task and start all other tasks.

2.3. Security face ID

2.3.1. Executive Summary

In response to the growing need for enhanced vehicle security and user identification measures, the system employs state-of-the-art facial recognition algorithms to verify user identities accurately and efficiently. Through a seamless verification process, users can gain secure access to the vehicle, while unauthorized attempts are promptly detected and thwarted. Furthermore, the system offers comprehensive user management capabilities, allowing for the seamless addition and deletion of user profiles as needed.

2.3.2.Introduction

Facial recognition technology has emerged as a promising solution for robust user authentication. The design and functionality of a state-of-the-art security system utilizing face ID technology are explored in this part, aiming to enhance vehicle security. An overview of the system's architecture, user interface, and authentication process is provided, highlighting its potential to revolutionize automotive security. Practical considerations and challenges associated with deploying facial recognition technology are also discussed, emphasizing privacy, data security, and system performance. Through systematic analysis, valuable insights into the implementation of facial recognition technology in real-world automotive environments are aimed to be provided, contributing to the advancement of vehicle security

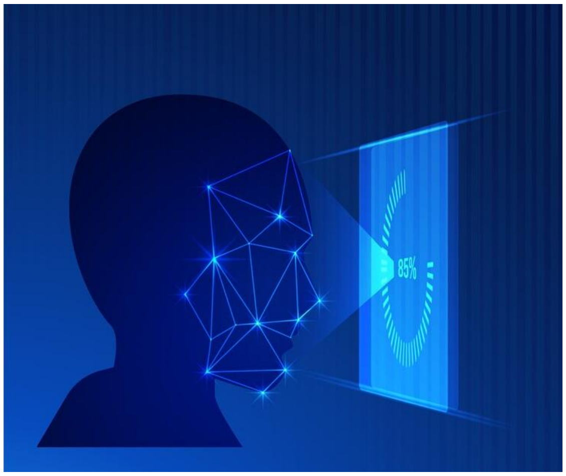


Figure 23:Face ID system

2.3.3.Literature review

The literature on facial recognition technology reveals a burgeoning interest in its application across various domains, including security, surveillance, and authentication. Studies have delved into the technical aspects of facial recognition algorithms, exploring their efficacy in identifying individuals accurately and reliably under different conditions. Research in this field has highlighted the rapid advancements in machine learning and computer vision techniques, which have significantly enhanced the performance of facial recognition systems.

I. Limitations of the existing Face ID systems

- **Easy to trick: The system can be fooled by fake photos, videos.**
- **Sensitive to surroundings: Changes in lighting or background can cause errors.**
- **Privacy worries: Concerns about how facial data is collected, stored, and used.**
- **Computational Resource Requirements.**

II. Previous suggested solutions

☒ **Cars' companies' solutions:**

The solutions proposed by companies depend on the increased cost of using the latest and most accurate hardware parts available.

2.3.4.Design and functionality

For our project, this feature should be implemented to solve the problems that affect it, but at the same time the problems found in the previous solutions should be avoided.

I. Hardware Components

- **Laptop**
- **Webcam**
- **FTDI**

I. *Our suggested solutions*

- **Using our laptop as the processing unit**
- **Add more than one security layer to check first if camera detects real person or fake , then if already real person , check will be done to know if this real person is verified to drive the car or not.**
- **Make a constant brightness in frames taken to make sure that regardless the lighting in background , the processed frames will be almost the same in brightness.**
- **Car users will be the only people who have access on the Images taken through face ID process.**
- **Send E-mail to all users when any user tries to make any action on car with quick image taken to him and verification code.**

II. *Algorithms Used*

Deep Face Algorithm

Deep Face, developed by Facebook's AI research team, is a facial recognition system known for its high accuracy in face verification tasks. It employs deep learning techniques to detect faces, align them to a standard pose, and extract robust facial features. These features are then used to represent each face as a vector, facilitating comparisons between faces for recognition purposes.

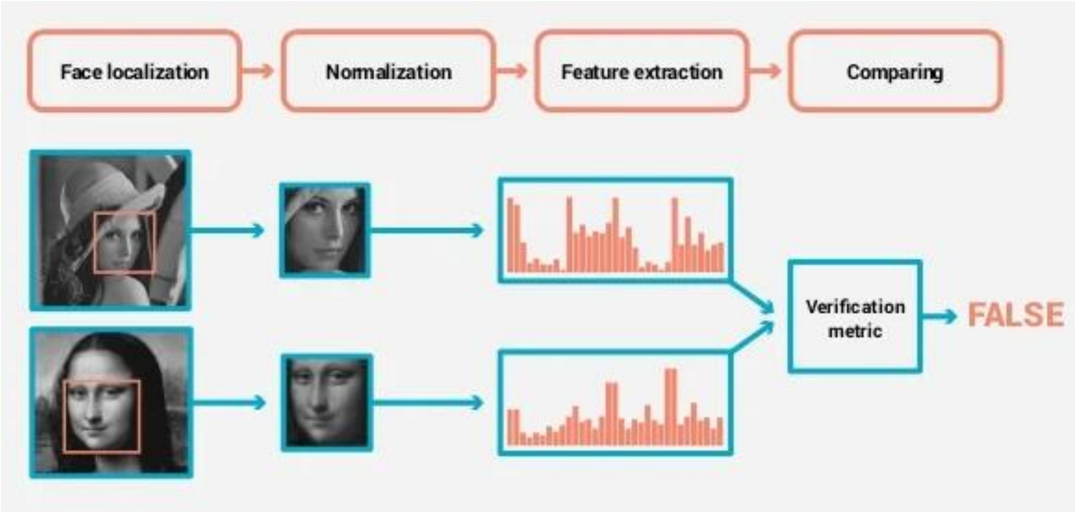


Figure 24: Deep Face Algorithm Steps

2.3.5.Methodology

As said before , in tasks related to AI , there are always 3 basic tasks that must be done:

I. *Implementation steps*

a. **Dataset Collection**
b. **Training**
c. **Testing and Validation**

II. *Applying steps on our Algorithms*

- **Dataset Collection**

  Dataset is collected in different way , it is collected by software using our additional feature 'ADD USER' , which enables us to add users easily to the database of the car , and 'DELETE USER' which enables us to delete users easily from the database of the car

- **Training**

  After each ADDING or DELETING process , system will be trained automatically on the new data found in the database.

- **Testing and Validation**

  The system can be tested by adding huge number of users and test if it will run in correct way or not.

2.3.6.Advantages of our work in Face ID

- Low cost (using webcam and using our laptop rather than buying expensive processing unit).
- Increase Enhanced Security: Face ID system offer robust security measures, making it difficult for unauthorized individuals to enter car system.
- Overcoming many problems such as:
  - Easy to trick.
  - Sensitive to surroundings.
  - Privacy worries.
  - Computational Resource Requirements.

2.3.7.Challenges and considerations

- ☒ Computational Resource Requirements.
- ☒ Enhancing the speed of check user process.

2.3.8. Conclusion

In conclusion, the adoption of a security face ID system represents a significant step towards enhancing access control and authentication processes in various sectors. The system's advantages, including high accuracy, convenience, and scalability, underscore its potential to revolutionize security measures. However, it's essential to acknowledge the existing limitations, such as susceptibility to spoofing and privacy concerns, which necessitate ongoing research and refinement. Despite these challenges, the continuous evolution of face recognition technology offers promising solutions and opportunities for further innovation. By addressing current limitations and leveraging advancements in the field, security face ID systems can continue to strengthen security measures, safeguard sensitive information, and provide a seamless and user-friendly authentication experience. As organizations and industries embrace the potential of facial recognition, collaboration between researchers, developers, and policymakers will be crucial in maximizing the benefits of this technology while mitigating its risks. Overall, the journey towards enhanced security through face ID systems represents a dynamic and transformative endeavor with vast potential for positive impact in the realm of authentication and access control.

2.4. Adaptive cruise control (ACC)

2.4.1. Executive Summary

The chapter presents the design and implementation of an Adaptive Cruise Control (ACC) system, an integral feature in modern automotive safety and convenience technologies. The system is developed to maintain a safe and efficient following distance between vehicles by autonomously adjusting the vehicle's speed in response to the traffic conditions ahead. Utilizing a combination of sensors, actuators, and control algorithms, the ACC system continuously monitors the relative speed and distance to the preceding vehicle, allowing for smooth acceleration, deceleration, and braking. This chapter delves into the underlying principles, architecture, and functionality of the ACC system, along with the integration of machine learning techniques for enhanced performance and adaptability. Furthermore, real-world testing and evaluation results are presented to validate the effectiveness and reliability of the implemented ACC system in various driving scenarios.

2.4.2. Introduction

In recent years, the automotive industry has witnessed a rapid evolution in the integration of advanced driver assistance systems (ADAS) aimed at enhancing vehicle safety, comfort, and efficiency. Among these innovations, Adaptive Cruise Control (ACC) stands out as a pivotal technology that has redefined the driving experience by automating the vehicle's speed control in response to changing traffic conditions. Unlike traditional cruise control systems that maintain a constant speed set by the driver, ACC employs a sophisticated array of sensors and control algorithms to adaptively adjust the vehicle's speed, ensuring a safe following distance from the preceding vehicle.

The primary objective of ACC is to mitigate the risks associated with rear-end collisions, one of the most common types of accidents on roadways worldwide. By continuously monitoring the relative speed and distance to the vehicle ahead, ACC enables smooth and seamless transitions between acceleration, deceleration, and braking, thereby reducing driver workload and fatigue, especially during long highway journeys.

This chapter aims to provide an in-depth exploration into the design, implementation, and functionality of an ACC system. We will delve into the underlying principles that govern ACC operation, discuss the key components and sensors involved, and examine the control algorithms responsible for decision-making in various traffic scenarios. Additionally, we will explore the potential integration of machine learning techniques to enhance the adaptability and performance of ACC systems, paving the way for safer and more efficient autonomous driving solutions.

Figure 25: ACC system

2.4.3. Literature review

Traditional cruise control systems have been a foundational component in automotive technology, offering drivers a means to maintain a constant vehicle speed with minimal manual intervention. Early implementations relied on mechanical and hydraulic mechanisms, evolving over time to incorporate electronic controls and microprocessor-based technologies for enhanced precision and adaptability. Research has focused on optimizing control algorithms, including proportional-integral-derivative (PID) controllers and adaptive strategies, to achieve stable speed regulation across varying driving conditions. While traditional cruise control systems have been praised for reducing driver fatigue and maintaining fuel efficiency, concerns regarding adaptability to changing traffic conditions and potential driver complacency have been raised. This has led to the development of more advanced driver assistance systems, such as Adaptive Cruise Control (ACC), to address the dynamic challenges of modern driving environments.

I. *Limitations of the existing ACC systems*

- **System Reliability.**
- **Environmental Constraints.**
- **Complex Traffic Scenarios.**

- **Driver Engagement.**
- **Integration with Other ADAS.**
- **Cost and Accessibility.**

II. *Previous suggested solutions*

a. Cars' companies' solutions:

Automotive manufacturers have addressed ACC limitations through advanced sensor fusion techniques, combining radar, lidar, and camera data to enhance reliability. They've also developed weather-resistant sensors and algorithms for better performance in adverse conditions. Improved machine learning algorithms enable ACC to handle complex traffic scenarios, while driver monitoring systems promote attentiveness. Enhanced coordination between ACC and other ADAS components ensures seamless integration, and scalable sensor technologies aim to reduce costs and broaden accessibility across vehicle segments.

b. Last Graduation Projects solutions:

Previous graduation projects have tackled ACC limitations through sensor fusion for improved reliability, adaptive algorithms for environmental adaptability, and machine learning for complex traffic prediction. They've also focused on enhancing driver engagement with intuitive interfaces and coordinating ACC with other ADAS features. Cost-effective sensor alternatives and modular designs aim to increase affordability and accessibility across vehicle segments.

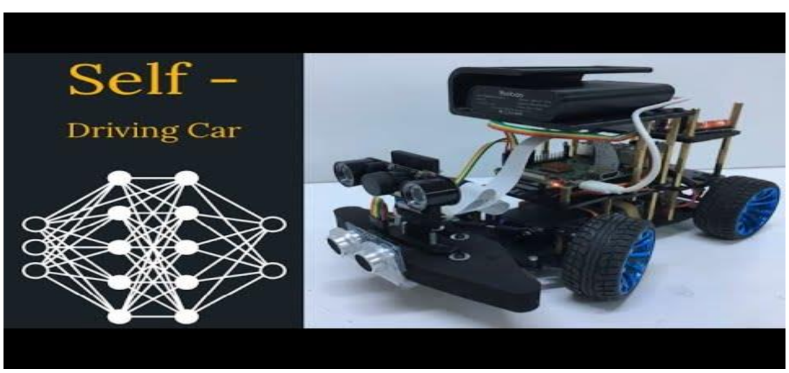


Figure 26:Last Graduation Projects solutions

2.4.4. Design and functionality

Implementing Adaptive Cruise Control (ACC) in our graduation project car is crucial to enhance both safety and driving convenience. ACC will autonomously control the car's speed, ensuring it maintains a safe distance from other vehicles ahead. This feature not only reduces the driver's workload but also mitigates the risk of rear-end collisions by adapting to changing traffic conditions. Integrating ACC aligns with modern automotive advancements and emphasizes the project's commitment to innovative and intelligent vehicle control systems.

- **Hardware Components:**

Figure 27:TF-Luna LiDAR

2.4.5.TF-Luna LiDAR block diagram

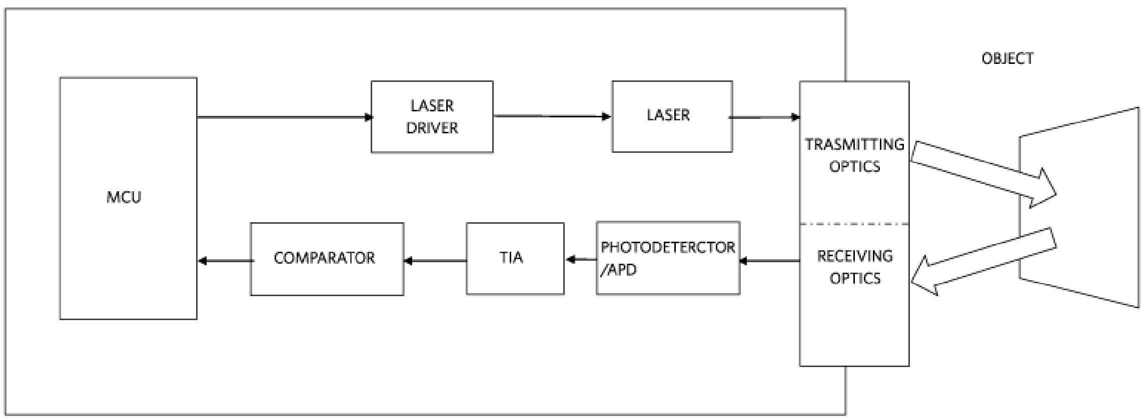


Figure 28:TF-Luna LiDAR block diagram

2.4.6. Methodology

The TF-Luna LiDAR sensor will be selected and calibrated, followed by the collection and processing of real-time data. A control algorithm will be developed to adjust the vehicle's speed based on the detected distances. The hardware will be integrated with this algorithm, and the system will be tested to validate its performance and safety features.

I. Implementation steps

a. **System Design and Integration**.
b. **Data Acquisition and Processing.**
c. **Control Algorithm Development.**
d. **System Integration and Testing.**
e. **User Interface and Feedback Mechanism.**

III. Applying steps on graduation project car

a. System Design and Integration:

- **Component Selection**: Choose the necessary hardware components, including the TF-Luna LiDAR sensor, microcontroller (stm32).
- Sensor Calibration: Calibrate the TF-Luna LiDAR sensor to ensure accurate distance measurement and reliable object detection in various driving conditions.

b. Data Acquisition and Processing:

- Data Collection: Collect real-time distance and speed data from the TF-Luna LiDAR sensor and vehicle's speedometer using stm32 microcontroller.
- Data Preprocessing: Implement filtering and noise reduction techniques to clean and preprocess the sensor data for accurate analysis.

c. Control Algorithm Development:

- Distance and Speed Control: Develop a control algorithm that uses the TF-Luna LiDAR data to adjust the vehicle's speed and maintain a safe following distance from the preceding vehicle.
- Adaptive Response: Implement adaptive control strategies to dynamically adjust the acceleration and deceleration based on the detected traffic conditions.

d. System Integration and Testing:

- Hardware Integration: Integrate the developed control algorithm with the hardware components, ensuring seamless communication and functionality.
- Software Implementation: Develop and deploy the control software on the stm32 microcontroller platform, ensuring efficient execution and real-time response.
- Performance Evaluation: Conduct comprehensive testing and validation of the ACC system in various driving scenarios to assess its reliability, accuracy, and safety performance.

e. User Interface and Feedback Mechanism:

- Dashboard Display: Design a user-friendly dashboard display to provide real-time feedback on the ACC system's status, including set speed and system warnings.
- Driver Control: Desing a switch in the car to generally turn off or turn on the whole system.

2.4.7. Conclusion

The implementation of the Adaptive Cruise Control (ACC) system using the TF-Luna LiDAR sensor in our graduation project demonstrates a significant step towards enhancing the safety and autonomous capabilities of modern vehicles. Through careful selection, calibration, and integration of the sensor with a developed control algorithm, we have aimed to create a system that effectively adjusts the vehicle's speed based on real-time distance measurements. While further testing and refinement are necessary to ensure optimal performance in diverse driving scenarios, this project lays a solid foundation for future advancements in intelligent vehicle control systems. Incorporating ACC not only aligns with current automotive innovations but also underscores our commitment to contributing meaningful solutions to contemporary transportation challenges.

2.5.Traffic sign recognition (TSR)

2.5.1. Executive Summary

Traffic Sign Recognition (TSR) is a pivotal component of modern automotive safety and driver assistance systems. This technology employs advanced computer vision algorithms and machine learning models to enable vehicles to autonomously identify and interpret road signs.

2.5.2.Introduction

In the present era of driving, where technology takes the wheel, Traffic Sign Recognition (TSR) emerges as a beacon of innovation in our project. Picture that your car not only observes road signs but comprehends their meaning, acting as a knowledgeable companion guiding you through the intricacies of the road. In the grand tapestry of our graduation project, TSR stands as a vital thread, intricately woven into the fabric of driving innovation. It's not a solitary entity; instead, it collaborates with an ensemble of cutting-edge features. Embarking on an exploration of how TSR seamlessly integrates into the broader project was an important step, working synergistically with other technologies to redefine the driving landscape.

Figure 29:TSR system

2.5.3.Literature review

Traffic Sign Recognition (TSR) stands as a testament to the remarkable advancements in automotive technology, providing vehicles with the capability to autonomously interpret and respond to road signs. This technology significantly enhances driving safety and convenience, offering drivers invaluable assistance in navigating complex road networks. However, it's essential to recognize that despite these advancements, TSR systems are not infallible. Their efficacy is contingent on numerous factors.

I. *Limitations of the existing TSR systems*

- **Variability in Sign Appearance.**
- **Adverse Weather Conditions.**
- **Computational Resource Requirements.**
- **Area not covered by the navigation system (requirement of Internet connection)**
- **Driving toward bright lights.**
- **Concealed or covered road signs.**
- **Overlapping of more than one sign in one frame**
- **The distance between the camera and the sign**

II. *Previous suggested solutions*

☒ **Cars' companies' solutions:**

The solutions proposed by companies depend on the increased cost of using the latest and most accurate hardware parts available.

☒ **Last Graduation Projects solutions:**

All the solutions proposed and implemented by the owners of previous graduation projects depend on reducing the car's scale to the size of children's toys.

Figure 30: Last Graduation Projects solutions

2.5.4.Design and functionality

For our project, this feature should be implemented to solve the problems that affect it, but at the same time the problems found in the previous solutions should be avoided.

I. Hardware Components

- **Laptop**
- **Webcam**
- **FTDI**

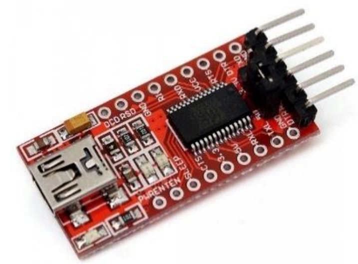


Figure 31:FTDI

II. Our suggested solutions

- **Using our laptop as the processing unit**
- **Make the feature works fully offline**
- **Using more powerful algorithms for traffic signs detection**

III. Algorithms Used

YOLO Algorithm

It is known for its real-time processing capabilities. It divides the input image into a grid and predicts bounding boxes and class probabilities directly for each grid cell in a single forward pass.

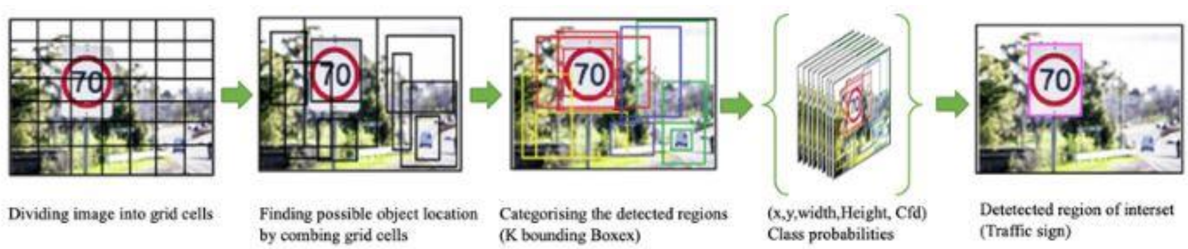


Figure 32:YOLO Algorithm Steps

IV. TSR block diagram

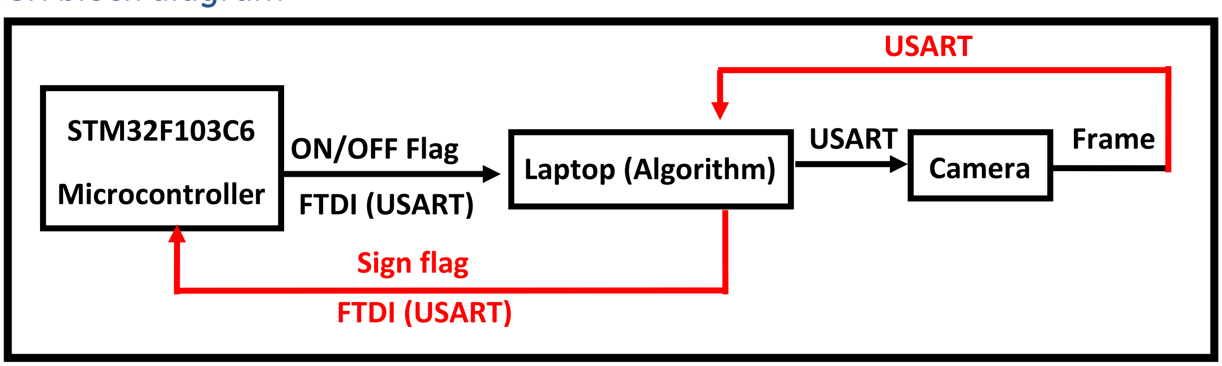


Figure 33:TSR block diagram

2.5.5.Methodology

In tasks related to AI , there are always 3 basic tasks that must be done:

I. *Implementation steps*

a. **Dataset Collection**
b. **Training**
c. **Testing and Validation**

II. *Applying steps on our Algorithms*

☒ Dataset **Collection**

21,035 images were collected for 42 sign and images are divided as follows:

Training: 19,583 images.

Validation: 725 images.

Testing: 727 images.

☒ **Training**

100 epochs were used to train the model using the YOLOv8 algorithm, and you will note that the accuracy of the model increases at each epoch.

☒ **Testing and Validation**

Python enables us to test the trained YOLOv8 model using Command line using only one line command.

2.5.6.Advantages of our work in TSR

☒ Low cost (using webcam and using our laptop rather than buying expensive processing unit).

☒ Increase the capability of real time performance (benefiting from the powerful capabilities of laptop's CPU&GPU).

☒ Overcoming many problems such as:

- Variability in Sign Appearance.
- Adverse Weather Conditions.
- Computational Resource Requirements.
- Requirement of Internet connection
- Driving toward bright lights.
- Concealed or covered road signs.
- Overlapping of more than one sign in one frame.
- The distance between the camera and the sign.

2.5.7.Challenges and considerations

- Computational Resource Requirements.
- Large quantity of data.
- Sign Detection from different distances.

2.5.8. Conclusion

In conclusion, Traffic Sign Recognition (TSR) stands as a testament to the ongoing evolution of automotive technology, ushering in an era where vehicles actively engage with their surroundings. The journey through TSR's landscape has unveiled its transformative impact on driving safety, efficiency, and user experience. TSR serves as a vigilant companion, decoding the language of road signs and empowering drivers with timely information.

This chapter has illuminated TSR's strengths in real-time sign identification, contributing to enhanced road safety and regulatory compliance. However, it is crucial to acknowledge the inherent challenges and limitations that accompany this technology, ranging from the variability in sign appearance to environmental factors like adverse weather and bright lights.

The future of TSR lies in the hands of researchers, engineers, and innovators committed to refining its design, functionality, and overcoming its limitations. Aesthetic integration, intuitive Human-Machine Interfaces (HMI), adaptive algorithms, and sensor fusion are integral components shaping the next generation of TSR systems. These advancements hold the promise of a more seamless and reliable TSR experience, fostering a harmonious coexistence between vehicles and the intricate signage that guides them.

2.6.Driver Monitoring System(DMS)

2.6.1. Executive Summary

In this chapter a discussion will be done with more details one of the most unique features in our electrical car the Driver monitoring system (DMS) sometimes called a driver state sensing (DSS) system. It will involve the "HOW" mechanism of this feature is done and applied in cars either diesel or electrical one knowing that the "HOW" of this feature costs a lot in automotive companies we learned ourselves to get it, Many other questions will be answered about : Is there are any alternative methods for most common used , the needed hardware tools and software algorithm , short brief about how this feature is applied in market now.

2.6.2 INTRODUCTION:

In the last 20 years and since many times car accidents have been increased every day. Many people lost their Life by a 10 seconds mistake and since the safety of the driver and passengers is our main purpose of this feature, we introduce this features that mainly focused on the driver and its behaviors and worn them to fix it immediately AS it is recognized from figure(34,35)it's had known that the main reason of accidents is the driver himself and how the driver might be Dispersed with external disturbance and since in these days every human is busy all the time, exhausted and has a busy brain the driver might face problems like :

a. Drowsiness and sleeping
b. Taking phone calls
c. Distraction

Behavior	2020 fatalities	% change from 2019
DUI	11,654	Up 14%
Speeding	11,258	Up 17%
Seat belt nonuse	10,893	Up 14%
Distracted driving	3,142	Up 0.7%
Hit-and-run	2,564	Up 26%
Drowsy	633	Down 9.2%

Figure 34:Causes Of Accidents In Last 10 Years

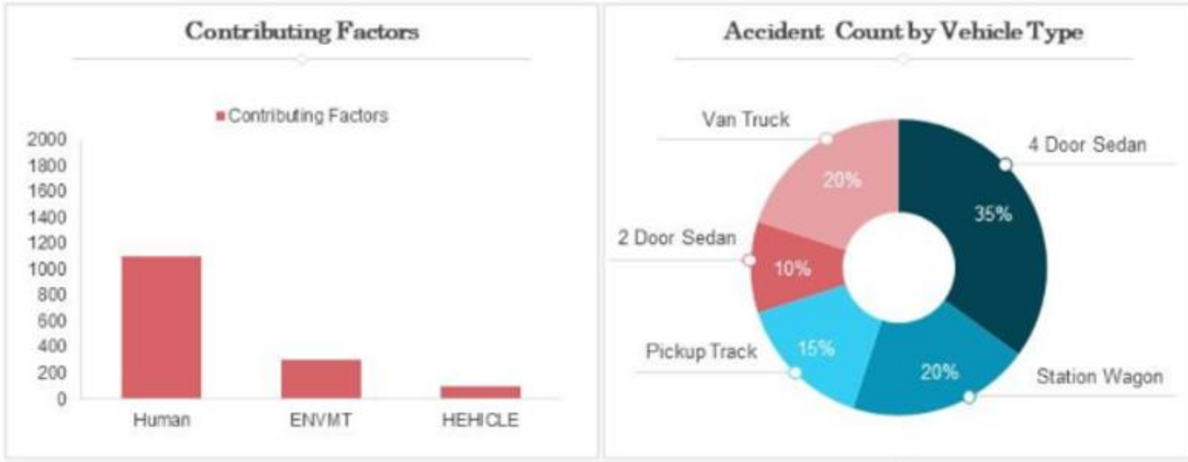


Figure 35:Share Of Car Type In Accidents

2.6.3.The most common type of monitoring

Nowadays full monitoring by typically use a driver-facing camera equipped with infrared light-emitting diodes (LEDs) or lasers so that it can “see” the driver’s face, even at night, and see the driver’s eyes even if the driver is wearing dark sunglasses. Advanced on-board software (AI algorithm) collects data points from the driver and creates an initial baseline of what the driver’s normal, attentive state looks like.

The software can then determine whether the driver is blinking more than usual, whether the eyes are narrowing or closing, and whether the head is tilting at an odd angle. It can also determine whether the driver is looking at the road ahead, and whether the driver is paying attention or just absent-mindedly staring. And then it could get the driver’s attention by issuing audio alerts, lighting up a visual indicator on the dashboard or vibrating the seat


Figure 36:Monitoring Face Expressions In Ai DMS

The second most common type DMS by Hands detection on the steering wheel using and appropriate sensor called HOD sensor . Numerous instances of drivers misusing the systems, acting as if the vehicle would be “self-driving” (taking the hands off the steering wheel or even leaving the driver seat) have been recorded. Unfortunately, this irresponsible behavior has already led to fatal crashes. Through the use of this HOD sensor, the vehicle is able to detect precisely if the driver’s hands are on the steering wheel, and if not, initiate an appropriate warning cascade.

Figure 37:Normal DMS System

2.6.4.What we offer?

We offer in our project an integration between the 2 most common types of DMS in order to enhance the safety and monitor driver in more than one direction ensuring that if one method gives a false reading the other one gives a true alert

I. First Direction(Embedded Part)

Using **touch sensor** sucked on the 4 sharp angels of steering wheel to sense the existence of the driver hand or even finger on any part on steering wheel to confirm that steering wheel is controlled

Components:

a. Touch Sensor
b. Buzzer
c. OLED

a. Touch sensor:

- simple input/output sensor capable to give a reading on the microcontroller connected pin of a digital reading (high (1)) when there is any pressure on it and (low(0)) if there are no pressure

Figure 38:Touch Sensor

- **Work principle :**

It is similar to switch principle when the touch sensor senses the touch or proximity is captured then it acts like a closed switch otherwise it acts as an open switch.

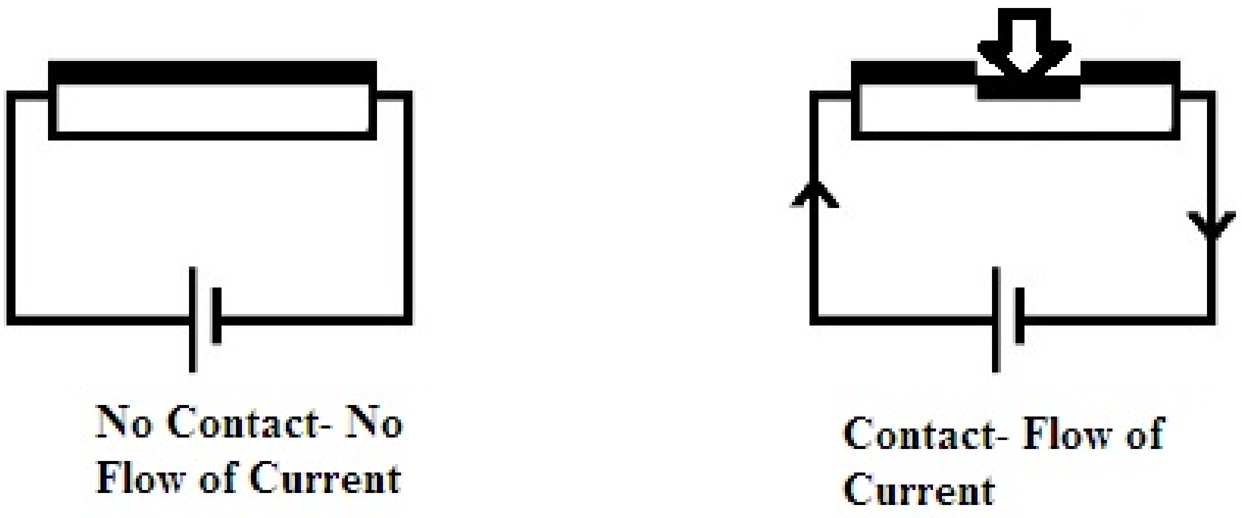


Figure 39:Flow of Current

b. Buzzer:

A buzzer is a small yet efficient component to add sound features to our project/system. The rapid movement of the diaphragm back and forth generates compressions and rarefactions in the surrounding air, creating sound waves. This sound is what we perceive as the buzzing or humming sound produced by the buzzer.

It is very small and compact 2-pin structure hence can be easily used on breadboard Perf Board and even on PCBs . It also works by sending a signal to the Gate of BJT shown in figure(38)

Specifications:

- Rated Voltage: 6V DC
- Operating Voltage: 4-8V DC
- Rated current: <30mA
- Sound Type: Continuous Beep
- Resonant Frequency: ~2300 Hz

Figure 40:Buzzer

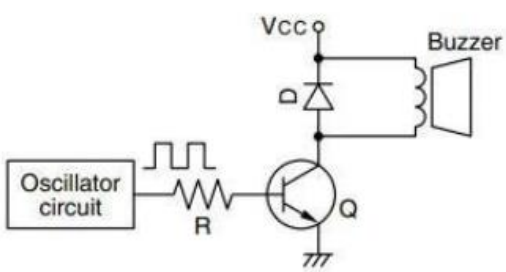


Figure 41:BJT Circuit Of Buzzer

c. OLED

To frequently show the heart rate and display warning messages if no signal or very small signal detected like " you should take rest " , "check your heartrate please" or " be conscious to road please"

Figure 42:OLED

✓ Feature sequence:

1. Initialization for all sensors to work and then start checking the 4 sensors sequentially using polling technique (in polling process unit keeps asking the I/O device whether or not it desires CPU processing) not interrupt technique in order to not stop all system and current process with each interrupt to follow its ISR code , these readings for sensors is done frequently every 10 ms (with respect to RTOS mechanism)

2. If any sensor of 4 sensors gives high reading (logical or) that mean that driver is controlling steering wheel and in safe position from this direction(First one) using UART a specific frame sent to laptop then a welcoming voice message emit by car "thank you, car is controlled now" and also displayed on OLED

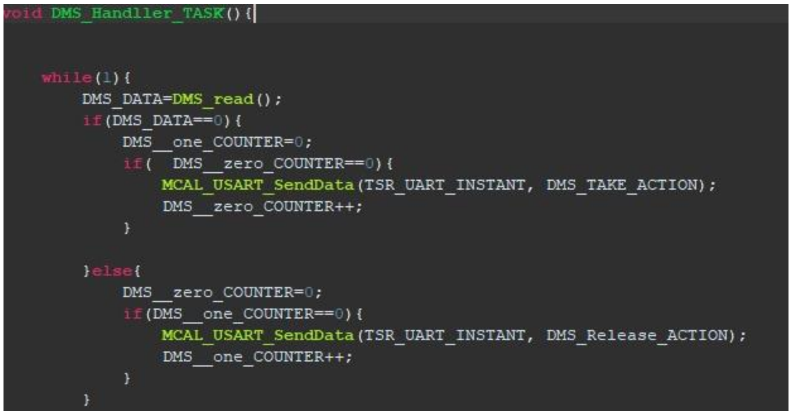
3. If the 4 sensors give low reading(logical and) that indicate that the driver is disturbed and not controlling the wheel

4. Buzzer is turned to warn the driver and get his attention

5. A warning voice message emit from the car" watch out you are in danger" and also an icon that describe case displayed on OLED

6. During polling and continuous read for sensors once the reading of any of sensors back to (high) the warning system stops

Figure 44: Figure That show up on OLED while non-Controlling



```
void DMS_Handller_TASK(){


    while(1){
        DMS_DATA=DMS_read();
        if(DMS_DATA==0){
            DMS__one_COUNTER=0;
            if(  DMS__zero_COUNTER==0){
                MCAL_USART_SendData(TSR_UART_INSTANT, DMS_TAKE_ACTION);
                DMS__zero_COUNTER++;
            }

        }else{
            DMS__zero_COUNTER=0;
            if(DMS__one_COUNTER==0){
                MCAL_USART_SendData(TSR_UART_INSTANT, DMS_Release_ACTION);
                DMS__one_COUNTER++;
            }
        }
```

Figure 43:Code Checking on Touch sensor Condition

II. Second Direction (AI part)

- This part went parallel to Hand on detection part to ensure safety by continuous monitoring for driver full face specially the eyes by the camera (web cam) fixed in front of him

- These feature's part work by a technique called **landmarks detection** using an open cv library in AI libraries this technique involves the detection of driver full face parts each part separately
- In this part we are concerning the eye detection specially as these libraries can specify when driver's eye is open or closed

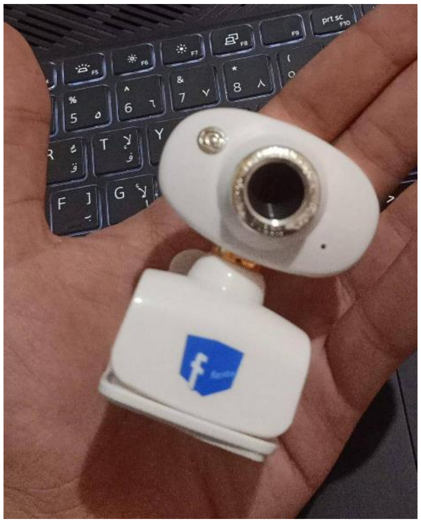


Figure 45:Web Cam Used

✓ Feature sequence:

a. Eye detected through camera if it's open normally with normal blinking rate no action is taken
b. If eye is detected to be closed for a relatively long period that is sufficient to put the driver in dangerous (4 seconds) an action is taken
c. Hence, if the driver sleeps or distracted not looking to the road is more dangerous than not holding steering wheel so the action will be taken this time directly to motor of the car and decreasing its speed gradually to avoid crashing until it completely stops .

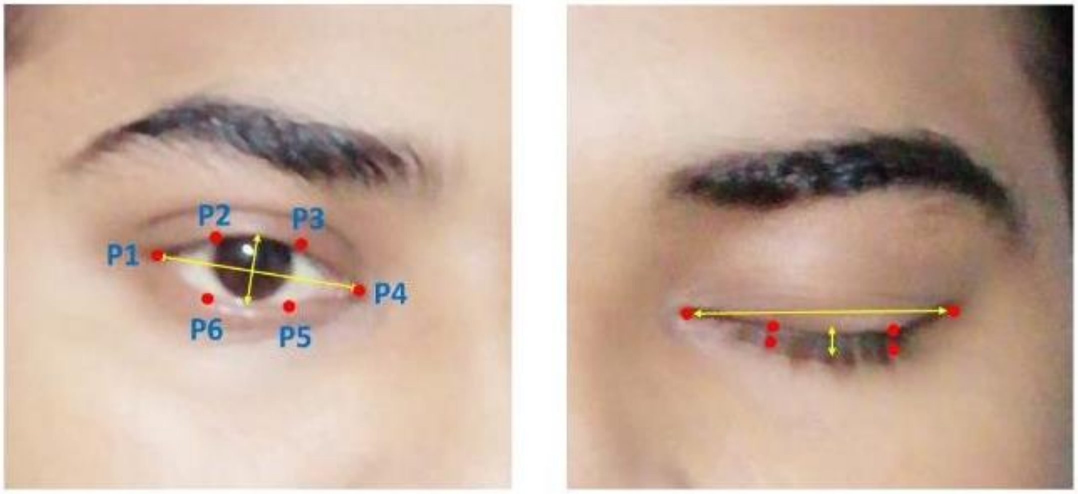


Figure 46:Detection Of Driver Eye Level Of Drowsiness

2.7.Internal Wheel jack System (IWJS)

2.7.1. Executive Summary

This chapter introduces a novel feature for electric vehicles (EVs) – the Internal Wheel Jack System (IWJS). Replacing the traditional jack and manual labor, the IWJS employs electric pistons located beside each tire, controlled by a push button within the car. This chapter details the design, functionality, simulation, advantages, and potential challenges of the IWJS, highlighting its benefits for user convenience, safety, and space optimization in EVs.

2.7.2.Introduction

Changing a flat tire can be a tedious and physically demanding task. Traditional car jacks require manual operation, often in inconvenient roadside situations. For EVs, the limited storage space further complicates carrying traditional jacks. The IWJS aims to address these challenges by offering a convenient, user-friendly, and compact solution for tire changes in EVs.

2.7.3.Design and Functionality

I. *Materials*

- Electric Pistons figure (47): Each wheel in the car has a dedicated electric piston installed beside it, discretely hidden within the wheel well.

Figure 47: Linear actuator.

Technical Parameters
1. Input voltage: DC 12V
2. Maximum load: 3000N≈300kg≈662lbs
3. Speed:5mm/s
4. Stroke length: 250mm
5. Working frequency: 10%
6. Noise level: <50dB

High quality: The linear actuator is made of high-quality aluminum; Equipped with high-performance motor and built-in limit switch, it can stop at any position and automatically stop at the top, with self-locking function.

- Control System: A push button inside the car triggers the desired piston to extend, lifting the corresponding wheel off the ground.
- Wires
- MCU (our main microcontroller)
- Safety Features:
    - Built-in overload protection prevents piston damage beyond its lifting capacity.
    - Automatic descent ensures controlled lowering of the vehicle even in case of power loss.

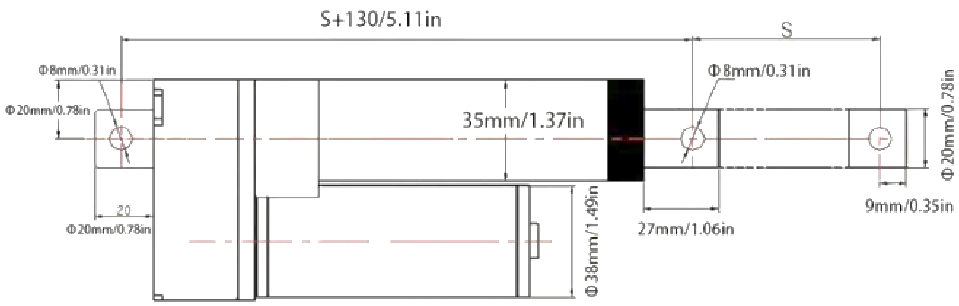


Figure 48:Shows the specifications of the linear electric actuator.

Mainly in linear actuators, a screw- gear is used for linear movement. Due to the rotation of the screw relative to the nut the linear motion of the staff is performed. The direction of movement of the staff basically is changed by the direction of rotation of the engine. To do this, a switch is designed in the device to alter the polarity of the power supply. As a result, by pressing the switch it is possible to change the direction of rotation in the engine, consequently the direction of the staff, too as shown in figure (50).

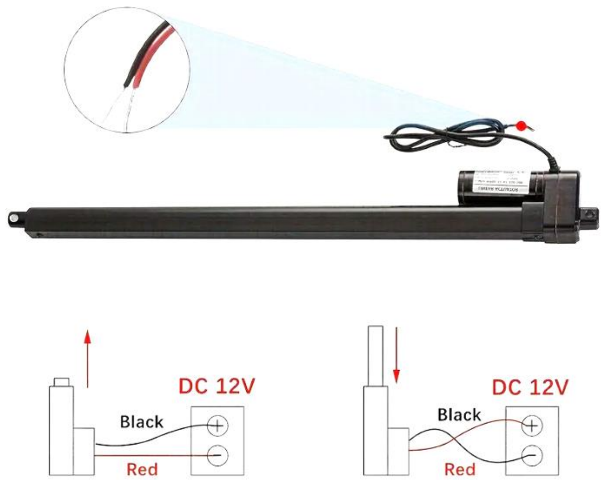


Figure 49:change the direction of rotation in the engine by changing the polarity.

The main criterions for the linear actuator are: pushing and retracting force, load capacity, staff length, speed, operating time and life time.

The pushing force is the maximum tensile force that the linear actuator can produce in Newton (N), and the retracting force is the maximum retracting force. Some actuators do not provide equal pushing and retracting forces, while others cannot provide the retracting force.

Load capacity is weight or mass with which the actuator can be applied, remaining motionless without permanent damage or without causing the actuator to move in the opposite direction. The maximum dynamic load is the maximum overall weight or mass that the actuator can move.
The significant factor of this value is the size of the engine and the type of gear train.

Stroke length means the length in mm by which the actuator pulls out or retracts. Retracted length is the smallest distance between two fixed points on the actuator when the pushing staff is retracted. This size reflects the measurement from the centers of the rear and front mounting holes.

IV. Calculations of some basic parameters

We calculate the utilization factor and the maximum load for the actuator, working on a cycle: 60 seconds work, 60 seconds' pause.

To calculate the load factor, we use the equation:

$$K = \frac{W}{W+p} \qquad (2.6)$$

Where:
K=Load factor.
W= working time of the piston.
P= pause time of the piston.

$$K = \frac{60}{60+60} * 100 = 50\%$$

When using a car jack to lift one wheel of a car off the ground, the jack typically supports the entire weight of that corner of the car. This means that the percentage of the car's weight that the jack holds would be close to 25% if you are lifting one of the four wheels.

Using the graph of the dependence of the load ratio on the allowable load, we determine the allowable load figure (50) at a load ratio of 50%.

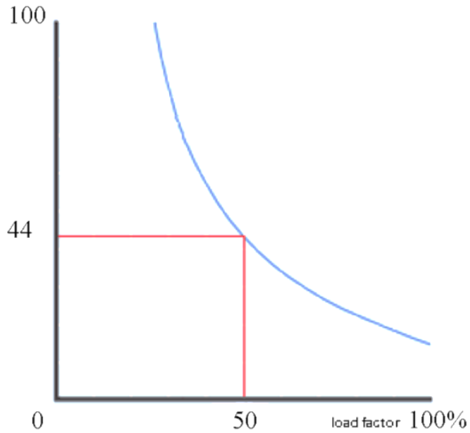


Figure 50: Shows the allowable load factor to the car.

The allowable load is 44% of the maximum dynamic load.

F_{max} = 3000 N

$F_{permissible}$ = 0.44* 3000 = 1320 N

So, the maximum allowed mass applied to the jack is nearly 135 Kg. That means that the entire car weight can't exceed 135*4 = 540 Kg.

V. *Modeling using Grab CAD*

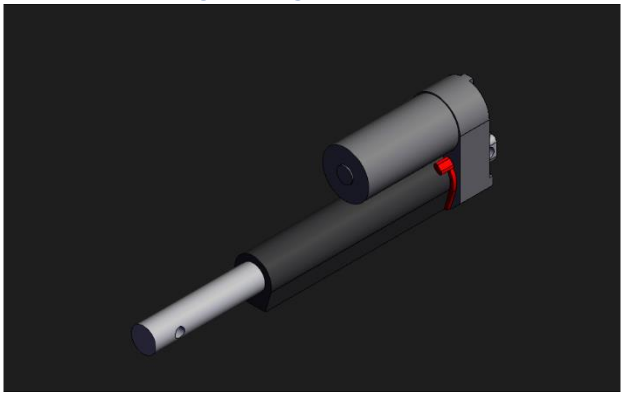


Figure 52: Isometric view.

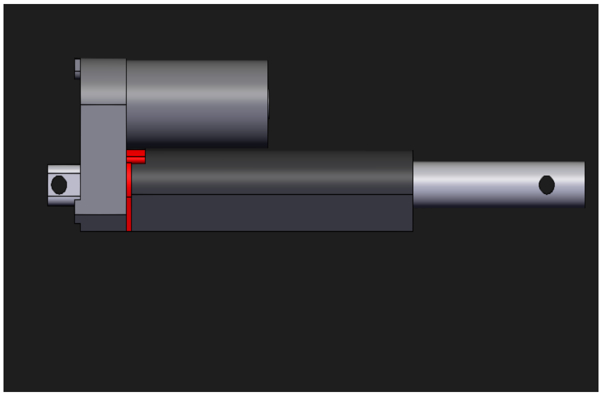


Figure 51:Left view.

2.7.4.Methodology

We can represent the load of the car by mass-spring system applied by its weight to make the mathematical model of our system.

One or two viscous dampers have been inserted in these systems, to take into account the effects of energy dissipation occurring during the motion of the carriages. For an actual system, the numerical value of the damping constants can be experimentally determined through a free oscillation test, simply by measuring the oscillation amplitude between two consecutive periods and applying the logarithmic decrement method.

Figure (7.10) also shows the motion command apparatus of the actuator, which consists of a position controller (usually implemented by means of a digital PID regulator), a linear motor with built-in transducer, a power amplifier and a feedback loop. Henceforth we will assume that the parameters of the control system are correctly tuned, so that the error between the position command $y_{ref}(t)$ and the actual position $y(t)$ of the translating element can be neglected; therefore, on the basis of this hypothesis, we can write: $y_{ref}(t) \sim= y(t)$.

The dynamic analysis of the system in figure (7.10) can be easily carried out by writing the motion equation of the mass m, which expresses the dynamic equilibrium of the forces acting on the mass in the horizonal direction; this equation assumes the following form:

$$m\ddot{x} + c(\dot{x} - \dot{y}) + k(x - y) = 0 \qquad (2.7)$$

Introducing the relative coordinate z = x − y, the circular natural frequency $\omega_n = \sqrt{k/m}$ and the damping ratio $\xi = c/2m\omega_n$, Eq. (7.2) can be rewritten in the form:

$$\ddot{z} + 2\xi\omega_n\dot{z} + \omega_n^2 z = -\ddot{y}(t) \qquad (2.8)$$

Knowing the analytical expression of the motor acceleration $\ddot{y}$ (t) and starting from null initial conditions (that is z(0) = 0, $\dot{z}$ (0) = 0), the solution of the differential equation (7.3) can be calculated through the convolution integral:

$$z(t) = -m\int_0^t \ddot{y}(\tau)h(t-\tau)\mathrm{d}\tau \qquad (2.8)$$

where h(t) is the response of the oscillator to a unit impulse; this function assumes the following forms, depending on the damping ratio of the system:

$$h(t) = \begin{cases} \dfrac{e^{-\xi\omega_n t}}{m\omega_d}\sin\omega_d t & \text{for } \xi < 1 \\ \dfrac{te^{-\omega_n t}}{m} & \text{for } \xi = 1 \\ \dfrac{e^{-\xi\omega_n t}}{m\omega_n\sqrt{\xi^2 - 1}}\sinh\left(\omega_n\sqrt{\xi^2 - 1t}\right) & \text{for } \xi > 1 \end{cases} \qquad (2.9)$$

where $\omega_d = \omega_n\sqrt{1 - \xi^2}$. The computation of the convolution integral can be carried out without particular problems, using a numerical algorithm. After calculating the z coordinate, the position x of the mass can be determined by adding the displacement of the linear motor y:

$$x(t) = z(t) + y(t). \qquad (2.10)$$

2.7.5.Installation

I. Pre-Installation Preparation

Tools and Materials Required

Before starting the installation process, following tools and materials were prepared:

- Internal wheel jack kit (including the jack mechanism, mounting brackets, and hardware) as shown in figure (54)

Figure 53: shows the kit.

- Switch and wiring components
- Screwdrivers
- Wrench set
- Drill and drill bits
- Electrical tape
- Welding

Figure 54:shows the welding process.

II. Installation Steps we followed

Step 1: Vehicle Preparation

1. vehicle's battery had been disconnected to prevent any electrical mishaps during installation.
2. Identified a suitable location inside the vehicle where the internal wheel jack can be securely mounted, ensuring it doesn't interfere with other vehicle components.

Step 2: Mounting the Internal Wheel Jack

1. Position the internal wheel jack mechanism in the chosen location.
2. Secure the mounting brackets to the vehicle's frame using the provided hardware.
3. Ensure the internal wheel jack is securely attached and does not move when tested.

Step 3: Electrical Wiring

1. Install the switch in a convenient location inside the vehicle.
2. Connect the wiring from the internal wheel jack mechanism to the switch, ensuring proper electrical connections.
3. Use wire connectors and electrical tape to secure and insulate the connections.

Figure 55:Shows the internal wheel jack while the tires are up.

Chapter 3: Testing and Optimization

3.1.Introduction

- This chapter focuses on the testing and optimization phase of the electric vehicle project. The primary goal during this phase was to ensure that all components and systems functioned harmoniously and met performance expectations. Rigorous testing was crucial to identify any operational challenges and to validate the vehicle's design and functionality.

3.2.Electric Vehicle (EV)

3.2.1.Testing Procedures

- The testing phase commenced with a series of structured trials designed to assess the overall functionality of the electric vehicle, particularly focusing on the electric motor, battery system, and Advanced Driver Assistance Systems (ADAS). Each component was subjected to real-world scenarios to closely monitor performance and identify any discrepancies or failures.

3.2.2.Challenges and Solutions

I. *Motor Attachment Challenges:*

- Finding a chain that matched the distance between the motor and the base proved challenging.
- Extensive research was undertaken to locate a suitable chain, and after persistent efforts, a better chain was identified. Then it was modified to fit perfectly, successfully overcoming the initial challenges.

II. *Motor Base and Chain:*

- Another problem, the motor base didn't fit well, and the chain hit the chassis, making the motor not work properly. Shown in figure (55)

Figure 56:Chain Hitting Chassis

- **SO,** Multiple measures were taken, including additional welding, to modify the motor base, ensuring a precise fit and eliminating interference issues.
- Extensive efforts were invested in finding the optimal placement for the motor and base. Through meticulous modifications, A perfect fit was achieved, enhancing the overall functionality of the system As shown in Figure (56).

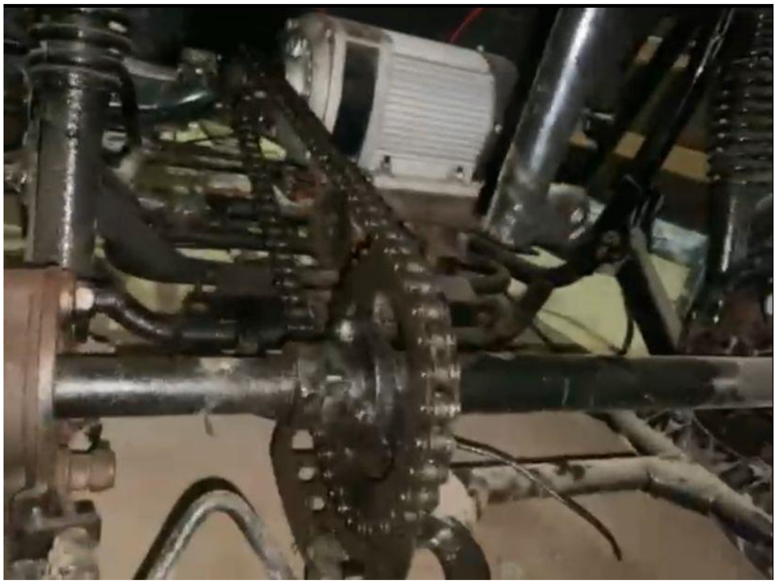


Figure 57:Chain and motor base fit perfectly

- Calculations were crucial in this process, allowing us to synchronize the motor, gears, and car shaft seamlessly. As a result, the full power of the car was harnessed, enabling it to reach speeds of up to 50 km per hour and carry a weight of 1000 kg.
- In overcoming these mechanical challenges, our team demonstrated resilience, problem-solving prowess, and a commitment to achieving optimal performance in our electric car project.

III. Battery

⇨ Issue: Voltage Drop affecting Motor Performance

⇨ Problem: When engaging the throttle, the voltage dropped from 48 to 31 due to a four-battery setup, rendering the motor inoperative under load.

⇨ Problem-Solving Process:

1. **Research and Identification:**

- Challenge: The initial battery configuration resulted in a significant voltage drop.
- Solution: After extensive research, the need for an additional battery was recognized to maintain the required voltage during load.

2. **Optimal Solution:**

In response to this challenge, the team experimented with various battery configurations, ultimately deciding to test multiple sets of batteries under real-world load conditions.

After evaluating several combinations, it was determined that a configuration of at least four high-quality, well-conditioned 12V batteries effectively stabilized the voltage across the system. This solution ensured that the motor received consistent power, even under high demand, thereby preventing operational failures and enhancing the vehicle's overall reliabilities. Verification through Testing.

3.3. Security Face ID

3.3.1.Introduction

The Security Face ID test delves into the rigorous evaluation process designed to validate the effectiveness and reliability of the facial recognition security system implemented in the project. As this critical phase is embarked upon, attention shifts towards a comprehensive series of tests meticulously crafted to assess the system's performance across various conditions and scenarios. From user authentication checks to profile management, each aspect of the Security Face ID feature undergoes thorough examination to ensure its functionality and integrity.

3.3.2.Methodology

The methodology adopted in the Security Face ID test embodies a meticulous and exhaustive investigative approach, meticulously crafted to evaluate the functionality, reliability, and security robustness of the facial recognition system integrated within the project's framework. This methodology is underpinned by a structured and systematic series of experiments, each carefully designed to simulate diverse real-world scenarios and scrutinize the system's performance under varying conditions. By employing a combination of quantitative metrics and qualitative observations, the methodology aims to provide a comprehensive understanding of the system's capabilities and limitations. Rigorous testing protocols are employed to assess key aspects such as user authentication accuracy, resistance to spoofing attacks, adaptability to varying lighting conditions, and resilience against occlusion or facial alterations. Furthermore, the methodology incorporates measures to ensure data privacy and confidentiality throughout the testing process, adhering to ethical guidelines and best practices in information security. Through this rigorous and methodical approach, the Security Face ID test endeavors to deliver actionable insights that inform decision-making and drive iterative improvements in the system's design and implementation.

3.3.3. Testing Procedures

I. Add user process Test

Figure 58:Add user process Test

Result: during the Add User Process Test, the system seamlessly sent verification code via E-mail , then guided the user through the necessary steps, including capturing facial data from multiple angles, entering user details, and successfully storing the information in the car database.

II. User Verification Accuracy Test

Figure 59:User Verification Accuracy Test

Result: The system accurately identified the added user during the verification process, promptly classifying them as a verified user upon attempting to access the car.

III. Mail sent Test

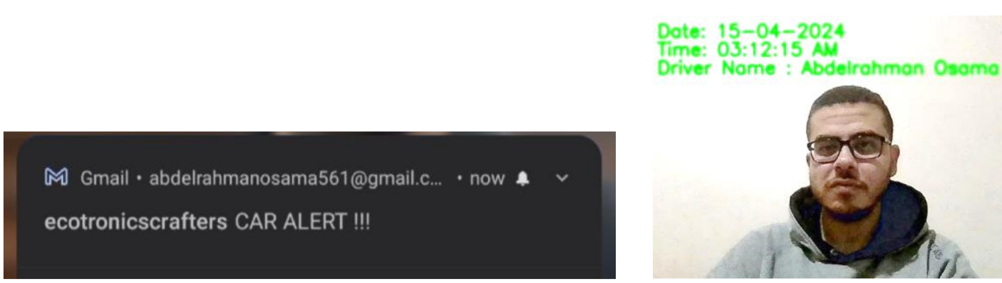


Figure 60:Mail sent Test

IV. Spoofing Attack Simulation

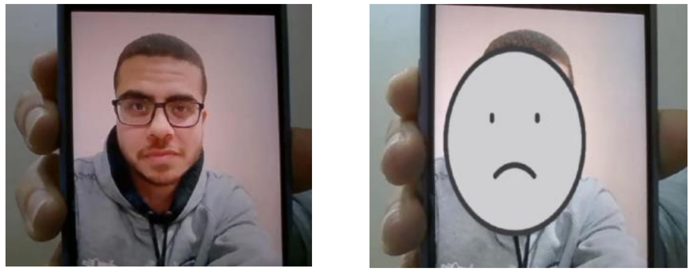


Figure 61:Spoofing Attack Simulation

Result: During the simulation of a potential spoofing attack, an attempt was made to gain access to the vehicle using an image of the added user displayed on a mobile device. The face ID system classified the attempt as an unverified user.

V. Adaptability to Lighting Conditions

Figure 62:Adaptability to Lighting Conditions

Result: The system exhibited exceptional adaptability to varying lighting conditions, consistently adjusting brightness levels for frames captured in different environments. While there were minor discrepancies between frames from low-light and bright settings, achieving about 90% similarity.

VI. Response Time Assessment

Result: The response time from the initiation of frame capture to the retrieval of results was consistently within the specified timeframe of average 20 seconds.

VII. Delete user process Test

Result: The system reliably dispatched a verification code via email to confirm the user's identity before proceeding with the deletion process. Once the user provided the required identification, the system swiftly executed the deletion command, erasing all associated information from the car database.

3.3.4. Conclusion

The comprehensive testing regimen conducted on the Security Face ID system has provided invaluable insights into its operational robustness and efficacy in fortifying vehicle security measures. Through meticulous examination of user registration and verification processes, the system has demonstrated seamless integration and functionality, ensuring smooth user onboarding and authentication procedures. Furthermore, the simulation of spoofing attacks has underscored the system's resilience to unauthorized access attempts, validating its ability to discern legitimate users from fraudulent impersonators. The system's adaptability to diverse lighting conditions has been a standout feature, with its ability to maintain consistent performance across varying environments, thereby enhancing its reliability and usability. Notably, the rapid response time exhibited by the system highlights its agility and efficiency in swiftly processing user authentication requests, contributing to an enhanced user experience. Additionally, the robust user management capabilities, including streamlined deletion processes, further solidify the system's position as a cornerstone of modern vehicle security solutions. In essence, the extensive testing efforts have reaffirmed the Security Face ID system's role as a trusted guardian of vehicle integrity, offering users unparalleled peace of mind and confidence in their vehicles' protection against unauthorized access.

3.4.ACC Testing

1. **Test the acceleration.**
    - The car smoothly accelerates when it has to.

2. **Test the deceleration.**
    - The car decelerates smoothly when it has to.

3. **Test following distance.**
    - When the car speed equals or less than 10 km/h the following distance set to be 3m for deceleration, and 2m for stop.
    - When the car speed between 10 km/h and 30 km/h the car starts to decelerate when the following distance is 7m and stops when it’s 5m.

4. **Test lidar output (object detection) while moving.**
    - In a closed place the lidar gave an accurate output at the range of 9m.
    - While testing the lidar in an open area it gave an accurate output at the range of 3m.
    - So, there must some changes be made in the code,
    - After the code changes the lidar finally gave an accurate output at the same range as it was in the closed place.

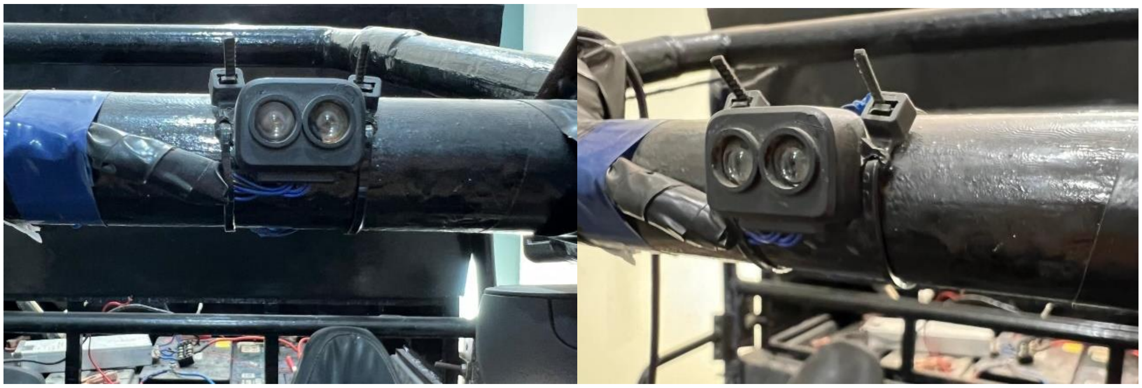


Figure 63:Lidar Position on Car

5. **Test the function in several sides.**
    - The function had been made in several directions and it gave an accurate output.

6. **Test the function in a traffic jam.**
    - The function had been tested in a place with a crowd of objectives and it worked accurately.

7. **Visual test.**
    - A rope had been tied with length of 8 meters to another car and have a visual test for the deceleration and the acceleration.

8. **Speed of response test.**
    - Something made been made to get in the way of the car suddenly and determining the time for the reaction of the system and it was so small to be detected.

9. **Test the priority of the throttle.**
    - Trying to push the throttle to speed up its cancels the priority of the cruise control and made it manually to control speed.

10. **Test disabling and enabling the feature.**
    - The cruise control on/off button works perfectly.

3.5.Traffic sign recognition Test (TSR Test)

3.5.1.Introduction

The testing phase of the Traffic Sign Recognition (TSR) feature is pivotal in ensuring the effectiveness and reliability of the system in real-world driving scenarios. By subjecting the TSR feature to rigorous testing procedures, the performance accuracy, robustness, and ability to accurately detect and interpret traffic signs under various environmental conditions are evaluated. Through systematic testing, any potential limitations or challenges faced by the TSR system are identified, and opportunities for refinement and improvement are explored. The insights gained from testing not only validate the functionality of the TSR feature but also inform future development efforts aimed at enhancing its performance and usability.

3.5.2.Methodology

The testing methodology employed for evaluating the Traffic Sign Recognition (TSR) feature involves a systematic approach designed to assess its performance across various parameters. The testing process includes the collection of real-world driving data encompassing diverse traffic conditions, road environments, and lighting conditions to simulate a wide range of scenarios. Additionally, controlled experiments are conducted in controlled environments to validate the TSR system's accuracy and responsiveness under ideal conditions. Various performance metrics, such as detection accuracy, recognition speed, and false positive/negative rates, are measured and analyzed to quantify the TSR system's performance. Through a combination of qualitative and quantitative assessments, the testing methodology aims to provide comprehensive insights into the TSR feature's capabilities and limitations, facilitating informed decisions regarding system optimization and refinement.

3.5.3. Testing Procedures

I. Color Recognition Test: Colored vs. Black & White Signs

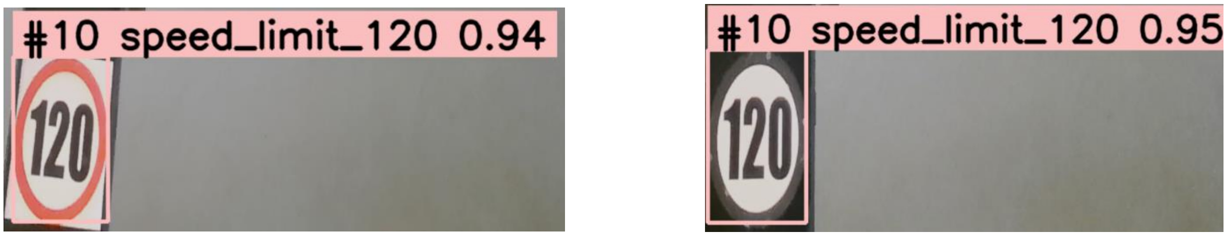


Figure 64:Color Recognition Test

Result: For the Color Recognition Test, achieving an accuracy range of 94% to 95% for both colored and black & white signs demonstrate robust performance in identifying signs regardless of their color composition.

II. Lighting Conditions Assessment: Bright vs. Low-Light Environments

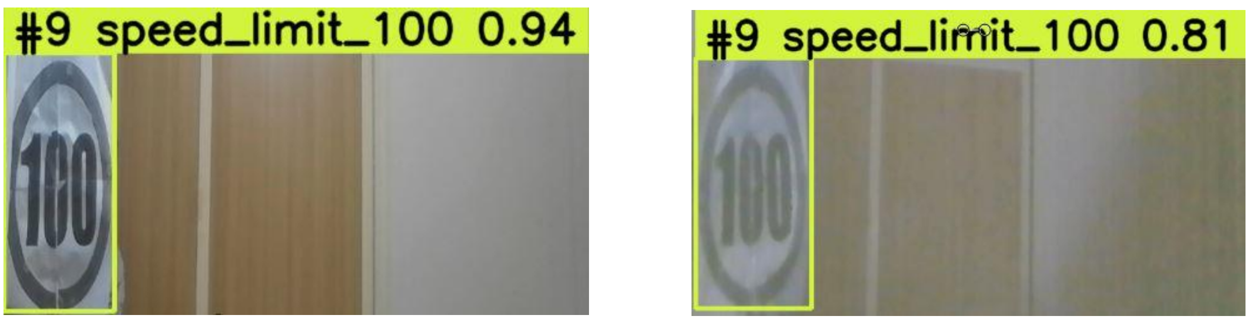


Figure 65:Lighting Conditions Assessment

Result: The Lighting Conditions Assessment reveals a higher accuracy of 91% under bright lighting conditions compared to 81% under low-light environments. This highlights the system's effectiveness in optimal lighting scenarios and indicates potential areas for improvement in low-light conditions.

III. Weather Resilience Evaluation: Normal vs. Adverse Weather Conditions

Figure 66:Weather Resilience Evaluation

Result: The Weather Resilience Evaluation demonstrates consistent accuracy rates of 92% for both normal weather conditions and adverse weather conditions (Blurry weather), suggesting robust performance regardless of weather variations.

IV. Distance Detection Test: Near vs. Far Distance Camera Operation

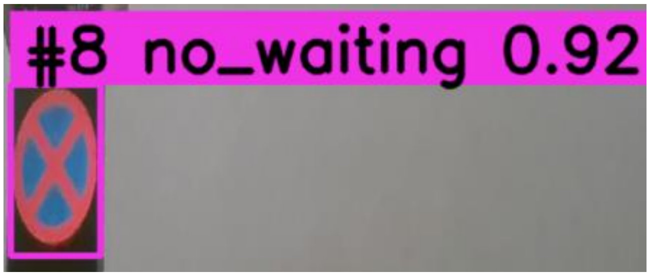


Figure 67: Distance Detection Test

Result: The Distance Detection Test indicates slightly higher accuracy rates for near camera operation at 95%, compared to 92% for far distance camera operation, highlighting the system's proficiency in detecting signs in close and far distances.

V. Response Time Measurement: Speed and Efficiency Assessment

Result: The Response Time Measurement test reveals commendable efficiency, with frame capture completed within 2 to 20 milliseconds, while processing time ranges between 60 and 100 milliseconds, indicating swift sign recognition and analysis by the system.

VI. Angle of Sign Detection: Straight-on vs. Oblique Angles

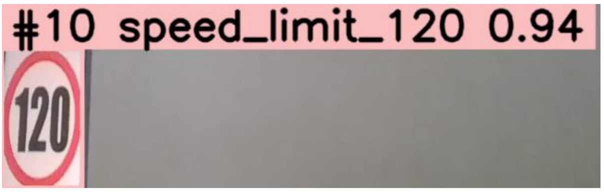


Figure 68:Angle of Sign Detection

Result: The Angle of Sign Detection test demonstrates robust performance, achieving a high accuracy rate of 94% for straight-on sign angles and maintaining commendable recognition capabilities even at oblique angles, with an accuracy of 89%.

VII. Sign Occlusion Test: Partially Obscured vs. Fully Visible Signs

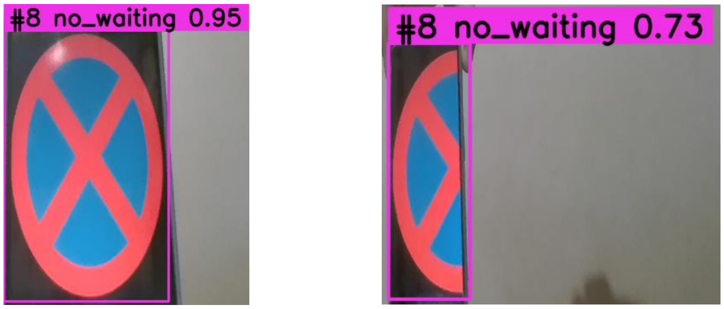


Figure 69:Sign Occlusion Test

Result: While the Sign Occlusion Test reveals exceptional accuracy in identifying fully visible signs, achieving an accuracy rate of 95%, the system faces challenges when signs are partially obscured, resulting in a reduced accuracy rate of 73%.

VIII. Dynamic Environment Test: Static vs. Moving Backgrounds

Figure 70:Dynamic Environment Test

Result: While the TSR system demonstrates robust performance in detecting signs against static backgrounds, achieving an accuracy rate of 92%, its accuracy diminishes slightly when signs are positioned against dynamic backgrounds, resulting in an accuracy rate of 89%.

IX. Variation in Sign Size: Small vs. Large Signs

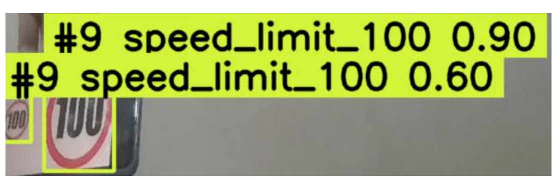


Figure 71:Variation in Sign Size

Result: While the TSR system exhibits commendable accuracy in detecting standard-sized signs, achieving a success rate of 90%, its performance diminishes notably when detecting smaller signs, resulting in a reduced accuracy rate of 60%.

3.5.4. Conclusion

In conclusion, the rigorous testing and evaluation of the Traffic Sign Recognition (TSR) system have revealed both its strengths and areas for improvement. Despite achieving high accuracy rates in various scenarios such as clear weather conditions and standard-sized signs, the system exhibits certain limitations, notably in adverse weather and with smaller signs. However, these challenges serve as opportunities for refinement and optimization, highlighting the need for continued research and development in the field of intelligent transportation systems. By addressing the identified shortcomings and leveraging emerging technologies, such as machine learning and sensor fusion, the TSR system can evolve into a robust and dependable solution for enhancing driver safety and situational awareness on the roads. Moreover, the real-time responsiveness and efficiency of the system demonstrate its potential to significantly reduce the risk of accidents and improve overall traffic management. Looking ahead, collaboration between industry stakeholders, researchers, and policymakers will be essential in driving innovation and ensuring the widespread adoption of advanced driver assistance technologies like TSR, ultimately ushering in a safer and more sustainable future for transportation systems worldwide.

3.6.Driver Monitoring System (DMS)

3.6.1.Testing the Embedded Part

I. First Test

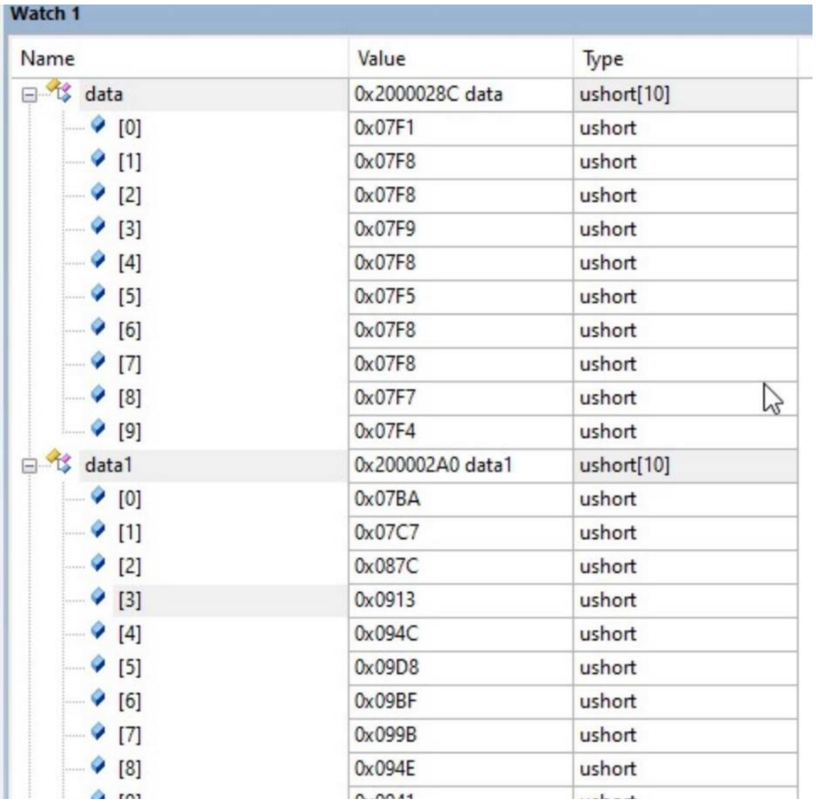
One of the big challenges that the previous plan was using heart pulse sensor instead of touch sensor in order to consider driver's health during monitoring and checking its heart rate continuously for those people who suffer from health problems ,also in order to achieve the feature with a creative method of implementation

So, it's implemented by using the heart pulse sensor in the previous version

a. The Result

The heart pulse sensors available in the market nowadays have insufficient accuracy to achieve these sensitive features as :

- The sensor many false warnings (as driver might be holding steering wheel but it also gives a false alarm)
- The sensor's readings in the same second vary in a wide range and gave many different readings in the same conditions (low precision)


Watch 1

Name	Value	Type
data	0x2000028C data	ushort[10]
[0]	0x07F1	ushort
[1]	0x07F8	ushort
[2]	0x07F8	ushort
[3]	0x07F9	ushort
[4]	0x07F8	ushort
[5]	0x07F5	ushort
[6]	0x07F8	ushort
[7]	0x07F8	ushort
[8]	0x07F7	ushort
[9]	0x07F4	ushort
data1	0x200002A0 data1	ushort[10]
[0]	0x07BA	ushort
[1]	0x07C7	ushort
[2]	0x087C	ushort
[3]	0x0913	ushort
[4]	0x094C	ushort
[5]	0x09D8	ushort
[6]	0x09BF	ushort
[7]	0x099B	ushort
[8]	0x094E	ushort

Figure 72:Heart Pulse Sensor Readings

b. Done solution

Replacing with more accurate sensor (touch sensor)

II. Second test

Implementing the feature using the touch sensor for a several repeating times to ensure its accuracy , repeatability and precision and show if the sequence is as desired

a. Results:

It’s found that it works well but sometimes the sensor may gave a wrong reading in a wide time range

b. Done solution :

- To avoid giving false warnings and get the best accuracy for feature ,some changes are done to the code in order to check and ensure that at least 2 of 4 sensors are (high) to ensure that the car is controlled not only 1 sensor
- Using debouncing technique by reading sensor more than one time before giving the final signal to on or off alarm system by making a delay for 30 ms between each read

3.7. Internal Wheel Jack Testing

3.7.1.Initial Inspection

Before activating the internal wheel jack system, visual inspection was informed to ensure all components are securely mounted and there are no loose connections or potential hazards.

3.7.2. Electrical System Test

1. **Switch Test**: The switch was activated to lift the car tires. internal wheel jack mechanism's movement were observed and listened for any unusual sounds. The switch operates smoothly without any delays or malfunctions. And no movement and sound were detected.

2. **Power Supply**: internal wheel jack system receives power from the vehicle's electrical system and the battery voltage is within the specified range. A multimeter used to check the voltage at the switch and the internal wheel jack mechanism.

3.7.3 Mechanical System Test

I. **Lifting Test**: Internal wheel jack system was activated to lift two of the car tires off the ground. lifting mechanism's performance was observed, ensuring it lifts the tires smoothly and steadily.

Figure 73: The Car while Testing the IWJ.

II. **Stability Test**: Once the tires are lifted, vehicle remains stable and does not wobble or shift unexpectedly. stability of the internal wheel jack system and the mounting brackets can support the vehicle's weight securely and for a time more than we expected.

3.7.4 Safety Features Test

I. **Emergency Stop**: Emergency stop feature was tested by activating it during the lifting process. Verify that the internal wheel jack system stops immediately, preventing any potential hazards.

II. **Overload Protection**: Additional human weight was added to the lifted tire to simulate an overload situation. The internal wheel jack system can handle the extra weight without malfunctioning or causing damage.

3.7.5. Operational Test

Switch Response Time: response time of the switch was evaluated when activating and deactivating the internal wheel jack system. There is no delay or lag in the system's operation.

3.7.6. Final Inspection

I. **Visual Check**: final visual inspection was observed of all components, wiring, and connections to confirm everything is in proper working order and there are no signs of wear or damage.

II. **Functional Test**: Conduct a comprehensive functional test by lifting and lowering each tire multiple times, checking for any issues or inconsistencies in the system's performance.

Chapter 4 : Future Work

This Chapter Talks About Future Features That Can Be Classified Into Features In Electric Cars And Embedded Systems.

4.1.Future in Electric cars:

The future of electric vehicles (EVs) and integrated systems is poised for remarkable advancements. Here are some key points to consider

4.1.1.Technology Integration:

The integration of cutting-edge technologies like artificial intelligence (AI), Internet of Things (IoT), and advanced sensors will revolutionize EVs. These technologies will enable real-time data analysis, predictive maintenance, and enhanced safety features.

I. Vehicle-to-Everything (V2X) Communication:

EVs will be equipped with V2X communication systems, allowing them to interact with other vehicles, infrastructure, pedestrians, and even smart cities. This technology enables real-time data sharing for improved traffic management, enhanced safety features, and optimized energy usage.

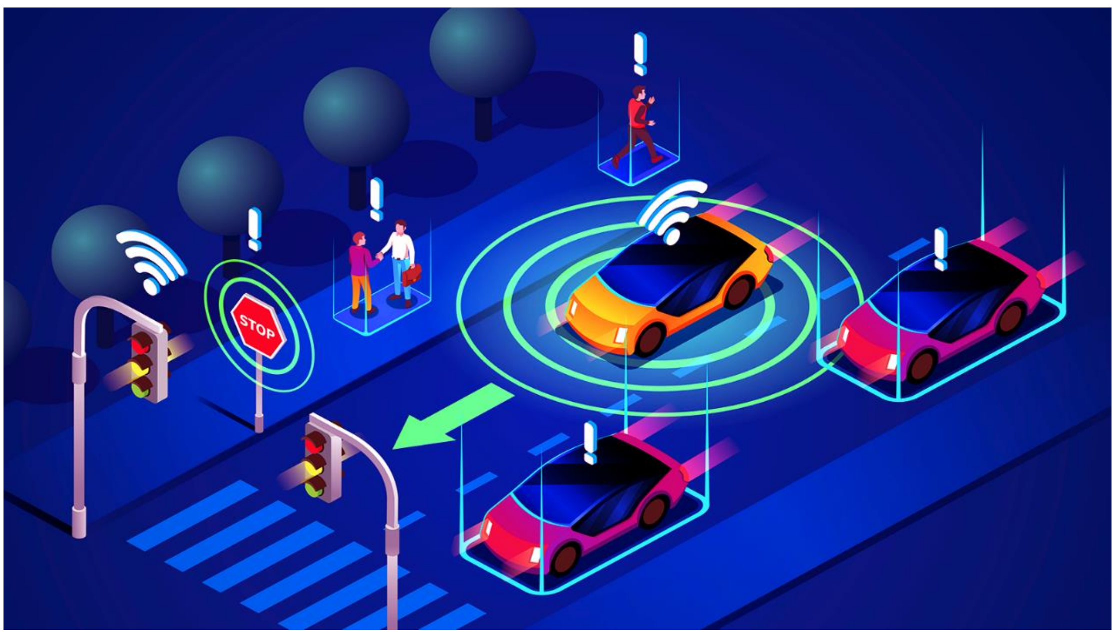


Figure 74:V2X Communication

II. *Internet of Things (IoT) Connectivity:*

EVs will become part of the IoT ecosystem, with sensors and smart devices embedded throughout the vehicle. This connectivity enables remote diagnostics, predictive maintenance, and personalized user experiences, such as customized driving modes and in-car entertainment.

III. Artificial Intelligence (AI) and Machine Learning (ML)

AI and ML algorithms will be integrated into EVs for various purposes. This includes advanced driver assistance systems (ADAS) for autonomous driving capabilities, predictive analytics for energy management and range optimization, and adaptive user interfaces that learn and adapt to driver preferences.

IV. Augmented Reality (AR) and Virtual Reality (VR)

AR and VR technologies will transform the driving experience in EVs. Heads-up displays (HUDs) will overlay real-time information onto the windshield, providing navigation guidance, hazard alerts, and contextual information about the surroundings. VR can also be used for immersive entertainment and training purposes.

V. Energy Harvesting and Regeneration:

EVs will incorporate energy harvesting technologies, such as solar panels integrated into the vehicle's body or regenerative braking systems that capture and store kinetic energy during deceleration. These innovations aim to increase the vehicle's energy efficiency and extend its range.

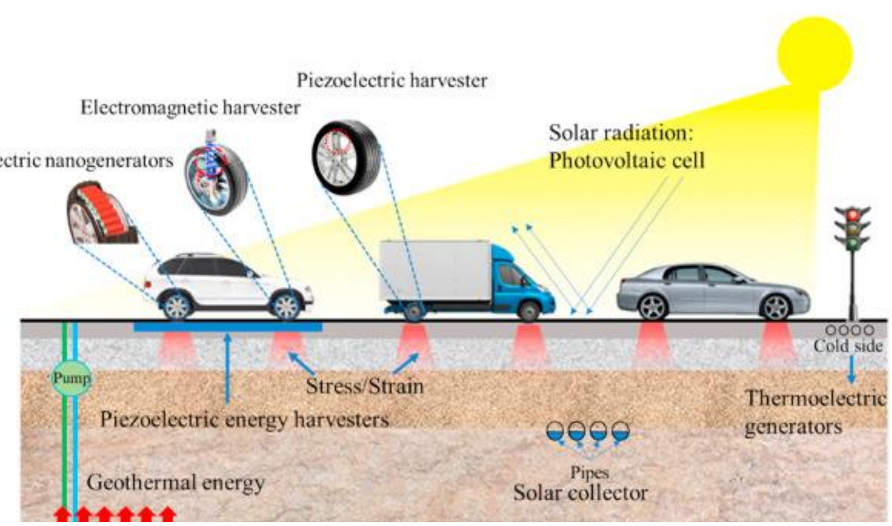


Figure 75:Energy Harvesting and Regeneration In Cars

VI. *Blockchain and Secure Data Exchange*

Blockchain technology will play a role in securing data exchange and transactions within the EV ecosystem. This includes secure payments for charging services, vehicle-to-grid (V2G) energy trading, and maintaining transparent records of vehicle history and maintenance.

VII. *Advanced Materials and Manufacturing*

EVs will utilize lightweight materials, such as carbon fiber composites and advanced alloys, to improve energy efficiency and performance. Additive manufacturing (3D printing) techniques will also be employed for rapid prototyping and customization of vehicle components.

VIII. *Cybersecurity and Data Privacy*

With increased connectivity, EVs will prioritize robust cybersecurity measures to protect against cyber threats and unauthorized access. This includes secure software updates, encryption protocols for data transmission, and privacy controls for user data collected by onboard sensors

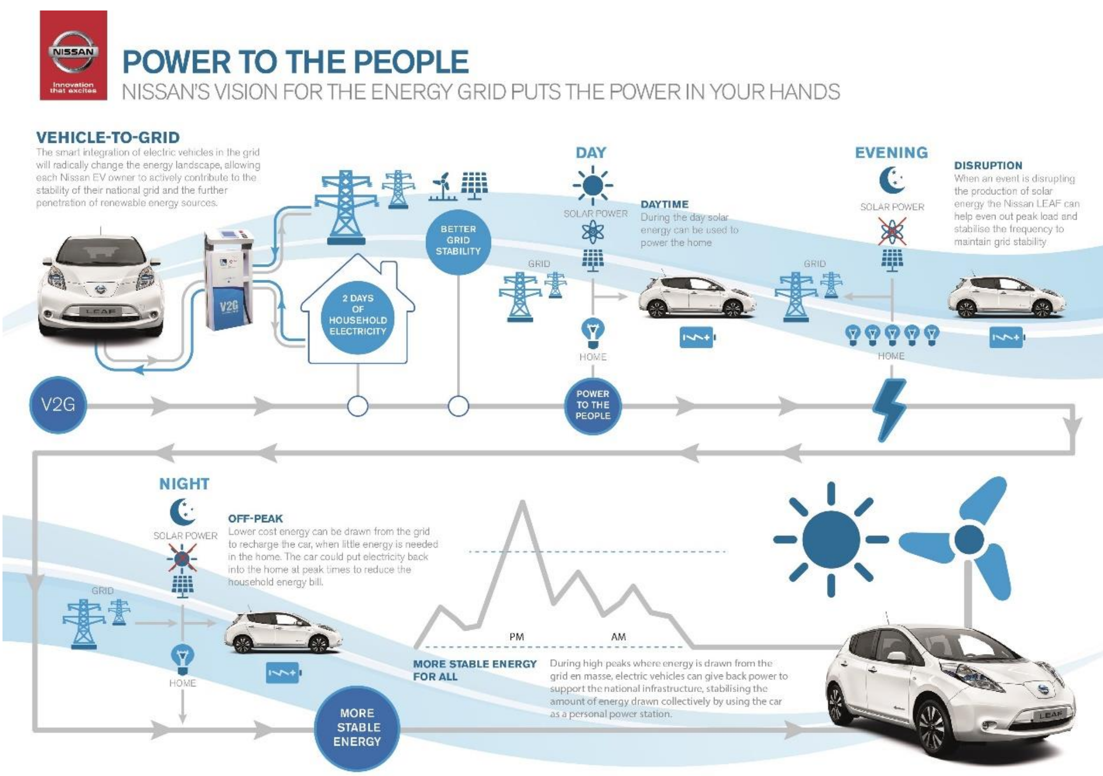


Figure 76:Cyber security and Data Exchange in Cars

4.1.2.Autonomous Driving

The development of autonomous driving systems will play a pivotal role in the future of EVs. These systems, powered by AI and machine learning algorithms, will enable self-driving capabilities, leading to safer and more efficient.

Figure 77:Autonomous Driving

I. **Levels of Autonomy:**
The Society of Automotive Engineers (SAE) has defined six levels of autonomy, ranging from Level 0 (no automation) to Level 5 (full automation). Most vehicles on the market today fall between Level 1 (driver assistance, like adaptive cruise control) and Level 2 (partial automation, where the vehicle can control both steering and acceleration/deceleration).

II. **Technological Components:**
Autonomous vehicles (AVs) are equipped with a range of sensors, including LiDAR (Light Detection and Ranging), radar, cameras, and ultrasonic sensors. These sensors collect data about the vehicle's surroundings, which is processed by onboard computers using AI algorithms to make driving decisions.

III. **Safety and Efficiency:**
One of the primary goals of autonomous driving is to improve road safety by reducing human errors, which account for the majority of accidents. AVs can react faster than humans, maintain safe distances, and adhere strictly to traffic rules, potentially leading to fewer accidents and fatalities. Additionally, autonomous driving can improve traffic flow and reduce congestion by optimizing routes and speeds.

IV. **Challenges and Limitations:**

Despite the promising advancements, autonomous driving faces several challenges. These include regulatory hurdles, ethical considerations (such as decision-making in critical situations), technical limitations in extreme weather conditions or complex urban environments, and public acceptance and trust in the technology.

V. **Impact on Society:**

Autonomous driving has the potential to transform various industries and aspects of society. For example, it can revolutionize transportation services, such as ride-sharing and delivery fleets, making them more efficient and cost-effective. AVs can also improve accessibility for individuals with disabilities or limited mobility, offering them greater independence.

VI. **Ethical and Legal Considerations:**

The widespread adoption of autonomous driving raises important ethical and legal questions. These include liability issues in case of accidents, data privacy concerns related to the collection and use of personal information by AVs, and the need for standardized regulations and guidelines to ensure safe and responsible deployment of autonomous vehicles.

4.1.3. Battery Technology

Advancements in battery technology, such as solid-state batteries and fast-charging solutions, will address current limitations in range and charging times. This will significantly enhance the practicality and appeal of EVs for consumers

I. **Increased Energy Density:**

One of the primary goals for future battery technology is to achieve higher energy density, allowing for longer-lasting and more powerful batteries. This advancement is crucial for electric vehicles (EVs), where extended driving ranges are desired, as well as for portable electronics that require prolonged usage between charges.

II. **Fast Charging and Rapid Energy Transfer:**

Future batteries are expected to feature rapid charging capabilities, reducing the time required to recharge devices and vehicles. Technologies like solid-state batteries and advanced charging protocols aim to enable faster energy transfer while maintaining safety and efficiency.

III. **Enhanced Safety:**

Safety remains a paramount concern in battery technology. Future batteries will integrate advanced safety features, such as improved thermal management systems, self-healing materials to prevent damage, and robust battery management systems (BMS) for real-time monitoring and control of battery parameters.

IV. **Sustainability and Environmental Impact:**

The future of battery technology is closely tied to sustainability. Researchers and manufacturers are exploring environmentally friendly materials, such as recycled metals and sustainable electrolytes, to reduce the environmental footprint of battery production and disposal. Additionally, advancements in battery recycling technologies are expected to improve the reuse and recovery of valuable materials from spent batteries.

V. **Solid-State and Beyond:**

Solid-state batteries represent a significant leap forward in battery technology. These batteries use solid electrolytes instead of liquid ones, offering higher energy density, improved safety, and wider operating temperatures. The future adoption of solid-state batteries in EVs, aerospace applications, and grid energy storage is anticipated, driving the transition towards cleaner and more efficient energy systems.

VI. **Integration with Renewable Energy:**

Batteries will play a crucial role in integrating renewable energy sources like solar and wind into the power grid. Energy storage systems (ESS) using advanced batteries enable efficient energy management, grid stabilization, and energy backup during peak demand periods or grid outages.

VII. **Internet of Things (IoT) and Wearable Devices:**

As IoT devices and wearable technology continue to proliferate, future batteries will be designed to meet the specific power requirements of these devices. Miniaturized and flexible batteries with high energy density and long cycle life will enable seamless integration into IoT networks and wearable gadgets.

VIII. **Next-Generation Transportation:**

Beyond electric cars, future battery technology will power innovative transportation solutions such as electric aircraft, autonomous drones, and hyperloop systems. These applications demand batteries with exceptional energy density, rapid charging capabilities, and robust safety features to ensure reliable and sustainable transportation solutions.

4.2.Future features of Embedded system

4.2.1.Internet of Things (IoT) Integration:

Embedded systems will play a crucial role in the proliferation of IoT devices. Future embedded systems will be designed to seamlessly integrate with IoT platforms, enabling connectivity, data acquisition, and remote monitoring/control across diverse applications such as smart homes, industrial automation, healthcare, and agriculture

I. **Connectivity**

Embedded systems are at the core of IoT devices, enabling them to connect and communicate with other devices and systems. This connectivity can be achieved through various communication protocols such as Wi-Fi, Bluetooth, Zigbee, and cellular networks, allowing IoT devices to exchange data and information seamlessly.

II. **Sensor Integration**

IoT-enabled embedded systems often include a wide range of sensors such as temperature sensors, humidity sensors, accelerometers, GPS modules, and more. These sensors collect real-time data from the physical environment, which is then processed and utilized for monitoring, analysis, and decision-making.

III. **Data Processing and Analytics**

Embedded systems in IoT devices are equipped with processing capabilities to handle data processing and analytics tasks locally. This enables real-time insights generation, anomaly detection, predictive maintenance, and other advanced analytics functionalities without relying solely on cloud-based processing.

IV. **Edge Computing**

IoT integration in embedded systems often involves edge computing capabilities. Edge devices, powered by embedded systems, can perform data processing and computation at the edge of the network, reducing latency, bandwidth usage, and dependency on centralized cloud resources.

V. **Security and Privacy**

Embedded systems play a critical role in ensuring the security and privacy of IoT devices and data. They incorporate security measures such as encryption, authentication protocols, secure boot, and firmware/software updates to protect against cyber threats, unauthorized access, and data breaches.

VI. **Remote Monitoring and Control**

IoT-enabled embedded systems allow for remote monitoring and control of connected devices and systems. This enables users to monitor device status, receive alerts, remotely configure settings, and control operations from anywhere via web interfaces or mobile applications.

VII. **Scalability and Flexibility**

Embedded systems designed for IoT integration are often scalable and flexible, allowing for easy integration with existing infrastructure, addition of new devices, and support for diverse IoT applications. They can adapt to evolving requirements and technologies, ensuring long-term compatibility and usability.

VIII. **Energy Efficiency**

IoT integration in embedded systems focuses on energy-efficient designs and power management techniques. This includes low-power hardware components, optimized algorithms, sleep modes, and energy harvesting methods, maximizing device battery life and sustainability.

4.2.2.AI and Security

Edge Computing Capabilities: As the volume of data generated by IoT devices continues to grow, there is a need for embedded systems with enhanced edge computing capabilities. Future embedded devices will perform data processing, analysis, and decision-making at the edge, reducing latency, conserving bandwidth, and ensuring real-time responsiveness.

AI and Machine Learning Integration: Embedded systems will increasingly leverage artificial intelligence (AI) and machine learning (ML) algorithms for intelligent decision-making and predictive analytics. Future embedded devices will incorporate specialized hardware accelerators, neural network models, and software frameworks optimized for edge AI applications such as image recognition, natural language processing, and anomaly detection.

Security and Privacy Enhancements: With the proliferation of connected devices and cyber threats, future embedded systems will prioritize robust security and privacy features. This includes hardware-based security mechanisms, secure boot protocols, encrypted communication channels, and tamper-resistant components to safeguard sensitive data and prevent unauthorized access.

Energy Efficiency and Power Management: Future embedded systems will focus on energy-efficient design principles to prolong battery life and reduce power consumption. This includes low-power microcontrollers, optimized firmware/software, dynamic power scaling techniques, and energy harvesting solutions to support sustainable and autonomous operation in battery-powered devices.

Multi-core and Heterogeneous Architectures: To meet the computational demands of complex applications, future embedded systems will feature multi-core processors and heterogeneous architectures. This allows for parallel processing, task partitioning, and optimized resource allocation, enhancing performance, scalability, and flexibility in embedded applications.

Real-Time Operating Systems (RTOS): RTOS will continue to evolve to meet the stringent real-time requirements of embedded systems. Future RTOS platforms will offer improved determinism, low latency, task prioritization, and scheduling algorithms tailored for critical applications such as automotive systems, robotics, medical devices, and industrial control.

Wireless Connectivity Standards: Embedded systems will leverage evolving wireless standards such as 5G, Wi-Fi 6, and LoRaWAN for high-speed data transmission, low-latency communication, and long-range connectivity. Future embedded devices will support seamless integration into wireless networks, enabling IoT deployments in diverse environments and use cases

Neuromorphic computing: This emerging technology aims to mimic the human brain's structure and function. Embedded systems with neuromorphic chips could process information in a more efficient and human-like way, enabling advanced capabilities like real-time pattern recognition and autonomous control in complex environments.

Bio-integrated systems: The line between humans and machines could blur with bio-integrated embedded systems. Imagine medical implants that continuously monitor health data or prosthetic limbs that respond to neural signals. These systems would require significant advancements in biocompatibility and miniaturization.

Energy harvesting: Embedded systems could become self-powered by harvesting energy from their surroundings. Technologies like solar, kinetic, and thermal energy harvesting could eliminate the need for batteries or constant recharging, making them even more sustainable and versatile.

Human-machine interfaces (HMI): The way we interact with embedded systems will continue to evolve. Natural language processing, gesture recognition, and brain-computer interfaces could create more intuitive and seamless HMIs, allowing for effortless control and data exchange.

Quantum-inspired embedded systems: While full-fledged quantum computers are still in their infancy, elements of quantum mechanics might influence embedded systems. This could lead to significant breakthroughs in areas like cryptography, sensor technology, and optimization algorithms for complex tasks.

Security with built-in trust: Security will be a top priority. Embedded systems could have features like hardware-based security enclaves and dynamic trust verification to ensure data integrity and prevent unauthorized access throughout the system's lifecycle.

Environmental monitoring and control: Embedded systems could be deployed for real-time environmental monitoring, tracking air and water quality, or even managing sustainable energy grids. Imagine smart sensors in buildings that automatically adjust heating/cooling based on occupancy or weather conditions.

Precision agriculture: Embedded systems with AI and sensor fusion could revolutionize agriculture. They could optimize irrigation systems, analyze soil health, and even guide autonomous farm equipment, leading to increased yields and reduced environmental impact.

Personalized healthcare: Tiny, biocompatible embedded systems could be used for continuous health monitoring, allowing for early detection of diseases and personalized treatment plans. This could include ingestible sensors that track internal vitals or smart patches that monitor chronic conditions.

Socially assistive robotics: Embedded systems could power robots that assist people with disabilities or the elderly. These robots could provide companionship, reminders for medication, or even physical assistance with daily tasks, promoting independent living and improving quality of life.

Sustainable infrastructure management: Embedded systems could be integrated into bridges, roads, and buildings to monitor their structural health and predict potential failures. This proactive approach could prevent costly repairs and disruptions, improving infrastructure safety and lifespan.
Disaster response and preparedness: Networks of embedded sensors could be deployed in disaster-prone areas to detect early signs of earthquakes, floods, or landslides. This real-time data could enable faster emergency response and evacuation procedures, saving lives and minimizing property damage.

These future features highlight the potential of embedded systems to address global challenges and improve our society's well-being. As these technologies develop, they can play a crucial role in creating a more sustainable, efficient, and resilient future.

5.Conclusion

An empty vehicle chassis underwent a revolution, emerging as a fully functional electric car (EC) seamlessly integrated with Advanced Driver Assistance Systems (ADAS) for enhanced safety and efficiency. The Traffic Sign Recognition (TSR) feature decoded the language of road signs, embodying the ongoing evolution of automotive technology. While unveiling TSR's strengths, the project transparently addressed challenges, emphasizing the future's promise through continuous refinement. Adaptive Cruise Control (ACC) marked a cornerstone in EV evolution, showcasing innovation in intelligent driver assistance. Driver Health Monitoring introduced an adaptive method for early detection of driver issues, contributing significantly to safety. The Internal Hydraulic Wheel Jack System (IWJS) promised a revolutionary shift in EV convenience, overcoming challenges through optimized design. Successful implementation of diverse technologies and meticulous system testing showcased technical prowess. As a convergence of innovations, this project not only redefines electric mobility but sets the stage for a future where sustainability, safety, and efficiency coalesce, promising continuous refinement and contributions to the intelligent and sustainable transportation landscape.

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Appendices

1. **Jira:** It is a project management and issue tracking tool that helps teams plan, track, and manage their work.
2. **Git & GitHub:** Git is a distributed version control system, and GitHub is a web-based platform for hosting and collaborating on Git repositories.
3. **STM32CubeIDE:** It is an integrated development environment for STM32 microcontrollers, facilitating firmware development.
4. **Circuit Wizard:** It is a software tool for designing and simulating electronic circuits before physical implementation.
5. **KeiluVision:** It is an integrated development environment for microcontroller programming, widely used for ARM-based devices.
6. **Proteus:** It is a software tool for circuit simulation and PCB design, aiding in the development of electronic systems.
7. **Eclipse:** It is an open-source integrated development environment (IDE) widely used for Java development but supports various languages.
8. **Microchip Studio:** It is an IDE for programming and debugging Microchip microcontrollers, formerly known as Atmel Studio.
9. **Cppcheck software:** It is a static code analysis tool for C and C++ code, helping identify potential errors and improve code quality.
10. **Understand software:** It is a code comprehension tool that analyzes and visualizes codebases to assist developers in understanding complex software.
11. **LTspice:** It is a high-performance SPICE simulation software used for electronic circuit simulation.
12. **C programming:** It is used in programming Embedded Systems applications in the project.
13. **Python 3.11:** It is used in programming AI applications in the project.
14. **Visual Studio Code:** It is a lightweight and powerful source code editor with built-in support for multiple programming languages.
15. **Anaconda Software:** It is a distribution of Python and R programming languages, along with tools for data science and machine learning.
16. **GrabCAD:** It is a cloud-based platform for collaborative product development, including CAD file management and sharing within engineering teams.