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European Nations Approach to Autonomous Vehicle Liability

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Abstract
Autonomous vehicles (AV) are considered alternative to conventional cars with overwhelming safety and mobility potentials. However, discrepancies in laws addressing auto-crashes involving AV in different countries, especially EU-Member States, makes the uptake of these cars on a global scale rather problematic. This paper examines current legislation addressing the use of AV in EU-Members States with key emphasis placed on parties that could be held responsible in different case scenario in an event of auto crash involving these vehicles. Also, different European laws relating to autonomous vehicle liabilities were compared. A technological solution was proffered in tackling the AVs liability. Additionally, stakeholders' involvement, including end-users, in investigation and decision-making involving AV crashes was also hinted as a possible option in advancing vehicle automation and formulating feasible laws addressing adverse events of these vehicles.

Introduction

Background of study

Hitherto, self-driving cars were once perceived as a fiction in science books and movies. However, with the advancement of technology, this imaginary idea has become a reality in our today's world. Self-driving cars are seen as computerised vehicles that require little to no assistance of humans in order to operate. They chiefly rely on aggregate of sensory devices and data sources to power the vehicle [1]. While approximately 94% of auto crashes in the United States of American have been found to be linked to human errors [2], self-driving cars have shown promising outcomes in terms of reducing auto crash from human-mediated errors [3], and improving the efficiency of most urban road networks

Despite the promising benefits of self-driving cars, it has its own challenges, some of which include the security and safety concerns of the technology [4,5]. More than 30 accidents have been recorded involving autonomous vehicle (AV) since 2014 [6]. Though these accident figures might not be so alarming, the absence of a well-agreed AVs regulation, particularly the discrepancies in laws around the liability of these vehicles in different countries will cause a major stir in solving the issue of vehicle liability.

The Society of Automotive Engineers published a new standard (J3016) of regulating vehicle automation. Based on this standard, vehicles can either be classified into six (6) levels of vehicle automation starting from level 0 –5 [7]. In level 0, there is no driving automation, level 1 consists of driver assistance while level 5 means the vehicle is in full automation. In this scope of study level 2 – level 4 will be investigated. Level 2 and Level 3 involves partial automation and conditional driving automation. Level 4 is known as highly automated vehicle.

Research Problems

Major technological advancement has occurred in the field of automation over the past decades, such as inventions on Advance Driver Support Systems (ADAS) and vehicle automation leading the way. With the increasing use of self-driving in our road today, major concerns on who bears the liability (Blame attribution) should an autonomous vehicle of level 2 – level 4 automation cause an accident. This is particularly interesting in the European Union member nations where legislation around self-driving differs among countries.

Aims

The Autonomous Vehicle (AV) is seen as the next big industrial revolution. It is set to bring a change to the traditional human driven vehicle system by increasing mobility and reducing number of accidents that occur. Self-driving car is regarded as an autonomous vehicle which requires little to no assistance of humans to sense and operate in the environment. This car

technology is being aided by sensory tools for adaptation and movement. With these sensor technologies road travel could be made safer [8].
Computers are fixed by programmers and hardware technicians and there is a high chance that these devices might act up due to the software's embedded in it. So, why should an AV be trusted to keep humans safe when it is on the road? Moreover, AVs were made to lessen bad driving pattern of humans and reduce the amount of accident occurrence. Though with the complication of the software in these vehicles they could faulter and result to accident problems. The first accident that occurred with an autonomous vehicle was as a result of a software issue where the vehicle did not see the pedestrian on the road and eventually knocked out the individual which resulted to a loss of a life [9]. Due to the accident that occurred assigning of blame was difficult because the vehicle was a test-driving autonomous vehicle. In the context of this paper, the aim is to review the legal discrepancies on autonomous vehicle among European Union member nations. Emphasis was placed on the shortcomings of existing laws and possible recommendations.

Research outcomes

What is gotten from this paper according to the research problem – **who could be held liable for an autonomous vehicle crash** are:

i. Existing liability laws among European Union member nations
ii. Technological solution in tackling AV liability
iii. Possible suggestions on the design of future autonomous vehicle
iv. Stakeholders' involvement in decision making on autonomous vehicle regulations

Benefits and Significance

Auto crashes are somewhat inevitable events only limited by occurrence, legal laws (in form of liability) addressing such events goes a long way in remedying the cumulative damage. Owing to different classifications of autonomous vehicles, such as partial and fully automated vehicles, the appropriate liability law addressing auto crashes involving partial automated vehicles remains important. Thus, not only would the right penalties be imposed on defaulters, but it would also comply car manufacturers to critically revise futuristic autonomous vehicles design to accommodate the interest of both end-users and insurance companies.

Methodology

A systematic review method was used to examine and study relevant literature. The key research question guiding the study is liability of Autonomous vehicle crashes. In tackling this problem, first, the levels of automation and individuals involved in liability was identified. Next, research was made on some papers highlighting some European nations law on liability of AV accident. Based on these findings, research will be done revealing technological solution to help solving the issue of liability in autonomous vehicle. Once done the stakeholders will be informed on the relative findings and technology.

Literature Review

Self-driving cars are being designed in effort to reduce, minimize car accidents, reduce traffic and lower carbon emission to save the environment. In conventional car accidents, the driver

is in complete control of the vehicle and therefore he is held liable [10]. However, with autonomous vehicles, the driver (humans) is not fully in control of the vehicle and shouldn't be held liable. Per se, all or some of the liability could be transferred to the Autonomous vehicle. The issue of who should be held accountable in auto crashes involving autonomous vehicle remains debatable [11]. There is no clear legal framework for allocating liability among parties involved [11].

Society of Automotive Engineers [7] classify vehicle automation in five levels ranging from Level 0 – Level 5. In Level 1 (assisted automation) and Level 2 (partial automation) the task is performed by humans. From Level 3 to Level 5, all driving tasks are executed by the autonomous driving system. At level 3, the humans should control the vehicle occasionally, this is called conditional automation. Level 4 and 5 are classified as fully autonomous mode. Level 4 has to do with high automation while level 5 deals with full automation. Only at level 5, it is expected for the vehicle to drive itself under all environmental conditions [12].

Legal rules relating to self-driving cars:

When an individual is injured due to a crash instigated by an autonomous vehicle, finding who is responsible depends on the cause of the collision. Legal liability can be split into three parts namely, administrative liability, civil liability and criminal liability [13]. Administrative liability is a branch in English law that deals with tort liability of public entities. On the other hand, criminal liability is primarily concerned with determining who is legally accountable in the event of an accident, it also addresses concerns such as cybercrime and hacking. For example, in 2015, a Jeep Cherokee automobile was hacked, exposing the vulnerability of this computerised vehicle [44]. Some researchers were able to remotely hack this automobile and disable its brake system, resulting in an accident. This further pose security concerns t to vehicle makers, demonstrating how vulnerable this mechanism is. Furthermore, with this type of catastrophe, certain European Nation countries' penal codes are based on the concept of personal responsibility and would undoubtedly require revision. While civil liability is a type of legal liability whereby payment is made to the aggrieved victim due to violation of a civil law or tort. A study published in a German insurance journal, two techniques that could help to establish clear liability guidelines for AVs and insurance coverage were discussed [45]. The first method emphasises the importance of mandatory motor insurance under the strict liability regime, which requires AV producers to contribute a percentage of the insurance for each vehicle. According to the second approach, manufacturers should be held accountable for injuries and damages caused by the way their products acted, as well as their failure to act.

Due to the nature of this research problem, civil liability would be selected because it helps in attributing blame. Civil liability can be divided into three areas which are,

i. Owner / operator liability
ii. Manufacture liability
iii. Insurance liability

In the context of Level 3 or a Level 4 AV, if an accident occurs, the humans should be able to control the vehicle occasionally. However, this is not always certain since the takeover technique from the AV remains unpredictable raising the fundamental question of who should be blamed should a self-driving car with a Level 3 or Level 4 automation cause an accident on its own? Addressing this issue is rather complex, one that borders on conflicting national laws of European Union member states.

French Law:
The French legal system that deals with accident liability called “Loi Bandinter” was passed mainly to compensate victims of road accident, AV crash victims inclusive. The basis of this law is that auto crash victims are permitted to claim compensation from the driver or even the owner of the vehicle [14]. Also, it helps the victim get swift compensation without bottlenecks. Here, it is not necessary for the victim to prove that the AV caused the incident, simply, the liability is placed on the owner or the driver of the vehicle [15]. As a result, the Loi Badinter is regarded a no-fault liability regime, as the conduct of the driver is irrelevant.

German Law:
The Germans on the other hand, have a bit strict law on liability like the French law. According to this law, the driver and the owner is liable for harms caused by the vehicle when in operation unless proven otherwise [16,17]. In this case both the owner and the operator are jointly liable for the accident, but the keeper could be exempted from liability if proven that the damage was not caused by her intentionally or negligently. However, this law was later amended in 2017 to mandate the installation of an Event Driven Recorder (EDR) to record the vehicles trip and to be used to determine auto crashes in autonomous vehicles [18,19]. This modified law was created to allocate liability in autonomous vehicles, thereby striking a balance in liability between the manufacturer and the driver [20].
United Kingdom Law:
In the United Kingdom, a different method of liability was implemented, with the strict liability doctrine adopted by France and Germany being excluded in favour of a system based on the driver's duty of care, whereby there is a mandatory insurance system in place [21]. There is not much difference with the other continental systems mentioned above. In this case, the third-party motor insurance has a huge impact on the cases of the outcomes [22]. The insurers are liable for death and damages caused by the insured AV vehicle [23]. However, if the AV owners are found to be at fault through the laws put in place, the insurance company is partially liable. This law helps the victim get faster compensation [24].

European Union Law:
Moreover, in the European Union (EU), the legal framework to include AV-related liability and its insurance risk has not been amended, although it is looking into potential solutions to liability matters. The GEAR 2030 was established by the European Commission (EC) in 2016 to investigate for AV-related problems. Around May 2016, the members of the European parliament urged the European Commission (EC) to establish a required insurance plan and an accompanying fund to ensure full compensation for AV accident victims [25].

To address the issue of liability, a proposed technology solution, Event Data Recorder (EDR), was proposed to help the insurance company investigate who is responsible for the crash if the blame is fixed on the insurer. EDR is a device planted in the car that records the vehicle data seconds before and after a possible crash. Also, it is equipped to record near-crash experience.

Liability issues with autonomous vehicles are mostly caused by the following factors:

Operator/owner of the AV:
The operator is someone who utilises the self-driving vehicle, hence plays major role in an AV accident [26]. Inadequate user experience places an operator of AV at a position where they could be held liable for adverse events. Hence accidents involving self-driving vehicles are

covered under the vehicle owner's strict liability, as in most European countries' strict liability regimes where AV crashes are cover under the car owner's obligation for accidents [27].

Manufacturer of the AV:
While the overall number of accidents is predicted to decrease, a significant shift in liability to the manufacturer is expected. In the argument over culpability, putting liability on the producers of new AV equipment has gotten the wide support which stems from the fact that these companies are solely responsible for the final design of AV [28, 29]. Malfunction in Automated vehicles could arise due to programming flaws or system failures, thereby implicating numerous parties involved in the block chain production of AV [30]. Product liability law binds the vehicle (and component) maker for design, manufacturing, and instruction flaws. Based on this law, car accidents caused by automated vehicles will solely be blamed as a product failure, clearing drivers of AV of any negligence charges.

Technological Solution in tackling AV liability

Studies have been conducted on various fronts to link autonomous liability to the rightful individual. The EU proposed that a compulsory third-party insurance will help in accompanying fund to ensure full compensation for AV accident victims. Technological solution, such as an Event Data Recorder (EDR), remains a welcoming approach for insurers as it helps in apportioning liabilities.

Event Data Recorder (EDR)
Though vehicles are a way of transportation, they are prone to accidents in a variety of ways. The mandatory inclusion of EDR, just as the black box in airplane, would not only help apportion liabilities but help manufacturer in designing safer generations of AV , ones that would base on investigations into auto crash of present day AV [31, 32]. The concept of EDR is in line with the NHTSA’s recommendation that in the event of a crash or a significant loss of vehicle control, the self-driving test vehicles should record data from the vehicle sensors, including the sensors monitoring and diagnosing the functionality of the autonomous vehicle [33].

The concept of equipping automobiles with EDRs is based on the similar concept used in airplanes to monitor and investigate crashes, the Flight Data Recorder (FDR). The FDR simultaneously records the various operating tasks of a plane such as airspeed, altitude, time, and heading [34], providing investigators with holistic information to probe into air crash in more details. This could be equally valuable if fitted in AV as it would allow for a more detailed investigations into autonomous vehicle accident.
Most of the time drivers of AV might frequently skip their concentration whilst driving since the vehicle requires little or no human input to drive, unlike the drivers in the regular automobiles. The data collected from the EDR could provide a more detailed information of the cause of the crash, hence giving insurers edge in an event that the crash was solely or partially from human error. There are two types of EDR which could help in this regard, they are:

Accident data recorder (ADR):
This is a type of event data recorder which capturers a great deal of information at a very high resolution. The ADR gather information from many components of the vehicle which include the speedometer, accelerometers, input channels, such as, emergency lights, brake lights and siren for emergency vehicles and records it in its integrated sensor system. The ADR system

saves 45 seconds of data captured: the last 30 seconds leading up to the accident, and the last 15 seconds following the event. This type of EDR is commonly used in Germany to record accidents [35]

Video Event Data Recorder (VEDR):
VEDR is also a type of EDR which can be used to record video images. VEDR is implanted on the windscreen of a vehicle, which can record both the images and data before and after the crash, providing a better knowledge of the situation. This technology is installed on many public transport vehicles and could be used to decide accident cases in court. VEDR can also be classified as dashboard cameras which have the resources to capture the front view of the car, the rear view of the car and the inside cabin view that could be used for recording driver and passenger behaviour [36]. The VEDR technology is used in Italy for crash investigation. [35].

Result and analysis

The table below shows the effective use of technology to tackle the legal liability issues of an autonomous vehicle. This liability span from the owner or the operator of an AV to the Manufacturer of the AV.
Table 1. Technological way of tackling legal liability

		Blame attribution	
	Technological Solution	Owner/Operator	Manufacturer
	Accident Data Recorder	*	*
	Video Data Recorder	*	

* indicates whom should be held responsible for liability in case of auto crash.

In the above table, the Accident Data Recorder could be used to attribute blame to both the Owner and the manufacturer of the vehicle. Also, the Video Data Recorder can be used to attribute blame to only the Owner or operator of the vehicle.

Identified gaps in literature
Major research has been done on autonomous vehicle liability and how the liability could be attributed rightfully, but there are some identity gaps which have not been rectified. Below are some areas where future work could be done.

There is no clear legal structure that explains how liability is divided amongst third parties involved in the creation of AV systems – the supplier, the software operator or the software provider which makes it harder to identify and separate the numerous components leading to the issue [36, 37]

Accidents resulting from design and production failures are increasingly putting manufacturers' reputations at risk [38, 39]. The present legal law does not clarify the practical and moral obligations of software programmers in constructing algorithms that determine life or death decisions which raises a slew of ethical questions about AVs. [40, 37]. Consensus on legal framework in addressing the decision-making criteria used by algorithms in the event of an accident are still lacking.

Also, these autonomous vehicles can also get disrupted by cyber hackers through one of the various electronic components of the vehicle. The information-entertainment system is one of the electronic components that has been known to be hacked in the past [41] also and that of Bluetooth [42] and cellular network connectivity [43]. The European nations are yet to develop a regulatory framework to ensure AV is safe from malicious actors.

Suggestion for future solutions

Based on the above-mentioned liability and technological solutions, some key recommendations are put forward to the government, car manufacturers, consumers, and researchers

The adoption of legal framework in all EU Countries which requires a compulsory insurance plan and accompanying funds to ensure full compensation is given to AV accident victims. By allowing liability to be solely covered by the insurer and not the manufacturer of the AV or the owner of the AV would speed up the process of compensation to the accident victim.
Also, the EU should implement a compulsory Event Data Recorder (EDR) in future AV designs, this could help in pining liability to the right party involved in the cause of the car crash and avoid the abuse of insurance privileges.
Since AVs are fitted with sophisticated hardware and software devices for mobility, this makes them potential targets for cyber-attacks, hence research to better protect these cars from such threat is highly recommended.

As the legislative and legal stance around product responsibility and autonomous vehicles evolves, manufacturers should be properly informed about impending legislation and regulatory requirements of AV, this will enable them design new AV to meet the legal expectations. The regulatory issues are predicted to serve as a direction to which AV models and technologies make it to the market.
Legal and technical departments must align to ensure that new generations of AV entering the market meets regulatory standards. For example, during the production of a Level 3 AV, the manufacturer is advised to ensure that the sufficiency of the automated warning system and interface would encourage the operator to resume control of the vehicle because this could be a problem that will undoubtedly arise in product liability claims. Also, AV may seek to design technology that includes override alternatives like manual handling in order to minimise manufacturer liability because it will be easier in the law court to prove contributory negligence in the event of a crash in scenarios where drivers interact and are able to control the car.

While AV technology have a lot of promise, it will be crucial to make sure that the consumers expectation do not surpass the technology's capabilities. At some point in the future fully autonomous vehicle will be implemented. But for now, the human driver will remain an integral aspect in the control of the AV. Some drivers may misuse this technology; thus, it will be critical to enact special laws penalizing drivers' misconduct whilst using these vehicles. The car makers should invest more on research and educating end-user on the safe use of their products.

Final outlook and Conclusion

Autonomous vehicles have the potential to change the way people travel and improve road safety. While these vehicles will be mainstream within decades, accident, which is an inevitable event, will continue to plague their progress and liability around such must be resolved. This paper identifies the major participant in autonomous vehicle liability and the current liability laws in some European nations. The present liability law in some European countries will not be able to fairly assess blame to the entity who cause the accident. Also, possible suggestion such as allowing AV liability solely to be on the insurer in order to facilitate payment for the victim of the crash was proposed. A technological solution, such as equipping the autonomous vehicle with an Event Data Recorder (EDR) technology which helps the insurer to trace and decide on who is liable between the owner of the autonomous vehicle or the manufacturer was also emphasized. The legislators of the European states must act quickly because uncertainties over the legal issues of AV may impact the uptake of these vehicles.

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