LIABILITY OF SELF-DRIVING CARS: CHALLENGES AND PROSPECTS IN THE ERA OF AUTONOMOUS VEHICLES

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ABSTRACT

Every day, road accidents caused by human errors result in countless injuries and fatalities worldwide. Factors like distracted driving, impaired judgment, fatigue, and recklessness contribute to a significant portion of these incidents. Self-driving cars, equipped with a sophisticated array of sensors, cameras, and advanced algorithms, have the potential to drastically reduce the occurrence of such accidents. Unlike human drivers who may become fatigued or distracted, autonomous vehicles maintain constant vigilance, monitoring their surroundings and making split-second decisions based on real-time data. This capacity to consistently adhere to traffic laws, maintaining safe distances, and anticipate potential hazards offers a promising solution to the issues of human fallibility. Despite, the advantages deployment of self-driving cars also raises critical questions regarding liability and responsibility in the event of accidents or incidents. Self-driving cars, while promising, present a range of challenges like Malfunctions, sensor errors, and system failures might occur, leading to accidents or vehicle shutdowns. Ethical dilemmas can arise when programming AI to make life-or-death decisions in accidents. It is also complicated the determination of responsibility in case of accidents involving autonomous vehicles. Job displacement is also a concern, and regulatory frameworks struggle to keep up with evolving technology. Additionally, cybersecurity vulnerabilities could expose vehicles to hacking, raising questions about data privacy and overall system integrity. Hence, there should be some proper legal policy and regulations to face these difficulties. So, this research paper provides an overview of the evolution of autonomous vehicles and the levels of automation of self-driving car systems. Subsequently, it examines the diverse stakeholders involved in the development, manufacturing, and deployment of autonomous vehicles. An in-depth analysis of the legal framework governing self-driving cars in different jurisdictions. Furthermore, we examined the case studies and real-world incidents to understand the practical application of liability principles. The paper concludes by proposing potential solutions and recommendations to address liability concerns surrounding self-driving cars. It discusses the importance of establishing standardized regulations that foster innovation while ensuring public safety. Overall, this research paper contributes to the ongoing debate on the liability of self-driving cars, aiming to shed light on the challenges and opportunities presented by autonomous vehicles and to assist policymakers, industry stakeholders, and the public in responsibly and safely navigating this transformative technology.

KEYWORDS

Self-driving cars, Liability, Safety regulations, Ethical dilemmas, Insurance implications.

I. INTRODUCTION

Self-driving cars, also known as autonomous vehicles, have brought significant advancements in transportation technology. They promise safer, more efficient, and convenient commuting experiences.

However, their introduction also raises complex legal and policy issues that need careful examination. Imagine driving in your self-driving car, surrounded by other vehicles. Suddenly, a heavy object falls off a truck ahead, leaving your car with little time to react. The self-driving car faces a moral dilemma, hit the object, swerve into an SUV, or swerve into a motorcycle. Programming the car to make such decisions can raise ethical concerns about prioritizing safety, minimizing harm, or making unbiased choices.

Although self-driving cars are expected to reduce accidents, accidents can still occur, prompting the need for decisions made in advance by programmers or policymakers. However, defining general decision-making principles like "minimize harm" becomes challenging when faced with complex scenarios. For example, if there are two motorcyclists, one wearing a helmet and the other without, who should the car prioritize?

Such scenarios [1] illustrate the ethical complexities of creating algorithms that may inadvertently discriminate against certain objects or individuals. As technology advances, other dilemmas arise, like choosing between cars designed to prioritize saving as many lives as possible or protecting the owner at all costs. These thought experiments aim to stress test our ethical intuitions and prompt discussions about who should be responsible for making these decisions - programmers, companies, or governments. For instance, In the event of an accident involving a self-driving car, who is legally responsible? Is it the vehicle manufacturer, the software developer, the owner, or a combination of these parties? Should manufacturers and developers be held liable if the technology malfunctions and leads to accidents or injuries? Who is accountable if an accident is caused by a software glitch or algorithm error in the self-driving system? How should the responsibility be determined between hardware and software issues? Who owns the data, and how can passenger privacy be protected? What kind of regulations should be established to ensure the safe operation of self-driving cars? How can regulators balance innovation with public safety? How can insurance policies adapt to the unique risks posed by self-driving cars? Who is liable in the event of a cybersecurity breach that leads to an accident involving a self-driving car? With a limited number of self-driving cars on the road, how can legal precedents be established to guide future cases and legal decisions? and many more.

As self-driving cars continue to develop rapidly and they may become more common on the roads in India, it is essential to understand the laws and liability related them. This research paper aims to explore the above legal aspects concerning self-driving cars, including product liability, negligence, regulations etc. By thoroughly studying the current legal framework and analysing real-life cases, the paper aims to highlight the fundamental legal principles that govern liability in autonomous vehicles.

The paper will also look into the different types of liability that could arise with self-driving cars, such as that of manufacturers, developers, vehicle owners, and operators. It will also consider shared liability between human drivers and autonomous systems. And aims to contribute to comprehensive and responsible regulations for self-driving cars.

II. SCOPE AND LIMITATIONS

Scope:
The scope of this research paper includes a comprehensive examination of various aspects related to liability in the context of autonomous vehicles. It aims to cover the following key areas:
- Analysis of the legal landscape and regulations governing self-driving cars in different regions, focusing on liability provisions and relevant laws.
- Exploration of the ethical dilemmas associated with programming autonomous vehicles and their decision-making algorithms, particularly in accident scenarios.

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[1] Patrick Lin, "The ethical dilemma of self-driving cars - Patrick Lin",(https://youtu.be/ixIoDYVfKA0), accessed July 5, 2003.

- Investigation of the roles and responsibilities of different stakeholders [2], including manufacturers, software developers, regulators, fleet operators, and passengers, concerning liability.

- Evaluation of the impact of self-driving cars on the insurance industry, potential changes in insurance policies, and the role of insurers in handling liability claims.
- Consideration of public attitudes, concerns, and acceptance levels toward self-driving cars and their impact on liability issues.

Limitations:

While the research aims to provide a comprehensive understanding of liability in the context of self-driving cars, there are some limitations that should be acknowledged:

- Self-driving cars are still relatively new and are not yet deployed on a massive scale. As a result, there may be limited real-world data available on accidents involving autonomous vehicles, which can impact the depth of analysis for case studies.
- The legal and regulatory framework governing self-driving cars is continuously evolving. Some regions may have recently introduced or modified laws, and the paper may not capture the most up-to-date developments.
- Addressing the full extent of ethical dilemmas related to self-driving car's liability in a comprehensive manner can be challenging due to the multifaceted and subjective nature of such dilemmas.
- Some information related to self-driving car technology and development may be proprietary and not publicly disclosed, limiting the paper's ability to delve into certain technical details.
- Liability laws and regulations vary significantly across different countries and regions. The research may focus on specific jurisdictions [3] and may not be fully applicable or representative of the entire global landscape.
- Interpreting and drawing conclusions from real-world case studies can be complex, as liability determinations may involve intricate legal processes and multiple contributing factors.
- Despite these limitations, the research paper endeavours to provide valuable insights into the liability challenges of self-driving cars and contributes to the ongoing discussions and considerations in this evolving field.

III. SELF-DRIVING CARS: AN OVERVIEW

Self-driving cars are equipped with advanced sensors, artificial intelligence, and complex algorithms, allowing them to navigate and function on roads independently, without human intervention.

The main goal of self-driving cars is to enhance transportation safety, efficiency, and convenience. By eliminating the possibility of human error, which is a major contributor to accidents, these vehicles have the potential to significantly reduce traffic fatalities and injuries. Moreover, they can optimize traffic flow, reduce congestion, and improve fuel efficiency, contributing to a more sustainable and effective transportation system.

Operating self-driving cars relies on a sophisticated combination of technologies, including computer vision, machine learning, sensor fusion, and real-time decision-making algorithms. These technologies enable the vehicles to perceive their surroundings, interpret the information, make informed decisions, and execute complex maneuvers like lane changes, braking, and accelerating with precision.

However, the introduction of self-driving cars raises complex legal and ethical questions regarding liability. As autonomous vehicles function without direct human control, determining responsibility in the event of accidents or incidents becomes challenging.

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[2] Stakeholder," A stakeholder is a party that has an interest in a company and can either affect or be affected by the business, examples are its investors, employees, customers, and suppliers.",(https://www.bing.com/search?q=A+stakeholder+is+a+party+that+has+an+interest+in+a+company+and+can+either+affect+or+be+affected+by+the+business%2C+examples+are+its+investors%2C+employees%2C+customers%2C+and+suppliers."&cvid=f30518268e2445edbe9b4f8775231f3d&aqs=edge..69i57j69i64.283j0j9&FORM=ANAB01&PC=HCTS), accessed July 5,2023.

[3] Jurisdictions," The official power to make legal decisions and judgements.",(https://intuitolegal.com/what-are-the-four-types-of-jurisdiction/#:~:text=The%20term%20jurisdiction%20means%20the%20official%20power%20to,an%20entity%20to%20make%20legal%20decisions%20and%20judgements.), accessed July 5,2023.

In the case of no automation, partial and conditional automation the liability lies upon the driver or the owner of the vehicle. But the conventional concept of driver liability needs to be redefined to accommodate the unique characteristics and capabilities of self-driving cars.

When it comes to liability, multiple stakeholders are involved. Manufacturers and developers bear the responsibility of designing and producing reliable and safe autonomous systems. Depending on the level of autonomy and human involvement, vehicle owners and operators may also share some degree of responsibility. In addition, regulatory bodies and policymakers play a crucial role in establishing comprehensive guidelines and regulations governing the operation and liability of self-driving cars.

The liability landscape for self-driving cars is still in its early stages and varies across different jurisdictions. Legal frameworks and regulations are continually evolving to address the complexities and uncertainties associated with autonomous vehicles. Striking a balance between encouraging innovation and ensuring public safety is of utmost importance when defining liability and establishing a legal framework for self-driving cars. A collaborative effort among stakeholders is necessary to ensure that self-driving technology continues to advance responsibly and safely.

IV. REAL - WORLD CASE STUDIES

There were several noteworthy real-world incidents involving self-driving cars, offering valuable insights into the safety challenges of autonomous vehicles. Notable examples include:

- **Uber's Autonomous Vehicle Fatality (2018)** [4]:
  This case involved a self-driving Uber vehicle [16] that hit and killed a pedestrian in Tempe, Arizona. Determining liability in this incident is complicated and depends on specific details. Potential parties that could be held liable include Uber as the vehicle owner and operator, the test driver responsible for monitoring the vehicle, the vehicle manufacturer if there were defects, and the pedestrian's actions if they were crossing unsafely.
  The investigation into the accident was conducted by the National Transportation Safety Board (NTSB). Liability in such cases involves a thorough examination by authorities, legal experts, and insurance companies. As self-driving technology evolves, addressing liability concerns and ensuring public safety remain crucial for regulators, lawmakers, and stakeholders in the autonomous vehicle industry.

- **Waymo Self-Driving Car Collision (2016)** [5]:
  This case raised important questions about liability and safety in the autonomous vehicle industry. There were 18 accidents involving pedestrians, cyclists, drivers, or objects, and 29 disengagements where human drivers had to take control, which sparked concerns.
  Potential parties that might be responsible include Waymo (the company operating the self-driving cars), the vehicle manufacturer, the human operator (if present), or other road users involved in the accident.
  Determining liability requires a thorough investigation by authorities, experts, and insurance companies. As the self-driving industry evolves, liability rules may change, and past cases like this can influence future decisions.

- **Tesla Autopilot Crashes** [6]:
  In 2019, a Tesla Model S on Autopilot was involved in a deadly crash, resulting in the first criminal prosecution of a driver-assist system in the U.S. The driver, Kevin George Aziz Riad, is facing charges of vehicular manslaughter. This case is significant because criminal charges are rare in such accidents. Tesla emphasizes that Autopilot is a driver-assist system and holds the driver responsible for staying attentive.

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[4] Jui Tao Tsai, "An analysis of Uber's self-driving software: The case of the first ever self-driving car accident" (Tsai_Jui_Tao_STS_Research_Paper.pdf),accessed July 5, 2023.
[5] John M. Scanlon, Kristofer D. Kusano, Tom Daniel, Christopher Alderson, Alexander Ogle, Trent Victor, "Waymo Simulated Driving Behaviour in Reconstructed Fatal Crashes within an Autonomous Vehicle Operating Domain",(https://www.scribd.com/document/497900366/Waymo-Simulated-Driving-Behavior-in-Reconstructed-Collisions?secret_password=oz4kiDGZtA3WD83jpbXS), accessed July 5, 2023.
[6] Dani Anguiano, " Landmark trial involving Tesla autopilot weighs if 'man or machine' at fault",(https://www.theguardian.com/technology/2022/nov/14/tesla-autopilot-landmark-case-man-v-machine), accessed July 6, 2023.

However, people may overly rely on automation, leading to questions about appropriate technology trust and clearer warnings from manufacturers like Tesla. The outcome of this prosecution could set a legal precedent and impact consumer trust in new technology. Expanding criminal liability based on technology reliance may lead to more similar cases in the future. Manufacturers, including Tesla, face challenges in gaining consumer trust as they introduce new technologies. Early trust is crucial as it affects the adoption of fully autonomous vehicles, which depends on consumer confidence in safety. Advancing technology will complicate liability issues with fully autonomous vehicles. The role of human drivers will decrease, and determining liability in crashes will be debated. Federal regulators will play a vital role in setting safety standards for fully autonomous vehicles, affecting future liability decisions.

- **Donoghue v. Stevenson** [8]:

"Donoghue v. Stevenson" stands as a pivotal legal milestone in the UK, shaping the evolution of negligence law. The case involved May Donoghue and David Stevenson, highlighting the duty of care concept. After Donoghue found a decomposed snail in a ginger beer bottle and suffered illness, she sued Stevenson, the manufacturer. The central query revolved around whether a duty of care existed between the manufacturer and the ultimate consumer, despite the absence of a direct contractual link. The House of Lords' landmark ruling, championed by Lord Atkin, introduced the "neighbour principle," mandating reasonable care to prevent foreseeable harm. This principle, a cornerstone of negligence law, dictates the avoidance of actions likely to injure others. The judgment expanded manufacturers' liability to consumers, irrespective of contractual ties, provided harm is foreseeable. "Donoghue v. Stevenson" profoundly influenced negligence law development, not just in the UK, but across common law jurisdictions. It continues shaping the foundation for assessing duty of care, breach, and causation in negligence cases, exerting enduring influence.

V. UNDERSTANDING AUTONOMOUS VEHICLES

A. **Evolution of Self-Driving Cars:**
- The journey of self-driving cars has spanned several decades, from early radio-controlled concepts to the development of autonomous vehicles in the 1950s and 1960s. The Stanford Cart in the 1960s - 1980s paved the way for further research by autonomously navigating controlled environments using sensors.
- The 1980s and 1990s saw the rise of DARPA's Autonomous Land Vehicle projects, driving advancements in computer vision and robotics for self-driving military vehicles.
- The DARPA[7] Grand Challenges between 2004 and 2007 were significant competitions that pushed the boundaries of autonomous vehicle technology, leading to increased investment from major tech companies and automakers in the late 2000s and 2010s.
- The Society of Automotive Engineers (SAE) defined levels of driving automation in 2014, creating a standardized language to describe self-driving car capabilities.
- Advancements in AI and Ml algorithms in the 2010s enabled self-driving cars to interpret complex real-world scenarios and conduct public road testing with actual traffic.
- Toward the end of the 2010s and today, some companies launched commercial pilot programs for autonomous ride-hailing and goods delivery to assess technology viability and acceptance.
- Currently, research and development in self-driving car technology remain active, with companies refining autonomous systems, enhancing safety features, and seeking regulatory approval for widespread deployment.

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[7] *DAPRA stands for the Defence Advanced Research Projects Agency.*
[8] *LawTeacher, "Donoghue v Stevenson [1932] Doctrine of negligence",(https://www.lawteacher.net/cases/donoghue-v-stevenson.php), accessed July 6 2023.*

<h1>LEVELS OF AUTOMATION</h1>

<h1>THE SIX LEVELS OF AUTONOMOUS DRIVING</h1>

LEVEL 0	LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	LEVEL 5
No automation	Driver assistance	Partial automation	Conditional automation	High automation	Full automation
The driver is in complete control of the vehicle at all times.	The vehicle can assist the driver or take control of either the vehicle's speed or its lane position.	The vehicle can take control of both the vehicle's speed and lane position in some situations.	The vehicle is in full control in some situations, monitors the road and traffic, and will inform the driver when they must take control.	The vehicle can do all driving under certain conditions.	The vehicle can drive in all situations.

As of the present time, most self-driving cars commercially available are at Level 2 or Level 3, with Level 4 and Level 5 vehicles still in the early stages of development and testing.

B. **Technological Components and Capabilities:**

- The technological components and capabilities of self-driving cars have advanced significantly, allowing them to perceive their surroundings, make decisions, and drive autonomously. These components include sensors such as LiDAR, cameras, radar, and ultrasonic sensors, which act as the car's "eyes" and "ears" on the road, helping detect obstacles and other vehicles. Sophisticated control systems manage steering, throttle, and brakes based on sensor data.

- The core of self-driving cars lies in their artificial intelligence and machine learning, which analyse data and make real-time decisions. HD mapping and localization technologies [9] provide precise road information, while connectivity allows access to cloud data and communication with other vehicles. Safety measures and redundancy ensure fail-safe operation, and the human-machine interface allows passengers to interact with autonomous features. Together, these components create a sophisticated system that enables self-driving cars to navigate complex environments safely and represents the future of transportation.

<h2 style="text-align:center">VI.   LEGAL AND REGULATORY FRAMEWORK</h2>

A. **Current Laws and Regulations for Self-Driving Cars:**

laws and regulations surrounding self-driving cars varied significantly among different countries and regions. Governments and regulatory bodies worldwide were actively working to address the challenges presented by the emergence of autonomous vehicles. It is crucial to note that the regulatory landscape is constantly changing. Here are some common themes and trends regarding the current laws and regulations for self-driving cars:

- ***Testing and Deployment Permits***:
    Various countries and regions have adopted their unique approaches to regulating self-driving cars. Some have been more proactive in permitting testing and deployment, while others have taken a cautious approach, prioritizing safety and thorough testing. Many countries require companies to obtain specific permits for conducting tests of self-driving vehicles on public roads. These permits often come with strict requirements, including the obligation to report safety data and demonstrate compliance with certain standards.

(Photograph): Eleks," THE SIX LEVELS OF AUTONOMOUS DRIVING",(https://eleks.com/research/deep-learning-for-autonomous-driving-urban-navigation/), accessed July 6,2023

[9] localization technologies, "Set of tools, systems, and platforms used to manage the translation and localization of digital products." , (https://phrase.com/blog/posts/localization-technology/), accessed July 7,2023..

- **Data Privacy and Security:** Regulations for self-driving cars often involve safety and performance standards that vehicles must meet before being allowed on public roads. These standards address various aspects of autonomous technology, such as sensors, software, and cybersecurity. Given the substantial amount of data collected by self-driving cars, regulations also focus on data privacy and security to safeguard user information and prevent unauthorized access to vehicle systems.

- **Liability and Insurance:** Determining liability in the event of accidents is one of the significant challenges with self-driving cars. Some jurisdictions have started addressing this issue by defining liability provisions and insurance requirements specific to autonomous vehicles.

- **Pilot Programs and Phased Deployment:** Several countries have initiated pilot programs to test self-driving cars in controlled environments before full-scale deployment. This gradual approach allows for incremental adoption and learning from real-world experiences. Some regulatory initiatives focus on public engagement and education to raise awareness of self-driving car technology, address concerns, and gain public acceptance.

B. **Liability Provisions in Different Jurisdictions:**

Liability provisions for self-driving cars differed among various jurisdictions, reflecting ongoing efforts by governments to navigate the complexities of autonomous vehicle technology. Determining liability in accidents involving self-driving cars is a crucial matter that requires careful consideration to ensure fairness, safety, and accountability. Here are some common approaches and considerations regarding liability provisions in different jurisdictions:

- **Strict Product Liability:** Certain jurisdictions adopt a strict product liability approach, holding manufacturers or developers of self-driving car technology fully responsible for any accidents caused by their autonomous systems. The premise is that the technology should be safe for use, and any malfunctions or failures should be the manufacturer's responsibility.

- **Shared Liability:** Other jurisdictions take a more balanced approach, considering shared liability among the autonomous vehicle's manufacturer, the vehicle owner, and potentially even the human driver, if applicable. This approach acknowledges that while manufacturers are responsible for ensuring technology safety, vehicle owners may have responsibilities related to maintenance, updates, and compliance with regulations.

- **Gradual Transition of Liability:** Given the evolving nature of self-driving technology, some jurisdictions may introduce liability provisions that transition from human drivers being primarily liable in traditional vehicles to manufacturers assuming more responsibility as the level of automation increases. This approach recognizes the gradual shift of driving tasks from human to machine.

- **No-Fault Systems:** Certain jurisdictions have no-fault insurance systems, which compensate accident victims regardless of fault. In such systems, liability for accidents involving self-driving cars may be managed through insurance mechanisms instead of determining fault.

- **International Collaboration:** Recognizing the global impact of self-driving technology, efforts are underway for international collaboration to harmonize liability provisions and establish consistency in liability rules across jurisdictions. It is important to note that liability provisions for self-driving cars are continuously evolving, and new laws and regulations may have been introduced. Additionally, specific liability provisions can significantly vary depending on individual countries and regions, as they are influenced by unique legal systems, cultural factors, and societal perspectives towards autonomous vehicles. To access the most current and accurate information on liability provisions for self-driving cars, it is essential to refer to official government sources and seek guidance from legal experts in the respective jurisdictions.

C. **Challenges in Adapting Existing Laws for Autonomous Vehicles:**

Adapting existing laws for self-driving cars presents several challenges [10] due to the unique nature of this technology. Some of the primary challenges include:

- Current safety regulations weren't developed for self-driving technology, requiring comprehensive standards and certification processes that consider autonomous systems. They were designed for human-operated vehicles and don't fully address self-driving complexities, like liability determination in accidents involving autonomous vehicles causing ambiguity.
- Traditional insurance models may need adjustments to accommodate the shift in responsibility from humans to machines, especially in cases where the vehicle's autonomy, the driver's intervention, and the vehicle's condition all play a role. New insurance structures that align with AV characteristics and potential risks need to be established.
- Autonomous vehicles gather extensive data, encompassing live location details, sensor inputs, and additional information. It's imperative to protect this data from unauthorized access and inappropriate use. Legal measures need to tackle worries about data privacy, establish ownership rights, and mandate consent procedures for both data gathering and sharing. However, existing privacy laws might fall short in addressing these specific issues and might lack the ability to effectively avert data breaches.
- Adapting road infrastructure for autonomous vehicles, like dedicated lanes and communication systems, presents logistical and financial challenges. Harmonizing regulations and standards internationally is challenging but crucial for seamless operation of self-driving cars across borders.

Solving these issues demands a collective effort involving governments, tech firms, and relevant stakeholders. This involves creating a thorough and adaptable regulatory framework that encourages innovation, prioritizes safety, and ensures the ethical incorporation of self-driving cars into our transportation systems.

VII. ETHICAL IMPLICATIONS OF LIABILITY IN SELF-DRIVING CARS

A. The "Trolley Problem" and Other Ethical Considerations:

The "Trolley Problem" is a famous moral scenario examining ethical choices in autonomous systems like self-driving cars. It presents a situation where one must decide to divert a trolley, choosing between saving passengers or pedestrians. This highlights the challenge of prioritizing safety in critical moments for autonomous vehicles.

Ethical considerations in self-driving cars go beyond the "Trolley Problem" and include various complex issues:

- Autonomous vehicles must make quick decisions to avoid collisions while considering minimizing harm and protecting vulnerable road users. Deciding the ethical behaviour of self-driving cars involves considering values and principles, such as prioritizing passenger safety or following traffic laws. Determining when and how human drivers should take over raises concerns about human readiness and overreliance on automation. The decision-making processes of self-driving cars must be transparent and understandable to users, regulators, and the public.

- Ethical considerations include data privacy, ownership, and obtaining consent for the use of collected data. Ethical algorithms should avoid biases that could result in discriminatory behaviour or preferential treatment. Consideration of the societal implications of widespread self-driving car adoption, such as employment, urban planning, and traffic patterns. Ethical programming and decision-making should involve public input and align with regulatory frameworks.

- Addressing these ethical considerations [11] requires collaboration among experts and ongoing dialogue to develop responsible and ethical autonomous systems that prioritize safety and societal well-being.

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[10] *Bagloee, S.A., Tavana, M., Asadi, M. et al. Autonomous vehicles: challenges, opportunities, and future implications for transportation policies. J. Mod. Transport. 24, 284–303 (2016), (https://doi.org/10.1007/s40534-016-0117-3), accessed July 8.2023.*

[11] *Brijesh Saluja, "WHAT ARE THE ETHICAL AND SAFETY CONCERNS WITH AUTONOMOUS VEHICLES?",(https://community.nasscom.in/communities/digital-transformation/what-are-ethical-and-safety-concerns-autonomous-vehicles#:~:text=There%20are%20also%20ethical%20concerns,should%20still%20be%20held%20responsible) accessed July 8.2023.*

B. **Programming Autonomous Vehicle's Decision-Making:**

Developing the decision-making capabilities of self-driving cars is a complex and crucial task that involves creating algorithms and rules to guide their behaviour in different driving scenarios. Safety, ethics, and compliance with traffic laws are key aspects of this process. Here are the essential elements:

Prioritizing Safety: The paramount goal of autonomous vehicles is to prioritize safety for all road users, including passengers, pedestrians, cyclists, and other drivers. Algorithms must consider factors like road conditions, traffic patterns, pedestrian behaviour, and emergencies to make appropriate decisions. Decision-making algorithms should aim to minimize the risk of accidents and injuries.

Compliance with Traffic Laws: Self-driving cars must strictly adhere to traffic laws, including speed limits and traffic signals, to ensure responsible driving behaviour. The programming should discourage aggressive driving behaviour, promoting safe and cooperative interaction with other road users.

Example: The vehicle should not speed up to block another vehicle attempting to merge, but rather adjust its speed to facilitate a smooth merge.

Ethical Considerations: Autonomous vehicles may face situations, where avoiding one danger could lead to another. Decisions should be guided by ethical principles that minimize harm while avoiding arbitrary decisions. They must respond appropriately to intricate driving situations, such as busy intersections and adverse weather conditions.

Transparency and Regular Updates: Machine learning allows self-driving cars to improve decision-making by learning from real-world experiences and refining algorithms with data. Regular updates to decision-making algorithms are essential to address emerging challenges and technological advancements. The decision-making process should be transparent and explainable to regulators, users, and the public, building trust in autonomous vehicles.

Developing effective decision-making algorithms requires collaboration among experts and engagement with regulators and the public. Continuous research, testing, and refinement are vital to ensure the responsible and safe operation of self-driving cars as the technology evolves.

Public Perception of Ethical Decisions in Self-Driving Cars: Public perception significantly affects the adoption of self-driving cars. While awareness of ethical complexities varies, safety remains a priority. Passive safety measures are preferred over active decisions. Protecting vulnerable road users, transparent decision-making, and cultural considerations matter. Liability, predefined ethics, and media shape opinions. Trust in gradual tech adoption impacts views. Public involvement and open communication are vital for ethical frameworks that match societal values, ensuring responsible integration of autonomous vehicles.

VIII.   LIABILITY ALLOCATION

A. **MANUFACTURERS AND DEVELOPERS:**

Design and Manufacturing Defects:

Manufacturers of self-driving cars can be held responsible for design and manufacturing issues that lead to accidents or injuries. Design defects involve flaws in the overall product concept, while manufacturing defects occur during the production process. If a self-driving car is inherently dangerous or unfit for its intended use due to design flaws, the manufacturer may be liable.

Software and Algorithmic Errors:

Developers of autonomous technology and the software used in AVs can be held liable for errors or malfunctions in the software or algorithms. These errors can lead to accidents or compromised safety. If the programming code has bugs, doesn't correctly interpret sensory input, or fails to make proper decisions while operating the self-driving car, the developer may be held responsible for any resulting damages or injuries. Liability may arise from negligence in designing, developing, testing, or updating the software.

Testing and Safety Standards:

- Both manufacturers and developers can be held liable if they fail to adhere to adequate testing and safety standards. This includes testing the self-driving car's technology in various real-world scenarios or controlled environments to ensure its safe and reliable operation.
- Failure to follow established safety protocols or meet industry standards can lead to accidents or injuries, making the manufacturer or developer liable for negligence. It is crucial for manufacturers and developers to conduct comprehensive testing, address identified risks, and comply with relevant safety regulations and guidelines to mitigate liability.
- Liability allocation for design and manufacturing defects, software and algorithmic errors, and testing and safety standards can vary depending on the specific laws and regulations in each jurisdiction. The Consumer Protection Act, 2019 [12], as well as relevant regulations and industry standards, may apply in India.

Cybersecurity and Data Privacy:

Manufacturers and developers are liable, if a breach occurs due to a flaw in the vehicle's software or hardware. If the breach is a result of inadequate security measures, negligence in design, or failure to provide regular updates, these companies could face legal consequences. If a breach occurs due to vulnerabilities in the software provided by third-party vendors, these vendors could share some of the liability. However, the extent of liability might depend on the contractual agreements between the parties.

B. **VEHICLE OWNERS AND OPERATORS:**

Human-Machine Interaction and Responsibilities:

While the autonomous technology may handle a significant portion of the driving tasks, human involvement is still necessary in certain situations. If an accident occurs due to the failure of the owner or operator to properly interact with the self-driving car or to exercise reasonable care, they may be held liable. This could include situations where the human fails to take control of the vehicle when necessary or disregards safety warnings issued by the autonomous system.

Proper Use and Maintenance of Autonomous Systems:

Vehicle owners and operators are responsible for maintaining the autonomous systems in self-driving cars correctly. This involves following manufacturer instructions and guidelines for safe operation. Neglecting proper use and maintenance could result in accidents or malfunctions. If an accident occurs due to the owner or operator's negligence in maintaining the autonomous systems, they may be held liable for any resulting damages or injuries. Liability would be determined based on negligence principles and relevant motor vehicle laws in India.

Failure to Monitor or Override Autonomous Systems:

- Owners and operators of self-driving cars must monitor the autonomous systems and be prepared to take control or override them if necessary. The responsibility to intervene arises when the autonomous system encounters situations that it cannot handle or when the system malfunctions.
- If an accident occurs because the owner or operator failed to intervene or override the autonomous system when it was necessary, they may be held liable for the resulting damages or injuries. This liability would be based on the failure to exercise reasonable care and may involve the application of provisions under the Motor Vehicles Act, 1988 [13], and related state laws. The allocation of liability between vehicle owners, operators, and others involved in self-driving car accidents can be complex and depends on the specific circumstances.

Cybersecurity and Data Privacy:

If a breach occurs due to the actions of the users of self-driving cars, such as connecting insecure devices to the vehicle's systems, the liability might shift partially to the users. However, manufacturers and service providers are still expected to implement safeguards to prevent unauthorized access.

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[12] *Consumer Protection Act, 2019, No. 35, Acts of Parliament, 2019 (India).*

[13] *Motor Vehicles Act, 1988, Act No. 59 of 1988, India.*

C. GOVERNMENT AND REGULATORY BODIES

Government and regulatory bodies play a crucial role in the allocation of liability in the context of self-driving cars. Their responsibilities include establishing regulations, overseeing safety standards, and ensuring compliance with applicable laws.

- *Setting Safety Standards:* Government bodies are in charge of establishing safety standards and regulations for self-driving cars. They define criteria for safe and reliable autonomous vehicle operation and set requirements for manufacturers and developers to follow. If an accident happens because of insufficient safety standards, the government could be held accountable for any resulting damages or injuries.
- *Oversight and Accountability Mechanisms:* Governments and regulatory bodies have a duty to have proper oversight and accountability mechanisms in place to monitor the development and deployment of self-driving cars. This includes conducting inspections, audits, and investigations to ensure compliance with regulations and safety requirements.
- If an accident occurs due to a failure in the oversight or accountability mechanisms, such as inadequate monitoring or enforcement of safety regulations, the government or regulatory body responsible may be held liable for any resulting damages or injuries.
- *Licensing and Certification:* Governments are responsible for the licensing and certification of self-driving cars and their operators. They establish requirements for operators to obtain valid licenses specific to autonomous vehicles. If an accident occurs due to a failure in the licensing or certification process, such as granting licenses to unqualified operators, the government may be held liable for any resulting damages or injuries.
- *Public Infrastructure:* Governments are responsible for maintaining and managing public infrastructure, including roads and traffic systems. If an accident is caused by a failure in the design, construction, or maintenance of roads or infrastructure, the government may be held liable.

IX. INSURANCE CONSIDERATIONS FOR SELF-DRIVING CARS

A. Traditional Auto Insurance vs. Product Liability Insurance:

The advent of self-driving cars introduces a shift in liability from human drivers to manufacturers and software developers. This shift raises the question of whether traditional auto insurance [14] policies would be sufficient to cover the unique risks associated with autonomous vehicles. It is likely that product liability insurance [15], which covers damages caused by defective products, will play a significant role in insurance coverage for self-driving cars. This type of insurance would provide protection to manufacturers and software developers against claims arising from accidents or malfunctions caused by their products.

B. Challenges and Opportunities for the Insurance Industry:
- The introduction of self-driving cars presents both challenges and opportunities for the insurance industry. While the shift in liability from drivers to manufacturers may reduce the number of claims against individual drivers, it may also lead to an increase in claims against manufacturers and software developers. Insurance companies will need to adapt their underwriting and risk assessment models to account for the unique risks associated with autonomous vehicles.
- At the same time, the rise of self-driving cars opens up new avenues for insurance products and services. For example, there may be a need for specialized insurance coverage for cyber risks and data breaches, as autonomous vehicles rely heavily on interconnected systems and data exchange. Additionally, insurers may offer policies that cover the loss of income or revenue for autonomous vehicle owners in the event of accidents or malfunctions.

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[14] *BB Editors, "6 Common Types of Car Insurance Coverage", (https://www.kbb.com/car-advice/insurance/types-car-insurance-coverage/), accessed July 10, 2023.*

[15] *Product liability insurance, "A policy that pays for damage or injury caused by a product sold by the policyholder.",([https://www.bing.com/search?q=Product+liability+insurance%2C+"A+policy+that+pays+for+damage+or+injury+caused+by+a+product+sold+by+the+policyholder."%2C&cvid=7f79acdc71ca48b99553664d919654dc&aqs=edge..69i57j69i64.311j0j4&FORM=ANAB01&PC=HCTS](https://www.bing.com/search?q=Product+liability+insurance)), accessed July 11,2023.*

C. **Insurance Models for Autonomous Vehicles:**

Several insurance models have been proposed to address the insurance considerations for self-driving cars:

- *Usage-based insurance:* This model involves assessing the insurance premium based on the usage and performance of the autonomous vehicle. Factors such as driving behaviour, distance travelled, and adherence to traffic rules could be taken into account to determine the premium.
- *Manufacturer-based insurance:* Under this model, the responsibility for insurance coverage would lie with the vehicle manufacturer. The manufacturer would provide insurance coverage as part of the purchase or lease agreement for the self-driving car.
- *Government-based insurance:* In some jurisdictions, there have been discussions about the government assuming a role in providing insurance coverage for autonomous vehicles. This model would ensure that all autonomous vehicles have adequate insurance coverage while also potentially allowing for lower premiums due to economies of scale.

It is important to note that the specific insurance models and regulations may vary from country to country. As self-driving technology continues to develop, governments, insurers, and other stakeholders will need to collaborate to establish appropriate insurance frameworks to address the unique risks and challenges associated with autonomous vehicles.

X. COMPARISON OF LAWS AND REGULATIONS FOR LIABILITY OF SELF-DRIVING CARS AMONG INTERNATIONAL JURISPRUDENCE

In September 2016, the USDOT jointly released the Federal Automated Vehicles Policy. This policy set standards for automated vehicles, including guidelines for technology failure, passenger privacy, and accident safety. The goal was to create consistent federal regulations, avoiding a confusing mix of state laws while promoting innovation.

Since then, the USDOT [17] has issued updates to improve the guidelines:

- Automated Driving Systems: A Vision for Safety 2.0 (September 2017)
- Preparing for the Future of Transportation: Automated Vehicles 3.0 (October 2018)
- Ensuring American Leadership in Automated Vehicle Technologies: Automated Vehicles 4.0 (January 2020)
- The National Highway Traffic Safety Administration (NHTSA) [16] also contributed with two important documents for public input:
- Occupant Protection for Automated Driving System (March 2020): To modernize safety standards for vehicles without traditional controls (like steering wheels) that have automated driving systems.
- Framework for Automated Driving System Safety (December 2020): An objective method to define and assess the competence of automated driving systems for safety, adaptable to evolving features.
- Finally, on March 10, 2022, the NHTSA updated and finalized the rule on Occupant Protection. This allows companies to produce and deploy autonomous vehicles without manual controls, such as steering wheels and pedals, as long as they meet other safety standards at the state and federal levels.

The laws and regulations concerning liability for self-driving cars at the state level are:

- California, as a pioneer in autonomous vehicle legislation, mandates that companies testing self-driving cars must report accidents and submit an annual disengagement report. Manufacturers are held responsible for any accidents caused by the autonomous vehicle outside the testing phase.
- Florida allows fully autonomous vehicles to operate without a human driver present, but manufacturers must have at least $1 million in financial responsibility for potential damages. Michigan, with its automotive industry presence, supports self-driving vehicle development by permitting their operation on public roads and including liability provisions for accidents.

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[16] *NHTSA stands for The National Highway Traffic Safety Administration (NHTSA) is tasked with ensuring the safety of individuals on American roads.*

[17] *USDOT stands for US National Economic Council and the Department of Transportation.*

- Nevada was among the first states to allow autonomous vehicle operation, requiring companies to demonstrate financial responsibility and placing liability on the manufacturers for damages caused by the autonomous technology. Arizona's permissive approach to regulation has made it a popular testing ground, as it does not require special permits and adopts a relatively hands-off stance on liability.
- Texas permits autonomous vehicles for testing on public roads, while manufacturers must maintain insurance coverage. Washington, D.C., has regulations allowing autonomous vehicle testing on public roads, but companies are also required to demonstrate financial responsibility for potential damages.

China:

China has been making rules for self-driving cars. In April 25, 2017, Chinese National Development and Reform Commission, Chinese Ministry of Science and Technology, and Chinese Ministry of Industry and Information Technology released the long-term development plan for the automobile industry. In 2018, they released national guidelines for testing these cars on public roads, emphasizing safety and responsibility. Different provinces and cities have their own rules for testing self-driving cars. Companies testing these cars must take responsibility for any accidents that happen. They may also need to share data with authorities and report incidents. The Chinese government supports research and development in self-driving technology through funding programs. The rules are changing as the technology advances, and the government is actively involved in promoting and regulating autonomous vehicles.

In terms of regulating autonomous driving vehicles on public roads, the United States has a comprehensive set of rules, whereas China currently lacks any national regulations and only has preliminary local policies. The U.S. has well-established guidelines, while China's regulations are still in the early stages and not fully developed.

Britain:

If a self-driving car causes an accident while driving itself, the car's insurance company is usually responsible for compensating the victims and paying for damages. However, if the accident happens because the driver didn't update the car's software or follow instructions correctly, the driver might be held responsible.

Germany:

Similar rule applies in Germany too. The owner of the self-driving car is generally responsible for accidents caused by the car while it drives autonomously. So, either the car's insurance or the owner would be liable if an accident occurs while the car is driving itself.

XI. LIABILITY ASSIGNMENT IN PAST CASES

In the case of the fatal self-driving car collision involving Uber [19] in Tempe, Arizona in March 2018, Uber itself was not found criminally responsible. However, the safety driver who was present in the vehicle during the crash pleaded guilty to an endangerment charge and received a three-year probation sentence. An analysis in the book series *"Perspectives in Law, Business and Innovation"* [18] suggests that if the same incident had occurred in China, both Uber and the driver would have shared liability. This is because Uber had modified the vehicle by disabling its original computer-controlled emergency braking function, introducing a defect. As a result, the original car manufacturer could have been exempted from responsibility due to Uber's alterations. The book's analysis also highlights Uber's aggressive approach to testing, which contributed to the accident. Additionally, since the safety driver was on duty during the collision, the employer, Uber, would have been deemed liable for the resulting damages.

In the Waymo self-driving car case [20] in 2016, Waymo made Anthony Levandowski, a former employee and self-driving car expert, liable for allegedly stealing proprietary LiDAR technology files before leaving Google to start his own company, Otto. Waymo claimed that Levandowski used these files to advance Uber's self-driving technology after Uber acquired Otto.

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[18] *Mark Fenwick, Perspectives in Law, Business and Innovation, (Publisher: Springer Publishing, 2013).*

[19] *David Shepardson, Heather Somerville, "Uber not criminally liable in fatal 2018 Arizona self-driving crash: prosecutors", (https://www.reuters.com/article/us-uber-crash-autonomous-idUSKCN1QM2O8), accessed July 20, 2023.*

[20] *Selena Larson, "What we learned in the Waymo v. Uber case", (https://money.cnn.com/2018/02/10/technology/waymo-uber-what-we-learned/index.html), accessed July 20,2023.*

The final judgment in the case came in 2018 when Uber agreed to settle with Waymo. As part of the settlement, Uber agreed to pay Waymo approximately $245 million, which was equivalent to about 0.34% of Uber's equity. This settlement resolved the legal dispute between the two companies over the alleged theft of trade secrets and intellectual property.

XII. LIABILITY SUGGESTIONS FOR SELF-DRIVING CARS

To ensure the responsible deployment of self-driving cars in India, various liability suggestions have been put forward:

- Firstly, there is a need to expand hacking provisions in relevant laws, such as the Information Technology Act, to cover incidents involving autonomous vehicles. This involves enacting strict regulations that mandate automobile manufacturers to implement anti-hacking systems and safety features.
- Additionally, compliance with the Geospatial Information Regulation Bill [21], 2016, is crucial to protect sensitive geospatial data and prevent unauthorized usage or acquisition. To accommodate self-driving cars within the regulatory system, amendments to the Motor Vehicle Act and the Consumer Protection Act are necessary. This may involve extending provisions that address issues beyond driver faults to include the owners of self-driving cars.
- To incentivize safety compliance, stringent penalties should be imposed on companies whose self-driving cars fail to meet safety standards for Indian roads, and in severe cases, their licenses should be cancelled.
- Considering the complexity of autonomous vehicles, dedicated legislation similar to other countries like Britain and Germany is recommended. This legislation should clearly define rules on liability in case of accidents and charging. Holding manufacturers liable for faults in the AI systems used in self-driving cars is essential to encourage them to improve safety and reliability. Encouraging transparency and reporting from manufacturers and developers is also important, along with implementing mandatory reporting of autonomous vehicle accidents to assess safety performance.
- Additionally, Continuous monitoring and upgrading of self-driving technology must be established to ensure AI systems remain up-to-date and meet evolving safety standards. Moreover, Public education campaigns are crucial to raise awareness about self-driving technology, its benefits, limitations, and safety precautions, thereby fostering public trust and confidence.
- Collaboration among various stakeholders, including government authorities, manufacturers, technology developers, insurers, and others, is necessary to create comprehensive and effective liability frameworks prioritizing safety and consumer protection.
- By implementing these liability suggestions, India can create a conducive environment for responsible self-driving car deployment, ensuring public safety, confidence, and promoting the growth of autonomous vehicle technology.

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[21] *Geospatial Information Regulation Bill, 2016, Bill No. XX of 2016, India.*

XIII. CONCLUSION

In conclusion, the liability of self-driving cars is a multifaceted and evolving matter. To unlock the full potential of autonomous vehicles, it is crucial to prioritize safety, collaboration, and transparency among all stakeholders. Manufacturers must be held accountable for any flaws in design or software, while vehicle owners must use and maintain the technology responsibly.

Governments play a pivotal role in setting safety standards and ensuring accountability in the self-driving car industry. As the technology continues to advance, the legal framework must keep pace, with some countries already establishing regulations for self-driving cars. Insurance industry is adapting to the changing landscape, devising new models to address the unique risks posed by autonomous vehicles. International cooperation and knowledge-sharing are vital to create consistent liability frameworks across borders.

By working together and learning from real-world case studies, we can navigate the complexities of liability and establish clear guidelines and standardized frameworks. Prioritizing safety and transparency will build consumer trust, leading to a safer and successful future for self-driving cars, revolutionizing transportation and enhancing road safety for all.

In conclusion, the future of self-driving cars liability is promising, but it necessitates collaboration to safely integrate autonomous vehicles into our transportation systems.

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