International Journal of Trend in Scientific Research and Development (IJTSRD)
Volume 9 Issue 6, Nov-Dec 2025 Available Online: www.ijtsrd.com e-ISSN: 2456 – 6470

Machine Learning in Autonomous Vehicles

Matthew N. O. Sadiku[1], Matthias Oteniya[2], Janet O. Sadiku[3]

[1,2]Roy G. Perry College of Engineering, Prairie View A&M University, Prairie View, TX, USA
[3]Juliana King University, Houston, TX, USA

ABSTRACT
An autonomous vehicle (or self-driving vehicle) is a vehicle that can sense its environment and drive itself without human assistance. Machine learning is already being applied to several aspects of driverless technology and it will also play an essential role in future developments. It can be used individually on the output of each sensor modality to better classify objects, determine distance and movement, and predict the actions of other traffic participants. It is also implemented for higher levels of driver assistance, such as perceiving and understanding the world around a car. Autonomous vehicles is a disruptive technology that has the potential to transform the current transportation system by reducing traffic accidents and enhancing driving safety. This paper studies how machine learning is used in autonomous vehicles.

KEYWORDS: *machine learning, artificial intelligence, deep learning, transportation, autonomous vehicles, self-driving cars.*

How to cite this paper: Matthew N. O. Sadiku | Matthias Oteniya | Janet O. Sadiku "Machine Learning in Autonomous Vehicles" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-9 | Issue-6, December 2025, pp.297-307, URL: www.ijtsrd.com/papers/ijtsrd99828.pdf

IJTSRD99828

INTRODUCTION
Autonomous vehicles are also known as self-driving cars as they are fitted with systems that make it possible for these cars to drive without a human being on the wheel. They are designed to navigate and operate without human intervention. One of the most critical aspects of self-driving cars is their ability to "see" the world around them. To achieve this, they rely on a combination of hardware and software systems, and at the heart of these systems is machine learning.

An autonomous vehicles use the Internet to access software apps, packages, or plugins to enhance the driving experience and increase the safety and security of all traffic participants. They use various sensors like cameras, LiDAR (Light Detection and Ranging), and radar to perceive their environment. Determining how to deliver safe, economical, and practical driverless cars is one of our era's most immense technical challenges. Machine learning helps automotive companies meet this challenge. Autonomous vehicle systems can improve perception and identify objects with greater accuracy with improved and more generalized training of machine learning models. ML can be applied to data acquired by onboard devices. Variables such as engine temperature, battery charge, oil pressure, and coolant level are fed into the system [1].

WHAT IS MACHINE LEARNING?
Machine learning is a subfield of artificial intelligence that uses algorithms trained on data sets to create models capable of performing tasks that would otherwise only be possible for humans, such as categorizing images, analyzing data, or predicting price fluctuations. It uses algorithms (essentially lists of rules) trained on data sets to create self-learning models capable of predicting outcomes and classifying information without human intervention. It focuses on algorithms that can "learn" the patterns of training data and, subsequently, make accurate inferences about new data. This pattern recognition ability enables machine learning models to make decisions or predictions without explicit, hard-coded instructions. To ensure such algorithms work effectively, however, they must typically be refined many times until they accumulate a comprehensive list of instructions that allow them to function

correctly [2]. A symbol of machine learning is shown in Figure 1 [3].

Generally speaking, a learning problem considers a set of samples of data and then tries to predict properties of unknown data. ML builds heavily on statistics because when we train a machine to learn, we have to give it a statistically significant random sample as training data. Intelligent machines are increasing doing incredible things: Facebook recognizes faces in photos, Siri understands voices, and Google translates websites [4].

Machine learning techniques are transforming many fields including computer science, engineering, mathematics, physics, neuroscience, and cognitive science. We are surrounded by ML-based technologies: search engines learn how to bring us the best results, digital cameras learn to detect faces, credit card transactions are secured by a software that detects frauds, and cars are equipped with accident prevention systems that are built using ML algorithms [5]. In ML, data plays an indispensable role, and the learning algorithm is used to learn from the data. ML algorithms are now easy to use. One can download packages in Python. Programming languages used in ML include C++, Java, Python.

As its name indicates, machine learning works by creating computer-based statistical models that are refined for a given purpose by evaluating training data, rather than by the classical approach where programmers develop a static algorithm that attempts to solve a problem. Because the algorithm adjusts as it evaluates training data, the process of exposure and calculation around new data trains the algorithm to become better at what it does. Algorithms are the computational part of a machine learning project. Once trained, algorithms produce models with a statistical probability of answering a question or achieving a goal. Unlike in expert systems, the logic by which a machine learning model operates is not explicitly programmed; it is learned through experience. Machine learning has come to dominate the field of AI: it provides the backbone of most modern AI systems, from forecasting models to autonomous vehicles to large language models (LLMs) and other generative AI tools. Machine learning has become a household term in recent years as the concept moved from science fiction to a key driver of how businesses and organizations process information [6].

As shown in Figure 2 [7], there are different types of machine learning. The four major types of machine learning are supervised learning, unsupervised learning, semi-supervised learning, and reinforcement learning, each suited to different kinds of data and outcomes. Different types of machine learning include the following [8]:

- *Supervised Learning*: The program is "trained" on a pre-defined set of "training examples" from a "teacher," which then facilitate its ability to reach an accurate conclusion when given new data. In this case, the data comes with additional attributes that we want to predict. A common case of supervised learning is to use historical data to predict statistically likely future events. Under supervised ML, we have regression ML and classification ML.
- *Unsupervised Learning:* As their name suggests, unsupervised learning algorithms can be broadly understood as somewhat "optimizing themselves." Unsupervised algorithms do not need to be trained with desired outcome data. The program is given a bunch of data and must find patterns and relationships therein. A typical goal of unsupervised learning may be as straightforward as discovering hidden patterns within a dataset. Without being told a "correct" answer, unsupervised learning methods can look at complex data and organize it in potentially meaningful ways.
- *Reinforcement Learning:* Reinforcement learning models are trained holistically through trial and error. Reinforcement learning is a method with reward values attached to the different steps that the algorithm must go through. So, the model's goal is to accumulate as many reward points as possible and eventually reach an end goal. Reinforcement learning is an area of machine learning concerned with how software agents ought to take actions in an environment so as to maximize some notion of cumulative reward.
- *Deep Learning:* Deep learning (DL) is a specialized form of machine learning that uses artificial neural networks to mimic the human brain. It is a type of machine learning technique that is modeled on the human brain. It is an advanced technique for handling complex tasks like image and speech recognition. The way in which neural networks are trained can be described as deep learning. It is called deep because the network of neurons is arranged in several hierarchical levels. Deep learning laid the foundation for advances in generative artificial intelligence.

MACHINE LEARNING IN AUTONOMOUS VEHICLES

Vehicles can be classified into different levels of autonomy which range from Level 0 to Level 5. The levels of automation are shown in Figure 3 [9] and briefly explained as follows [10]:

- Level 0 consists of complete control by a human driver or no automation at all.
- In level 1, there are some features to assist the driver.
- Level 2 has some automation where the vehicle can steer or accelerate, but the driver should always pay attention.
- In level 3, under most conditions and performance of most tasks by the vehicle, a driver will have to carry out intervention in complicated cases only.
- In level 4, you have highly autonomous vehicles, which require very few interactions with humans but only within certain geographic limits.
- Level 5 means the vehicle is able to drive himself without any conditions to the driver

Figure 4 shows autonomous driving tasks [9].

Machine learning is the driving force behind self-driving cars. It enables autonomous vehicles to perform three key tasks: perception, decision-making, and control. Perception for an autonomous vehicle is defined as the ability of a vehicle collecting information and extracting relevant knowledge from sensor data to develop a contextual understanding of the environment. The perception system of self-driving vehicles is developed using various computer vision techniques including modern ML/DL-based methods for identifying objects, e.g., pedestrians, traffics signs, symbols, etc. The perception system of self-driving vehicle is highly vulnerable to the physical world and adversarial attacks. Decision-making is vital in self-driving cars. They need a system that is dynamic and precise in an uncertain environment. Decision matrix algorithms are mainly used for decision making. These algorithms are models composed of multiple decision models independently trained and whose predictions are combined in some way to make the overall prediction while reducing the possibility of errors in decision making. Path tracking control algorithm can be developed by uniting the algorithm with adaptive model predictive control intended for lateral pathway pursuing control. As a part of motion control, vehicle lane changing is an important aspect of autonomous driving. Together with localization and mapping, path planning, decision making, and vehicle control modules, an autonomous vehicle is able to successfully navigate itself on roads [11].

Machine learning allows autonomous vehicles (AVs) to interpret their surroundings, make critical decisions, and ensure the safety of all road users. It allows the autonomous vehicle to "see" its surroundings by identifying objects like pedestrians and other cars, decide on actions like braking or accelerating based on those perceptions, and control the vehicle's speed, steering, and other functions to execute those decisions. Machine learning helps the vehicle interpret the complex visual environment, understanding lane markings, road boundaries, and other crucial information to create a comprehensive picture of its surroundings. Due to machine learning, autonomous vehicles will increase accessibility for people with disabilities, ensure faster and more economical delivery to remote and outback areas, and, will help improve road safety, reduce accidents and deaths.

Figure 5 shows the components of an autonomous car [12]. The three major sensors used by self-driving cars work together as the human eyes and brain. These sensors are cameras, RADAR, and LiDAR. Cameras capture 2-D and 3-D images and video and provide vision to the car; RADAR (Radio detection and ranging) uses long-wavelength radio waves to detect objects; LiDAR (Light Detection and Ranging) maps surroundings with precision. Together, they give the car a clear view of its environment. They help the car to identify the location**,** speed, and 3D shapes of objects that are close to it. Figure 6 shows a typical autonomous car [1], while Figure 7 shows a lot of in traffic [13].

Autonomous cars are very closely associated with industrial Internet of things (IoT). IoT combined with other technologies such as machine learning, artificial intelligence, local computing etc. are providing the essential technologies for autonomous cars. Machine learning is essential in self-driving cars because it continuously renders the surrounding environment and makes predictions of possible changes to those surroundings. The type of machine learning commonly used to train autonomous cars to drive is deep learning and there is a concrete reason for this. AVs function on end-to-end learning and everything takes place in real-time, hence the data processing must be at lightning fast speed. The deep learning is performed by the massive technology structure that enables the vehicle to perceive, plan, coordinate, and control. Deep learning allows autonomous cars to develop complex representations and models of the driving environment, enabling them to navigate and respond to various real-world situations [14]. Figure 8 shows a representation of deep learning [15]. Edge computing will offer service off-loading and data provision for automated vehicles.

FEATURES OF MACHINE LEARNING IN AUTONOMOUS VEHICLES

The development of self-driving cars is one of the most trendy and popular directions in the world of AI and machine learning. Common features of these vehicles are presented as follows [16,17]:

- *Autonomous Driving:* Autonomous driving (AD) system research is gaining importance in recent decades, disrupting the automotive industry in a big way. In crowded countries like India, traffic problems are a big issue because of the large population. So, autonomous driving is becoming increasingly common and has the potential to disrupt our transportation system. Self-driving cars are on their way to becoming legal, but they are still not safe enough to be used in the real world due to a lack of trust. To ensure autonomous vehicles' safety, nations still need to develop adequate infrastructures, make laws, and establish new standards to regulate the industry.
- *Prediction:* Algorithms predict the future movements of other vehicles and pedestrians to anticipate potential conflicts and make proactive decisions. Conventional prediction techniques are only effective in basic prediction scenarios and short-term prediction assignments. Deep learning-based trajectory prediction models have gained popularity due to their ability to consider various factors that contribute to accurate predictions. These models take into account physical factors, such as the position, velocity, acceleration, size, and shape of vehicles. Various standard datasets are used to test prediction algorithms, and appropriate metrics are used to assess their performance.
- *Motion Planning*: Once the behavior layer decides how to navigate through a certain route, the motion planning system orchestrates the motion of the car. The motion of the car must be feasible and comfortable for the passenger. Motion planning includes speed of the vehicle, lane-changing, and more, all of which should be relevant to the environment the car is in.
- *Training:* For self-driving cars to become more widely available, their AI systems must be trained using globalized data sets. These cars (agents) are trained for thousands of epochs with highly difficult simulations before they are deployed in the real world. During training, the agent (the car) learns by taking a certain action in a certain state. Based on this state-action pair, it receives a reward. This process happens over and over again. Each time the agent updates its memory of rewards. This is called the policy. The policy defines the behavior of the agent at a given time. So in order to avoid the negative rewards, the agent checks the quality of a certain action. This training approach is depicted in Figure 9 [16]. Training a self-driving vehicle is a process of continuous improvement.
- *Driving Analysis:* In order to track the operator and their behavior in self-driving cars, neural networks can identify trends. For instance, facial recognition technology can be used to identify a driver and determine whether they are permitted to operate the vehicle, helping to prevent theft and unauthorized use. According to the quantity and location of passengers, the air conditioner may automatically adjust. The assessment of an object's closeness as well as its speed and the direction of motion is done through visualization.

BENEFITS

Autonomous vehicles (AVs) present numerous safety and transportation efficiency benefits. They enable people with no driving experience or people with disabilities to travel with luxury and flexibility, allowing them to read, relax, or even work in the passenger seat, increasing efficiency. With ML, the car is not limited by boundary conditions set at the factory. ML allows boundary conditions to be adjusted as the vehicle system ages, the transmission changes, and the car gradually breaks in. Other benefits include [18]:

- *Cybersecurity:* The possibility of cyber-attacks in autonomous vehicles increases with the propagation of embedded technologies in connected vehicles and infrastructure. Developing systems that better support AV cybersecurity is vital. Adding computer systems and networking capabilities to vehicles increases focus on vehicle cybersecurity. And that is where machine learning takes center stage. In particular, it can be used to detect attacks and anomalies and then overcome them. ML models help detect attacks and anomalies in order to keep the vehicle, its passengers, and roads safe. Those who supply computer systems for autonomous vehicles must ensure that their systems are safe and uncompromising. Figure 10 gives an overview of cyber-attack types, modes, and attack surfaces [9].
- *Improved Safety:* The safety of self-driving cars' propulsion and their ability to avoid causing traffic accidents are without a doubt the most crucial factors to take into account with autonomous cars. For autonomous driving, safety is a critical aspect, and various acts done while driving depend on the results of the perception

algorithm. Safety is the crucial requirement of automated vehicles, and diagnosis of faults is an efficient method to augment vehicle security. Self-driving cars are equipped with advanced safety systems. They can detect dangerous situations more quickly than humans and react faster. This is crucial in preventing accidents and reducing the severity of collisions.

- *Enhanced Security:* Automotive cybersecurity is more clearly emphasized as more automobiles use computer systems as well as networking capabilities. However, ML can be applied here to improve security. A particular car is at risk from a hostile attacker accessing its system or using its data. In order to keep the car, its occupants, and the roadways safe, ML models must be able to recognize various types of threats and anomalies. The fundamental security goals include confidentiality, integrity, and availability.
- *Environmental Impact:* Self-driving cars have the potential to reduce traffic congestion and improve fuel efficiency, which could have a positive impact on the environment.

CHALLENGES

While autonomous vehicles hold great promise, there are challenges and concerns. One of the major challenges of using machine learning to detect and classify objects is that massive datasets are required. Machine learning is also limited when training the system to respond to what humans naturally have. Other challenges include [15,18]:

- *Technical Challenges:* AV technology is particularly challenging from the technical perspectives of sensor robustness and "edge cases" or idiot-proofing. A major challenge is how to guarantee that these amazing capabilities of AI systems—driverless cars and pilotless planes—are safe *before* deploying them in places where human lives are at stake.
- *Ethical Concerns:* Safety and ethical concerns are of utmost importance in the development and use of self-driving cars, especially as they interact with human-driven vehicles on the road. The combination of advanced technology and ethical responsibility is essential.
- *Privacy Concerns:* Preventing hacking of the connected networks on which cars operate is of paramount importance. In the worst case, an attack can lead to serious collisions, injury, and death. Data privacy concerns are also a high-profile facet of the AV debate, as the more connected nature of AVs can make them susceptible to hacking or data breaches, and pose risks for passengers and infrastructure.
- *Bias:* It takes time and enormous computational processing resources to get enough training to avoid such bias in the data. It takes time and enormous computational processing resources to get enough training to avoid such bias in the data.
- *Collaboration:* Collaboration around automotive innovation is key. It will go a long way in helping the industry to provide standardized vehicles with similar or identical specifications. Car manufacturers will need to establish technology partnerships with AI-specialized custom software developers to validate and future-proof innovative ideas and turn them into full-fledged next-gen connected car solutions.
- *Human-Machine Interface:* This is where we, as humans, interacting with machines, have to hope that the machines have made the right choice. And if they have not, we have to hope even more keenly that their incorrect decision does not dovetail with our incorrect decision and lead to a chaotic situation.
- *Human Error:* Annually, approximately 1.35 million deaths occur due to road crashes. Human error is consistently identified as a major factor in road crashes, emphasizing the need to address this preventable distress. The main advantage of autonomous driving systems is the disassociation of the driver from the vehicle reducing the human intervention. One major concern is how intelligent, autonomous vehicles that drive "perfectly" in terms of their speed and road positioning will cope with cars driven by people that are easily distracted and prone to making wrong judgements. Understanding human error and learning how, when and why they occur will, ultimately, make the task of driving inherently safer. The significant contribution of human errors to road crashes leading to casualties, vehicle damages, and safety concerns necessitates the exploration of alternative approaches. ML and AI are teaching autonomous vehicles to expect mistakes that are caused by the human beings at the wheel of other cars that are sharing the road space.
- *Complexity:* Autonomous vehicles are an important component of future vehicular networks that are equipped with complex sensory equipment. The systems themselves are extremely complex, but the environments we are asking them to operate in are incredibly complex. The amount of data needed to maintain an

autonomous vehicle (AV) is staggering. Current estimates suggest a level-five autonomous automobile in production generates between one and 20 terabytes per hour. In light of these complexities, designers of autonomous vehicles have come to rely on simulations to test autonomous vehicles' ability to steer clear of danger.

FUTURE OF MACHINE LEARNING IN AUTONOMOUS VEHICLES

Major tech companies and major car manufacturers are competing to develop proposals for autonomous vehicles. Each of them wants to be the first to enter the market in order to dominate this area. Car manufacturers will have to do their part to ensure these vehicles' safety, reliability, and vitality. They will need to prove the safety of self-driving vehicles before consumers readily accept them. Governments also have a role to play. They will need to pass laws on vehicle autonomy and driver lessness. They can also help promote and encourage the use of autonomous vehicles.

Here are some trends that we expect to continue shaping the future of autonomous vehicle technology. Vehicles will be able to process many of their decisions on the fly and respond in real time, ideal for the multimodal, complex environment they travel in. With self-driving capability growing in popularity and machine learning promising revolutionary advancements for our transportation systems, the future of transport is incredibly wide open. Autonomous vehicles are expected to play a significant role in reducing crashes and enhancing road safety in the foreseeable future. More is expected in the AV domain in the coming years, something to wait and watch out for.

CONCLUSION

Self-driving cars are autonomous decision-making systems. Humanity has been waiting for self-driving cars for several decades. This idea recently went from "possible" to "commercially available in a Tesla." With today's high-performance graphics cards, processors, and huge amounts of data, self-driving is more powerful than ever. Automotive AI is rapidly displacing human drivers by enabling self-driving cars that use sensors to gather data about their surroundings.

Autonomous driving system research is gaining importance in recent decades, disrupting the automotive industry in a big way. Self-driving cars and trucks are definitely around the corner. In recent years, autonomous driving (AD) has become increasingly popular in the automotive industry. Prominent automobile manufacturers, including Tesla, General Motors, and BMW, have been the front runners in introducing autonomous transportation to ease the pressure off. They have made significant investments on the development of AD technology. More information on the use of machine learning in autonomous vehicles is available in the books in [5,19-28] and the following related journals:

- Vehicular Communications
- Journal of Advanced Transportation
- Machine Learning with Applications
- Journal of Artificial Intelligence Research

REFERENCES

[1] R. Ashtagi, S. Katale, and S. Sabnis, "Machine learning in self-driving cars," October 2023, https://medium.com/@katalesanket90/machine-learning-in-self-driving-cars-8b5d1c685d3b

[2] "What is machine learning? Definition, types, and examples," August 2025, https://www.coursera.org/articles/what-is-machine-learning

[3] "Army hosts global AI, machine learning event," May 2021, https://www.army.mil/article/246398/army_hosts_global_ai_machine_learning_event

[4] "Machine learning" *Wikipedia*, the free encyclopedia https://en.wikipedia.org/wiki/Machine_learning

[5] S. Shalev-Shwartz and S. Ben-David, *Understanding Machine Learning: From Theory to Algorithms*. New York, NY: Cambridge University Press, 2014.

[6] M. N. O. Sadiku, S. M. Musa, and O. S. Musa, "Machine learning, " *International Research Journal of Advanced Engineering and Science*, vol. 2, no. 4, 2017, pp. 79-81.

[7] "Machine learning: Application in gaming and various industries," October 2020, https://www.linkedin.com/pulse/machine-learning-application-gaming-various-industries-radha--1f

[8] T. Wuest et al., "Machine learning in manufacturing: Advantages, challenges, and applications," *Production & Manufacturing Research*, vol. 4, no. 1, 2016, pp. 23-45.

[9] M. R. Bachute and J. M. Subhedar, "Autonomous driving architectures: Insights of machine learning and deep learning algorithms," *Machine Learning with Applications,* vol. 6, December 2021.

[10] "The future of transportation: Autonomous vehicles and machine learning," October 2024, https://www.automate.org/robotics/news/the-future-of-transportation-autonomous-vehicles-and-machine-learning

[11] Q. Yang et al., "Machine-learning-enabled cooperative perception for connected autonomous vehicles: Challenges and opportunities," https://par.nsf.gov/servlets/purl/10281452

[12] P. Christianson, "Autonomous car machine learning and data collection," September 2020, https://www.cloudfactory.com/blog/autonomous-vehicle-training-conundrum

[13] "Self-taught, self-driving cars? Like babies learning to walk, autonomous vehicles learn to drive by mimicking others," https://www.bu.edu/articles/2021/self-taught-self-driving-cars/

[14] "Machine learning algorithms in autonomous driving," https://www.iiot-world.com/artificial-intelligence-ml/machine-learning/machine-learning-algorithms-in-autonomous-driving/

[15] L. Eckstein, "How machine learning is teaching autonomous vehicles to factor in driver error," February 2024, https://www.intertraffic.com/news/ccam/how-machine-learning-teaches-autonomous-vehicles-driver-error

[16] N. Barla, "Self-driving cars with convolutional neural networks (CNN)," April 2024, https://neptune.ai/blog/self-driving-cars-with-convolutional-neural-networks-cnn

[17] S. Singh, "How AI and machine learning is powering self-driving cars?" https://www.labellerr.com/blog/how-ai-and-machine-learning-is-powering-self-driving-cars/

[18] "How machine learning is used in autonomous vehicles," https://www.rinf.tech/how-machine-learning-is-used-in-autonomous-vehicles/

[19] S. Kuutti et al., *Algorithms, State-of-the-Art, and Future Prospects*. Morgan & Claypool Publishers, 2019.

[20] S. Ranjan and S. Senthamilarasu, *Applied Deep Learning and Computer Vision for Self-Driving Cars: Build Autonomous Vehicles Using Deep Neural Networks and Behavior-cloning Techniques.* Packt Publishing, 2020.

[21] S. Rajendran et al. (eds.), *Artificial Intelligence for Autonomous Vehicles: The Future of Driverless Technology (Advances in Data Engineering and Machine Learning).* Wiley-Scrivener, 2024.

[22] Orbit Consult Research Guide, *Autonomous Vehicles and Machine Learning: : Exploring the Use of Machine Learning Algorithms in the Development of Self-Driving Cars.* Kindle edition, 2025.

[23] L. B. Eliot, *Advances in AI and Autonomous Vehicles: Cybernetic Self-Driving Cars: Practical Advances in Artificial Intelligence (AI) and Machine Learning.* LBE Press Publishing, 2017.

[24] A. Alruwaili, S. M. N. Islam, and I. Gondal, *Cybersecurity in Robotic Autonomous Vehicles: Machine Learning Applications to Detect Cyber Attacks.* Boca Raton, FL: CRC Press, 2025.

[25] P. Rao, *AI Agents in Autonomous Vehicles: Unlocking the Potentials of AI Agents from Sensors to Steering.* Kindle edition, 2025.

[26] L. Eliot and M. Eliot, *Autonomous Vehicle Driverless Self-Driving Cars and Artificial Intelligence: Practical Advances in AI and Machine Learning*. LBE Press Publishing, 2017.

[27] I. Myles, *ML in Autonomous Systems Driving Intelligent Vehicles: Explore ML's Role In Self-Driving Cars and Navigation.* Independently Published, 2025.

[28] A. A. K. Soumya, *Python for Machine Learning and Natural Language Processing in Robotics and Autonomous Vehicles.* Budha Publication, 2024.

Figure 1 A symbol of machine learning [3].

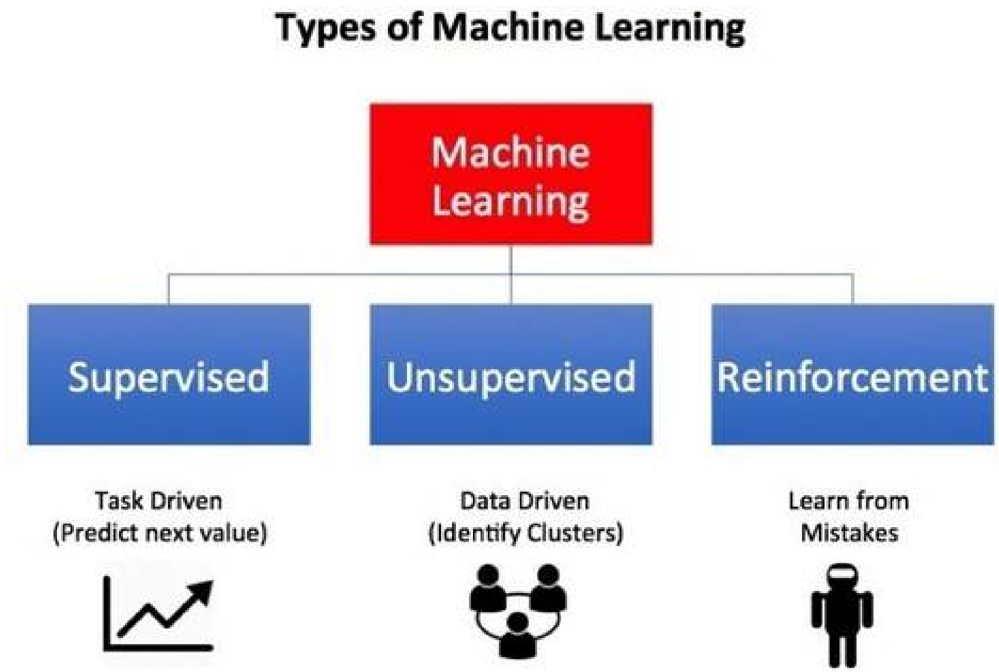

Figure 2 Different types of machine learning [7].

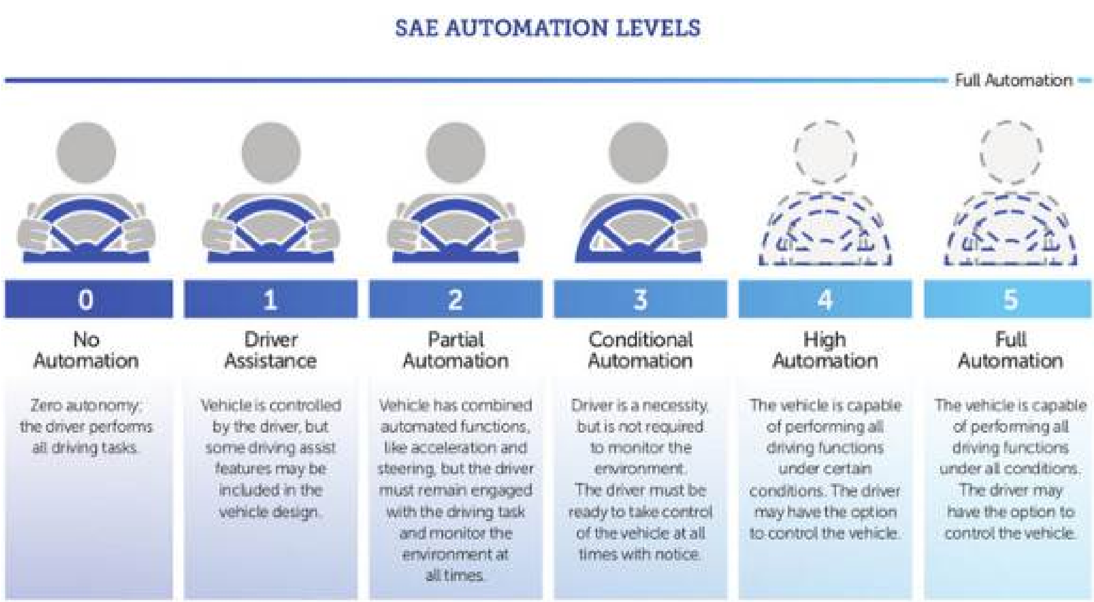

Figure 3 The levels of automation [9].

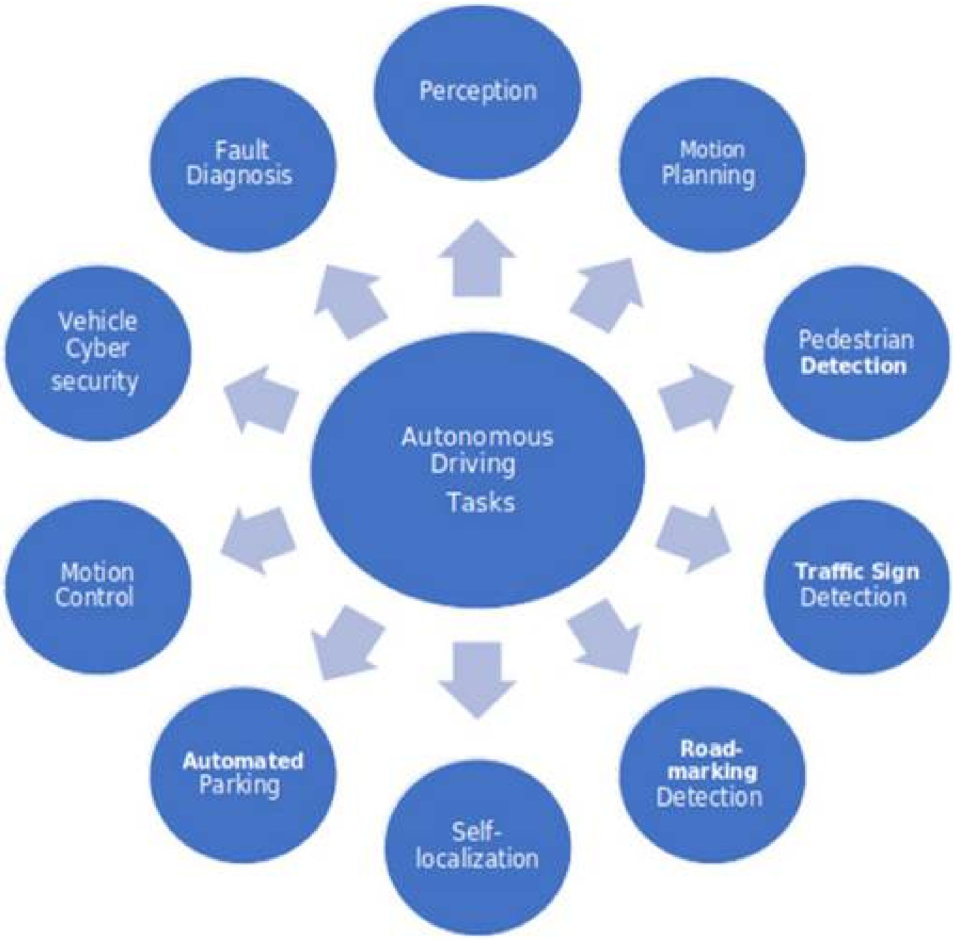

Figure 4 Autonomous driving tasks [9].

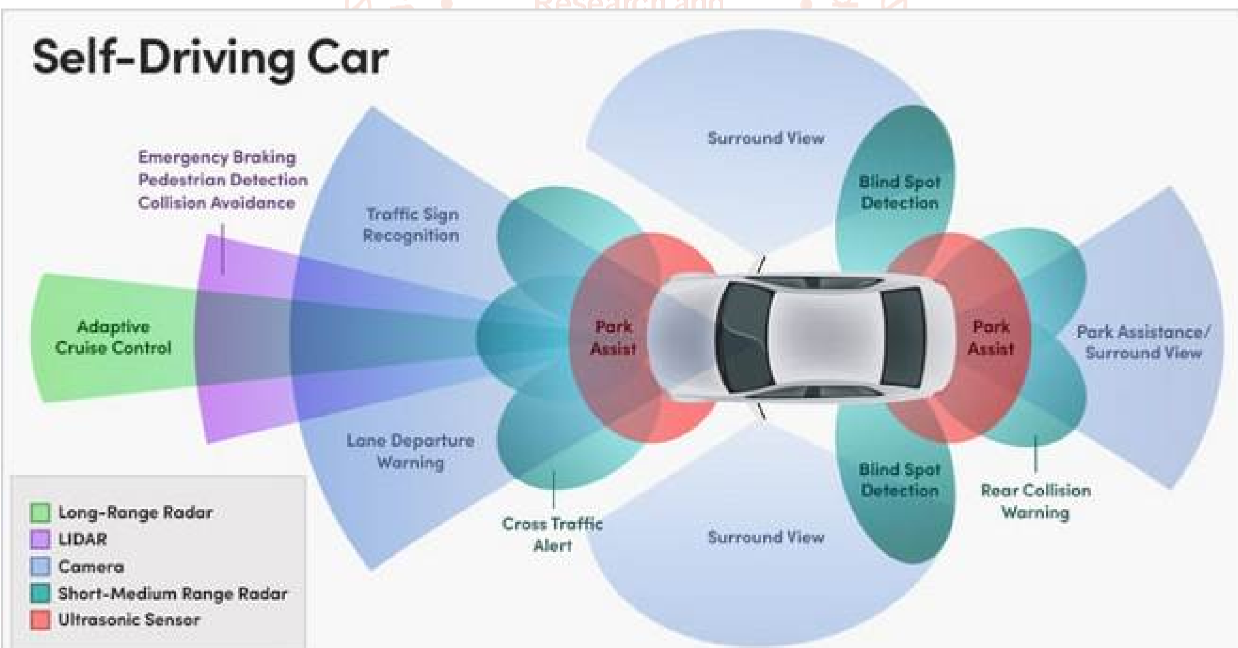

Figure 5 Components of an autonomous car [12].

Figure 6 A typical autonomous car [1].

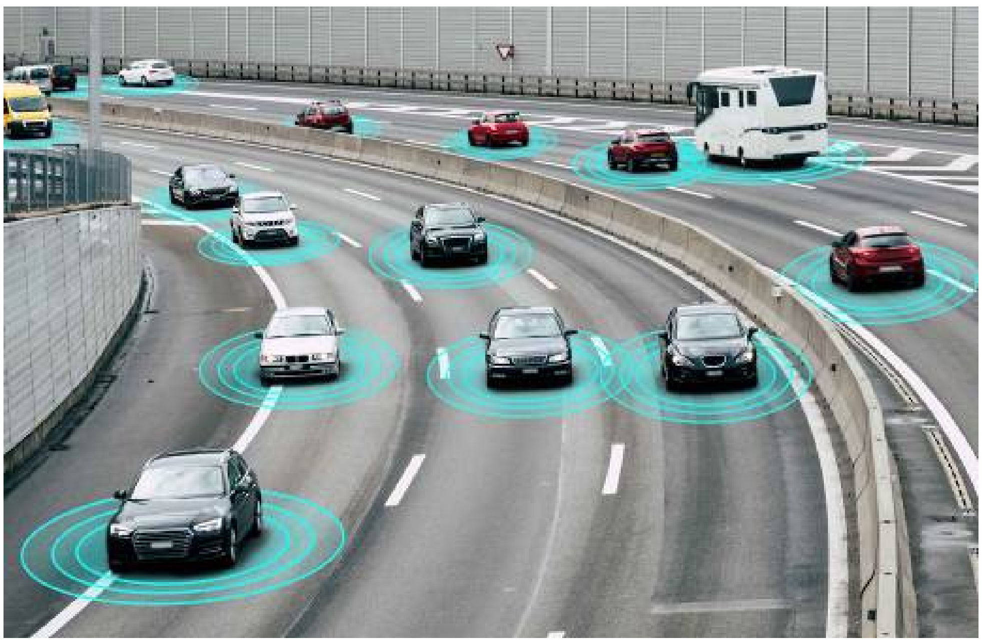

Figure 7 Autonomous vehicles in traffic [13].

Figure 8 A representation of deep learning [14].

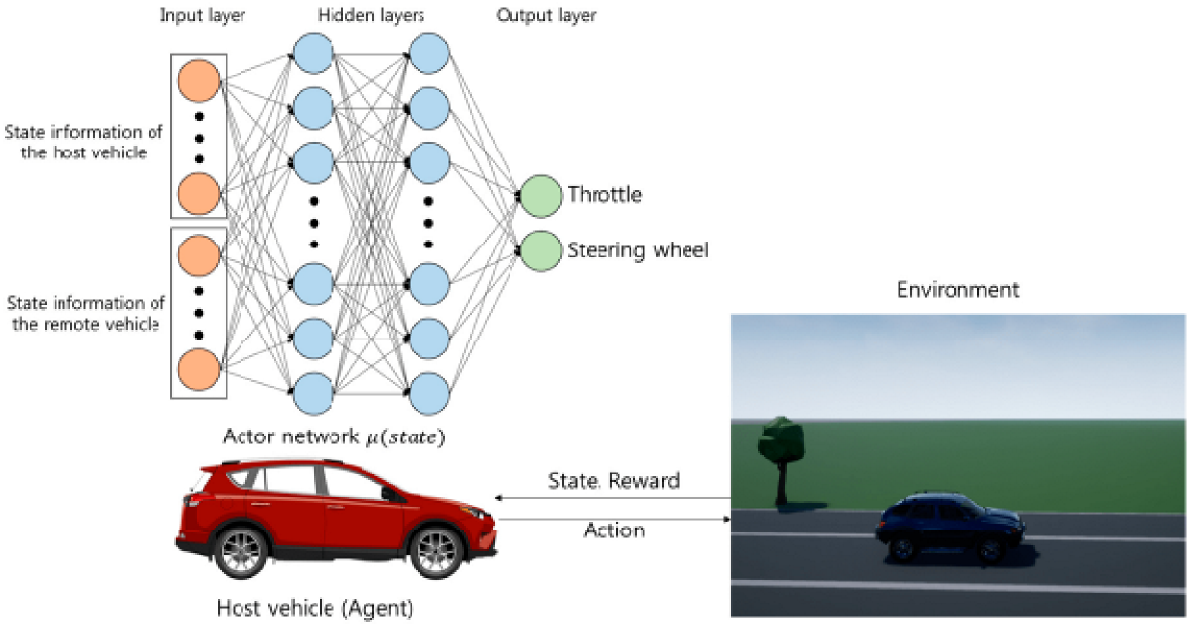

Figure 9 Training of an autonomous car [16].

Figure 10 An overview of cyber-attack types, modes, and attack surfaces [9].