Ethical and Legal Governance in Artificial Intelligence Autonomous Driving

A Case Study of Apollo Go Robotaxi Service

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Abstract. Recent advances in artificial intelligence, particularly in autonomous driving, have improved transportation efficiency and safety. Platforms like Apollo Go are transforming travel habits and reducing accidents. However, these advancements raise ethical and social issues, including safety, privacy and fairness concerns, as well as large-scale employment transformations. Using Apollo Go incidents in Wuhan as a case study, this paper explores ethical considerations, legal regulations, and policy responses. It proposes a comprehensive solution set as a reference for research and policy-making, aiming to balance technological development with social justice.

Keywords: Artificial Intelligence, Autonomous Driving, Ethical Challenges, Employment Transformation, Social Governance, Technological Ethics, Legal Regulations

1 Introduction

In recent years, artificial intelligence (AI) technologies, particularly in the field of autonomous driving, have made remarkable advancements. This has not only improved transportation efficiency but also significantly enhanced road safety. Autonomous ride-hailing services like Baidu's "Apollo Go," which is known in China as "Luo Bo Kuai Pao" are transforming people's travel experiences and realizing more intelligent traffic management with their advanced AI algorithms. However, along with these technological advances, a series of ethical and social issues have emerged.

In July 2024, Baidu's "Apollo Go" robotaxi operation in Wuhan, China, experienced a series of high-profile incidents that garnered public attention. These included minor collisions with pedestrians and complaints about traffic congestion caused by the vehicle's improper handling in complex road conditions. See Figure 1 and Figure 2.

Fig. 1. Apollo Go Robotaxi Accidents Images on Internet.
https://finance.sina.com.cn/roll/2024-07-09/doc-inccphwp7472213.shtml.
http://k.sina.com.cn/article_1912222221_71fa320d02000yd1c.html.

Fig. 2. Traffic Congestions Caused by Apollo Go Robotaxi.
https://www.sohu.com/a/782534911_121218495.
https://www.bilibili.com/video/BV1Ub421n7uN/.

However, the most significant issue that sparked public debate was a petition signed by many taxi drivers in Wuhan, requesting the government to introduce policies limiting the operations of Apollo Go Robo-Taxi to preserve their livelihoods. These events not only highlight the challenges faced by autonomous driving technologies in practical applications but also underscore the friction between technological progress and societal ethics,[1] as well as legal frameworks.[6] While technology can address technical issues such as safety performance and privacy protection, it is less equipped to handle socioeconomic problems like technological unemployment,[2] which require deeper governance and policy adjustments.

Facing the global issue of technological unemployment, we must recognize that ethical concerns are not isolated but are deeply intertwined with societal structures,[3] economic forms, and legal frameworks. Technology providers can contribute by continuously innovating and optimizing design to enhance the safety of autonomous driving systems and reduce the likelihood of accidents. At the same time, governments and all sectors of society need to work together to build a more inclusive policy framework that provides retraining and social security support for individuals who lose their jobs due to technological advancements, facilitating a smooth transition in the job market.

This article aims to delve into the ethical and legal governance issues arising from artificial intelligence-driven autonomous driving technologies. By analyzing the ethical considerations, current legal regulations, and policy responses behind the Apollo Go Robo-Taxi events in Wuhan, we propose a comprehensive set of solutions. Our

goal is to provide valuable references for academic research and policy-making in related fields. We believe that through interdisciplinary collaboration and dialogue, we can find a balance that accommodates both technological advancement and social justice, guiding us towards a future society that is both technologically vibrant and humanely considerate.

2   Overview of Ethical Issues in Artificial Intelligence Autonomous Driving Technology

Artificial intelligence autonomous driving technology, as a hallmark of the Fourth Industrial Revolution, is transforming our lifestyles and work patterns at an unprecedented pace. However, alongside its development come not only technological leaps and efficiency gains, but also a series of complex and profound ethical issues that demand our careful exploration and thoughtful consideration.[4] These ethical issues go beyond the design and application of the technology itself, touching upon fundamental shifts in social structures, economic models, and even our core human values.[5]

From the online discussions by Chinese internet users regarding Apollo Go autonomous taxi service operating in Wuhan, the ethical issues associated with AI autonomous driving technology at least include safety, privacy breaches, fairness, and unemployment. See Figure 3.
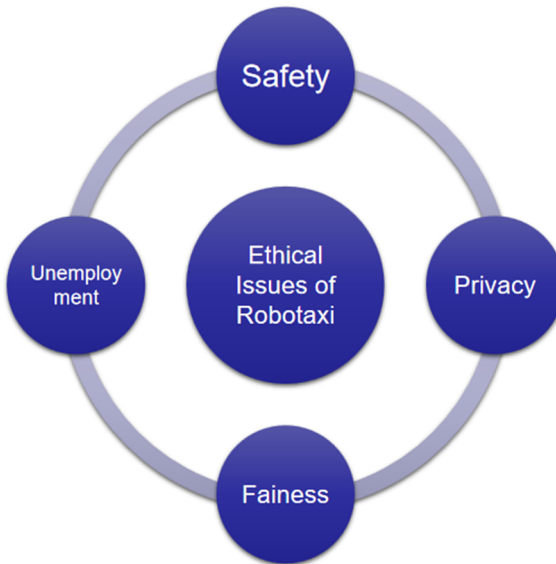

Fig. 3. Ethical Issues of Robotaxi

2.1   Safety

Safety concerns are undoubtedly the most direct and sensitive ethical issues surrounding AI autonomous driving technology. On July 7, 2024, an accident occurred involving the Apollo Go autonomous taxi service in Wuhan. Baidu responded promptly to the incident, stating that they would fully cooperate with the traffic police investigation and assume any corresponding responsibilities. Baidu emphasized the potential and value of autonomous driving technology in improving road safety and reducing traffic accidents. This incident sparked widespread public concern and discussion about the safety of autonomous vehicles.

As the autonomous decision-making capabilities of vehicles increase, ensuring the safe operation of driverless cars in complex and dynamic traffic environments and avoiding or minimizing accidents becomes a shared focus for both technology developers and the general public. The ethical dilemmas encountered by autonomous driving technology, such as the famous "trolley problem", highlight the contradictions between technical decisions and human ethical values. In emergency situations, how should a vehicle make decisions—should it prioritize protecting passengers inside the car or avoid harming more pedestrians on the road?

2.2   Privacy

In the discussions triggered by Apollo Go autonomous taxi service and other topics related to autonomous driving, some have raised concerns about surveillance cameras installed within the vehicles, expressing worries about personal information security. In response to questions about the in-vehicle cameras, Apollo Go customer service stated that cameras are installed in the vehicles primarily to meet regulatory requirements and ensure safety during testing. Unless customers request to view the surveillance footage, data collection and storage will not occur.

Autonomous vehicles collect large amounts of environmental data and personal information during operation, including location data, travel routes, and passenger behavior within the vehicle. The collection, storage, and use of this data directly relate to issues of personal privacy protection.

2.3   Fairness

Algorithmic fairness is a crucial ethical issue in the application of artificial intelligence, especially in the realm of autonomous driving systems.[7] When these systems identify pedestrians, other vehicles, and other road participants, if there is bias in the design or in the training datasets, they may make discriminatory decisions. This bias is not limited to differences in recognition among different racial or gender groups but can also manifest in different treatment of people of different ages or health statuses. Although the specific issues mentioned did not directly arise in the Apollo Go events (primarily because the service is still in a limited pilot phase with a small scale), such problems could likely occur as autonomous driving technology becomes more widespread.

If the design goals of AI autonomous driving algorithms emphasize profit maximization, they might disproportionately serve younger individuals who can get in and out of the vehicle quickly, potentially neglecting elderly or disabled individuals with mobility issues. This bias not only limits travel options for specific groups but may also exacerbate social inequalities.

People living in remote areas may also face algorithmic discrimination. Typically, residents in these regions have poorer economic conditions, and algorithms tend to provide services in densely populated urban areas where the demand for transportation is higher and operational costs are relatively lower, thus offering greater profit margins. As a result, residents in remote areas may find it difficult to book rides from autonomous vehicles, further widening the gap between urban and rural areas.

2.4   Unemployment

The most socially prominent aspect of the Apollo Go incidents is the issue of unemployment caused by autonomous taxis for ride-hailing drivers. Compared to other professions, the ride-hailing profession has unique characteristics. During periods of macroeconomic downturn, many people face unemployment. After failing to find new jobs, some turn to the demanding work of food delivery or ride-hailing driving. Thus, these jobs serve as a rare buffer and lifeline for those already unemployed. However, with the increase in unemployment, ride-hailing drivers have also faced saturation issues, leading to declining income levels. With the advent of autonomous ride-hailing services, the competitive environment for ride-hailing drivers has become even more challenging. Unlike autonomous driving technology, ride-hailing drivers cannot operate at full capacity 24 hours a day, making it difficult to compete with AI-driven systems. If jobs like ride-hailing driving are replaced by AI autonomous driving technology, the society will lack a buffer mechanism for unemployment. Many people who have lost jobs in other sectors may not be able to find work as ride-hailing drivers, and the lack of such a buffer mechanism could lead to systemic unemployment and potential social instability.

The ethical issues associated with AI autonomous driving technology encompass multiple dimensions, including technology, society, and law. Addressing these issues requires interdisciplinary cooperation and the concerted efforts of society as a whole. However, the approaches to solving these different ethical issues vary, and it is necessary to categorize them further from a problem-solving perspective.

3   Ethical Issues Resolvable Through Technology Versus Those Requiring Broader Solutions

The development of artificial intelligence autonomous driving technology has not only transformed the landscape of the transportation industry but has also garnered widespread social attention, particularly due to the ethical issues underlying its implementation. These ethical issues can be categorized into two major types based on their nature and the approaches required to address them: one type consists of ethical issues

that can be resolved through technological means, while the other comprises issues that are difficult to solve solely through technological approaches. This chapter delves into a detailed analysis of these two categories of ethical issues, aiming to clarify their characteristics and differences, thereby providing theoretical guidance for subsequent policy formulation and technological development. A detailed classification of the different ethical issues is outlined in Figure 4.

3.1   Ethical Issues Addressable Through Technological Solutions

This category of ethical issues primarily focuses on the design, implementation, and functional optimization of the technology. Through technological innovation and algorithm improvement, these issues can be effectively addressed or alleviated. Specifically, they include:

3.1.1 Enhancing Safety Performance.

Safety is the cornerstone of autonomous driving technology, requiring technology providers to continuously improve the safety performance of their systems to ensure stable operation in complex traffic environments. Solutions include the following. Employing higher-precision sensors and optimizing algorithms to enhance the vehicle's ability to respond quickly to complex road conditions, thereby reducing misjudgment rates. Implementing multiple layers of safety redundancy to ensure vehicle controllability even when some systems fail, safeguarding the safety of passengers and pedestrians. Strengthening data encryption technologies to protect vehicle communication networks from cyberattacks, ensuring the security of driving data, maintaining network security, and preventing unauthorized data access.
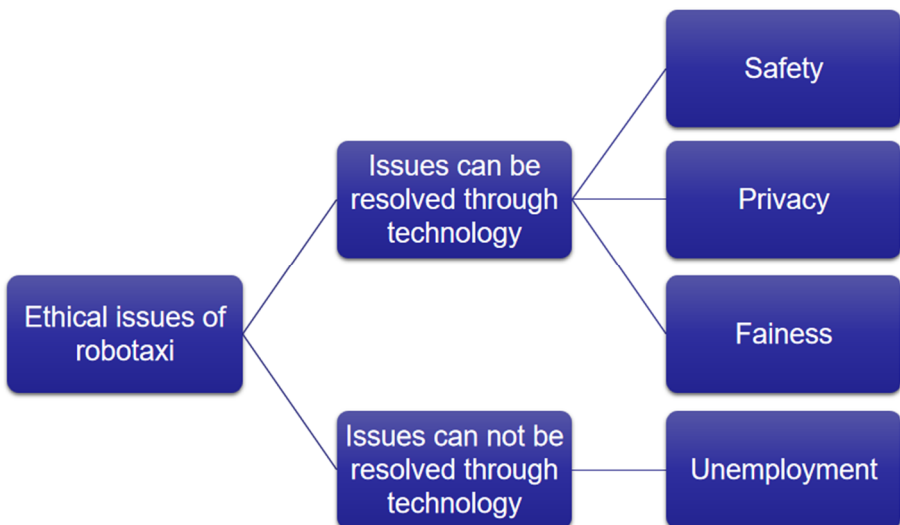

Fig. 4. Classification of different ethical issues of Robotaxi

3.1.2 Strengthening Privacy Protection.

Autonomous driving cars collect large amounts of personal information and environmental data during operation. How to use this data without infringing on personal privacy is a challenge that technology designers must address. Solutions include the following. Employing advanced data encryption techniques and anonymizing collected data to prevent the disclosure of personal identity information. Granting users control over their personal data, including the rights to view, delete, and share their data, enhancing their knowledge and choice over how their data is used. Establishing transparent data usage policies and clearly informing users about the purposes and methods of data processing, increasing the transparency of data handling procedures and building user trust.

3.1.3 Ensuring Algorithmic Fairness.

To avoid biases in algorithmic decision-making, technology providers can take the following measures. Use data sets that contain a variety of features for algorithm training, reducing biases against specific groups and enhancing the fairness of algorithmic decisions. Establish an algorithmic fairness assessment system to regularly monitor the outcomes of algorithmic decisions, ensuring that the algorithm does not discriminate against different groups, thus upholding social equity.

3.2   Ethical Issues Difficult to Address Through Technological Solutions

Unlike ethical issues that can be addressed through technological means, these problems are often rooted in deeper social structures, economic models, and ethical value judgments, and technology itself cannot reach their core. One of the most typical examples is the issue of unemployment.[8] The widespread adoption of autonomous driving technology has had a significant impact on the traditional driving industry, leading to large-scale employment restructuring. This is not merely a technological issue but a complex matter involving social equity, economic policy, and workforce transition.

Addressing unemployment requires multifaceted efforts, encompassing various aspects. Governments should develop forward-looking employment transition plans, providing retraining and educational opportunities to help affected workers adapt to new job markets. This includes vocational training, skill enhancement, and career guidance to ensure a smooth transition to new positions. Governments should also establish flexible social security systems to provide basic living support and reemployment assistance to the unemployed. Through comprehensive unemployment insurance, social welfare, and reemployment aid, the social disruption caused by technological changes can be mitigated. Additionally, governments should encourage businesses and industries to innovate and transform, promoting the development of new industries to create more new job opportunities. Through policy guidance and financial support, economic restructuring can be promoted, offering more diverse employment options to the workforce.

4   Ethical Decision Tree Model for Artificial Intelligence Autonomous Driving Technology

To ensure that the development of AI autonomous driving technology promotes social progress while avoiding potential ethical and social risks, this paper constructs an ethical decision tree model aimed at systematically identifying and resolving ethical issues. This section will detail the construction and application of the model, with a particular emphasis on establishing legal baselines and prohibitive measures against harmful business models, to achieve harmony between technology, society, and law. Figure 5 is a brief description of the decision tree.
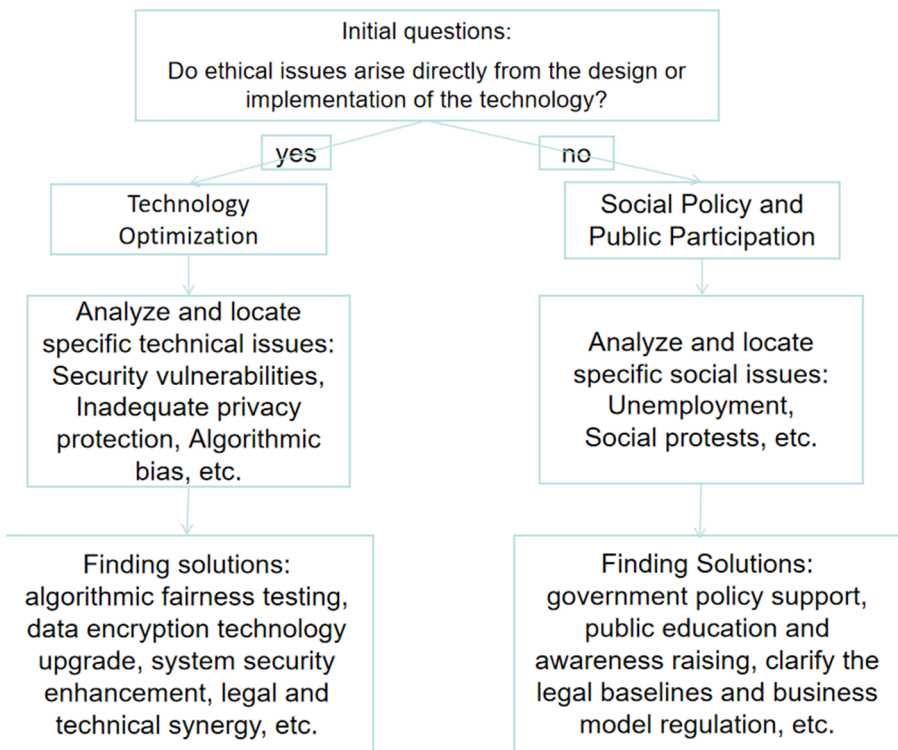

Fig. 5. Decision Tree of Robotaxi Ethical Issues

4.1   Problem Identification

Initial Question: Does the ethical issue directly originate from the design or implementation of the technology?

    If Yes: Proceed to the Technical Optimization Path.

    If No: Proceed to the Social Policy and Public Participation Path.

4.2   Technical Optimization Path

When ethical issues in autonomous driving technology originate from design or implementation, take the Technical Optimization Path. This involves pinpointing specific technical issues, such as safety vulnerabilities, privacy breaches, or algorithmic bias.

To ensure non-discriminatory decision-making, developers and engineers could conduct rigorous algorithm fairness testing to detect and mitigate biases, particularly in areas like route selection, to prevent unequal treatment of different communities. To protect passenger privacy, security experts could upgrade data encryption techniques to secure sensitive information, including data collected by sensors and cameras, and secure communication channels for vehicle interactions. To reduce accident risk, safety teams could enhance system safety performance by upgrading sensor capabilities and improving obstacle detection algorithms, and implement redundant systems and fail-safes to maintain vehicle control in case of system failures. To ensure technological development complies with legal baselines, legal and compliance teams could align innovations with existing legal frameworks, such as prohibiting algorithmic discrimination and enforcing data protection regulations, and work closely with regulatory bodies to establish clear guidelines and standards.

4.3   Social Policy and Public Participation Path

When ethical issues in autonomous driving extend beyond the technical domain and affect broader social structures or ethical values, taking the Social Policy and Public Participation Path is essential. This involves addressing specific societal issues like unemployment or social resistance.

For government policy support, providing vocational transition training and innovative social security systems is key. Offering retraining opportunities for displaced workers helps them acquire new skills and transition into new roles within the economy. Implementing flexible social security systems that offer basic support and reemployment assistance ensures that those affected by technological change are supported during their transition.

Enhancing public understanding and trust through targeted education campaigns is crucial. Informing the public about the benefits and limitations of autonomous driving technology builds a bridge between the technology and the community, reducing social resistance and promoting smoother integration.

Clarifying legal baselines and business model regulation is also essential. Legislation to ban price wars and prevent harmful business models ensures a fair and competitive market. Establishing clear legal frameworks prevents exploitative practices, benefiting all stakeholders involved.

4.4   Implementation and Evaluation of the Decision Tree Model

The decision tree model for addressing ethical issues in autonomous driving technology involves a structured process. First, specific ethical dilemmas are identified, including concerns over safety, privacy, and impacts on employment. Next, a path forward is

chosen, either focusing on technical optimization to enhance AV systems or emphasizing social policy and public participation to foster trust and engagement.

Following the selection of the appropriate path, solutions are executed, which might include developing new algorithms, implementing testing protocols, or establishing community outreach programs. To ensure alignment with ethical and legal standards, legal baselines and business model regulations are integrated, ensuring compliance with laws and ethical guidelines.

Regular effectiveness assessments are conducted to evaluate the impact of implemented solutions, monitor compliance with legal baselines, and assess public reception. Based on these evaluations, adjustments and optimizations are made to refine strategies and improve outcomes.

This model integrates legal and regulatory considerations, promoting social fairness, maintaining market order, and upholding ethical values through collaborative efforts among governments, businesses, and the public.

5   Constructing a Framework of Government Responsibilities

Within the ethical regulatory framework for artificial intelligence autonomous driving technology, the government plays a critical role. Its responsibilities not only include establishing prohibitive norms at the technical level, clearly defining areas where technology should not venture, but also implementing necessary restrictions on harmful business models. This ensures that technological progress does not expand unchecked, potentially harming public interests. Additionally, the government can adopt a range of proactive policies to mitigate the impact of AI autonomous driving technology on social structures. Table 1 briefly lists the targeted measures that various entities can take.

Table 1. Targeted measures that various entities can take related to Robotaxi Ethical Issues

	Government (prohibitive norms)	Government (incentives and guidance)	Technology Providers	Affected Parties
Ethical issues that can be resolved through technology	Establishing prohibitive norms for what technology is prohibited from doing	Promoting awareness to encourage people to protect their privacy and actively defend against the negative impacts of technology.	Complying with legal standards, improving and enhancing through technical means to solve the problem.	1. Sueing technology providers and claim damages. 2.Calling on the government to strengthen ethical oversight of technology.
Ethical issues that cannot be resolved through technology	Prohibition of unfair business models, e.g., low price competition.	Implementing proactive policies, such as reemployment training for those who are unemployed.	Avoiding unethical business practices, unfair competition, predatory pricing, and actions that exacerbate unemployment.	Seeking government help to find other opportunities for re-employment.

5.1   The Role and Responsibilities of the Government

In maintaining legal baselines, the government drafts and enforces laws, regulates compliance, and safeguards market health by intervening against harmful business models. Legal baselines guide technological development within ethical, legal, and social frameworks, ensuring that autonomous driving technology promotes social equity and stability. The government formulates laws and policies that steer technology towards beneficial outcomes and enhance societal welfare. Addressing the social challenges of AI autonomous driving requires collaborative efforts across government and society, encompassing direct policy measures, education, public participation, and inter-departmental cooperation.

5.2   Prohibitive Norms at the Technical Level

From a technical perspective, legal baselines establish prohibitive norms to constrain technology providers and prevent technology misuse. In autonomous driving, laws may ban discriminatory algorithms and mandate safety standards to protect users and society.

In autonomous driving, the government should prohibit predatory practices like excessively lowering prices to eliminate competitors, which can lead to unsustainable market conditions and decreased service quality. In the Apollo Go Robotaxi case, despite its innovative model and low pricing, the company faced scrutiny over pricing fairness. Wuhan regulators stated that pricing was market-determined and not subject to interference, sparking public debate. Pricing of autonomous ride-hailing services, while typically market-driven, affects competition, consumer welfare, and social good. The government must carefully consider whether pricing strategies fall under market-regulated pricing, predatory pricing, or unfair competition. Legislation can prohibit harmful practices and enforce fair competition, such as setting minimum service price thresholds and requiring transparency in business models.

5.3   Encouragement and Guidance Measures at the Social Level

The government can develop large-scale career transition and retraining programs to assist workers impacted by autonomous driving technology, ensuring labor market stability through vocational education and skill enhancement. Improving the social security system provides basic support and psychological assistance to unemployed individuals, alleviating financial pressures and boosting their confidence to find new employment. Encouraging the growth of emerging industries through tax incentives, financial subsidies, and technical support creates additional job opportunities and drives economic restructuring. Strengthening public education through campaigns and educational activities enhances understanding and acceptance of autonomous driving technology. Establishing mechanisms for public participation, such as public hearings and online discussions, ensures transparency and democratic decision-making processes. Inter-agency collaboration among government departments is essential for consistent and effective policy development and implementation. Facilitating cooper-

ation between businesses and academia promotes technological innovation and addresses ethical and social issues, providing a scientific basis for policy formulation.

6   Conclusion

The rapid development of artificial intelligence autonomous driving technology has not only brought numerous conveniences and efficiency improvements to society but has also triggered a series of complex ethical and social issues. This article has analyzed the main ethical issues associated with autonomous driving technology and proposed a comprehensive solution that combines technical means with social governance. At the technical level, enhancing safety performance, strengthening privacy protection, and ensuring algorithmic fairness can effectively address some of the ethical issues. On the social level, concerted efforts by the government and all sectors of society are required to solve employment transformation and social equity issues through career transitions, social security, public education, and inter-departmental cooperation.

Ultimately, through the construction of a comprehensive and systematic ethical decision tree model and the establishment of clear legal baselines, we can achieve the healthy development of autonomous driving technology and promote social equity and stability. We believe that with continuous technological progress and the improvement of social governance, artificial intelligence autonomous driving technology will bring even greater benefits to society in the future, achieving a harmonious coexistence of technology and humanity.

Acknowledgments

References

1. Geisslinger, M., Poszler, F., Betz, J. et al. Autonomous Driving Ethics: from Trolley Problem to Ethics of Risk. Philos. Technol. 34, 1033–1055 (2021). https://doi.org/10.1007/s13347-021-00449-4
2. Nikitas, A.; Vitel, A.-E.; Cotet, C. Autonomous Vehicles and Employment: An Urban Futures Revolution or Catastrophe? Cities 2021, 114, 103203, https://doi.org/10.1016/j.cities.2021.103203
3. Bissell, D., Birtchnell, T., Elliott, A., & Hsu, E. L. (2020). Autonomous automobilities: The social impacts of driverless vehicles. Current Sociology, 68(1), 116-134. https://doi.org/10.1177/0011392118816743
4. Saber, E.M., Kostidis, SC., Politis, I. (2024). Ethical Dilemmas in Autonomous Driving: Philosophical, Social, and Public Policy Implications. In: Parkinson, S., Nikitas, A., Vallati, M. (eds) Deception in Autonomous Transport Systems. Wireless Networks. Springer, Cham. https://doi.org/10.1007/978-3-031-55044-7_2

5. Bergmann, L.T. (2022). Ethical Issues in Automated Driving—Opportunities, Dangers, and Obligations. In: Riener, A., Jeon, M., Alvarez, I. (eds) User Experience Design in the Era of Automated Driving. Studies in Computational Intelligence, vol 980. Springer, Cham. https://doi.org/10.1007/978-3-030-77726-5_5

6. Contissa, G., Lagioia, F. & Sartor, G. The Ethical Knob: ethically-customisable automated vehicles and the law. Artif Intell Law 25, 365–378 (2017). https://doi.org/10.1007/s10506-017-9211-z

7. Hansson, S.O., Belin, MÅ. & Lundgren, B. Self-Driving Vehicles—an Ethical Overview. Philos. Technol. 34, 1383–1408 (2021). https://doi.org/10.1007/s13347-021-00464-5

8. Pettigrew, S., Fritschi, L., & Norman, R. (2018). The Potential Implications of Autonomous Vehicles in and around the Workplace. Int. J. Environ. Res. Public Health 2018, 15, 1876; https://doi.org/10.3390/ijerph15091876