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Determining the Liability of Operators for Injuries Caused by Algorithm-Driven Unmanned Logistics Delivery Vehicles

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ABSTRACT

As the commercial operation of autonomous delivery vehicles continues to expand in settings such as residential communities, industrial parks, and urban public roads, the determination of tort liability for harm caused by algorithmic recognition errors has become a central point of contention at the intersection of law and technology. Current tort law, which centers its assessment on human behavior, is difficult to apply directly to scenarios involving autonomous algorithmic decision-making. The determination of an operator's liability for negligence faces three structural challenges: conflicts in the application of liability principles, the "black box" nature of algorithms that disrupt the chain of causation, and a mismatch of rights and responsibilities among supply chain participants. Centering on the core issue of the operator's liability for negligence in the context of algorithmic recognition errors in unmanned logistics delivery vehicles, this paper first catalogs the types of accidents and real-world disputes arising from such errors in delivery scenarios, analyzing foundational issues such as the ambiguous legal characterization of unmanned delivery vehicles, theoretical divergences regarding liability principles, and obstacles in proving causation. Second, it dissects institutional bottlenecks in determining the operator's negligence, including difficulties in meeting the burden of proof, gaps in the content of safety assurance obligations, and unclear boundaries of liability across multi-tiered supply chains; Finally, within the framework of the tort liability rules of the Civil Code, the paper proposes improvement measures, including establishing a presumption of causation for algorithmic torts, refining the operator's safety obligations regarding algorithm operation, maintenance, and real-time monitoring, clarifying the boundaries of responsibility between operators and algorithm developers, specifying statutory grounds for liability reduction or exemption, and unifying judicial adjudication standards. These measures aim to provide institutional safeguards for the orderly development of the autonomous delivery industry within the framework of the rule of law.

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KEYWORDS: *Autonomous delivery vehicles; algorithmic recognition errors; operator liability; tort liability; allocation of the burden of proof; algorithmic black box.*

INTRODUCTION

Currently, as the commercialization of drone delivery vehicles accelerates, cases of personal injury caused by algorithmic recognition errors in unmanned logistics delivery vehicles are becoming increasingly prominent, and the determination of liability for such infringements has emerged as a central issue. The current principle of fault-based liability faces obstacles in application; the "black box" nature of algorithms makes it difficult to prove fault on the part of operators, while the presumption of fault and product liability may stifle innovation. Therefore, the key priority is to strike a balance between redressing victims' rights and ensuring the healthy development of the industry, and to establish a new framework for assessing fault based on risk allocation and operational profits. The significance of this research lies in introducing objective criteria—such as algorithmic risk and system controllability—to redefine the operators' duty of care and clarify the boundaries of liability. However, this process faces

challenges in adapting foreign experiences and implementing domestic theories. Our research focuses on determining the negligence of operators and refining their obligations regarding pre-event review and real-time oversight.

Real-World Legal Issues Regarding Infringement Arising from Algorithm Recognition Errors in Autonomous Delivery Vehicles

The challenge of determining tort liability for injuries caused by autonomous delivery vehicles due to algorithmic recognition errors involves three structural difficulties: conflicts in the application of liability principles, obstacles in proving causation, and ambiguity in defining the liable party.

A. Types of Incidents Caused by Algorithm Recognition Errors in Delivery Scenarios and Related Real-World Disputes

Autonomous logistics delivery vehicles are already in operation in communities, industrial parks, campuses, and on public roads in urban areas. Accidents caused by algorithmic recognition errors can be categorized into three types based on legal issues: collision accidents resulting from errors in recognizing static obstacles; personal injury accidents resulting from errors in recognizing moving objects; and traffic violation accidents resulting from errors in recognizing traffic rules.

Based on practical observations, the current determination of liability presents a threefold dilemma. Law enforcement agencies often handle cases by referring to traditional traffic regulations, but autonomous vehicles do not meet the standards for motor vehicles nor fit the definition of non-motorized vehicles; liability is frequently attributed to the operating companies, yet the legal basis and principles of liability are unclear; pilot program regulations vary across regions; for instance, the *Beijing Municipal Measures for Road Testing and Commercial Demonstration of Unmanned Delivery Vehicles* and the *Shenzhen Nanshan District Measures for the Testing and Application of Functional Unmanned Vehicles* exhibit significant differences regarding driver requirements and the definition of liable parties[1]. The root cause of these dilemmas lies in the unique characteristics of unmanned delivery vehicles, which make it difficult to accommodate them within traditional legal frameworks.

B. Conflicts in the Application of Liability Arising from the Unique Characteristics of Autonomous Delivery Vehicles

Unmanned logistics delivery vehicles combine the characteristics of both smart devices and vehicles, creating a fundamental conflict with traditional liability frameworks.

The current "Road Traffic Safety Law" is based on a binary classification of motor vehicles and non-motor vehicles. Unmanned delivery vehicles not only fail to meet the mandatory requirements for motor vehicles—such as registration and licensed driving—but also generally exceed the weight and power limits set by national standards for non-motor vehicles.

The product liability theory advocates applying Article 1,202 of the Civil Code, under which manufacturers bear strict liability if an accident can be attributed to algorithmic design or system defects; however, there remains controversy over whether "algorithmic errors" constitute "product defects." The presumption of fault theory advocates for a reversal of the burden of proof, but this requires explicit legislative clarification. The direct consequence of these divergent scholarly views is a high degree of uncertainty regarding the determination of the operator's liability—if product liability applies, the operator is merely an intermediary liable party; if fault-based liability applies, the operator may become the directly liable party[2].

C. Practical Challenges in Proving Causation Arising from Algorithmic Black Boxes

The "algorithm black box" refers to the lack of explainability and transparency in the decision-making process of autonomous driving algorithms. In a litigation context, its core legal implication is not merely technical inexplicability, but rather the imbalance in the allocation of the burden of proof resulting from the information asymmetry it creates.

First, victims are often unable to determine whether the damage stemmed from an algorithmic recognition error, a hardware malfunction, or external environmental interference, as a single accident frequently involves the combined effects of multiple factors. Second, key evidence—such as algorithm logs and operational parameters—is held by the operator or technology provider. This structural imbalance in the distribution of evidence effectively deprives victims of the basic means to prove causation. Furthermore, if the traditional rule of "he who asserts must prove" continues to apply, victims will find it difficult to obtain relief; if they pursue a product liability claim, they face issues such as delays in determining when an algorithmic "defect" occurred and ambiguous standards for such determinations[3].

D. The Dilemma of Blurred Boundaries of Operators' Responsibilities in Multi-Tiered Industry Supply Chains

The autonomous logistics and delivery industry has developed a multi-tiered supply chain structure involving various entities, including algorithm developers, vehicle manufacturers, platform operators, site providers, and remote safety officers. The ambiguity surrounding the scope of operators' liability can be analyzed from three perspectives.

The legal status of operators is inherently ambiguous; they may be vehicle owners or lessees, and they may be responsible for algorithmic dispatch decisions or merely manage commercial revenue. There is no uniform legal definition of an "operator," and its scope and implications vary significantly across different business models. Algorithm developers argue that they merely provide technology licenses and bear no responsibility for real-time decision-making; vehicle manufacturers claim that accidents result from operational scenarios or algorithm updates; while operators contend that they cannot intervene in the underlying logic of the algorithms.

These three interlocking dilemmas—conflicts over liability that leave the legal foundation of the operator in limbo, the algorithmic "black box" [4]that severs the chain of causation, and the fragmented supply chain that disperses liability—collectively constitute practical obstacles to establishing the operator's liability for negligence[5].

Summary of the Legal Analysis on the Determination of Liability for Operators of Autonomous Delivery Vehicles

Since the commercial deployment of autonomous delivery vehicles, disputes over liability have become increasingly frequent. Current civil regulations have not yet established uniform standards for determining fault regarding this type of smart device, posing challenges in the application of law when adjudicating such cases. This analysis focuses on determining the operator's fault, clarifies the scope of the research, identifies practical legal challenges, and provides a theoretical foundation for future regulatory improvements[6].

A. Definition of Basic Concepts: Delineating the Research Subject and Establishing the Scope of Discussion on Practical Issues

1. Legal Classification Challenges for Unmanned Logistics Delivery Vehicles

Current laws do not contain specific regulations for low-speed unmanned logistics delivery vehicles; they are neither classified as ordinary motor vehicles nor considered traditional mechanical equipment. Under the *Road Traffic Safety Law*, while such vehicles formally meet the characteristics of motor vehicles, they cannot satisfy mandatory requirements such as registration, licensing, and compulsory traffic insurance. Inconsistent regulatory approaches across regions and an ambiguous legal classification directly give rise to practical disputes regarding the burden of proof, principles of liability, and the determination of liable parties.

2. Defining the Scope of the Study

While some localities have enacted regulations governing the operation and insurance of autonomous delivery vehicles, there is a lack of uniform standards at the national level. This study focuses on the scope of operators' liabilities, delineating the boundaries of the analysis to avoid overly broad conclusions[7].

B. Addressing the Burden of Proof Challenge: Analyzing Legal Contradictions by Combining the Principles of Fault-Based Liability and the Duty of Care

1. The Burden of Proof for Victims Under the Fault-Based Liability System

Under the principle of fault-based liability, victims must prove that the operator was at fault. Key evidence—such as autonomous vehicle operation logs, maintenance records, and algorithm-based dispatch data—is held by the operating company. Victims lack access to this evidence, resulting in a significant disparity in the parties' ability to present evidence and making it difficult for victims to prove their case when seeking redress.

2. Conflicts in Judicial Rulings Arising from the Lack of Standards for Safety Obligations

Current laws do not specify the exact standards for operators' safety management obligations, and the performance standards for equipment maintenance and remote risk monitoring remain unclear. Judicial practice often struggles to determine whether operators have fulfilled their safety management obligations, and the lack of uniform judicial guidelines leads to conflicts in the application of the law[8].

C. Addressing Conflicts of Liability: Analyzing Obstacles to Adapting Self-Driving Cars to Special Scenarios Based on the Four Elements of Tort Liability

1. The Basis for Assessing Liability Under Traditional Tort Law

Traditional tort liability centers on the conduct of natural persons and subjective fault[9]. Autonomous delivery vehicles operate independently based on algorithms; when an accident occurs, there is no person on-site controlling the vehicle, and remote safety officers perform only monitoring functions.

The law does not explicitly stipulate whether their inaction constitutes negligence under tort law.

2. Limitations of Applying Traditional Liability Rules

Directly applying traditional tort adjudication rules to handle liability cases involving autonomous vehicles presents significant challenges. Since there is no driver in the traditional sense involved in such accidents, the courts find it difficult to establish fault arising from the operation of algorithms and the corresponding causal relationship; the existing liability framework struggles to address disputes arising from new technologies[10]. Although some scholars have proposed applying the doctrine of "high-risk liability" as a reference, no unified judicial consensus has yet been reached.

D. Addressing the Dilemma of Ambiguous Responsibility: An Analysis of the Institutional Roots of Unclear Roles Among Supply Chain Actors

1. Current State of Differentiation Among Key Players in the Autonomous Vehicle Industry Chain

The division of labor within the autonomous logistics industry chain has become increasingly specialized, with research and development, manufacturing, algorithm operation and maintenance, and actual operations handled by different market entities. Issues such as algorithmic flaws, equipment quality, and operational maintenance problems may occur in combination, leading to overlapping lines of responsibility.

2. Lack of Clear Liability Boundaries Leads to Shifting of Blame in Practice

Existing laws primarily regulate the product liability of manufacturers and sellers, while the standards for determining fault and the boundaries of liability for new types of entities—such as algorithm service providers and operations and maintenance platforms—remain unclear. Following an accident[11], these entities are highly prone to shifting blame onto one another: operators claim the fault lies with algorithmic defects, while R&D teams argue that the issue stems from improper operations and maintenance. This makes it difficult to assign responsibility and is the institutional root cause of confusion in judicial determinations.

Unmanned logistics delivery vehicles face practical challenges in terms of legal characterization, rules of evidence, application of liability principles, and the allocation of responsibility within the supply chain. Clarifying these issues will lay the theoretical foundation for establishing rules of fault determination tailored to intelligent delivery devices.

Measures to Improve the Determination of Liability for Negligence on the Part of Operators

With regard to infringement disputes arising from algorithmic recognition errors in unmanned logistics delivery vehicles, there is no need to pursue specialized legislation; such issues can be addressed through legal interpretation within the existing framework of tort liability under the Civil Code. Research on autonomous passenger vehicles and aerial drones provides valuable insights, but given the differences in risk levels and operating scenarios between these vehicles and low-speed ground-based unmanned delivery vehicles, their approaches cannot be directly applied[12].

A. Optimize the rules for the allocation of the burden of proof and establish a mechanism for presuming causation in algorithmic infringement cases

The "black box" nature of algorithms creates an imbalance in the status of evidence between the parties. Since key materials—such as algorithm logs and device operating parameters—are effectively controlled by the operator, victims face practical difficulties in proving causation under the traditional "he who asserts must prove" rule. A tiered burden of proof approach could be considered, moderately adjusting the burden of proof based on the principle of fault liability and introducing a mechanism for presumption of causation. It should be noted that relevant theories are primarily aimed at high-risk autonomous passenger vehicles; when applied to unmanned delivery scenarios, adjustments should be made to account for their specific risk characteristics, and existing solutions should not be directly applied.

During litigation, the victim need only prove that the damage actually occurred and that there is a preliminary link between the damage and the operation of the autonomous delivery vehicle's algorithm to shift the burden of proof to the operator. The operator would then be required to submit algorithm operation records and original accident materials to demonstrate that there was no negligence on its part in the operation and maintenance process. If the operator refuses to submit key evidence without just cause, a causal relationship between the algorithm's recognition error and the resulting damage may be presumed, thereby alleviating the burden of evidence collection on the victim.

B. Refine the standards for interpreting the security obligations of operators regarding algorithm maintenance and real-time monitoring

Currently, the judiciary mostly relies on general provisions regarding the duty to ensure safety when

adjudicating such cases, and there is a lack of specific criteria for evaluating operators of unmanned delivery services[13]. In the absence of specific legislation for the time being, the content of these obligations can be elaborated through interpretation based on the provisions of the Civil Code. The safety obligations of operators can be broadly divided into three dimensions: pre-operation, during operation, and post-operation. These include completing real-world scenario testing before an algorithm model is deployed; implementing remote monitoring during vehicle operation to promptly intervene and address any anomalies detected by the algorithm; and fully retaining algorithm operation logs after an accident to preserve evidence for tracing liability. If an operator fails to fully fulfill the aforementioned operational maintenance and monitoring obligations, it may be deemed to have acted negligently. This provides an objective reference for judicial determinations of unlawful conduct and alleviates the conflicts arising from the application of traditional tort rules to smart devices.

C. Clearly define the boundaries of responsibility between the operator and the algorithm developer

In a multi-tiered supply chain model, it is common for parties to shift blame onto one another following an incident, and in practice, there is often confusion regarding the scope of liability between the operator and the algorithm developer. The approach to distinguishing liability in drone logistics infringement cases provides some guidance, but since the risk scenarios differ, it cannot be directly applied[14].

The operator leads actual commercial operations and holds authority over vehicle dispatch; it primarily bears liability for negligence during the algorithm's implementation phase, such as oversights in pre-launch reviews, deficiencies in daily operations and maintenance, or delays in remote response. If the root cause of the damage lies in inherent design or recognition defects in the algorithm, liability should fall on the algorithm developer. External victims may directly claim compensation from the operator; after the operator has paid compensation, it may seek recourse internally from the at-fault algorithm developer in accordance with the cooperation agreement, thereby distinguishing between external tort compensation and the allocation of liability within the supply chain[15].

D. Specify the statutory grounds for reduced or exempted liability in cases where the operator is solely at fault

To prevent the operator's liability from being unduly expanded, reasonable boundaries of liability should be established. In cases where the operator is solely at fault, if the damage is primarily caused by the victim's intentional act or gross negligence, the operator's liability may be mitigated in accordance with the relevant provisions of the Civil Code. If an incident is caused by a third party's malicious tampering with algorithms or unforeseeable extreme environmental conditions that interfere with detection, and the operator has fully fulfilled its operational and maintenance monitoring obligations, the operator may be exempted from tort liability. The conditions for applying liability reduction and exemption should be interpreted strictly to prevent operators from using these provisions to evade their statutory safety obligations.

E. Unifying Judicial Standards for Rulings on Infringement Cases Involving Unmanned Delivery

Regulations in pilot programs across different regions vary, leading to inconsistencies in judicial rulings. In the absence of specific legislation, key points for adjudicating such cases can be clarified by issuing guidelines and compiling representative case law. When determining whether an operator is at fault, courts should focus on whether obligations such as algorithm testing, real-time monitoring, and data retention have been fulfilled. This approach will help standardize judicial reasoning, reduce discrepancies in rulings for similar cases, and alleviate the confusion caused by differences in local pilot program rules[16].

Conclusion

When unmanned delivery vehicles cause personal injury due to algorithmic recognition errors, determining the liability of the operating entity faces three structural obstacles: conflicts in the application of liability principles, the "black box" nature of algorithms severing the chain of causation, and a mismatch of rights and responsibilities among supply chain entities. Traditional tort law, which centers its assessment on human behavior, is difficult to apply directly to scenarios involving autonomous algorithmic decision-making.

Our research proposes that these challenges should be resolved within the framework of fault-based liability through legal interpretation rather than specialized legislation: establishing a mechanism for presuming algorithmic causation to balance the burden of proof; specifying the operator's safety obligations regarding algorithm maintenance and real-time monitoring, thereby transforming them into actionable standards for determining negligence; clarifying the boundaries of liability between operators and algorithm developers by focusing on risk control capacity and

profit attribution; and simultaneously defining circumstances for reduced or exempted liability to prevent the undue expansion of liability. By unifying judicial standards through guiding cases, it is possible to provide remedies for victims without stifling technological innovation, thereby providing institutional safeguards for the orderly development of the autonomous delivery industry within the framework of the rule of law.

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