Research on Legal Responsibility Issues of Artificial Intelligence Technology in Autonomous Driving

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Abstract: As artificial intelligence technology rapidly advances, autonomous driving technology is gradually becoming a key driving force in the field of intelligent transportation. However, the application of this technology requires analysis from multiple dimensions such as traffic violation liability, accident liability determination and accountability, and the principles of legal liability distribution in autonomous driving. The assignment of traffic violations and accident liabilities for autonomous vehicles needs to comprehensively consider various factors including manufacturers, technology providers, vehicle owners, and passengers, and a fair and reasonable liability allocation mechanism should be established based on actual situations. In response to the legal challenges faced by autonomous driving technology, such as autonomous decision-making, data security and privacy protection, and technological defects and product liability, there is an urgent need to strengthen the construction of laws and regulations, improve technical safety standards, and establish a multi-party collaboration mechanism.

Keywords: Artificial Intelligence; Autonomous Driving; Legal Liability; Traffic Violations; Accident Liability

1. Introduction

As technology advances rapidly, the application of artificial intelligence in the field of autonomous driving is becoming increasingly widespread. It not only revolutionizes transportation but also poses a profound challenge to the traditional legal responsibility system. The emergence of autonomous driving technology marks an important step towards an era of intelligence and automation for humanity, but it has also sparked extensive discussions on a series of complex issues such as liability attribution, data security, privacy protection, and ethical morality.

Market research institutions predict that by 2030, the global market size for autonomous vehicles could reach several trillion US dollars. This figure underscores the enormous market potential and social impact of autonomous driving technology. However, as autonomous vehicles gradually become more common, the legal responsibilities involved have become increasingly prominent. For example, when an accident occurs involving an autonomous vehicle, how should liability be assigned?[1] Should it be attributed to the vehicle manufacturer, software developer, owner, or other related parties? These questions are not only relevant to the protection of victims' rights but also directly affect the sustainable development of autonomous driving technology.

Moreover, autonomous driving technology faces serious challenges regarding data security and privacy protection. Autonomous vehicles generate vast amounts of data during operation, including vehicle trajectory, passenger information, and road condition data. If this data is leaked or misused, it could pose a severe threat to personal privacy and social security. Therefore, establishing a robust data protection mechanism to ensure that autonomous driving technology operates legally and safely is one of the urgent issues that need to be addressed[2].

At the ethical and moral level, autonomous driving technology has also sparked widespread controversy. For example, in emergency situations, how should an autonomous vehicle make decisions? Should it prioritize the safety of passengers or pedestrians? These questions touch upon the moral baseline and values of human society, requiring in-depth discussions and weighing from legal, ethical, and technical perspectives[1].

The application of autonomous driving

technology has raised many new legal responsibility issues. These issues not only involve the definition and division of legal responsibilities but also relate to privacy protection, data security, and ethical morality. Therefore, conducting in-depth research on the legal responsibility issues within autonomous driving technology holds significant practical importance and theoretical value. By clarifying the legal responsibilities of various responsible entities, strengthening data security and privacy protection, and exploring ethical and moral issues, we can provide strong legal safeguards and moral support for the healthy development and widespread application of autonomous driving technology[3-5].

2. Legal Liability Analysis in Autonomous Driving

2.1 Analysis of Traffic Violation Legal Liability

When examining the legal liability attribution for traffic violations by autonomous vehicles, it is necessary to consider a variety of factors including technical autonomy, operational errors, system design, and manufacturing defects. With the rapid development of autonomous driving technology, its ability for independent decision-making and action has significantly increased, which also brings complexity to the definition of legal responsibilities.

If an autonomous vehicle commits traffic violations such as running red lights or speeding during operation, the attribution of legal liability becomes an urgent issue to address. On one hand, due to the autonomy of the vehicle, its behavior may not be completely under human control; on the other hand, technical failures or misjudgments can lead to illegal actions. Therefore, we need to conduct an in-depth analysis of these factors to determine the responsible parties.

For traffic violations resulting from autonomous vehicle decision-making, the allocation of legal liability may involve the vehicle manufacturer, software provider, and the vehicle owner or user. In such cases, it is necessary to examine whether the vehicle manufacturer and software provider have fully considered safety and compliance in the design and manufacturing process. If the illegal act is due to design flaws or software bugs, then the manufacturer and software provider may need to bear corresponding legal responsibilities[6,7].

If traffic violations are caused by mistakes or malfunctions in the autonomous decision-making process of the vehicle, the assignment of legal liability may be more complex. In this scenario, various factors such as the vehicle's technical level, transparency of the decision-making process, and the presence of human intervention must be comprehensively considered. If there are obvious deficiencies in the vehicle's autonomous decision-making process or human intervention leads to illegal actions, the relevant parties may need to bear corresponding legal responsibilities[6-9].

2.2 Assignment and Pursuit of Liability for Accidents

When accidents occur involving autonomous vehicles, the mechanisms for determining and pursuing liability become complex and crucial issues. Due to the unique nature of autonomous driving technology, traditional methods of accident liability determination may no longer be applicable, necessitating the exploration of new mechanisms for liability assignment and pursuit.

In the event of an accident involving an autonomous vehicle, it is first necessary to identify the liable party. In conventional driving scenarios, the driver is considered the responsible party, but in autonomous driving, this role is replaced by the automated system. Therefore, when an accident involving an autonomous vehicle occurs, the responsibility of the technology provider should be considered first. Technology providers must ensure that their autonomous driving systems meet relevant safety standards and are free from defects during design and manufacturing. If an accident is caused by system defects, then the technology provider should bear corresponding responsibilities[10].

Apart from technology providers, vehicle owners or users may also bear certain liabilities. For example, if a vehicle owner or user fails to update or maintain the autonomous driving system promptly, leading to system malfunctions and an accident, they should also bear corresponding responsibilities. Moreover, if a vehicle owner or user deliberately sabotages or tampers with the

autonomous driving system, causing an accident, they should bear primary responsibility[10].

In pursuing liability, it is necessary to act according to relevant laws and regulations. For instance, according to the provisions of China's "Tort Liability Law," if damage is caused by product defects, the victim can seek compensation from either the producer or the seller of the product[11]. This provision is equally applicable to the pursuit of liability in accidents involving autonomous vehicles. If an autonomous vehicle causes an accident due to system defects, the victim can request compensation from either the technology provider or the seller.

2.3 Legal Principles for Liability Allocation

In autonomous driving technology, the principles for legal liability allocation are complex and critical. Since autonomous driving technology involves multiple related parties, including vehicle manufacturers, software system providers, users (vehicle owners or operators), and possibly third-party service providers, how to reasonably allocate legal liability has become an urgent issue to address.

We need to clarify the roles and responsibilities of each related party. Vehicle manufacturers should be responsible for the safety performance of their autonomous vehicles, including but not limited to hardware design, manufacturing, and the stability and reliability of vehicles in various environments. Software system providers must conduct rigorous testing and verification of their autonomous driving system software to ensure compliance with relevant safety standards and maintain compatibility with vehicles during system updates and upgrades. Users, on the other hand, need to comply with relevant laws and regulations, use autonomous vehicles correctly, and carry out timely system updates and maintenance.

In the allocation of legal liability, the principle of "consistency between rights and responsibilities" should be followed. That is, whoever enjoys the rights should bear the corresponding responsibilities. For example, if an autonomous vehicle is involved in a traffic accident during use, and the cause of the accident is related to vehicle manufacturing or system design, then the vehicle manufacturer

and software system provider should bear corresponding legal responsibilities. If the accident is caused by improper operation or failure to update the system promptly by the user, then the user should bear the corresponding responsibilities.

Considering the complexity and multi-entity nature of autonomous driving technology, the principle of "common but differentiated responsibilities" can also be referenced. That is, in allocating legal liability, both the common responsibilities of all related parties and the actual role and degree of fault in the accident of each party should be considered to differentiate responsibility allocation. This principle helps to resolve legal liability issues in autonomous driving technology more fairly and reasonably.

In practice, the application of principles for allocating legal liability requires analysis combined with specific cases. For example, when an autonomous vehicle is involved in a traffic accident, a detailed accident investigation should be conducted to determine the cause of the accident and the liable party. If the investigation shows that the accident was caused by vehicle manufacturing defects, then the vehicle manufacturer should bear the primary responsibility; if the accident was caused by software system malfunctions, then the software system provider should bear the primary responsibility; if the accident was caused by user misconduct, then the user should bear the primary responsibility. At the same time, secondary or joint liabilities of other related parties should also be considered.

3. Challenges of Legal Liability in Artificial Intelligence Technology

3.1 Autonomous Decision-Making and Legal Liability

In autonomous driving technology, the autonomous decision-making capability of artificial intelligence is key to achieving autonomous driving. However, as the authority for autonomous decision-making increases, corresponding legal liability issues gradually emerge. When autonomous vehicles face complex traffic environments, they must rely on their autonomous decision-making systems to make judgments. Once these decisions lead to traffic violations or accidents, a series of legal liability issues arise.

We need to clarify one point: the autonomous decision-making of autonomous vehicles is not completely independent of human control. In fact, during the design and programming phases, developers have already set a framework and algorithms for these vehicles. However, due to the complexity and variability of real-world traffic environments, the autonomous decision-making systems of autonomous vehicles may sometimes make judgments that do not conform to human expectations, leading to traffic violations or accidents.

How should legal liability be defined in this situation? One viewpoint suggests that the providers of autonomous driving technology or automobile manufacturers should bear responsibility because they designed the vehicle's autonomous decision-making system. However, this view overlooks the fact that the decision-making system of autonomous vehicles is constantly learning and evolving, and its decision-making process is not entirely determined by initial design. Therefore, attributing full responsibility to technology providers or automobile manufacturers may not be fair.

Another viewpoint considers that vehicle owners or users should bear responsibility. This view believes that although autonomous vehicles have autonomous decision-making capabilities, their owners or users still have supervisory and management responsibilities. If the autonomous decision-making leads to traffic violations or accidents, then the owners or users should bear corresponding legal liabilities. However, this view also has problems because the original intention of autonomous driving technology is to reduce or eliminate human factors affecting driving. If owners or users are required to be responsible for every autonomous decision made by the vehicle, then what is the significance of autonomous driving technology?

In fact, the relationship between autonomous decision-making and legal liability is not a simple choice between two extremes. We need to consider multiple factors comprehensively to define responsibility. First, if the failure of the autonomous decision-making system is due to design or manufacturing defects, then technology providers or automobile manufacturers should bear corresponding responsibilities. Second, if the failure is due to

improper operation or maintenance by owners or users, then they should bear certain responsibilities. Finally, we also need to consider the complexity and uncertainty of autonomous driving technology, as well as the diversity of real-world traffic environments, which may require a more detailed division of responsibilities.

3.2 Data Security and Privacy Protection

With the rapid development of autonomous driving technology, issues of data security and privacy protection are becoming increasingly prominent, posing significant challenges to its widespread application. During operation, autonomous vehicles continuously collect, process, and transmit vast amounts of sensitive data, including but not limited to vehicle location, driving trajectory, passenger information, and surrounding environmental data. Should this data be leaked or illegally utilized, it could pose serious threats to individual privacy, national security, and even social stability.

According to an industry report, with the popularization of autonomous driving technology, it is expected that by 2030, global autonomous vehicles will generate over ZB levels of data. Such a massive volume of data poses unprecedented challenges to data security protection capabilities. In recent years, there have been several incidents of data leakage involving autonomous vehicles exposed to the public, such as a well-known automobile manufacturer experiencing a system vulnerability that led to hackers stealing user data from thousands of autonomous vehicles, sparking widespread concern about the safety of autonomous driving technology among the public.

To address this challenge, governments and enterprises around the world are strengthening data security and privacy protection efforts. For example, the European Union has passed laws and regulations such as the General Data Protection Regulation (GDPR), setting strict requirements for data processing, storage, and transmission while imposing hefty fines to deter non-compliant behavior. Meanwhile, some leading companies in autonomous driving technology actively adopt encryption technologies and anonymization processes to ensure the security and privacy of user data. However, solving data security and privacy

protection issues is not an overnight task. In the practical application of autonomous driving technology, numerous challenges still need to be faced. For example, how to achieve efficient utilization and sharing of data while ensuring data security? How to ensure the effectiveness of security measures amidst rapid technological iteration? These questions require continuous exploration and practice from us.

3.3 Technical Faults and Responsibility Attribution

In discussing legal liabilities within autonomous driving technology, technical faults and responsibility attribution are undoubtedly one of the core topics. With the rapid development of artificial intelligence technology, autonomous vehicles demonstrate enormous potential but also bring unprecedented legal challenges due to their technical complexity and uncertainty. According to the classification by the Society of Automotive Engineers (SAE), autonomous driving technology is divided into six levels from L0 to L5, with L5 representing fully autonomous driving without human intervention. However, even before L5 technology matures, autonomous vehicles at any level face the risk of technical faults.

Taking Tesla as an example, as a global leader in electric vehicles and autonomous driving technology, its Autopilot system has been involved in several traffic accident disputes. A notable case occurred in 2016 when a Tesla Model S collided with a truck crossing the road while in Autopilot mode, resulting in the death of the driver. This incident sparked widespread discussion about the safety of autonomous driving technology globally and prompted a reexamination of technical faults and responsibility attribution. Although Tesla emphasized that Autopilot is only an assistive driving system, public and regulatory attention generally focused on whether technical faults should be considered in responsibility division. The attribution of responsibility for technical faults involves multiple levels, including manufacturers, software developers, vehicle owners, and users. According to general principles of product liability law, manufacturers are responsible for defects in their products, including design defects, manufacturing defects, and warning defects. In the field of autonomous driving, if technical faults stem from manufacturers failing to adequately test or warn about potential risks, then manufacturers should bear corresponding responsibilities. However, when technical faults are related to improper operation or negligence by vehicle users, responsibility attribution becomes more complex. For example, if a driver overly relies on the system despite knowing its limitations, leading to an accident, then the driver also needs to bear part or all of the responsibility.

To scientifically define technical faults and responsibility attribution, academia and industry are actively exploring the establishment of risk assessment and responsibility determination models. These models typically utilize big data analysis, machine learning techniques to monitor and analyze operational data of autonomous vehicles in real-time, predicting potential technical faults and assessing their impact on driving safety. Simultaneously, models also consider legal, ethical, and social factors to provide a scientific basis for responsibility division. For instance, some scholars propose the concept of a "black box," similar to devices installed in airplanes, recording all data during vehicle operation to facilitate responsibility tracing after accidents occur.

4. Strategies and Recommendations for Resolving Legal Liabilities

4.1 Strengthening the Construction of Laws and Regulations

Since the promulgation of the "Cybersecurity Law of the People's Republic of China" in 2017, China has gradually established a legal and regulatory system for unmanned driving. In particular, with the implementation of the "Hangzhou Intelligent Connected Vehicle Testing and Application Promotion Regulations" on May 1, 2024, China's legal exploration in the field of unmanned driving has entered a new stage. This regulation not only specifies the testing areas and times for unmanned driving but also emphasizes the importance of technical safety standards and regulatory mechanisms. This government-led, regulation-first strategy reflects China's determination to ensure the safe and orderly development of unmanned driving technology. When discussing the legal liabilities of

unmanned driving technology, strengthening the construction of laws and regulations is an indispensable part. With the rapid development of unmanned driving technology, the current legal system faces unprecedented challenges. To effectively address these challenges, governments and legislative bodies worldwide need to accelerate their pace in formulating and improving relevant laws and regulations to provide solid legal support for the healthy development of unmanned driving technology.

Specifically, strengthening the construction of laws and regulations requires action from multiple dimensions. First, the legal status of unmanned vehicles should be clarified, establishing their principal status within the traffic legal system to lay the foundation for liability allocation. For example, Germany's "Road Traffic Act" has taken the lead in incorporating autonomous vehicles into legal scope, stipulating that under certain conditions, they can be regarded as "drivers," providing a clear definition of the legal status of unmanned vehicles.

Second, detailed standards for liability division should be developed in response to potential legal liability issues caused by unmanned driving technology. This includes clarifying the boundary of responsibility between drivers and unmanned driving systems, and how to determine the responsible party in case of an accident. A bill in California, USA, proposes that manufacturers should bear primary responsibility when unmanned vehicles are in autonomous mode, offering a useful reference for liability allocation.

Furthermore, strengthening the construction of laws and regulations also needs to focus on technical faults and liability attribution. The complexity of unmanned driving technology means it may face various technical faults, such as sensor failures or algorithm errors. To effectively address these risks, strict technical safety standards and accountability mechanisms should be established. For instance, manufacturers could be required to conduct thorough safety tests and verifications before vehicles are launched to market, ensuring compliance with safety standards; meanwhile, after accidents occur, manufacturers should be held accountable according to relevant laws and regulations.

In terms of data security and privacy protection, strengthening the construction of laws and regulations is equally crucial. Unmanned vehicles generate massive amounts of data during operation, involving personal privacy and public safety. Therefore, strict data protection regulations should be enacted to standardize the collection, storage, processing, and transmission of data. Additionally, penalties for illegal activities should be increased to ensure effective protection of data security and personal privacy.

4.2 Enhancing Technical Safety Standards

Enhancing technical safety standards is key to achieving reasonable allocation of legal liabilities and risk avoidance in the field of unmanned driving. Currently, with continuous advancements in sensor technology, algorithm optimization, and big data processing capabilities, the safety of unmanned driving systems has significantly improved, but efforts must continue to achieve higher safety standards. According to the SAE's classification standards, unmanned driving technology is progressing from Level 2 (partial automation) towards Level 5 (full automation), with each level up representing a significant enhancement in technical safety standards.

Taking Tesla as an example, its Autopilot system has introduced more advanced visual recognition algorithms and radar sensor fusion technology through continuous iterations and upgrades, significantly improving the vehicle's perception and decision-making abilities in complex road environments. However, despite this, Tesla has attracted attention due to accidents caused by technical faults, highlighting the urgency of enhancing technical safety standards. As a result, Tesla has increased R&D investments, focusing on improving system redundancy design and fault tolerance capabilities to ensure vehicles can still operate safely in case of a single sensor or algorithm failure.

In the process of enhancing technical safety standards, introducing international standards such as ISO 26262 as guidance is crucial. This standard specifically addresses functional safety requirements for automotive electronic and electrical systems, including system architecture design, requirement management,

and development process control. By following these standards, unmanned driving systems can integrate safety concepts from the design phase, reducing potential safety hazards.

Moreover, constructing safety assessment models based on big data and machine learning is an effective way to enhance technical safety standards. By collecting and analyzing a large amount of actual driving data, potential safety risks can be identified, and algorithm and parameter settings can be optimized accordingly. For example, using deep learning techniques to predict collision risks allows for early evasive actions, thereby effectively reducing the accident rate. As renowned tech entrepreneur Elon Musk stated: "Safety is the top priority for autonomous driving technology; we must continuously push technological innovation to ensure that unmanned vehicles are safer than human driving."

4.3 Establishing a Multi-party Collaborative Governance Mechanism

When discussing legal liabilities in unmanned driving technology, we must face a reality: the pace of technological development far exceeds the speed of legal formulation and updating. Therefore, solely relying on the perfection of laws and regulations may not comprehensively solve the various complex issues faced in the application of unmanned driving technology. In this context, establishing a multi-party collaborative governance mechanism is particularly important.

Governments should play a core role in this mechanism. They are responsible for formulating and enforcing relevant laws and regulations, as well as establishing specialized regulatory agencies to strictly supervise and manage every aspect of unmanned driving technology research and development, testing, and operations. Additionally, governments should actively promote the deep integration of industry, academia, research, and application, encouraging cooperation among enterprises, universities, and research institutions to jointly advance the innovative development of unmanned driving technology. Enterprises play a vital role in the research and application of unmanned driving technology. They should increase investment in unmanned driving technology R&D to continuously improve system safety and reliability. At the same time, enterprises should also assume corresponding social responsibilities, strictly comply with national laws and regulations, and ensure the compliant application of unmanned driving technology.

Various sectors of society, including consumers, industry associations, and media, should also play active roles in the multi-party collaborative governance mechanism. Consumers should enhance their own safety and legal awareness, use unmanned products correctly, and safeguard their legal rights. Industry associations should strengthen industry self-discipline and norms to promote healthy industry development. Media should strengthen the promotion and education of unmanned driving technology to enhance public awareness and acceptance of the technology.

5. Research Conclusion

After thoroughly analyzing the legal liabilities of artificial intelligence technology in unmanned driving, it is evident that the rapid development of unmanned driving technology has significantly changed the landscape of transportation. According to data from the International Society of Automotive Engineers (SAE), the testing and deployment of Level 3 to Level 5 autonomous vehicles are accelerating globally, with autonomous vehicles expected to occupy a significant proportion of global new car sales by 2030. This trend highlights the urgency of clarifying the legal liability framework for unmanned driving.

Currently, the legal status of unmanned vehicles remains ambiguous. Although some countries like Germany have recognized the "driver" status of autonomous systems through legislation, a unified standard has yet to be formed globally. This leads to ambiguity in accident liability allocation between drivers and unmanned driving systems. For example, in several fatal accidents involving Tesla's "Autopilot" mode, there has been widespread controversy over liability attribution among the court and the public, highlighting the lag of law behind technological development. As Tesla CEO Elon Musk said: "Autonomous driving cars will be safer than human driving." However, achieving this goal requires our collective effort to continuously explore and

perfect the legal liability framework for unmanned driving technology.

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