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Cruising into the Future: Navigating the Challenges and Advancements in Autonomous Vehicle Technology

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Abstract: Autonomous vehicles have numerous challenges facing today's driving in urban areas. The installation of artificial intelligence in autonomous cars has become capable of communicating with road users and determining the user's intentions. With the help of AI, computer vision, sensors, machine learning, deep learning, and other fields of study, they analyze the environment for autonomous cars. The behavior of users aids in the understanding and analysis of various factors such as the environment, traffic lights, and demographics. In this paper, we determine these factors involve autonomous vehicle surveying to assess the behavior of pedestrian drivers. Autonomous vehicles use various techniques and classifiers to analyze pedestrian behavior further approaches. We sincerely need help to review interaction challenges and independent vehicle design approaches. Understanding is complex reasoning to communicate visual perception. The main aim of this survey is to discuss the various sensors and their roles in autonomous vehicles. Communication technologies facilitate transmission in three main categories short-range, medium-range, and long-range. In addition, the automotive industry is developing and manufacturing to connect autonomous vehicles to communication safety and promote transportation. The survey also focuses on protecting and implementing various attacks that threaten the security of the CAVs. Hence, AV's environment of CAVs highlights the future and current challenges to identify the security issues-based communication networks and cyber-security risks. The cyber-attacks have many types, but we will focus on the primary attacks or damage to the data.

Keywords: Autonomous Vehicles, Sensors, Pedestrian Behavior, Traffic Interaction, Survey, Cyber-Attack, Range of Sensors, Controlling, Intelligent Transportation System.

1. Introduction

In the early stages, people only accepted that a vehicle could move forward and backward with a driver, striving to achieve engineers and scientists' future goal of autonomy. Autonomous vehicles positively impact human involvement in controlling the car safely. With the help of sensors, the sensors analyze the vehicles' surrounding environment. The control system of autonomous driving identifies traffic flow, ensures social interaction phenomenon safety, and protects other road users [1, 2, 3]. Besides, researchers and scientists still emphasize the need to predict the upcoming actions of the users, most of whom can respond appropriately to such acts [4]. Autonomous vehicles face numerous problems and ambiguities in resolving traffic roles, regulations, and social interaction. Recently, a survey indicated a lack of social understanding and unawareness is spreading among the public. Social awareness is vital in protecting and preventing traffic accidents [5, 6]. To determine the challenges autonomous cars face in 2019, the United Kingdom's transportation experienced 25,080 vehicles in 2018 [7]. After the experienced experts decided, there is a further need to improve the intelligent transport system (ITS) to protect humans and safe road users [8]. If you focus on humans, avoiding errors and careless driving, you will face accident problems.

Therefore, the current survey discusses two main factors of ITS: AV systems are designed to (1) collect significant data from the sensors around them and (2) enable and develop the communication technologies of the sensors. This survey also focuses on various sensors' roles in AVs and how sensors analyze the environment. The range of sensors includes three main categories: short-range, medium-range, and long-range. However, short-range communication through ZigBee, Bluetooth, and ultra-wide for autonomous vehicles is limited. In the same way, medium-range communication through DSRC while long-range communication through 5G and 6G presents the cellular vehicle [9, 10, 11, 12]. Another survey paper focuses on unresolved issues in architecture, technical aspects, emerging methodologies, planning, core functions, localization, perception, and human interfaces [14]. On the other hand, the state-of-the-art classifiers were applied and compared on our platform with the real-world driving dataset and tools for ADS development. Technology helps people, boosts productivity, and improves quality of life [15,16]. In current urban locations where the old transport system is growing more disorganized and inefficient, technological advancements and automation in vehicle networks will improve road safety and reduce congestion [17, 18]. In order to improve traffic safety and offer its customers a variety of services, the development of the intelligent transport systems (ITS) idea has been suggested [19,20]. Significant contributions have been made as a result of extensive research in ITS (see [21] and the references therein). Lane departure warning system (LDWS), adaptive cruise control (ACC), self-parking assistance (SPA), auto-pilot, and traffic sign recognition (TSR) were developed for AVs in the early 2000s [22, 23]. By 2022, intelligent speed adaption systems will be accessible, and by 2030, fully automatic AVs will be available without the need for a driver [24]. This development will further pave the way for the Internet of Vehicles' (IoV) upcoming, evolutionary stage. Physical sensors, machine-type gadgets, and cars will be other Internet users in IoV networks in addition to people. This research advances the state-of-the-art by offering a comprehensive analysis of the key wireless technologies that enable ITS [25,26]. It not only outlines the key components of the network architecture that underlies AVs, but it also examines the advancement of technological trends, obstacles, and limitations that AVs must overcome before being fully adopted. The study connects theoretical technological ideas with the anticipated practical effects that AVs can have on infrastructure, transportation systems, and human mobility [27,28,29]. The majority of recent publications address these topics independently and concentrate on technology advancements, adoption, or regulatory concerns [30,31]. A conventional vehicle can be transformed into an autonomous one by adding a few more parts, such as sensors that enable the vehicle to decide for itself by perceiving the environment and regulating its mobility [32,33,34]. Figure 4 depicts the general AV communication process/protocol and identifies the necessary sensors, actuators, hardware, and software controls. The ability to operate autonomous vehicles in urban settings is now one of their biggest obstacles [35,36]. Autonomous vehicles need to be able to communicate with other drivers and comprehend their intentions in order for it to become a reality. Pedestrians are the most vulnerable road users, thus exchanges like this are crucial [37,38]. Understanding pedestrian behavior, however, is difficult since it depends on a variety of variables, including the demographics of the pedestrians, traffic patterns, the surrounding environment, and more [39,40]. In this article, we analyze studies on pedestrian behavior, including both traditional works on the interaction between pedestrians and drivers and contemporary studies including autonomous cars, to identify these elements. In order to achieve this, we will go over various techniques for researching pedestrian behavior and examine the relationships between the components noted in the literature [41,42,43]. A priori map-based localization systems' central concept is matching: localization is accomplished by comparing online readings to the data on a thorough pre-built map and locating the place of the best match [44, 45, 46]. The matching method frequently starts with an initial pose estimation, for instance using a GPS [47]. There are several methods for creating maps and preferred modalities. Environment changes have a negative impact on the effectiveness of map-based techniques [48,49]. This phenomenon is common, especially in rural areas where changes in roadside plants and buildings can lead the map's historical information to differ from the real environment [50, 51, 52]. Additionally, this approach necessitates the creation of a new map.

The following are the work's main contributions:

(i) A thorough analysis of research projects on AI and IoT-based autonomous cars is conducted.

(ii) The safety requirements and difficulties for autonomous vehicles are examined, along with the present remedies.

(iii) Research and development issues for autonomous vehicles with IoT and AI support are discussed.

(iv) Researchers and organizations using autonomous vehicle frameworks and tools are emphasized.
(v) Researchers and organizations are encouraged to pursue recent developments in autonomous vehicles employing cloud computing, machine learning, and deep learning.

2. Literature Review

Researchers focus on determining and corresponding interactions with pedestrians' users to communicate with an autonomous vehicle-like human behavior. On the other hand, users can ask questions about their experience of driving from AVs when the vehicle stops the traffic signals while the AVs can respond to the users asking. The autonomous vehicle can examine the surrounding environment and control the sensor's activities. Pedestrian behavior divides into main categories classical and pedestrian factor studies interacting with the human driver's experience of vehicles [53, 54, 55, 56]. Another survey addressed the current challenges and problems in autonomous vehicles [57]. It's a vast area for researchers to discover Undiscovery studies in AVs. Intelligent transport system (ITS) further needs to improve security and safe driving in public places while avoiding human errors [58,59]. Furthermore, survivor emphasizes collecting AV data from sensors for environment detection and enabling them to communicate with road users—the holistic review of wireless advanced technology enabling architecture state-of-the-art for the ITS system [60,61,62]. The authors studied, facing the current challenges of localization, perception, core functions, emerging methodologies, high-level system architectures, machine interfaces, etc. Furthermore, the researcher implemented and compared state-of-the-art algorithms in real-world driving settings [63, 64].
Researcher, proposed a survey to operate the performance of hardware and software race vehicles' edge limits, such as high accelerations, high speeds, and low reaction times, and determine the highly uncertain adversarial environments [65,66]. The holistic survey covers the autonomous racing field of research and increasing the range of high-performance platforms [67, 68,69, 70]. Farhatullah studied ADAS technology design navigation systems for AVs such as traffic lights, car road lanes, road blocker detection, traffic sign, and recognition in intelligent transport systems. The survey described and implemented the possible solution to the problems. Researchers emphasized finding the optimal research direction context analysis of the next-generation drawbacks [71, 72, 73]. The surveyor, emphasized communication between cyber-attackers and AV's corresponding defense strategies to control the environmental attacks of CAVs. In addition, several challenges facing autonomous vehicles through security and safety standards of CAVs [74,75]. The researcher localization and perception for the deep learning methods implemented in sensor fusion autonomous vehicles [76]. Scholars expect AV's more advanced in the future, and still, companies will struggle to improve, reshape and revolutionize ground transportation [77]. The communication technologies 5G and 6G anticipated self-driving vehicles perceive the environment and surroundings and perform driving tasks [78]. The scholar reviews the perception system of electromagnetic spectrum operating cameras, IMU, RTK, LiDAR, RADAR GNSS, and ultrasonic sensors systematic and simulator used for autonomous vehicles [79, 80].

Table 1. Overview of Research in the Field of Autonomous Racing Perception

Name & Reference	Year	Perception Categories	Method	Sensor Type	Tested on Hardware	Limitation
Amir Rasouli et.al [1]	2020	Object Detection	N/A	Cameras	Yes	Driving in urban environments.
M. Nadeem Ahangar et.al [2]	2021	Mapping, Object Detection	Particle Filters, Kalman Filters	RADAR, LiDAR, IMU, GNSS, UWB and camera, Ultrasonic Sensors	Yes	Further needed to improve road safety and security
Ekim Yurtsever et.al [3]	2020	Localization, mapping perception,	Image Based Object Detection, Semantic Segmentation,	Stereo Camera, Lidar, Radar Ultrasonic Camera, Flash	Yes	ADSs are complicated robotic systems that operate in inde-

			Object Tracking, Road Lane Detection,	Camera, Event Camera, thermal Camera, GPS-IMU FUSION		terministic environments. As such, there are myriad scenarios with unsolved issues.
Johannes Betz et.al [4]	2022	localization	AMCL, Kalman Filter, extended H∞ Filter, YOLO v2 ,	Lidar, Radar Ultrasonic Camera,	Yes	Low reaction times, highly uncertain, dynamic and adversarial environments
Farhatullah et.al [5]	2020	Pedestrian Detection, Car Detection, Road Blocker Detection,	Segmentation, Dataset, Cone Detection, Kalman Filter	LIDAR, RADAR, GPS, IMU, Camera	NO	Further needed to improve road sign, road lane, cone, traffic light, car, and pedestrian, text detection and recognition
Henry Alexander Ignatious et.al [6]	2021	Mapping, Radio Detection, Light Detection, Localization	Dataset	Radar, LiDAR, Camera, ultrasonic sensors, IMU, GNSS	Yes	The key issues with a wireless sensor networks are (i) selection of appropriate hardware and operating infrastructure, (ii) sensing network calibration, deployment, and programming model
Jun Wang et.al [7]	2020	Object Detection, Mapping	Tracking, Road Testing, Lanes	LIDAR sensors, cameras, radars, ultrasonic sensors, contact sensors, GPS	Yes	Improving transportation safety, reducing traffic congestion
Palafox et al [8]	2019	Free Space Detection	Semantic Segmentation	Camera	NO	N/A
Leon Prochowski et.al [9]	2022	Object Detection, Localization	Tracking, Semantic Segmentation, Cone Detection	Lidars; Cameras; Radars, GPS	Yes	Improve road safety and set directions for the further development of AVs. Future scenarios should also include the study of necessary changes to road infrastructure to facilitate the operation of AVs.
Xiaoqiang Sun et.al [10]	2021	Detection, Road Boundaries Detection	Segmentation, Classification, and 3D reconstruction	ultrasonic sensor, radar, and lidar,	Yes	Security problems and challenges
Azim Eskandarian et.al [11]	2019	Planning-Control architecture, Object	SLAM, Segmentation,	Ultrasonic, radar, lidar, and camera	Yes	The remaining challenges and unsolved problems

		Detection, Localization, Mapping	EKF, Kalman Filters,			of CAVs in each Section which would be helpful to researchers in the field.
Amr Mohamed et.al [12]	2018	Object Detection	Segmentation, EKF, Kalman Filters, particle Filter, ML Methods	Radar, Lidar, and camera	Yes	Hardware and software faults increase in terms of sensor failures, actuators malfunctions, and processing failures
Jamil Fayyad et.al [13]	2020	Object Detection, Localization, Mapping	Segmentation, EKF, SLAM, YOLO, RNN	GNSS, Lidar, IMU, INS, Radar, Cameras	Yes	improve, reshape, and revolutionize the future of ground transportation.
Francisca Rosique et.al [14]	2019	Detection, Mapping, Localization	Segmentation, EKF, SLAM, Gaussian filters (e.g., Kalman filter (KF) or particle filters (PF)	Ultrasonic, RADAR, LiDAR, cameras, IMU, GNSS, RTK	Yes	Driving in urban environments.

3. Sensors for Autonomous Vehicle and It's Abilities

3.1 Sensors

Sensors are severely challenging tasks to analyze the environment and detect objects. The world's top AV companies investing large amounts of money on sensors to produce accurate object detection and tracking. Reliability and robustness are needed to obtain high sensor redundancy [81, 82, 83].

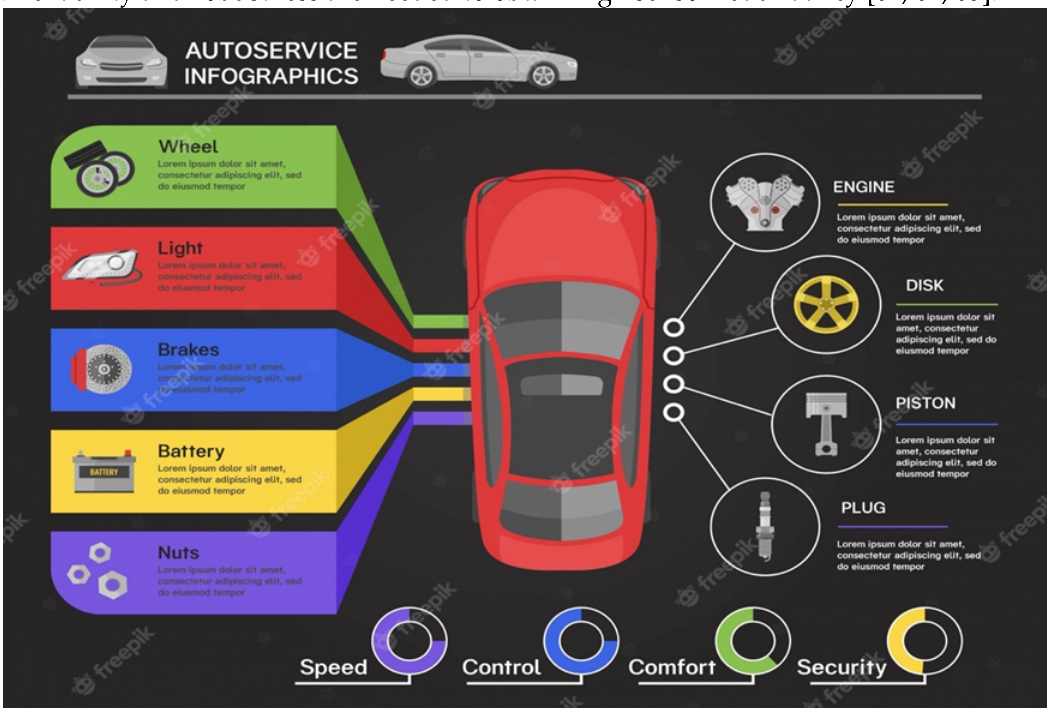

Figure 1. Important Features and Controls of the Autonomous Vehicle [85]

3.1.1 Light Detection and Ranging (LiDAR)

LiDAR is a modern sensor that operates important roles in Autonomous vehicles. This sensor works incredibly to measure and calculate the distance between AVs and pedestrian users to track the objects with a high accuracy rate. LiDAR sensors [86, 87] detect the maximum range of lengths up to 200 meters.

Using sensors 905 to 1550 nm spectra affected the human eye, while the 905 nm spectrum is more dangerous and damages the eye retinal. In the same way, 1550 nm spectra minimized the damage to the eye and protected human life. Furthermore, LiDAR sensors working with 2D and 3D images analyze the object and produce reliable results with high accuracy. A 2D LiDAR sensor rotates the mirror quickly and generates impressive performance for the single laser beam. On the other hand, 3D images detect the surrounding environment of multiple objects a few centimeters with the help of 360 degrees of horizontal movement. In comparison, vertical movement is 20 to 45 degrees integrating lasers [88,89,90,91]. The sensors capture images using a detector and analyze everything inside an image to identify the pixels of images. If any issues are created in the captured image, the process repeats repeatedly until it achieves complete image object detection. With the help of LiDAR sensors, detect the environmental object positioning place. Researchers and Engineers are still working to improve the LiDAR performance and accuracy for the future autonomous vehicle. Mainly, Engineers emphasized to used 3D LiDAR sensors because it's advanced and procurements technology for the AV system. LiDAR objects determine processes that use significant functions for 2D and 3D. The ACC functions are used for 2D, while maps for 3D objects are in real-time. According to experts, 2D and 3D image analysis have many problems facing upcoming life [92, 93, 94, 95]. Japan and USA universities are rapidly researching to solve the facing problems. It's a complex task to train the sensors to 100% achieve accuracy and detect environmental objects. In the same world, top companies invest massive amounts in developing new technology [96,97].

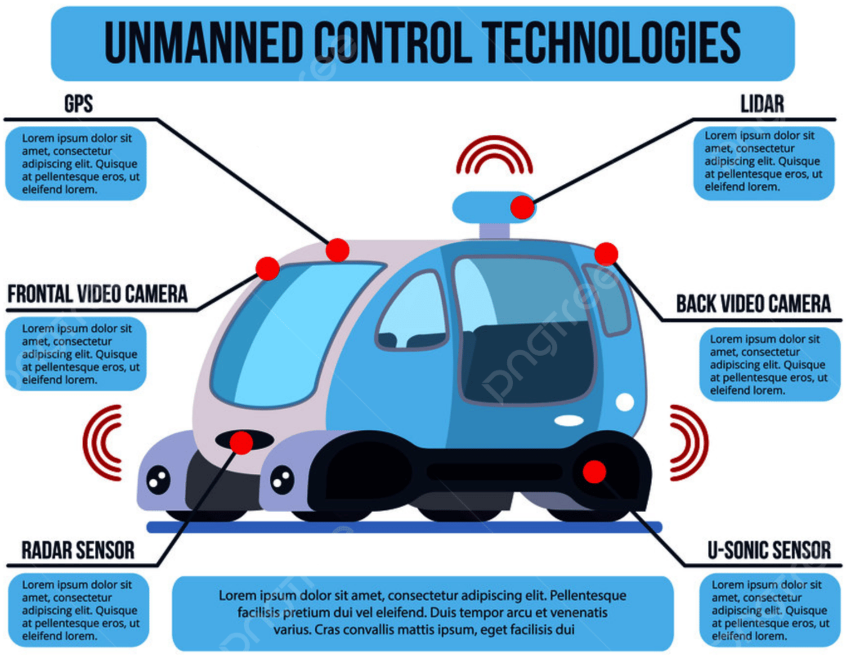

Figure 2. How Sensors Technologies Connected to Autonomous Vehicle [99]

3.1.2 Radio Detection & Ranging (RADAR)

RADAR is a modern sensor to scan the environment surroundings to detect objects' presence in a cars AV's location [98]. The advanced sensors mainly used for military, meteorological systems, airports, and other civil applications operate by RADAR millimeter-wave (mm-Wave) spectrum. The range of modern sensors is 5 to 200 m, while RADAR has various frequency bands of 24,60,77, and 79 GHz are calculated distance between the AV and object measuring. RADAR in AVs generates a set of lobes and works through micro-antennas to target multiple object detection and update the range resolution [100]. The bandwidth RADAR has higher and is measured accurately in short-range utilizing mm-Wave in any direction. The longer wavelength of RADARS has a significant role in anti-pollution, and anti-blocking can determine fog and low light and cope with rain and snow. However, mm-wave sensors can calculate or measure Doppler shift velocity in an autonomous vehicle. The primary function of RADARS is extensive AV application vehicle recognition, obstacle detection, and pedestrian recognition alert traffic controlling assistance [101,102,103].

3.2 Ultrasonic Sensors

Ultrasonic Sensors also include modern and advanced technology operating in the 20-40 kHz range. The waves are produced by magneto-resistive membrane calculated distance between AVs and object and with the help of time-of-flight (ToF) emitted wave calculated distance echoed signal updated after every 20ms [104, 105]. The range of these sensors is minimal, approximately less than 3 m, while updated every 20ms provides output. The directional multiple sensors provide a full-field view beam detection range. Furthermore, various sensors used have more chances to create extreme-ranging errors—measuring short distances in AVs with low speeds [106].

3.3 Camera 2D & 3D

The autonomous vehicle camera is classified into two main infrared-based and visible-light based, depending on the device wavelength. The image of the camera builds a complementary metal-oxide semiconductor and charge-coupled device (CCD) [107]. The quality image depends on the camera lens and specification of the hardware and software performance of the latest version range around 250 m. Most cameras use 400-780 nm, consisting of RGB means Red, Green, and Blue same wavelength as the human eye. The stereoscopic VIS cameras combine the focal length and produce new channel information. The camera (RGBD) setting in autonomous vehicle capture 3D image around the vehicle object detection [108,109]. In the same way, infrared (IR) cameras set passive sensing between 780 nm and 1 mm wavelength to control peak illumination. These autonomous cameras help assists in object detection, view directing, and accident recording. The camera also analyzes and determines the weather conditions identification such as moment-of-light variation, snow and fog changes. The significance of a camera in AVs together texture, recording, contour of the environment, and color segmentation or distribution accurately. According to experts, AV camera lenses also play essential roles observation and setup of pixels of images or videos [110, 111]. However, multiple cameras are adopted in autonomous vehicles to monitor the surrounding situation and track objects. Most researchers want to use RGBD architecture for deep learning and neural networks to achieve the target results. It's very complex to deal with massive data, and I need help finding the appropriate solution for AVs. Most of the sensor's capabilities and reliabilities are limited to detecting the object from the environment [112]. Still, engineers and researchers need help to improve the performance of sensors to detect the object accurately. The autonomous vehicle has multiple sensors to obtain accuracy and find the target destination. They are further needed to improve the range of sensors, cost, and balance function development [113, 114].

4. Planning and Decision Making

4.1 Mission Planning

It's a critical phase to follow the traffic rules regulation mechanism according to semiautonomous planner assigned path trajectories like lane change, passing, and merge [115]. The most significant difficulty in recovering from operational mistakes is parking drivers on the path. The local motion planner will be launched when the way is assigned immediately [116]. Our mission planner clearly defined drive through cruising lane, provided by a commodity navigation application system. There are some approaches to changing the route of AVs when our autonomous vehicle is proceeding or passing [117].

4.2 Motion Planning

The motion planner is designed for driving behavior and corresponding target scenarios from the environments. This platform provides a fundamental motion planning strategy and added high-level intelligence [118]. The settings included the structure and unstructured paths. Structure environments, such as graph search classifiers, parking lots, and minimum cost paths, while unstructured environments, such as density of vertices, edges, roads, and traffic lanes functionalities in autonomous vehicles [119].

4.3 Global Planning

The global planning split into various strategies using the primary objective optimization in the field of research geometric properties of the race lines, lap time, and energy spent. The optimization provides a quality measure of lap time taken part of agents [120]. Hence, naturally, trap became a popular choice and included global planning. Global planning approaches applied to evolutionary algorithms (EAs) and variations to improve and optimize the lap times. In this approach, classify the various parameterizations and sit in the search spaces individual and category base to configure the model's performance vehicle hardware and software. The models require evaluation functions' performance on lap time given a configuration. The genes evaluated and mutations referred to sampling and population search space classifiers iterations depending on various strategies [121, 122]. Initially, the individual population tracks the optimal optimization for lap time objective clearly defined. The proposed methods choose from dynamic models and find multiple solutions to the optimization problem formulated by eliminating [123].

4.4 Local Planning

The local planning objective is clearly defined, the motion of the car avoiding collisions and fixed horizon by adversaries. Regional planning described some essential strategies of the following [124, 125].

1) Classifying optimization problems via a global planning
2) Choose the best obstacles and dynamically feasible trajectories
3) To find the feasible trajectory around the free space of obstacles

The local planning trajectory methods used for the model predictive control (MPC). The control approach is suitable for the regional trajectory addressing the planning problems. The first phase of the global plan described allows obstacle avoidance [126]. The model predictive controllers based on optimization utilized the international method while defining the formulation types. The newly formulated functions optimization issues will be addressed in the new motion plan encountering an obstacle. The professional driver needs help to optimize the minimum-time purposes or maximum velocity objective switch among the MPC modes [127,128].

4.5 Behavioral Planning

Behavior planning is used for high-level decision-making to choose the appropriate tasks for different weighting objectives. Most of the researchers emphasize two different strategies of the following [129].

1. Provoking multiple cost functions choosing the weighting low plan overall cost
2. Together the local planner with theoretical techniques

In the first steps, cost functions indicate the specific racing values, such as control of the inputs and tracking the optimal global plan, obstacles, proximity, and procurements along the track. However, the overall cost will be determined locally, combining all cost function trajectories [130].

5. Controlling AV's

5.1 Path Following / Trajectory

The motion planner's responsibility is to create a path and control the autonomous vehicle pursuit algorithms. With the help of algorithms, we can easily find an accurate way to follow the problem. According to experts, AVs suggest that they should first break down the path into multiple waypoints [131]. Each control cycle specified the threshold distance and was close to the way heading direction. If you want to reach your target destination, you should update the waypoints of the space [132]. The localization errors will face the problem of unexpected obstacles. The minimum distance to obstacles followed the path of overwriting.

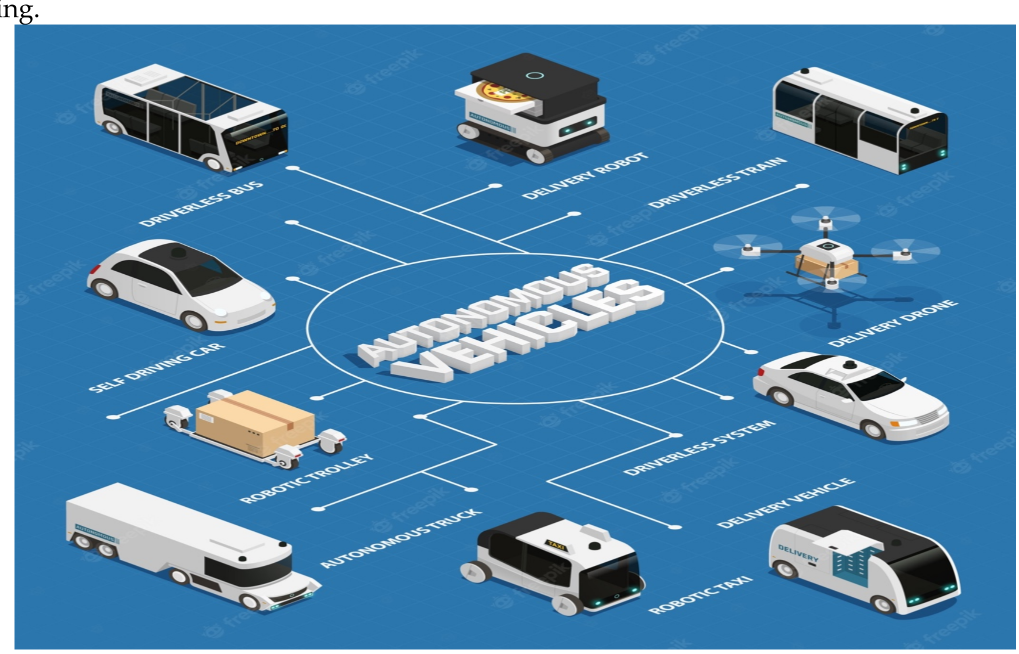

Figure 3. Autonomous Vehicle isometric flowchart [133]

6. Details Information of Detection

6.1 Image-Based Object Detection

Object detection determines the size of objects and location from the creating AV's environment. Object detection is divided into static and dynamic objects. Some static things play a significant role in detecting objects, such as traffic lights and road crossing signs, while dynamic objects include pedestrians or cyclists [134]. If you focus on each thing, have specific classes and features in an image to identify the size and rectangular bounding box. The state-of-the-art object tracking and object detection techniques understand the scene and starting point of the picture. Sometimes researchers use frameworks for a single network to generate the object detection location and predict the class [135]. The region of proposal techniques guiding the current detection benchmarks, but cost gaining with high power computation. Implementing, training the model, and fine-tuning it can be challenging. Furthermore, single-stage object detection classifiers consume fast inference time and use low memory cost beneficial for real-time driving automation. The most popular single-stage detector needs to improve continuously. Meanwhile, DCNN is used to extract meaningful image features and reduce the resolution of the coarse grid and input image. The neural networks are fully connected, classify the bounding box parameters, and predict the probabilities grid cell class [136, 137].

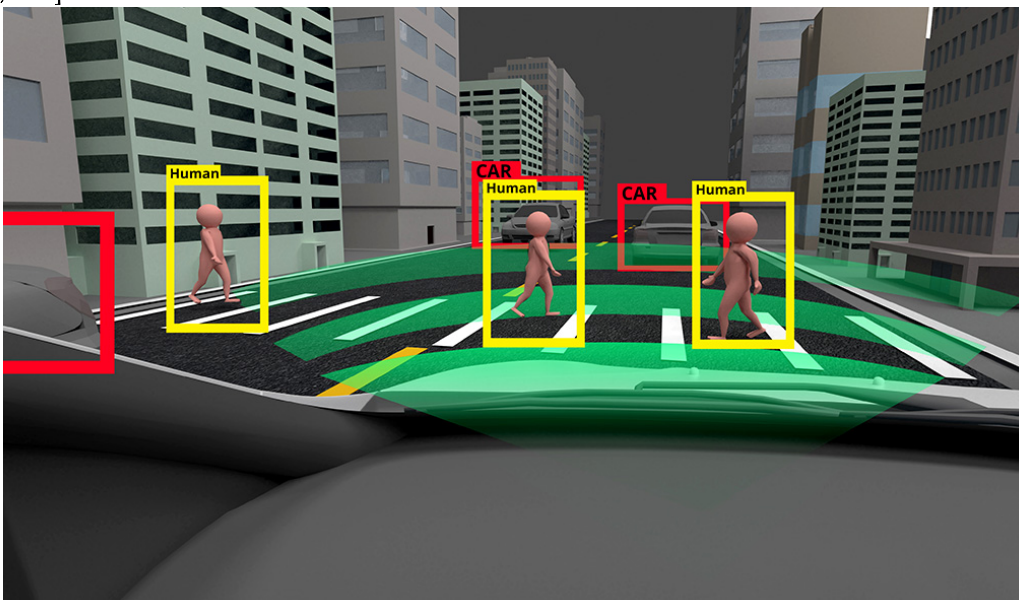

Figure 4. Pedestrian Detection by Autonomous Vehicle [138]

6.2 Object Tracking

Object tracking is also a technique for the autonomous vehicle. Object tracking implements both (MOT), which stands for multiple objects tracking, and (DATMO) for detecting and monitoring various things referred to. Autonomous vehicle fully automated driving is a complex implementation, and monitoring the location with high-speed scenarios is insufficient. It is needed to determine dynamic objects' velocity and the heading through motion model to predict the future trajectory over time and track the thing without collisions. The multiple cameras are connected with lidars or radar sensors to estimate trajectories of vehicle frame range of information [139]. The sensors often detect objects and provide various data on AV periods. Most sensors have better cope detectors depending on the degree of sensor limitation and uncertainties sensing modalities tracking strategy. Object tracking methods are commonly associated with simple data traditional filters. When objects detect in 3D space, it will change the whole scenario with a high frame rate and high pixels of image association appearance. The model accurately gains the results. Image-based techniques are suitable for the classifiers to analyze color histograms, gradients, and other features of data evaluation. All sensors of autonomous vehicles association occupancy maps and frame through data and algorithms. Deep learning techniques are applied to solve tracking object problems while also being more beneficial to track the real-time object [140].

6.3 Road And Lane Detection

Road and Lane Detection is also a broad concept in autonomous vehicles to determine the drivable surface. The drivable surface can be identified with the help of semantic segmentation, AV's vehicle necessary to understand the road semantics. The above detection methods are the bounding box estimation techniques previously discussed in detail. Road detection is also a complex problem initially, while researchers and engineers gradually achieve the target goals [141]. Still, thousands of issues are also generated as engineers need help finding the optimal solutions accurately. Experts say it emphasized improving AV hardware and software solutions with high accuracy. Road lane detection is understanding AVs through advanced algorithms and connected perspectives of perception. In this section, we discussed the current road and lane detection techniques, refer to in-depth surveys, state-of-art methods, and traditional approaches. The problems are divided into subdivided levels of automation. The lanes of the road splatted and host the vehicles identified. The ADAS technology estimated the host lane and measured the reasonable distance. The ADAS technology solves lane keeping, lane departure warnings, and adaptive cruise control. Each avenue of the road is a challenging task to train the models to provide performance and analyze proper future direction with multiple sensors merging turning lanes [142]. The road structures detection by ADAS technology reliable rates to understand semantic several streets at long ranges automated driving preprocessing exteroceptive data. The cameras of AVs performing image color segmentation and lighting normalize conditions map-based filtering.

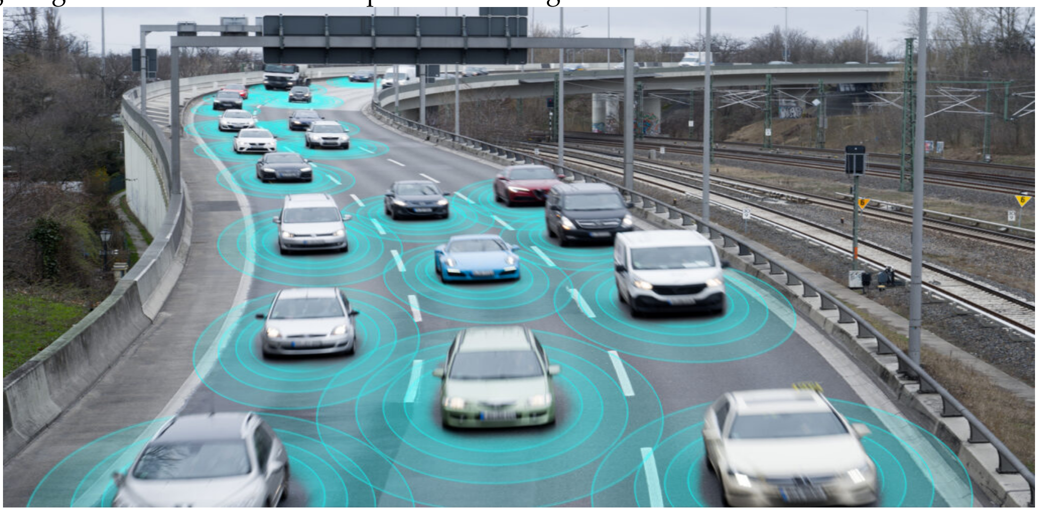

Figure 5. Autonomous Vehicle Road and Lane Detection [143]

7. Motivation of Autonomous Vehicles

7.1 Prevention of car crashes

The advanced system based on computers and algorithms will substantially eliminate costly human errors. If you focus on most road accidents, including drunk or distracted driving, high speed, and sleeping, sometimes will not be a factor in self-driving vehicles. Most researchers and experts estimated that self-driving can reduce road accidents by up to 90% [144].

7.2 Societal cost-savings

Automated cars are major factors weighing the benefits of the cost to society. According to the latest reports detailed explained autonomous vehicles assist in saving money by almost $800 billion each year. The reduction of autonomous cars, such as car crash-associated costs, better fuel savings, and more efficient and reliable transportation, reduced the strain on healthcare and contributed to whole societal cost savings.

7.3Traffic efficiency

Self-driving cars have massive abilities to communicate efficiently during travel efficiency and optimize the route from each other. During traffic jams, autonomous vehicles facilitate and eliminate the best way and protect you from bumper-to-bumper traffic problems.

Environmentally friendly

The environment is another impressive factor of autonomous vehicle automated detection and debate. Self-driving cars will be feasible electric cars utilizing engines' internal combustion. Autonomous vehicle contributes to reducing the speeds of cars and also control the emission sustainable environment [145].

7.4 Dataset AV'S

Autonomous Vehicle has a few datasets available on public online, GitHub repositories, and other sites. Most researchers download pedestrian datasets such as KITTI, Caltech [67]. This data is available online, but there needs to be more data to predict the crossing behavior of pedestrian users. In the above, some datasets include having a large number of samples bounding multiple pedestrians' frames. Pedestrians are crossing behavior datasets, allowing them to detect and understand contextual and meaningful information. The pedestrian dataset contains features like group size, pedestrian state, demographics, communication, street structure, and weather condition.

8. Cyber-Attacks in Connected and Autonomous Vehicles

We classify the environment of autonomous vehicles as controlling and protected from cyber-attacks. Attacks have many types, such as vehicle to every-thing network attacks, in-vehicle network attacks, and other cyber-attacks. However, controller area vehicle (CAVs) is a protected environment from the existing cyber-attacks. Furthermore, we summarize the risky cyber-attacks on the AV environment of CAVs. First, we should determine the attack surfaces of the AVs applied to these attacks [146]. The cyber-attack characters have various points to inject and extract meaningful data from the existing vehicle security system. In addition, compromised radar sensors can apply remote sensor attacks, which focus on the attack surface.

8.1 In-Vehicle Network Attacks

Attacks have many types, but some are dangerous and bankrupt for autonomous vehicles. It is a big responsibility to protect the AV's vehicle. In-vehicle network attacks consist of location trailing attacks, society of Automotive engineers (SAE), remote sensor attacks, Controller area network (CAN), GPS spoofing attacks, electronic control units (ECUs), integrated business services, software flashing episodes, described in details of the following --

8.2 Remote Sensors Attacks

The environment of the controller area network (CAN) is a big challenge for the various electronic components such as Cameras, Radar, Lidar, Ultrasonic, and other sensors applied in-vehicle networks. If you focus, each sensor has capabilities and weaknesses based on detection strength, sensors range, and reliability. With the help of wireless technologies, establish external entities' relationships with existing sensors. We can quickly determine the sensors and detection capabilities by comparing the sensors. The adversary in CAVs can access peripheral sensors and is vulnerable to control the remote sensors attacks in autonomous vehicles.

8.3 GPS Spoofing Attacks

The Controller Area Networks (CAV) are loaded on GPS, which administers location and time information. It is vital for multiple key processes like timestamps, essential safety messages, and pseudonym certificates in letters. The CAV plays a crucial role in improving the accuracy rate and truthfulness. GPS spoofing attacks elevate the adversary and receive the signal of the GPS cyber-attack area. In addition, the fake information receivers, through GPS signals, broadcast adversaries. The signal strength should be higher than the actual GPS signal. The attack of GPS spoofing occurs in the physical layer. Thereby, GPS attacks interfere with or replace GPS signal adversaries, drifting the desired trajectory of the model.

8.4 Location Trailing Attacks

The AV's driver has access to track the vehicle location and get private information to discover the activities and behaviors of vehicles. The driver adversary matched the personal profile information and protected privacy in the real world. The safe security information no one damage your transportation-based id or account through cyber-attack. To save security frequently when transmitting data from one place to another, anonymous pseudonyms. Location trailing attract is insufficient to resist the existing location position and pseudonymous location profiles. The adversary is the help of a specific autonomous vehicle that efficiently operates and protects the security issues. For instance, profiles consist of the starting and ending location tracking home and word addresses.

8.5 ECU's Software Flashing Attacks

Software Flashing attacks (ECUs) embedded systems, controlling various electronics components, software such as servo steering, electronic window lift, ignition system, and climate controls. However, ECUs are helpful in reprogrammable and integrating new methods to correct bugs without replacing ECUs. In addition, ECU consists of installation software, development, and delivery to protect the possible attacks. Software Flashing attacks (ECU) related to code modification, phishing attacks, reverse engineering, and fuzzing attacks. Code modification degrades and corrupts information while fuzzing attacks affect the vulnerability in hardware-embedded system performance. Phishing attacks connected remote devices to flash firmware machines never rebooted.

8.6 Integrated Business Services Attacks

Most autonomous vehicles' embedded systems are connected via back-end network development. Driver capable of using the allowing services manufacturers like remote software update, remote telediagnosis, and entertainment. There are several attack possibilities to deploy the business service, such as gaining access to the vehicle system, client-level, and gaining user data access. Adversary system-related client-level use for the business platform will be startup phishing attacks and malicious codes. Hence, adversaries related to client-level implementation are another cyber-attack that can protect business platforms from attack when adversary systems run on arbitrary software and control the embedded system for business platform vehicle systems.

8.7 Vehicle to Everything Network Attacks

Vehicle to Everything network facilitates to exchange of data between the connected car and other vehicles based on the controlling area vehicle. The ways of communication through network access at each point and vehicle communication with external devices. The communication protocols are established through Bluetooth, WIFI, and mobile communication [147, 148].

9. Details Challenges in Autonomous Vehicles

Challenge 1 : Autonomous Vehicle High-Speed Perception

Autonomous vehicles currently have many issues facing high-speed object detection insight details with various fusion methods for high-speed localization. Unfortunately, high-speed driving has no dataset available publicly repository. For autonomous vehicles, a small amount of data is available on hold while uploading the high dataset and provide opportunities for researchers to find problem solutions. The object detection or SLAM techniques adapted to the field AV of racing. The researchers still need help to find the missing methods and algorithms to detect high-speed driving, speed motion blur, and synchronization of sensors' significant roles in AVs. According to experts analyze, 100 m above distance is reliable to achieve enhancement of the sensor (Camera + LiDAR + RADAR + Ultrasonic) fusion performance speedily object detection. Still, sensors are needed to improve the ranges and analyze the object detection accurately with a high accuracy rate. The field of autonomous and drone racing successfully localization vision-based adopted in the research.

Challenge 2 : Multi Vehicle Trajectory Planning

Suppose you focused most of the researchers dealing with single-vehicle planning trajectory while we need how to deal with multi-vehicle scenarios. Multi-vehicle planning further needs a deep investigation into how to control the multi-vehicle system setup management in future self-driving. The multiple-vehicle overtaking is a complex process. High speeds vehicles not handling completely dynamic local trajectory planning display state of the art for future challenges. However, the trajectory path must find the optimal way in a non-convex incorporating active vehicle, collision-free, recursive feasible, and executable in real-time. The car's path and velocity performance must be planned, creating new types of techniques and classifiers for trajectory planning and new heuristics to decrease the heavy computational calculations.

Challenge 3 : Multi Vehicle Interaction:

This is also a severe challenge in autonomous when two or more vehicles interact in head-to-head racing, such as overtaking, blocking, and other related activities. On the other hand, most of the researchers and experts team emphasized designing new prediction algorithms to control the uncertainty of behavior of automated vehicles explored extensively. Hence, the object prediction according to the given instruction of lane and traffic rules understanding of interactive scenarios. A severe issues model can provide and deal with a weighted thrifty setup of the trajectory that controls the space of acceptable outcomes. In addition, there are no planners to handle the sophisticated behavior interaction drive from the evaluation environment of any circuit.

Challenge 4 : High Computational Time of Algorithms:

The creation of autonomous cars significantly relies on sophisticated computations and algorithms that allow for real-time sensing, decision-making, and control. The lengthy computational time needed by these methods is one of the major problems faced by researchers in this field. This problem has ramifications for autonomous cars' effectiveness and safety, and it has sparked a concentrated research effort to find a solution. Here, we examine the causes of lengthy computations, their effects, and current efforts to address this problem.

Challenge 5 -: Safety and Reliability

The safety and dependability of autonomous cars continue to be of utmost importance. The creation of fail-safe systems that can manage improbable events and technological faults is a challenge for researchers. It is a difficult task to achieve a degree of safety that is similar to that of human drivers in all circumstances.

Challenge 6 : Limited Sensors data about the environment

LiDAR and webcams are two examples of existing sensor technologies that have limits in specific situations, including limited visibility. Researchers are looking into ways to enhance sensor fusion methods and create sensors that can accurately perceive the environment under various conditions. An essential component of autonomous vehicle operating is the environment's perception. The accuracy and dependability of self-driving automobiles can, however, be severely hampered by the quantity and caliber of sensor data. Here, we examine the effects of scant sensor data and the solutions being developed by researchers. Researchers are investigating novel sensor technologies and combinations as autonomous vehicle technology develops to address the problems brought on by the lack of sufficient sensor data. The goal of emerging technologies is to provide a more precise and thorough awareness of the environment.

Challenge 7 : Unpredictable Environments:

Environments that are unpredictable and dynamic must be navigated by autonomous vehicles. The perception and decision-making systems are challenged by bad weather, road construction, and unforeseen barriers. Researchers are attempting to make self-driving cars more equipped to deal with these unforeseen circumstances.

Challenge 8 -: Human Interaction

Autonomous vehicles must operate in perfect harmony with human-driven vehicles, bicycles, and pedestrians. The use of standardized signals or displays is one strategy being looked into by researchers to improve communication between autonomous vehicles and other road users.

Challenge 9 -: Data Privacy and Security

Large volumes of data are produced by autonomous vehicles, which raises questions regarding data security and privacy. Researchers are developing strategies to safeguard user privacy and safety by preventing illegal access to car systems and protecting critical data.

Challenge 10 -: Ethical Decision-Making

The significant moral conundrum of programming autonomous vehicles to make moral choices under dire circumstances is presented. Researchers are investigating methods to make sure that autonomous vehicles make decisions that minimize harm while adhering to societal standards.

Challenge 11 -: Public Acceptance and Trust

Autonomous vehicles must first win the confidence and acceptance of the general population in order to be successfully integrated. Researchers are looking into methods for educating the public on the advantages and capabilities of self-driving automobiles in order to allay anxieties and clear up myths.

Challenge 12 -: Long-Term Infrastructure Changes

The widespread deployment of autonomous vehicles may need considerable alterations to traffic control systems, signs, and road infrastructure. Researchers are thinking about how to make the transition from a world where human-driven and autonomous vehicles coexist to one where they do not.

Challenge 13: - Economic and Job Disruption

The widespread use of autonomous cars may result in job losses in industries like transportation and ride-hailing. Researchers are investigating methods to lessen these economic disruptions and guarantee a seamless transfer for impacted employees.

10. Applications of AV's

The application of autonomous vehicles (AVs) has several benefits deploying to access transportation. According to the government analysis data, 94% of crashes deeply investigated driver-involved errors and behavior. In the same way, delivery vehicles assist and enable shuttles, and the robot axis increases travel efficiency while reducing traffic congestion challenges. Nowadays, generally recognized self-driving vehicles at the current time shuttles, delivery vehicles, and robotaxis are tested for commercial use.

10.1 Self-Driving Shuttles

This vehicle was recently made for automotive driving suppliers from one place to another. The new innoviz's fully automated shuttle program to find out the accurate location of passengers and cargo transported in disparate geo-fencing settings.

10.2 Robotaxis

This is a significant project of Waymo's robotaxi corporations through various advanced companies such as GM, Ford, and Daimler to deliver reliable traveling for passengers. Companies need help to develop self-driving vehicles have more efficient and reliable for traveling.

10.3 Delivery Vehicles Services

Recently, dominos companies introduced new self-driving pizza delivery vehicles to the marketplace. Dominos and Nuro partnership to develop the new automated vehicles launch in various USA states such as Texas, California, and Arizona. These states US Department of Transpiration approved prepared pizza delivery vehicles to facilitate the customers. The pizza delivery vehicle process is straightforward: enter the PIN code and receive their pizza.

10.4 Automation in the Farming and Agriculture Sector

Self-driving vehicles also play an essential role in agriculture and farming, operating large machinery for longer hours than a person. The automation vehicle also eliminates the need to perform tilling or harvesting crucial areas.

10.5 Automation in Construction and Mining

It's a significant factor in our daily life to construct and map unexpected construction to create changes through technology safety and the project's success. The LiDAR technology plays impressive roles and supports construction and mining through self-driving vehicles within a minute.

11. Recent Trends in Autonomous Vehicles

Self-driving automobiles, also known as autonomous vehicles, are a ground-breaking technical development that is transforming the future of transportation. Research and development activities have significantly increased in recent years with the goal of improving the capabilities, safety, and wide-scale implementation of autonomous vehicles [116]. This essay explores the numerous viewpoints surrounding current developments in autonomous vehicle research, looking at technological advancements, legal issues, societal effects, and the forecast for the future.

11.1 Sensor Fusion

To build a powerful perception system that is capable of precisely detecting and comprehending the vehicle's surroundings, researchers are actively concentrating on combining numerous sensor modalities including as LiDAR, radar, cameras, and ultrasonic sensors.

11.2 Machine Learning and AI

To analyse sensor data, make judgments in real-time, and adapt to complex and dynamic settings, autonomous cars mainly rely on machine learning algorithms. Neural networks, deep learning models, and reinforcement learning are crucial in enhancing the decision-making abilities of the vehicles.

11.3 Connectivity and V2X Communication

Through vehicle-to-everything (V2X) communication, vehicles can communicate with infrastructure, pedestrians, and other vehicles to exchange information. With this technology, traffic flow is optimized, congestion is decreased, and safety is improved [149].

11.4 Regulatory and Legal Challenges

Safety Standards: Creating global safety requirements for autonomous cars is still a difficult task. To ensure the dependable and secure operation of self-driving cars, researchers and legislators are working together to design extensive safety measures .

11.5 Liability and Insurance

It can be difficult to determine who is responsible for accidents involving autonomous vehicles. Researchers are looking at legal systems and insurance models that equitably allocate liability among producers, programmers, and human operators.

11.6 Societal Impacts

Metropolitan planning and infrastructure: The introduction of self-driving cars has sparked discussions regarding the layout of metropolitan areas. Researchers are looking into how cities may modify their infrastructure, such as designated lanes and charging stations, to accommodate self-driving automobiles.

11.7 Environmental Considerations

By maximizing routes and encouraging ride-sharing, autonomous cars have the potential to lower traffic congestion and pollution. The environmental effects of the widespread deployment of driverless vehicles are being researched.

11.8 Mobility-as-a-Service (MaaS)

The emergence of platforms that allow consumers to receive transportation services on-demand through mobile apps is predicted to be significantly influenced by autonomous vehicles. The way people commute and engage with transportation could change as a result of this trend.

11.9 Ethical Decision-Making

When designing autonomous vehicles to make split-second decisions in life-threatening scenarios, researchers are confronted with difficult ethical issues. The topic of discussion is whether or not the safety of passengers in self-driving automobiles should take precedence over that of pedestrians. Recent developments in autonomous vehicle research cover a wide range of societal, legal, and technological issues. Even though tremendous progress has been made, there are still many obstacles to overcome before autonomous vehicles are a commonplace reality. To design the future of transportation in a safe, moral, and ecological way, researchers, politicians, and stakeholders must keep working together.

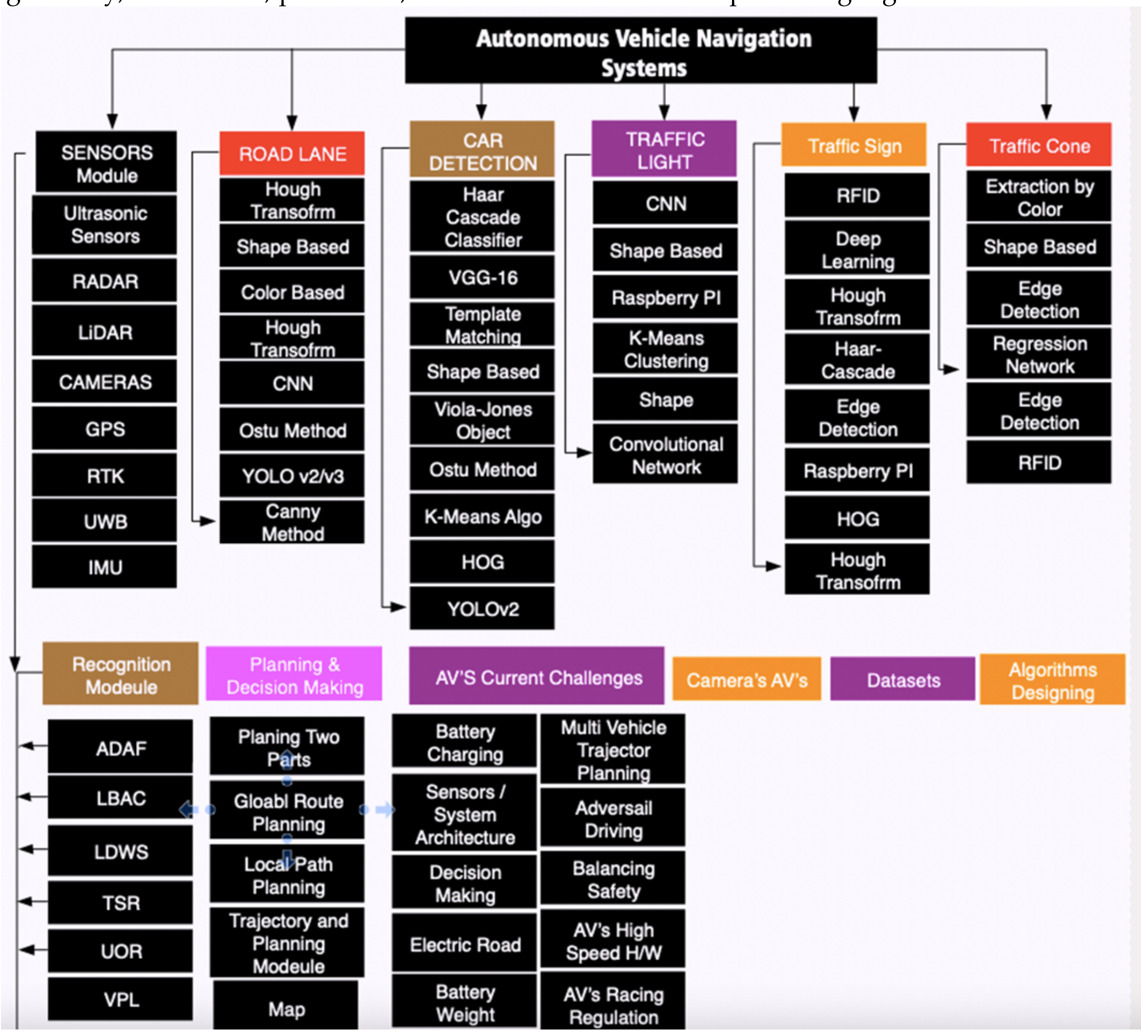

Figure 6. Block Diagram of Research Paper [50]

12. Conclusions and Future Research Directions

In this survey on autonomous vehicle driving systems, we defined some optimal innovations in the existing systems. The survey highlighted current challenges facing autonomous vehicles, clearly gaps in the research. The proposed model architecture still meets accuracy, efficiency, and other proper methods intemperate the ideal road conditions. The communication between vehicle-to-vehicle centralized the data and information management of a complex infrastructure open under the researcher's field of study. Today the world is speedily increasing road traffic challenges and facing a missive collision of road accidents growing daily. The primary purpose of the autonomous vehicle is "How to drive safer, more reliable, and more efficient traveling from one place to another as well as reduce congestion issues. The autonomous vehicles' communication process gathers information about their surroundings from the environment usage of various intelligent sensors. Most of the time, the obtained data from the sensors may be inaccurate, therefore should synthesize the raw data to create accurate results. The autonomous vehicle driving system development connected scientific disciplines and new optimal technologies impacts automated driving technology. The old methods and algorithms face many issues while the existing technologies struggle to address the problems and find the optimal solution. We covered some of the major advancements as well as current systems in this survey on autonomous driving systems. Despite the allure of automated driving, which has already been promoted to consumers, our survey has revealed that there are still significant gaps in the literature. From fully modular to entirely end-to-end, various architecture models have been put forth, each with their own drawbacks. The best sensing modality for localization, mapping, and perception is still up for debate, algorithms are still inefficient and inaccurate, and a good online assessment is now clearly required. Dealing with unfavorable weather conditions and poor road conditions are ongoing issues.

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