AN EXPLORATION OF THE ADVANTAGES AND CHALLENGES OF ARTIFICIAL INTELLIGENCE (AI) AND ROBOTICS IN THE EVOLUTION OF AUTONOMOUS DRIVING

By

Dr. Mark P. Augustine
Department Of Mathematics and Computer Science
Freie Universität Berlin
Kaiserswerther Str. 16-18
14195 Berlin
Germany

And

AKPAN, E. Ebenezer, Ph.D., FCICN, AP, PPGDCA, PHDCDPM
Corporate institute of Research and Computer Science
140 Ikot Ekpene Road
Uyo, Akwa Ibom State

ABSTRACT

This study explored the advantages and challenges of artificial intelligence (AI) and robotics in the evolution of autonomous driving systems within modern transportation. 'Artificial intelligence' refers to the capability of machines and computer systems to perform tasks that normally require human intelligence, such as learning, reasoning, decision-making, and problem-solving, while 'robotics' involves the design, programming, and operation of automated machines capable of carrying out tasks with minimal human intervention. The integration of AI and robotics has contributed significantly to the development of autonomous vehicles that can sense their environment, analyse road conditions, and make driving decisions automatically through technologies such as sensors, machine learning, LiDAR, radar, cameras, GPS, and onboard computers. The study further examines the major advantages of autonomous driving, including improved road safety, efficient traffic management, reduced fuel consumption, environmental sustainability, and increased accessibility for elderly and disabled individuals. However, despite these benefits, the study also explores several challenges affecting the implementation of autonomous driving technologies, such as sensor failures during poor weather conditions; cyber security threats; ethical and legal concerns; high operational costs; inadequate infrastructure; and limitations in regulatory frameworks. The study concluded that artificial intelligence (AI) and robotics have significantly contributed to the evolution of autonomous driving by improving vehicle intelligence, road safety, traffic management, and transportation efficiency. The study recommended that governments and transportation authorities should develop comprehensive legal and regulatory frameworks to guide the safe implementation and operation of autonomous vehicles.

KEYWORDS: Artificial Intelligence, Robotics, Autonomous Driving

INTRODUCTION

Through the creation of autonomous driving systems, robotics and artificial intelligence (AI) have emerged as significant technologies that are revolutionising the transportation industry. The ability of robots and computer systems to carry out tasks like learning, reasoning, problem-solving, and decision-making that often require human intelligence is referred to as "artificial intelligence." AI makes it possible for robots and digital systems to do intelligent tasks with little assistance from humans. The design, construction, programming, and operation of devices that can carry out automatic or semi-automated operations are all included in robotics. Perception, decision-making, and control procedures are how autonomous driving systems work. Before robotic systems perform actions like steering, braking, and accelerating, AI algorithms evaluate environmental data gathered by sensors. Thus, modern technological growth in industries like healthcare, manufacturing, agriculture, and transportation has been tremendously aided by the merging of AI and robotics.

One of the main uses of robotics and artificial intelligence in contemporary transportation systems is the development of autonomous driving. The term "autonomous driving" describes the application of robotic systems, artificial intelligence (AI), sensors, cameras, and machine learning to enable cars to function with little or no human supervision. According to Grigorescu, Trasnea, Cocias & Macesanu (2020), autonomous vehicles are designed to detect their environment, analyse road conditions, and make driving decisions automatically in real time. To enhance navigation and road safety, these systems make use of technology including LiDAR, radar, GPS, and onboard computers. Numerous benefits have resulted from the development of autonomous driving, including as fewer traffic accidents, better traffic control, fuel efficiency, and more accessibility for people with disabilities and the elderly. Kuutti, Fallah, Katsaros, Dianati, McCullough & Mouzakitis (2021) further noted that intelligent transportation systems improve vehicle coordination and reduce traffic congestion through advanced communication technologies.

Even while AI and robotics have many benefits for autonomous driving, their successful use is currently hampered by a number of issues. One significant issue is sensor dependability in inclement weather, such as rain, fog, and snow, which can lower autonomous systems' accuracy. How autonomous cars should make decisions during inevitable collisions also raises ethical and legal questions. Furthermore, insufficient infrastructure, high operating expenses, and cybersecurity risks continue to impede the broad use of autonomous vehicles. According to Mahmoud, Hussein & Al-Khateeb (2022), securing autonomous systems against cyber-attacks is necessary to ensure public safety and trust. Therefore, although artificial intelligence and robotics have greatly improved autonomous driving technology, addressing these challenges remains essential for the successful future development of autonomous transportation systems.

CONCEPT OF ARTIFICIAL INTELLIGENCE (AI)

Artificial intelligence (AI) refers to the branch of computer science concerned with designing systems capable of performing tasks that normally require human intelligence, such as learning, reasoning, problem-solving, and decision-making. as noted by Akpan & Henry (2025) Artificial intelligence (AI) is the ability of a digital computer or computer-controlled robot to perform tasks commonly associated with intelligent beings. Artificial intelligence is the study of how the human brain makes decisions, learns new things, and thinks through difficulties. A lot of

companies in a lot of different areas are migrating to AI-based solutions to make things simpler and more precise (Adesemowo & Hameed, 2025), such as in sectors like healthcare, finance, and manufacturing, where AI can enhance efficiency and accuracy in operations.

Additionally, AI can be seen as a revolutionary technological advancement that combines algorithms and massive datasets to increase productivity and accuracy in a variety of fields, including industry, healthcare, and education. AI improves logistics planning, inventory control, and forecasting accuracy in supply chain management (Umofia & Uwana, 2026).Furthermore, artificial intelligence (AI) focuses on learning from experience and adapting to new inputs by simulating human intelligence processes through technology, particularly computer systems. As noted by Ghosh and Singh (2020), AI includes the use of bio-inspired algorithms and machine learning models that enable systems to perform complex tasks such as prediction, classification, and automation across multiple sectors.

Moreover, the concept of AI also incorporates ethical, social, and philosophical considerations, particularly regarding trust, autonomy, and decision-making.AI-powered systems now perform complex tasks such as medical diagnoses, financial predictions, and even creative writing, reducing human effort and enhancing productivity (Kingsley & James2025). As highlighted by Amuzat (2025), the strategic application of artificial intelligence across various organizational and public sectors plays a pivotal role in driving competitive innovation and operational automation.

CONCEPT OF ROBOTS

Robotics is a branch of science and engineering that focuses on the design, construction, programming, and operation of robots. It combines disciplines such as mechanical engineering, electrical engineering, computer science, and artificial intelligence (AI) to create machines capable of performing tasks automatically or semi-automatically. Robots are designed to carry out functions that may be dangerous, repetitive, complex, or difficult for humans. The increasing development of robotics has transformed industries such as manufacturing, healthcare, agriculture, transportation, education, and defense.

Fig. 1: A Picture of Robots

Robots operate through the integration of sensors, actuators, control systems, and intelligent software. Sensors enable robots to perceive their environment by collecting information such as movement, temperature, sound, and object location. Modern robotics systems also incorporate AI and machine learning to improve decision-making, adaptability, and autonomous operation. As noted by Javaid. (2021), robotics has become an essential technological innovation that improves productivity, accuracy, and operational efficiency in industrial and service sectors. The authors emphasized that intelligent robotic systems can perform tasks with minimal human intervention while reducing operational risks. According to Akpan and Henry (2025), adopting AI models allows complex systems to analyze vast operational parameters, significantly streamlining decision-making processes across high-tech domains.

The advancement of robotics has led to the development of autonomous robots capable of learning from their environment and interacting intelligently with humans. According to Yang et al. (2020), robotics technology is increasingly integrated with AI, cloud computing, and the Internet of Things (IoT) to enhance automation and communication between machines. In healthcare, robotic systems are used for surgery, rehabilitation, and patient monitoring, while industrial robots are widely applied in manufacturing and assembly operations. Furthermore, Haddadin and Croft (2021) noted that collaborative robots, also known as cobots, are designed to work safely alongside humans, improving workplace flexibility and efficiency.

CONCEPT OF AUTONOMOUS DRIVING

Autonomous driving refers to the use of advanced robotic systems, artificial intelligence (AI), sensors, and machine learning technologies that enable vehicles to operate with little or no human intervention. Autonomous cars are made to sense their surroundings, make decisions while driving, and regulate their own motion. These systems combine technologies such as LiDAR, radar, cameras, GPS, and onboard computers to detect objects, interpret road conditions, and navigate safely in real time (Grigorescu, 2020).

In order to increase road safety, lessen traffic, and improve transportation efficiency, autonomous driving is based on the integration of robots and intelligent transportation systems. The three main processes that autonomous cars use to operate are perception, decision-making, and control. In the perception stage, sensors collect environmental data about roads, pedestrians, traffic signs, and nearby vehicles. The decision-making system then analyses this information using AI algorithms to determine the safest driving action, while the control system manages steering, braking, and acceleration automatically (Fayyad, 2020).

From Level 0 (completely manual driving) to Level 5 (totally autonomous driving without human input), autonomous driving systems are typically categorised into various automation levels. Modern autonomous vehicles also utilise vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication technologies to improve coordination and traffic management (Kuutti, 2021).

ADVANTAGES OF ARTIFICIAL INTELLIGENCE AND ROBOTICS IN THE EVOLUTION OF AUTONOMOUS DRIVING

By enhancing vehicle intelligence, safety, efficiency, and decision-making skills, robotics and artificial intelligence (AI) have revolutionised the development of autonomous driving. By combining robotic control systems, computer vision, machine learning, and sensors, these technologies allow cars to run with little assistance from humans. AI and robotics provide a number of important benefits to contemporary transportation systems as autonomous driving develops.

- **Improved road safety**

Increased road safety is one of the main benefits. A significant portion of traffic accidents brought on by sleepiness, distraction, speeding, or intoxicated driving are the result of human error. Autonomous vehicles with AI capabilities are able to recognise impediments, continuously monitor road conditions, and react more quickly than human drivers. According to Grigorescu

(2020), AI-based perception systems improve object detection, lane tracking, and traffic sign recognition, thereby reducing accident risks and enhancing driving accuracy.

- **Efficient traffic management and reduced congestion**

Effective traffic control and less congestion are two other significant benefits. AI algorithms and robotic systems are used by autonomous cars to interact in real time with other cars and traffic infrastructure. This reduces needless braking or delays, maintains safe spacing between cars, and enhances route optimisation. Li (2021) noted that AI-driven transportation systems can significantly reduce traffic congestion and fuel consumption through intelligent navigation and coordinated vehicle movement.

- **Greater accessibility and convenience**

Additionally, increased accessibility and convenience are facilitated by robotics and AI. People with impairments, the elderly, and those unable to drive themselves can all benefit from autonomous driving technologies. Vehicle robotic automation offers mobility solutions that enhance accessibility to transportation and social inclusion. Additionally, self-driving systems improve comfort and lessen the effort for drivers while travelling long distances.

- **Enhanced operational efficiency and cost reduction**

Improved operational efficiency and cost savings are further benefits. AI-powered autonomous cars maximise fuel efficiency, lower maintenance requirements via predictive diagnostics, and enhance logistics in sectors like delivery and transportation. Additionally, robotics allows for accurate vehicle control and effective synchronisation in challenging driving situations. According to Kuutti (2021), autonomous systems improve transportation productivity by combining real-time environmental perception with intelligent decision-making.

- **Environmental sustainability**

Additionally, by encouraging more effective energy use and smoother driving patterns, particularly in electric autonomous vehicles, AI and robotics contribute to environmental sustainability. Improved urban mobility systems and reduced carbon emissions are two benefits of reduced traffic congestion and optimised acceleration.

CHALLENGES OF ARTIFICIAL INTELLIGENCE AND ROBOTICS IN THE EVOLUTION OF AUTONOMOUS DRIVING

The development of autonomous driving systems has been greatly aided by robotics and artificial intelligence (AI), which allow cars to sense their surroundings, make judgments, and function with little assistance from humans. Despite these developments, a number of obstacles still prevent autonomous vehicles (AVs) from being widely used and safely deployed. These issues are of an ethical, legal, technological, and infrastructural character.

- **Environmental perception and sensor reliability**

Environmental perception and sensor dependability are a significant problem. To identify things and navigate highways, autonomous cars use sensors including LiDAR, radar, cameras, and ultrasonic devices. However, unfavorable weather—such as rain, fog, and snow—can lower sensor accuracy and have an impact on AI decision-making. According to Yurtsever (2020), autonomous systems still struggle with complex urban environments where unpredictable human behaviours and dynamic road conditions occur frequently.

- **Decision-making and ethical dilemmas**

Making decisions and resolving moral conundrums present another difficulty. During emergencies, AI algorithms must make quick decisions, often considering moral issues. For instance, it is still debatable how the car should respond in accident scenarios that cannot be avoided. Shariff (2021) noted that ethical programming in autonomous driving is difficult because societal values differ across cultures and legal systems.

- **Cyber security threats**

Because autonomous cars rely so heavily on software, cloud computing, and internet connectivity, they are susceptible to hacking and cyber-attacks, which could alter vehicle controls, steal confidential information, or interfere with transportation networks. Mahmoud (2022) emphasized that ensuring secure communication between AI systems and robotic components is essential for public trust and safety.

- **High computational requirements and data processing limitations**

High computational requirements and data processing limitations impact the efficiency of autonomous driving technologies. In order for AI models to function accurately, they need large datasets and real-time processing capabilities, which raise hardware costs and energy consumption. Moreover, training AI systems with biased or insufficient datasets can result in poor performance in unfamiliar environments.

- **Lack of legal and regulatory frameworks**

The absence of legal and regulatory frameworks is another crucial problem. Comprehensive legislation covering liability, insurance, and operating standards for autonomous vehicles is still lacking in many nations. Public acceptance and commercialization are slowed by this uncertainty. The integration of robotics and artificial intelligence (AI) into transportation systems is further complicated by infrastructure constraints, such as inadequate smart traffic systems, unreliable internet access, and poor road markings.

CONCLUSION

In conclusion, artificial intelligence (AI) and robotics have significantly contributed to the evolution of autonomous driving by improving vehicle intelligence, road safety, traffic management, and transportation efficiency. Through the integration of sensors, machine learning, robotic control systems, and intelligent communication technologies, autonomous vehicles are now capable of operating with minimal human intervention while enhancing convenience and

accessibility. Despite these advantages, challenges such as sensor limitations, cyber security threats, ethical concerns, high computational costs, and inadequate legal frameworks continue to affect the widespread adoption of autonomous driving systems.

RECOMMENDATION

- Governments and private organizations should invest in modern transportation infrastructure such as smart traffic systems, reliable internet connectivity, and properly marked roads to support the effective operation and communication of autonomous vehicles.
- Researchers, engineers, and technology companies should continue improving the accuracy and reliability of AI systems, sensors, and robotic technologies used in autonomous vehicles, especially in difficult weather conditions and complex urban environments.
- Governments and transportation authorities should develop comprehensive legal and regulatory frameworks to guide the safe implementation and operation of autonomous vehicles.

REFERENCES

Akpan E. E & Henry L.P (2025) Adoption of AI for Search of Entrepreneurial Business Opportunities. *Shared Seasoned International Journal of Topical Issue*s 12(2) 1-2

Akpan, E. E. & Henry, L. P. (2025). Adoption of AI for Search of Entrepreneurial Business Opportunities. *Shared Seasoned International Journal of Topical Issues,* 12(2): 1-11.

Amuzat, O. (2025). How AI Will Shape up Government of Alberta and the Benefits it can reap and Become More Competitive Globally by the Strategic Application of AI. *Shared Seasoned International Journal of Tropical Issues,* 12(1): 17-23.

Emmert-Streib, F., Yli-Harja, O., &Dehmer, M. (2020). Artificial Intelligence: A Clarification of Misconceptions, Myths and Desired Status. Frontiers in Artificial Intelligence, 3, 524339.https://doi.org/10.3389/frai.2020.524339

Fayyad, J., Jaradat, M. A., Gruyer, D., &Najjaran, H. (2020). Deep learning sensor fusion for autonomous vehicle perception and localization: A review. Sensors, 20(15), 4220.

Ghosh, S., & Singh, A. (2020). The scope of Artificial Intelligence in mankind: A detailed review. Journal of Physics: Conference Series, 1531, 012045. https://doi.org/10.1088/1742-6596/1531/1/012045

Grigorescu, S., Trasnea, B., Cocias, T., &Macesanu, G. (2020).A survey of deep learning techniques for autonomous driving. Journal of Field Robotics, 37(3), 362–386.

Haddadin, S., & Croft, E. (2021).Physical human–robot interaction.*Springer Handbook of Robotics,* 1(1), 1835–1874. DOI: 10.1007/978-3-319-32552-1_69.

Hameed H, Adesemowo A. O &Babatunde A. T (2025) The Application of Artificial Intelligence In Human Resource Management: Emerging Challenges And Strategic Pathways. *King-UK International Journal of Academic Anthology, United States.* 9(1)15-25

Javaid, M., Haleem, A., Singh, R. P., & Suman, R. (2021). Substantial capabilities of robotics in enhancing industry operations. *Cognitive Robotics,* 1, 58–75.

Javaid, M., Haleem, A., Singh, R. P., Suman, R., & Gonzalez, E. S. (2021).Understanding the adoption of robotics in manufacturing industries.*Journal of Industrial Integration and Management,* 6(2), 193–215. DOI: 10.1142/S2424862221500098.

Kingsley P. K & James C (2025) The Barriers To Effective Information Dissemination By Mass Media: Assessing The Mitigating Strategies Using Modern Technologies In The 21st Century. *GASPRO International Journal of Language and Linguistics* 5(1)53-56

Kuutti, S., Fallah, S., Katsaros, K., Dianati, M., Mccullough, F., &Mouzakitis, A. (2021).A survey of the state-of-the-art localization techniques and their potentials for autonomous vehicle applications. *IEEE Internet of Things Journal*, 8(13), 10422–10440.

Li, Y., Ma, D., & Wang, Y. (2021). Intelligent transportation systems and autonomous vehicles: A review of technologies and future perspectives. Sustainability, 13(20), 11100.

Mahmoud, M., Ahmad, I., & Kim, D. (2022). Cybersecurity challenges in autonomous vehicle systems. *Sensors*, 22(9), 3335.

Mahmoud, M., Hussein, T., & Al-Khateeb, H. (2022).Cybersecurity challenges in autonomous vehicles: A systematic review. IEEE Access, 10, 11234–11250.

Shariff, A., Bonnefon, J. F., &Rahwan, I. (2021).Psychological roadblocks to the adoption of self-driving vehicles. Nature Human Behaviour, 5(5), 546–554.

Umofia S. O &Uwana O. U (2025) Roles Of Artificial Intelligence In Library Automation In South-South Nigeria: Assessing Its Potency In Streamlining Operations And Enhancing User Services. *Universal Journal of Library and Information Science* 5(1) 44-46

Yang, G. Z., Bellingham, J., Dupont, P. E., Fischer, P., Floridi, L., Full, R., Jacobstein, N., Kumar, V., McNutt, M., Merrifield, R., Nelson, B. J., et al. (2020). The grand challenges of science robotics.*Science Robotics*, 3(14), 7650. DOI: 10.1126/scirobotics.aar7650.

Yurtsever, E., Lambert, J., Carballo, A., & Takeda, K. (2020). A survey of autonomous driving: Common practices and emerging technologies. IEEE Access, 8, 58443–58469.