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ROAD ACCIDENTS INVOLVING AUTONOMOUS VEHICLES: QUESTIONS OF MECHANISM

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Abstract

Transport is a multicomponent human-machine system that comprises multiple subsystems. Transport as a system comprises (a) machinery; (b) information; (c) situation; and (d) operator. This research is an attempt to model the mechanism of road accidents involving autonomous vehicles (AV) in order solve several problems of criminology, forensics, and criminal law; to that end, the authors use the existing theory on the mechanism of traffic crime. The latter is a far broader concept in criminology than it is in criminal law. The concept covers multiple sociopsychological phenomena and describes safety-compromising interconnection and interaction of the constituents of a human-machine system. These phenomena are objective and do not depend on how crime is characterized by word of law. From the standpoint of criminal law, the mechanism of crime specifies the criminological etiology and shows how crime results in legal consequences. This paper highlights the constituents of the crime mechanism involving autonomous vehicles (the vehicle, the information system, and the situation); it describes the essence and the role of each component in the accident etiology. The paper also maps further research of this mechanism on the basis of the so-called AV safety breach map, which includes possible outside interference (tampering with software, meddling with the road infrastructure, etc.).

Keywords: Autonomous vehicle, road accident, accident mechanism, mechanism components, information system, situation

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1. Introduction

Any vehicle that is claimed to be autonomous must contain systems that control the core vehicle controls: braking, steering, gearbox, and fuel supply. Vehicle robotization is an essential and yet the easiest step towards autonomous vehicles.

The next step is to equip cars with instrumentation to monitor the traffic. A driverless car needs cameras to watch the road and stay within the road/lane, to scan the signs, and to recognize traffic lights. It also needs 'vision' to steer itself in the traffic, including a precise global navigation satellite system, an inertial navigation system, a lidar, ultrasonic sensors, and stereo cameras mounted on the front stands inside the cabin. All the systems must be connected to a computer to process the input and control the movement. The computer is also tasked with applying image recognition to the input from the cameras.

2. Problem Statement

Engineering a vehicle capable of self-driving requires a comprehensive approach to the development and implementation of various subsystems. The first step is to design individual automated driving assists as well as automatic controls for some of the vehicle assemblies. The next step is to merge these L1 systems into larger autonomous vehicle control modules. The third step is to create a single module that combines all the assemblies and units present in a vehicle into a single Automated Driving System. The next step is to create a single traffic control system to control vehicle behavior.

Despite all the progress in this industry, many issues remained unresolved. One such pressing issue is the causation and mechanism of road accidents involving autonomous vehicles.

3. Research Questions

Transport is a human-machine system that comprises multiple subsystems. Transport as a system comprises (a) machinery; (b) information; (c) situation; and (d) operator. It is therefore necessary to model the mechanism of road accidents involving autonomous vehicles (AV) in order solve several problems of criminology, forensics, and criminal law; to that end, the authors use the existing theory on the mechanism of traffic crime.

The latter is a far broader concept in criminology than it is in criminal law. The concept covers multiple sociopsychological phenomena and describes safety-compromising interconnection and interaction of the constituents of a human-machine system. These phenomena are objective and do not depend on how crime is characterized by word of law. From the standpoint of criminal law, the mechanism of crime specifies the criminological etiology and shows how crime results in legal consequences.

4. Purpose of the Study

This paper highlights the constituents of crime involving autonomous vehicles (the vehicle, the information system, and the situation); it describes the essence and the role of each component in the accident etiology. The paper also maps further research of this mechanism on the basis of the AV safety breach map, which includes possible outside interference.

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5. Research Methods

The methodology hereof comprises engineering and legal (doctrinal) methods. The proposal is to introduce and substantiate criminal sanctions on the operation of autonomous vehicles on the basis of the identified AV specifications and AV accident mechanism.

6. Findings

For apparent reasons, the mechanism of road accidents involving autonomous vehicles (AV) has not been researched yet, as specialists focused on the mechanism of drivers' crimes (Ishchenko et al., 2014). However, with the ever-larger scale of AV development and adoption coupled with AV-involving road accidents (RA) that are already happening (Chuchayev & Malikov, 2019), this becomes a pressing issue to research.

In general, accident is a subject matter of multiple disciplines. For instance, forensics studies the forensic mechanism of road accidents or human as a source of danger (Korma, 2006). Nevertheless, all authors recognize a road accident as an event. This interpretation emphasizes road accidents as a cause of further criminal procedure. However, it fails to disclose the essence of this phenomenon. Besides, accident alone does not necessarily result in a criminal procedure, since the latter require filing a case. The case is the legal fact that actually triggers a criminal procedure. Secondly, criminal law does not use the concept of the subject matter of criminal justice response; instead, the term it uses is 'act'.

Traffic accident is recognized as an event in criminal law literature; however, the interpretation is different. Road accident is defined as "an event that disrupts traffic, results from the loss of control over a vehicle, and is associated with human toll and damages." (Lukyanov, 1983, p. 34). Without criticizing this definition (in particular the fact that it incorporates loss of control, i.e., a timeframe of uncontrollability, etc.), we'd like to note that (a) it interprets a road accident as a traffic disruption, and (b) renders it as an umbrella term that incorporates traffic crime.

In criminal law, accident as such has no significance; in the crime-accident relation, crime is a part and accident is the whole. In other words, criminal law highlights the relations between the combination of circumstances (or elements of a single object) and the linkage that unites such circumstances and complements their combination with new, integrative properties and patterns that are not inherent in such circumstances in their diversity. With this in mind, it seems acceptable to investigate the mechanism of accidents as the basis for further research of the mechanism behind AV-involving traffic crimes (so far, Russian criminal law does not identify such acts).

In criminology, traffic crime mechanism is interpreted as the interaction and interconnection of the driver and the machinery/information/situation (external factors), all of which determine the driver's behavior and cause a violation of traffic rules (Belokobylskiy & Chuchayev, 1991).

Traffic crime mechanism comprises the following constituents: the driver, the vehicle, information system, and situation (Shemyakin, 2010). All of them are present in road accidents, too.

All the authors that researched the mechanism of crime in general and the mechanism of traffic crime in particular highlighted the driver (personality) as the core element of such crime. Here, we should mind the definition: an autonomous vehicle is a one that is capable of self-driving.

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In general, 'conventional' vehicles constitute a monocomponent human-machine system, i.e. its objects are involved in all kinds of interaction, but it is human that guides such interaction. Thus, it may seem first that the personality factor is part of traffic crime etiology. The problem is that AVs are essentially designed to be self-driving, i.e. to plot their route and control their speed using data their software receives from the Internet, traffic scans, traffic lights, etc. Humans are only involved in the development of such software. Therefore, traffic safety may be jeopardized before travel if automated systems are not duly developed and tested. That means the personality factor is no longer a part of the traffic crime mechanism, which should be borne in mind when criminalizing the core act: making of poorly programmed software rather than traffic violations.

It should be borne in mind that the manufacturer or the software developer might insist on timely full or partial software updates. Shall the vehicle operator/owner ignore this requirement, then human factor applies as part of the road accident mechanism. Perhaps this should be interpreted as failure to comply with passive safety requirements, which cover the structural, technological, and operating vehicle properties intended to prevent or mitigate road accidents. We believe that this should also be included in criminal law as an independent element of offence.

The information system is a fundamental component of the road accident mechanism (Hamida et al., 2015; Lemann, 2019; Vellinga, 2017). In case of self-driving cars, it functions both as an information system as such, and as a driver. The system ensures that the vehicle operates safely by providing two independent arrays of data: external data, which the driver receives personally while driving by monitoring the information model, the traffic lights, etc.; and internal data stored in the memory. The information system assists the safety 'hardware', i.e. fully operational assemblies and components, to ensure that the vehicle operates normally. This is why the theory of reliability identifies two aspects of accident-free transport operation: hardware and software. Software-associated safety stems from error-free condition of software and other data arrays, which enables the vehicle to operate as required given the circumstances and data array parameters specified in the data sheets (Ljungholm, 2019).

The information system of an AV can fail as a result of:

(1) data-associated failure, an event that consists in hardware malfunction arising from errors in data arrays that resulted from incorrect data collection or the use of hardware reliant on such data;

(2) loss of data due to hardware failure;

(3) data error due to incorrect interpretation of, for example, traffic lights. Experiments have shown that traffic sign scans might contain errors that will jeopardize further decision-making.

For the etiology of traffic crime, the so-called uncertainty is of utmost significance; the terms refers to a specific state of the information system arising from external circumstances such as change in weather, intransitive behavior of the operator, etc. Uncertainly is classified into three types: (1) uncertainty of the situation, in which the system needs to make a decision; (2) uncertainty of the requirements to be followed in decision-making; (3) uncertainty or randomness of the decision itself. This applies to autonomous vehicles, too. In that case, uncertainty of the situation is particularly important, as it exists objectively and stems from multiple circumstances including incomplete data on external influences, natural limitations, the properties of car systems and assemblies, etc. This uncertainty is descriptive of the situation that led to a traffic accident.

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Scientifically, the concept of situation remains disputable; researchers continue to debate not only the definition, but also the properties of situation (Dubovik, 1977). We believe that a road accident situation should be defined as the total of objective external circumstances, under which autonomous vehicles operate. Different types of situations are essentially different combinations of such circumstances.

Criminologists identify three properties of situation: criminogenesis, cumulative, and conflict (Dubovik, 1977). Strictly speaking, these properties do not apply universally. That is easy to see by analyzing neutral situations, even more so by investigating obstructive situations. In other cases, only some constituents of a situation will be criminogenic. Besides, being a dynamic process, the situation can in fact mitigate some of the hazards.

We believe that the situation properties are as follows:

(1) specificity: a situation exists within a specific spacetime rather than universally;

(2) systematicity and reproducibility, which enable defining the situation in the future by applying gnosiology and logic. However, it should be borne in mind that a situation does not reoccur in full; rather, only its general pattern reproduces itself in future situations. In other words, there arise the so-called relative situations;

(3) informativity, i.e. the ability to carry sufficient information on the actual status of the environment;

(4) the ability to capture the factors that could be further used to prevent adverse outcomes.

7. Conclusion

The development and adoption of autonomous vehicles, on the one hand, calls for advanced research of AV-involving road accident mechanisms to solve some potential problems of criminology, criminal law, and forensics; on the other hand, this is a challenging issue unless there is made an AV safety breach map that will also cover possible outside interference including tampering with the software or meddling with the road infrastructure, etc. We believe that in the current state of the art, focus should be made on researching the accident (crime) mechanism in general, further joining forces with AV design and engineering specialists to see which roles the AV components have to play in crime etiology.

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