International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 11 Issue: 04 | Apr 2024 www.irjet.net p-ISSN: 2395-0072

# Self-Driving Car using Artificial Intelligence: A Comprehensive Review

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**Abstract -** *Self-driving cars powered by AI face a range of challenges. Ensuring safety and reliability in all conditions is paramount, requiring robust decision-making capabilities in complex situations. Regulatory and legal hurdles vary widely between jurisdictions, while concerns over data privacy and security must be addressed to safeguard sensitive information and prevent cyberattacks. Ethical dilemmas, such as prioritizing passenger safety versus pedestrian well-being, pose complex moral questions. Building public trust and acceptance, interfacing with legacy infrastructure, and minimizing environmental impact are critical considerations. Using cutting-edge technology like Python, PyTorch, TensorFlow, and Unity's ML-Agents, this project delves into the fascinating realm of self-driving cars. We examine the underlying principles of autonomous cars, their AI-powered powers, and the transportation possibilities they present in the future. The project's goal is to analyse several self-driving car models that can navigate a simulation environment built in a safe and effective manner. We work to advance AI in autonomous driving by integrating components of perception, decision-making, and control. The reason for the review paper is that the existing review papers don't summarize all the types of techniques in a single paper; therefore, this paper represents a comprehensive review of self-driving cars using artificial intelligence.*

***Key Words***: Traditional Driving, Self Driving Car, Radar, Sensors, Unity, Real time, Cameras.

## 1.INTRODUCTION

Traditional driving refers to manual operation of a vehicle by a human driver, using physical controls like steering wheels and pedals, as opposed to autonomous driving where vehicles operate without direct human input. Agnihotri et al. [1] proposed Self-driving vehicles are a bright example of human creativity and innovation in the rapidly developing fields of artificial intelligence and technology. This project uses modern technologies like TensorFlow, PyTorch, Python, and ML-Agents in the Unity game engine to explore the world of autonomous automobiles.

Kudaka et al. [2] introduce about the specifics of self-driving cars, investigate the underlying technology that allow them to function safely and effectively, and dive into the revolutionary potential they hold for the future of transportation as we navigate this fascinating topic as seen in Fig.1 below.

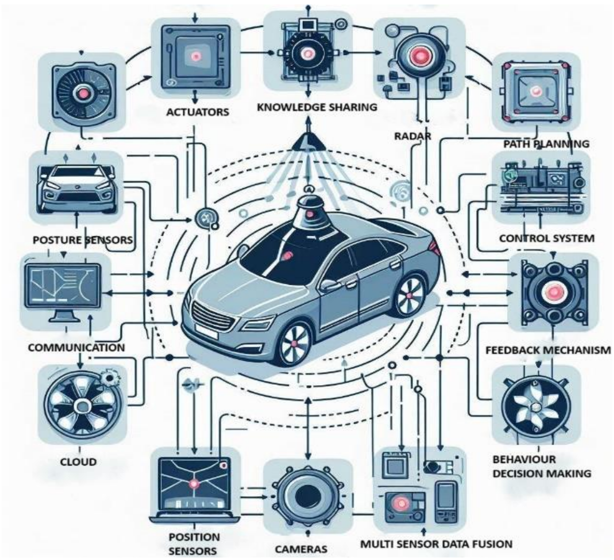


**Fig.1.** Components of Self Driving Car

Alheeti et al. [3] presented Autonomous vehicles, or self-driving cars, mark a revolutionary paradigm change. Kang et al. [4] delivered that In the car industry, these vehicles are equipped with advanced sensors, AI algorithms, and a plethora of complex technologies that enable them to sense their environment, make judgments in real time, and drive themselves over roads.

Soares et al. [5] presented Science fiction fans have been fascinated with the concept of driverless cars for decades, but new developments in artificial intelligence and machine learning have made this goal more attainable than in the past Soares et al.

The convergence of Python, PyTorch, TensorFlow, and ML-Agents within the Unity environment is the central idea of this project. Mihalea et al. [6] developed the core programming language used to create the AI algorithms required for self-driving cars is Python, which is also very adaptable Mihalea et al. Gandhi et al. [7] proposed two well-known deep learning frameworks, PyTorch and TensorFlow, offer the tools and resources needed to construct and train complex neural networks, allowing the car to sense its environment and make judgments.

Rassõlkin et al. [8] with the help of Unity Technologies' cutting-edge ML-Agents framework, we can simulate and train autonomous agents inside the Unity game engine, providing a realistic setting for testing and improving the capabilities of our self-driving automobile Rassõlkin et al.

Novickis et al. [9] introduced the technical nuances of self-driving automobiles as we set out on our adventure, covering everything from sensor fusion and perception to control and decision-making. We will explore the difficulties in teaching neural networks to understand sensor data and guarantee safe navigation. Dong et al. [10] introduced about the moral and legal issues related to driverless cars, which will help us understand the wider ramifications of this innovative technology.

Korkmaz et al. [11] proposed delve into the technical details of self-driving cars, covering everything from vision and sensor fusion to control and decision-making. Byeloborodov et al. [12] presented the ethical and legal concerns surrounding autonomous vehicles, which will aid in our comprehension of the broader implications of this cutting-edge technology.

The existing review papers don't summarize all the types of techniques in a single paper; therefore, this paper represents a comprehensive review of self-driving cars using artificial intelligence.

## 1.1 Challenges

**1.1.1 Technical Complexity**: Li et al. [13] developed AI systems that can navigate the vast array of scenarios encountered on the road is incredibly complex. These systems must process and react to data from multiple sensors in real-time, requiring advances in machine learning, computer vision, sensor fusion, and decision-making algorithms.

**1.1.2 Safety and Reliability**: Chernikova et al. [14] developed safety and reliability of self-driving cars is paramount. These vehicles must perform safely under all conditions, including bad weather, complex urban environments, and unpredictable actions from pedestrians and other drivers.

**1.1.3 Regulatory and Legal Issues**: Farag et al. [15] established a legal framework for self-driving cars involves addressing liability in the event of an accident, setting standards for safety and performance, and navigating a patchwork of local, national, and international regulations.

**1.1.4 Security Concerns**: Farag et al. [16] introduced other connected technologies, self-driving cars are susceptible to hacking and other cybersecurity threats. Ensuring the security of these vehicles is crucial to protect passengers and the vehicles' operational integrity as seen in Fig.2 below.

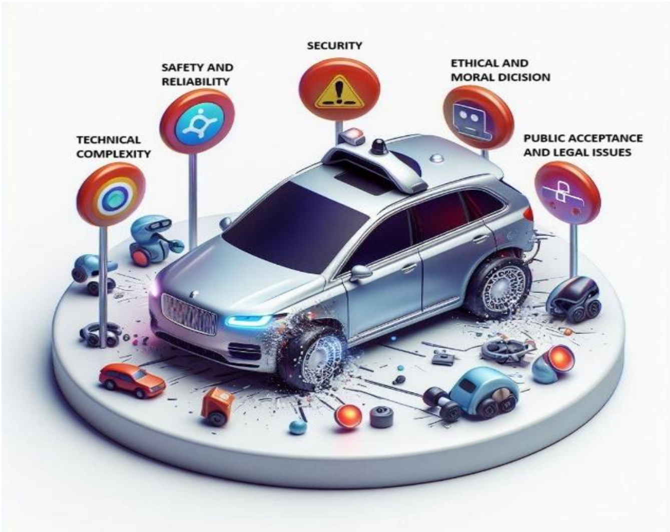


**Fig.2.** Demerits and Challenges

**1.1.5 Ethical and Moral Decisions** : Jain et al. [17] developed AI systems may need to make split-second decisions in emergency situations, raising ethical questions about how these decisions are programmed and the values they reflect.

**1.1.6 Public Acceptance and Trust** : Manchekar et al. [18] proposed Gaining public trust in the safety and reliability of self-driving cars is a significant hurdle. Negative publicity from any accidents or malfunctions could set back public acceptance.

## 1.2 Applications

**1.2.1 Personal Transportation**: Thadeshwar et al. [19] proposed Self-driving cars can provide personal mobility for everyone, including those unable to drive due to age, disability, or other reasons. They offer the promise of a convenient, on-demand transportation solution.

**1.2.2 Ridesharing and Taxis**: Nugraha et al. [20] introduced Autonomous vehicles are expected to significantly impact the ridesharing and taxi industries by reducing the cost of these services and potentially increasing their convenience and safety.

**1.2.3 Freight and Delivery**: Gupta et al. [21] presented Self-driving technology is being applied to freight and delivery services, promising to improve efficiency, reduce costs, and address the shortage of truck drivers.

**1.2.4 Public Transportation**: Pahadiya et al. [22] proposed autonomous vehicles could supplement or integrate with existing public transportation systems, providing "last mile" solutions that help people get from transportation hubs to their final destinations.

**1.2.5. Reduced Traffic Congestion**: Gupta et al. [23] developed optimizing driving patterns and reducing the need for parking, self-driving cars could alleviate urban traffic congestion.

**1.2.6. Environmental Benefits**: Gupta et al. [24] optimized driving and the potential for electric self-driving vehicles to be more widely adopted could lead to reduced emissions and a smaller environmental footprint for personal transportation.

## 2.LITERATURE REVIEW

The researchers have presented various papers based on machine learning and deep learning on the self-driving car, but there are still some challenges with the self-driving car. Therefore, this paper reviews recent 10-year papers on self-driving cars using artificial intelligence.

Self-driving vehicles, also known as autonomous vehicles (AVs), have recently garnered significant attention due to their potential to revolutionize transportation and improve road safety. Gupta et al. [25] introduced these vehicles depend on artificial intelligence (AI) and deep learning to autonomously navigate, perceive their surroundings, and make driving decisions. This literature review examines pivotal research and progress in employing AI in the realm of self-driving cars. We investigate the historical backdrop, technological base, challenges, and prospective developments in the area of AV innovation. The concept of autonomous driving has intrigued people for many years. Initial investigations in this arena set the stage for autonomous vehicle development. The early 2000s saw DARPA's DAVE (Driver Assistance for Vision Enhancement) project showcase the possibility of using cameras and steering instructions to train a model for autonomous driving. This endeavour signalled the start of end-to-end learning for autonomous navigation. A fundamental element in the evolution of self-driving vehicles is the application of Convolutional Neural Networks (CNNs). These advanced deep learning models are tailored for processing visual information, making them extremely valuable for computer vision tasks, including object detection, image classification, and segmentation.

In the field of autonomous driving, CNNs (Convolutional Neural Networks) are instrumental in analyzing images from the vehicle's sensors to identify objects, lane markings, and other vital elements in the surrounding environment. The technique of end-to-end learning has shown great promise for this application. It involves directly training a neural network to convert sensory input, like images, into driving decisions, such as steering angles, eliminating the need for handcrafted feature engineering and complex processing stages. This method's effectiveness was showcased in projects like NVIDIA's self-driving car, which used a CNN to translate visual input from cameras into steering decisions as seen in Fig.3 below.

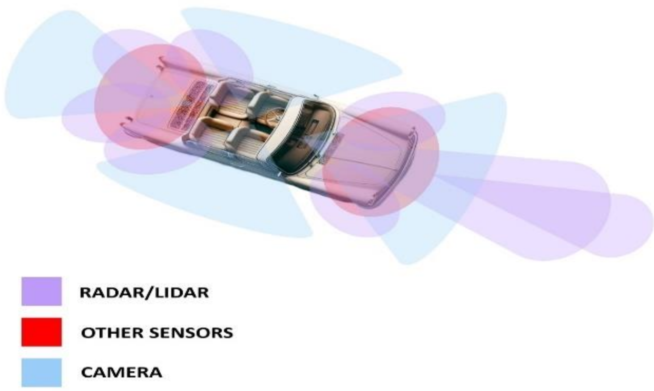


**Fig.3.** Component's placement

The collection of data is a critical component in developing models for autonomous driving. This data is gathered from both simulations and real-world driving conditions, with platforms like Udacity's offering a simulated environment for collecting data and training models. Preprocessing this data is a vital step to make the raw images suitable for use by the model, involving methods such as cropping, resizing, and converting colour spaces. Data augmentation techniques, which introduce variability in the data, are crucial for helping the model learn to navigate a range of driving conditions more effectively. Saxena et al. [26] developed a major challenge in the field is enhancing the models' ability to robustly generalize to the unpredictable nature of real-world driving. Research to date has largely been conducted in controlled environments or well-defined settings, whereas actual road conditions can vary widely due to different weather, traffic patterns, and unforeseen obstacles. Achieving a level of safety and reliability in AVs that can navigate these complex and unstructured environments is an ongoing and significant challenge.

### 2.1 Objectives

- To summarize the existing work based on self-driving cars using artificial intelligence.

- Finding the research gap based on existing techniques.

**Table-1:** Summary of Feature Reduction and ANN Techniques

| S.N O. | Author Year | Technology | Accuracy | Limitation | Remark |
|---|---|---|---|---|---|
| 1. | Agnihotri et al. [1] | CNN | High | Highly dependent on training data and conditions. | CNNs have revolutionized image recognition and pattern recognition. |
| 2. | Kudaka et al. [2] | Stream-Oriented Accelerator Framework | Varies | Limited information on specific image recognition implementation. | The technology utilizes a stream-oriented acceleration framework for self-driving cars. |
| 3. | Alheeti et al. [3] | Fuzzy Petri Net Model | High | Dependent on features extracted from trace files. | The technology proposes an IDS system for self-driving and semi self-driving cars. |
| 4. | Kang et al. [4] | Social Generative Adversarial Network | High | Requires a large amount of training data. | The technology focuses on predicting vehicle trajectories in self-driving car applications using deep learning. |
| 5. | Soares et al. [5] | SVM, KNN, Adaboost, | High | Imbalanced dataset, Need for feature engineering. | High accuracy, interpretable models, transparent linguistic fuzzy rules. |
| 6. | Mihalea et al. [6] | CNN, ResNet backbone model | Varies | Difficulty in adapting to local behavior. | Higher autonomy with augmentation.<br>Effective with augmentation. |
| 7. | Gandhi et al. [7] | Blockchain Technology, Artificial Intelligence | High | Scalability challenges, energy consumption. | Efficient information sharing and decentralized ledger. |
| 8. | Rassõlkin et al. [8] | Traction Effort Calculation. | High | Assumes constant parameters for simplicity. | Useful for assessing traction effort in different driving conditions. |
| 9. | Novickis et al. [9] | DNNs, Sensing Hardware | Varies | Limited to line-of-sight, reduced performance in adverse weather. | Combines multiple sensor modalities for robust perception. |
| 10. | Dong et al. [10] | Vision-Based Self-Driving System. | Varies | Limited to specific road conditions and lighting conditions. | Utilizes computer vision and deep learning for perception and decision-making. |
| 11. | Korkmaz et al. [11] | Fuzzy Logic, Computer Vision, Control Theory | Varies | Vision-based lane detection may have difficulties in certain conditions, such as abrupt lane changes or adverse weather. | The research presents a fuzzy logic-based self-driving car control system in a game environment with vision-based lane detection and fuzzy logic-based controls. |
| 12. | Byeloborodov et al. [12] | Computer Vision, Machine | Varies | Data availability, the need for algorithm refinement, and unspecified algorithm | Importance of continued research in the field of autonomous vehicles to improve safety |

| | | | | | |
|---|---|---|---|---|---|
| | | learning, Neural Networks | | accuracy. | |
| 13. | Li et al. [13] | Model-based path planning algorithm for self-driving cars in dynamic environments | High | Assumptions about constant obstacle velocities may not always hold in real-world scenarios, and the algorithm's performance in complex traffic situations is not extensively validated. | Algorithm offers promise for enhancing self-driving car navigation and safety but requires further validation and refinement for real-world applications. |
| 14. | Chernikova et al. [14] | Deep Neural Networks (DNNs) | High | Vulnerable to adversarial attacks | Evasion attacks demonstrated for steering angle prediction in self-driving cars. Shows vulnerability in both classification and regression settings. Security implications for autonomous vehicles. |
| 15. | Farag et al. [15] | Computer Vision, Lane Detection | Fairly accurate | Shadows affect precision in some scenarios | LaneBD is suitable for ADAS or self-driving cars. |
| 16. | Huynh et al. [16] | AC3R (Automatic Crash Constructor from Crash Report) | Accurate simulations | Limited to information available in police reports | Proposed approach for generating crash simulations from police reports for testing self-driving cars. |
| 17. | Jain et al. [17] | CNN, Raspberry Pi, Arduino | Varies | Minor issues with car staying on track during operation | Proposed some of the working model of self-driving car using image processing as well as machine learning. |
| 18. | Manchekar et al. [18] | Deep Learning, CNN, LSTM | Varies | Lack of real-world data for robustness testing. Focused on lane-following. | Successfully trained a CNN for autonomous driving using a Unity-based simulator. |
| 19. | Thadeshwar et al. [19] | ANN, Softmax-based neural network, CNN | High | Limited to lane detection and turns.<br>Costly Lidar sensor, large-scale cars | Uses grayscale images and is limited in functionality. |
| 20. | Nugraha et al. [20] | YOLO, Road Lane Detector, Convolutional Neural Network (CNN) | High | Over-lighting can affect detection - Limitations in sharp-turned roads - Limited applicability in urban roads | Proposed system integrates YOLO, lane detection, and a controller - Suitable for highway conditions |

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Volume: 11 Issue: 04 | Apr 2024 www.irjet.net p-ISSN: 2395-0072

## 3.RESEARCH GAP FINDINGS

**3.1 Limited Real-world Testing**: Gupta et al. [27] proposed a lot of progress in replicating real-world situations for self-driving cars, thorough real-world testing is still lacking, especially in demanding environments like extreme weather, intricate metropolitan landscapes, and unpredictable traffic scenarios. To guarantee the security and dependability of self-driving automobiles, further research is required to close the performance gap between virtual environments and the real world.

**3.2 Ethical and Legal Implications**: Pahadiya et al. [28] delivered autonomous vehicles have the potential to lower traffic fatalities and accidents, there are still unanswered moral and legal questions. Pahadiya et al. [29] developed more research to address concerns about decision-making algorithms in emergency scenarios, responsibility, and accountability. Widespread deployment of autonomous vehicle technology depends on research into creating moral frameworks and legislative guidelines to regulate it.

**3.3 Human-AI Interaction**: Rassolkin et al. [30] introduced gaining acceptance and trust from users of self-driving automobiles requires an understanding of how people engage with these vehicles as seen in Fig.4 below.

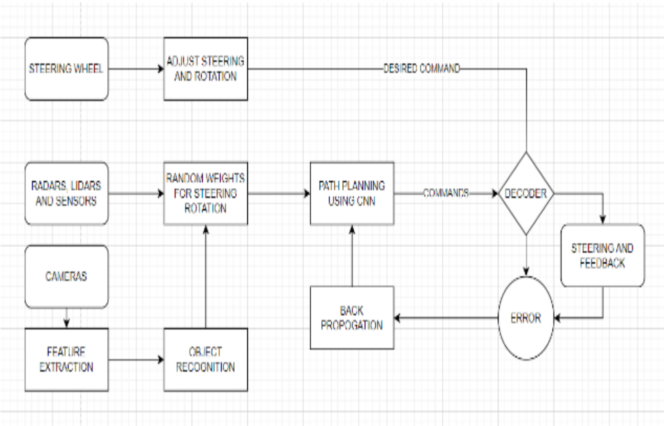


**Fig.4.** Flowchart and working of AI Car

Gambi et al. [32] introduced a study in this field might examine what motivates people to behave, perceive, and have faith in autonomous vehicles. Sharma et al. [33] developed smooth integration into current transportation systems, it is also crucial to look into ways to enhance communication between self-driving cars and other road users, like pedestrians and human-driven vehicles.

## 4. CONCLUSIONS

The Integration of Python, PyTorch, TensorFlow, and Unity's ML-Agents marks a significant advancement in the field of autonomous vehicle technology. Holstein et al. [34] presented this combination provides a powerful framework for developing intelligent agents that can navigate in the real world with unprecedented levels of autonomy and safety. Utilizing Unity's sophisticated 3D simulation capabilities, developers can rigorously test and enhance autonomous driving systems. Python serves as the critical intermediary, connecting Unity's simulations with the advanced machine learning capabilities of PyTorch and TensorFlow. Ruixin et al. [35] proposed this integration facilitates a comprehensive approach to autonomous system development, encompassing sensor simulation, deep learning for environmental perception, reinforcement learning for strategic decision-making, and extensive testing and evaluation using Python scripts. This architecture is instrumental in fostering the evolution of autonomous vehicles, paving the way for the widespread adoption of self-driving cars as a reliable form of transportation in the near future.

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