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Regulatory Perspectives on AI in Autonomous Vehicles Global Approaches and Challenges

Chaudhry Abu Bakar Imran
NUST Institute of Civil Engineering، School of Civil and Environmental Engineering، National University of Sciences and Technology Pakistan
Email: chabubakar2001@outlook.com

Malik Kamran Shakir
NUST Institute of Civil Engineering، School of Civil and Environmental Engineering، National University of Sciences and Technology Pakistan
Email: kamranshakir@nice.nust.edu.pk

Muhammad Abu Bakar Qureshi
NUST Institute of Civil Engineering، School of Civil and Environmental Engineering، National University of Sciences and Technology Pakistan
Email: abubakarqureshi330@gmail.com

Abstract

The advent of autonomous cars will necessitate society to confront a new set of hazards, involving socially integrated artificial intelligence that can make complex risk mitigation decisions with profound life-and-death consequences. There are concerns about how AI evaluates decisions, how humans should mediate these conclusions, and what these decisions entail in respect to others because AI decisionality is fundamentally different from human decision-making processes. Consequently, society, policymakers, and end-users must thoroughly comprehend these distinctions. Although AI judgements may be contextualized to specific meanings and considerable obstacles persist regarding the technology of AI decision-making. This is especially pronounced with the analysis of the advantages and disadvantages of AI judgements. Autonomous cars are frequently positioned as important risk reduction technology because of the possible safety advantages. The potential additional hazards that autonomous vehicle driving decisions may pose must be understood. Artificial intelligence will be lacking in some decision-making skills resulting in these new risks referred as decisional limits. This is particularly evident in the inability to annotate and categorize the driving environment according to human values and ethical understanding. In each case, we need to take a wise look at how we conceptualize autonomous vehicles' decision-making ability and how it affects our overall comprehension of the benefits and risks of this technology. This study examines the substantial deficiencies in the existing framing of the debate, particularly with safety debates and the consideration of AI as a moral agent, and proposes many pathways ahead.

Keywords: Autonomous vehicles, Artificial Intelligence, Machine Learning, Vehicle navigation, Intelligent transportation system.

Introduction

Transportation is only one aspect of our everyday lives that has been significantly impacted by new robotics and communication technology. These technologies led to the emergence of autonomous vehicle (AV) technology, which seeks to diminish accidents, energy usage, pollution, and congestion, while simultaneously enhancing transportation accessibility. The concept of autonomous cars has been around for decades, but large-scale manufacturing has been hampered by their prohibitive costs (Fagnant and Kockelman, 2015). Autonomous vehicles (AV) provide the potential to utilize advanced sensory technology and artificial intelligence (AI) to make driving judgements that reduce several dangers linked to human driving choices. The emphasis on AI in autonomous vehicles generates two opposing interpretations of the decision-making advantages and hazards of the technology that reflect wide spread confusion about machine decision-making including its societal benefits and concerns. The integration of sensory and cognitive technology offers a topographical depiction of road conditions, enabling AI to make more prompt and precise driving judgements (Martin et al., 2019).

Autonomous vehicles (AVs) eliminate human error in decision-making due to factors including fatigue, confusion, intoxication and poor judgment when operating a motor vehicle. This depiction of the technology advantages of autonomous vehicles presents a safety argument that highlights the welfare benefits of machine decision-making and advocates for legislative support for autonomous vehicles. Conversely, the other perspective emphasizes these possible additional hazards as decision-making faults and constraints of the driving AI. Consequently, it is imperative to articulate and propagate the advantages of AV decisional intelligence to prevent the underutilization of the technology due to erroneous risk perception (Floridi, 2018). Autonomous vehicles have become a business model and a necessity in industrialized nations due to the rapid advancement of communication technology (Hong et al., 2008). In consideration of emerging concepts and technology such as social networks, smartphones, and autonomous vehicles, several experts have strongly cautioned that the transportation scene is undergoing fast transformation (Anderson et al., 2014). Uber exemplifies a phenomenon that is overwhelming urban areas, causing taxi businesses to struggle in maintaining their competitiveness. A further study elaborates that vehicle automation as one of the top ten disruptive technologies of the future (Manyika et al., 2013).

Real-time data, encompassing journey duration and incidents, may be centrally processed and analyzed to compute and guide (or recommend) autonomous vehicles towards the optimal path. Consequently, more advanced and dependable vehicle routing models may be formulated, which we refer to as vehicle navigation (Bagloee et al., 2016). AV represents a pertinent illustration of a socially integrated and potentially pervasive AI technology. This elaborate the concept of risk with other technologies responsible for risk governance confront the duality of empirical objectivity and ethical quandary. There are undoubtedly strong utilitarian reasons for AV safety based on the decrease in fatalities and injuries, but more troubling moral issues surface that highlight the need for prudence when AV introduced to the system. These discussions focus on situations when autonomous cars must make moral decisions during operations and address the basic tenet that machines should have the power to make decisions that affect human life and death.

At one extreme, AV selections might enhance route-planning algorithms to circumvent schools or identified dangerous zones, while at the other extreme, such selections could affect potential road traffic accident (RTA) judgments. These brief pre-collision decision windows are therefore contextualized in situations involving inevitable traffic accidents that have the potential to cause fatalities and serious injuries (Martin et al., 2019). Autonomous cars have several substantial social advantages like boosting transportation for the underserved, altering urban environments, benefiting the ecosystem, significantly improving safety, and preserving lives. The potential benefits of autonomous vehicles must be balanced with the need to mitigate risks because each major technological advancement bring new and existing dangers. Furthermore, the mitigation of AV risk cannot be just the responsibility of state governance systems therefore it must be a collaborative effort among several stakeholders. In this context, conventional state governance and contemporary governance models are clearly surpassed, as demonstrated by the current age of digital innovation (Marchant, 2011). The rapid advancement of HAVs, along with the complexity and originality of these developments, poses a risk of surpassing the Agency's traditional regulatory processes and capacities. Consequently, intelligence technologies necessitate a collaborative risk reduction procedure including several stakeholders. The conceptualization and framing of technology on its meaning, advantages, and hazards will ultimately dictate stakeholder engagement with the technology (Nash., 2017).

The AV is linked to several beneficial social effects, including a safer transportation system, reduced transportation costs, and enhanced mobility for the non-ambulatory, handicapped individuals, and low-income households. The potential direct social value gained is expected to vary from $0.2 trillion to $1.9 trillion by 2025. AV technology is rendered a viable business model in the near future and beyond due to the favorable consequences which serve as an impetus for its development. (Manyika et al., 2013).

Levels of Automation of Vehicles:

The degree of automation can range from none to complete automation. The vehicle automation categorized at five levels which are elaborated in table 1.

Table 1: *Different Levels of Automation of Vehicles.*

Levels	Title of Levels	Working Principles
Level 0	No-Automation	The driver maintains absolute and exclusive authority over the vehicle's steering, braking, throttle, and propulsion at all times.
Level 1	Function-specific automation	Certain control functions, such as electronic stability control or recharged brakes automation.
Level 2	Combined function automation	At least two primary control functions, such as adaptive cruise control in conjunction with lane centering are automated.
Level 3	Limited self-driving automation	In specific traffic or environmental circumstances, the driver relinquishes complete control of all safety-critical tasks and depends significantly on the vehicle to monitor any changes in conditions that necessitate a shift to driver control. The driver must regain control of the vehicle, allowing for adequate changeover time.
Level 4	Full self-driving automation	The car is adeptly engineered to assess roadway conditions and operate autonomously with the execution of all safety-critical driving activities during the whole journey (a completely driverless level).

AV navigation model:

There are two categories of cars: non-autonomous vehicles (non-AVs) and autonomous vehicles (AVs). The non-AVs persist in their self-serving conduct as there is no incentive to compel them to pursue the non-optimal route. AVs constitute a crucial element of transportation planning that necessitates the formulation of suitable models. The last phase of transportation modeling involves simulating vehicle movements inside the road network, referred to as traffic assignment. Therefore, there are two primary simulations including micro and macro simulations. Micro-simulation incorporates the intricate motions and behaviors of individual vehicles in its analyses. The fundamental characteristics of automation (Levels 1 and 2) have led several researchers to include AV technology into micro-simulations (Levin and Boyles, 2016). The interconnectedness of autonomous vehicles has been examined in signal control strategies leading to substantial reductions in latency (Fajardo et al., 2011). Other research aims to broaden the applicability of current dynamic traffic assignment models to incorporate autonomous vehicles. The scale of micro-simulation is restricted to a section of a metropolis rather than the full city despite current modeling expertise and processing technology (Levin and Boyles, 2015). Conversely, macro-simulation readily accommodates extensive road networks. The necessity for However, the ostensibly restrictive nature of AVs being linked may be exploited to substantially improve vehicle routing. Vehicle routing pertains to the methods by which vehicles choose their paths to reach their destinations.

A prevalent theory or framework is predicated on the quickest route. In this paradigm, referred to as Wardropian principles, each vehicle autonomously selects its optimal route without regard for the decisions of other cars (Bagloee et al., 2016). This results in a state of balance known as **User Equilibrium (UE)**, wherein no vehicle can independently discover a more efficient route. This self-interest will likely lead to ultimate traffic patterns characterized as non-cooperative. Due to cars lacking awareness of one other's routes and destinations, the non-cooperative traffic pattern is the most prevalent traffic model. In other words, while driving one is entirely oblivious to the destinations of other cars and the paths they may pursue. Conversely, the cooperative traffic pattern presupposes that cars possess knowledge of one another's destinations and itineraries. It has been demonstrated that the cooperative traffic pattern is preferable to the non-cooperative traffic pattern potentially by a factor of 2 (Bagloee et al., 2013).

It is assumed that autonomous vehicles (AVs) exhibit the same characteristics as conventional vehicles in terms of routing namely adhering to a self-interested (or non-cooperative) traffic pattern. The vital real-time traffic data that connected cars provide journey duration and incident reports that can be utilized in a cooperative traffic pattern. Consequently, AV data may be aggregated and analyzed at traffic monitoring centers, which will thereafter suggest the most suitable routes. This means that every car will now physically know the paths and locations of other cars. Consequently, a more advanced, efficient and knowledgeable vehicle routing system is achieved (Bagloee et al., 2013). This is termed as vehicle navigation.

In the transportation terminology the cooperative pattern is designated as "SO: System Optimal" whereas the non-cooperative pattern is termed "UE," both arising from the resolution of Traffic Assignment Problems (TAP). The intricacy of autonomous vehicles' navigation arises from their necessity to coexist on roadways with non-autonomous vehicles leading to heterogeneous traffic patterns. Currently, we possess the capacity to implement a vehicle navigation strategy for the autonomous vehicles. The current objective is to develop a model for a mixed traffic pattern that incorporates both SO and UE traffic patterns. In these traffic patterns, a fleet of autonomous vehicles collaborates to choose their routes (vehicle navigation) while other drivers pursue just the quickest roads (vehicle routing). The emergence of Intelligent Transportation Systems (ITS) has resulted in advanced traveler information systems (ATIS) that include radio and variable message signs. This help in making real-time traveler information a reality (Bagloee et al., 2014).

Certain experts have suggested utilizing this information source to advocate for cooperative routing. Nonetheless, the concept has not yet materialized due to several challenges including the absence of an enforcement plan and concerns over the accuracy and trustworthiness of the information combined with limited penetration of the ATIS (Van et al., 2016).

How does the AV Work?

Autonomous vehicles typically function based on a three-phase framework termed "**Sense-Plan-Act"** which underlies several robotic technologies (Behere and Tonrgren, 2015). A significant hurdle for autonomous vehicles is in interpreting the intricate and evolving driving environment. This is accomplished by equipping the AVs with a range of sensors, cameras, radars, and other devices that gather unprocessed data and information from their surroundings. This data would then be utilized by algorithms to identify suitable courses of action including acceleration, lane change, and overtaking. A suite of surveillance technologies is utilized to address this demanding task. This duty is often addressed using a mix of Radar, Lidar, and mono or stereo camera systems (Savasturk et al., 2015).

Sensors and monitoring technologies:

Sensors and monitoring technologies in traffic management encompass various electronic devices and systems employed to detect, measure and gather data on vehicle movement, traffic flow, road conditions and environmental elements. These technologies facilitate real-time traffic monitoring, enhance safety, optimize traffic signals and bolster smart transportation systems.

Camera-based systems:

Camera-based systems are cost-effective devices capable of visual perception at extensive distances. The extensive data obtained from the cameras requires interpretation. This procedure is referred to as image processing which is a rapidly advancing field of research. In comparison to the image processing capacities of these camera-based devices, the human brain exhibits far more sophistication in processing and interpreting visual information. Moreover, the cameras will need continual calibration based on road and weather conditions and this is an ongoing area of study in robotics (Sonak et al., 2014). Camera-based systems are cost-effective devices capable of perceiving and monitoring extensive distances. The extensive data gathered from the cameras requires interpretation. This procedure is termed as "**Image Processing"** which is a rapidly advancing field of research. In comparison to the image processing capabilities of these camera-based devices, the human brain exhibits far greater sophistication in processing and interpreting visual input. Moreover, the cameras will need continual calibration based on road and weather conditions, which remains an ongoing research focus in robotics (Wang et al., 2014).

Lidar:

Lidar, an abbreviation for Light Detection and Ranging, is a remote sensing device that measures distance by lighting an object with a laser beam and analyzing the reflected light and its time of flight (Lillesand et al., 2014). A collection of LIDAR's is integrated and coordinated with swiftly revolving mirrors to provide a 3D representation of the world (Shang et al., 2015). The primary drawbacks of the Lidar system include its inadequate coverage and range, rendering it unsuitable over long distances as well as concerns related to reflection. In contrast to the camera-based technology, Lidar operates effectively only at limited ranges and with specific materials. The Lidar device used to be pretty expensive but its price is going down which make it more reasonable and useful (Bengler et al., 2014).

Radar

Radar (radio detection and range) utilizes the time-of-flight of signals to ascertain the distance to things in the environment, analogous to Lidar. Conversely, radar systems send and receive radio waves rather than laser beams that lead to various restrictions and advantages. The reflectivity constraints of radar are more pronounced than those of Lidar such as it can alone identify metallic items like automobiles while non-metallic entities such as pedestrians remain undetectable by radar sensors. These deficiencies have been thoroughly examined in the automotive radar domain due to the widespread use of radar in automobiles particularly in driver assistance systems (Ilas., 2013).

Ultrasonic Technology:

Ultrasonic, drawing inspiration from the navigational capabilities of bats in darkness and dolphins and whales underwater, is a sensing system that transmits and receives acoustic energy as waves at frequencies above the human hearing range. The operation resembles radar in utilizing high-frequency acoustic waves for transmission and reception. These sensors deliver precise short-range data (1–10 m). Due of their relatively low cost, ultrasonic technologies are essential in backup warning systems and parking assistance systems (Wang et al., 2014).

Infrared:

Infrared sensors are predominantly utilized for lane marker identification unaffected by environmental constraints like illumination and camera conditions. They are considered effective at detecting lane departures due of their restricted coverage range (Mathas., 2016). Additionally, infrared sensors are employed to identify walkers and bicycles, especially during nighttime (John et al., 2015).

Table 2:
Type of IR sensors in Traffic Management.

Type of IR Sensors	Working Principle
Active IR sensors	It emits their own IR beam and detect reflections (used in vehicle detection).
Passive IR sensors	It detect heat from objects (used in pedestrian or vehicle presence detection).

Geographic Positioning Systems (GPS)

Geographic Positioning Systems (GPS) are becoming ubiquitous in daily life, transportation and other businesses. The GPS gadgets function by using signals from orbiting satellites to determine their position in global coordinates. The coordinates are subsequently cross-referenced with the road network's topography to accurately determine a vehicle's location on the route. GPS inaccuracies can still reach several meters (Miura., 2015). Many positioning errors escalate rapidly when obstructions or topography obstruct the sky, preventing GPS devices from acquiring signals from an adequate number of satellites. This is a legitimate worry in metropolitan centers, where towering structures form "urban canyons" that significantly impair GPS functionality (Dupuis et al., 2014).

Inertial navigation systems (INS):

Inertial navigation systems (INS) are navigational aids that utilize accelerometers, gyroscopes, and a computer to continuously compute the position, velocity, and orientation of a moving entity without reliance on external references. GPS receivers can be integrated with INS to reduce location mistakes (Velaskar et al., 2014).

Advantages and disadvantages of AVs:

Transportation unavoidably has negative externalities including pollution, accidents and human casualties even if it may help civilizations become more prosperous. A significant number of studies quantify these expenses of human-operated vehicles. These expenses contrast with direct expenditures incurred such as fuel, car upkeep, registration, licensing, or public transportation fares. The externality cost is an implicit burden placed on society, encompassing expenses related to transportation congestion, accidents, environmental damage, and security concerns. Generally, AV technology is widely regarded as having the capacity to significantly mitigate (if not eradicate) several present negative externalities (Link et al., 2014). According to one estimate these external expenses can reach the same level as the gasoline price which affects everyone in society even those with low incomes who depend entirely on public transportation. Autonomous vehicles can potentially provide supplementary advantages like enhanced accessibility, mobility and improved land utilization (Anderson et al., 2014). The benefits of AVs are generally seen to exceed the potential drawbacks notwithstanding the possibility of serious drawbacks.

Congestion:

Anderson has identified three primary aspects associated with autonomous vehicles (AVs) that influence congestion both favorably and negatively: (i) the decrease of traffic delays resulting from fewer vehicle collisions; (ii) the improvement of vehicle throughput; and (iii) alterations in the total vehicle-kilometer traveled (VKT). A projected decrease in vehicular collisions would lead to diminished delays and, consequently, enhanced reliability of the transportation system (Anderson t al., 2014). The impact of autonomous vehicles on **Vehicle Kilometers Traveled** (VKT) remains ambiguous. Nevertheless, some scholars contend that VKT may actually rise a phenomenon referred as the "**Rebound Effect**." They hypothesize a confluence of causes, including augmented vehicle kilometers traveled (VKT) owing to self-fueling and self-parking. It led to an increase in the frequency of trips (both occupied and unoccupied), a transition from public transportation, and extended commutes. Additionally, it increased the use of autonomous vehicles (AVs) by individuals who are unable to drive (Litman et al., 2015).

The NHTSA concluded that the rebound rate will stabilize at 10%. The connectivity of AVs may present a possibility to alleviate congestion burdens. Dresner and Stone offer a reservation-based approach to mitigate traffic congestion particularly at crossings where cars are interconnected. The findings indicate that the reservation-based system developed for linked autonomous vehicles can operate two to three times more efficiently than traffic signals. Consequently, it can adeptly manage far more crowded traffic circumstances Dresner and Stone, 2004). The traffic delays decrease to the levels shown in their earlier studies as the number of autonomous cars on the road increases (Dresner and Stone, 2007). Thus, it is evident that AV technology would likely positively impact traffic congestion reduction until it generates extra demand that might exacerbate an already strained network. The comprehensive effect of the AV on traffic congestion remains untested (Fajardo et al., 2011).

Safety and crashes:

The numbers for traffic accidents in the United States in 2010 are alarming: 32,999 fatalities, 3.9 million injuries, and 24 million cars damaged, with the total physical and intangible expenditures amounting to $277 billion (Blincoe et al., 2015). This financial burden creates a ripple effect, influencing productivity, medical expenses, legal and judicial fees, workplace losses, emergency service expenditures, congestion costs, insurance administration expenses, and property damage (NHTSA., 2012). The decline in crash incidents in the United States is largely attributable to the use of advanced technology including airbags, anti-lock brakes, electronic stability control, head-protection side airbags, and forward collision alerts. These are characteristics that will be incorporated into autonomous vehicle technology (Jermakian., (2011). Certain studies project that the incidence of collisions might decrease by as much as one-third if all vehicles are outfitted with adaptive headlights, frontal collision alerts, lane departure warnings and blind spot assistance which are associated with Level 0 or Level 1 vehicle automation (Maddox., 2012). Human mistake accounts for almost ninety percent of accidents. Consequently, autonomous vehicles should be capable of averting a significant proportion of these collisions hence reducing the majority of traffic delays (Anderson et al., 2014).

Taxi and car ownership:

Autonomous vehicle technology can allow driverless taxis or other car sharing initiatives that eliminate the expenses associated with compensating cabdrivers' time and expertise. Consequently, autonomous taxis are anticipated to decrease in cost perhaps dissuading automobile ownership. The notion of autonomous taxis parallels the successful economic model of car sharing (Fagnant and Kockelman, 2015). Autonomous vehicles can enhance automobile and ride-sharing initiatives by accommodating many individuals on demand. As a result, families may see autonomous taxis as more convenient and cost-effective than automobile ownership. Moreover, autonomous taxis should not be more expensive than car-sharing services. The autonomous taxi eliminates the necessity for yearly fixed expenditures, maintenance often linked to car-sharing and parking hence offering more convenience. Car-sharing has recently been demonstrated to reduce Vehicle Kilometers Traveled (VKT) in the United States market (Martin and Shaheen, 2011).

Nonetheless, as previously indicated, more affordable journeys will entail new demands. It is particularly from impoverished individuals who can now afford to either drive or utilize taxi services. An examination of US household data reveals a notable decline in car ownership and a corresponding transition to vehicle sharing. This decrease may reach 43%, decreasing from 2.1 to 1.2 autos per family. Conversely, this transition is expected to increase individual car consumption by 75%, rising from 11,661 to 20,406 miles per vehicle year. This mileage increase does not account for the extra miles accrued on each "return-to-home" journey (Schoettle and Sivak, 2015). In summary, autonomous vehicles have significant potential to reduce various expenses linked to private transportation, since they are expected to encourage increased trip frequency leading to an expansion in vehicle kilometers traveled (VKT). Autonomous vehicles may potentially precipitate the rise of driverless taxis, the final impact of which on vehicle kilometers traveled remains uncertain.

Roads Capacity:

AV systems deliver precisely calibrated acceleration and braking movements continuously while persistently monitoring the surrounding traffic environment. Consequently, autonomous vehicles can operate at elevated speeds while sustaining reduced distances (shorter headways) (Ploeg et al., 2011). Semiautonomous cars with Adaptive Cruise Control (ACC) have demonstrated a highly promising capability. Consequently, the road throughput (or capacity) is projected to expand significantly some estimates predict by as much as five fold (Fernandes and Nunes, 2012). Certain studies have utilized the connectivity of autonomous vehicles (AVs) in signal regulation leading to significantly reduced delays at traffic signals or conversely enhanced road capacity.

AV and electric vehicles:

Environmental issues, along with elevated oil prices during the past decade, have propelled the development of Electric Vehicle (EV) technology. The electric vehicle experiences several operating limitations, notably a travel range constrained by the size and endurance of its batteries (Melis., 2014). It restricts the electric vehicle to short-distance driving and might render the search for charging facilities a source of persistent concern. In this context, a natural and organic synergy exists between shared autonomous vehicle (AV) fleets and electric vehicle (EV) technology. A fleet of AVs can address the practical constraints of EVs, such as range anxiety, access to charging infrastructure and control of charging duration (Kang et al., 2015). Chen has demonstrated that fleet-managed autonomous vehicles alleviate these difficulties by utilizing real-time trip demand and predetermined charging station locations. Their financial research indicates that the total expense for charging infrastructure, vehicle acquisition and maintenance, power, insurance and registration for a fleet of autonomous vehicles varies between $0.42 and $0.49 each occupied mile driven. Therefore, shared autonomous vehicle services may be provided at a per-mile cost comparable to that of private car ownership for households with modest mileage. Consequently, autonomous electric vehicles are expected to rival existing manually controlled car-sharing services and be considerably more economical than on-demand driver-operated transportation services (Chen., 2015a).

Use of Land:

Autonomous vehicles may significantly and enduringly influence land-use patterns. The value of property escalates in direct correlation to its nearness to the core city, where employment possibilities abound across several sectors including banking, financial markets, and numerous other service businesses. Transportation serves as an indicator of proximity. The introduction of vehicles in the early 20th century led to the development of suburbs. The relationship between autonomous vehicles and land use is intricate and perhaps counterintuitive. In one possibility, the advent of autonomous vehicles might stimulate a trend towards increasingly scattered and low-density land-use patterns around urban areas.

Autonomous vehicles may contribute to the expansion of suburban regions and maybe encroach onto exurban areas. Conversely, AV technology eliminates the pressing demand for parking spots, so allowing urban areas to repurpose these locations for alternative uses (Bagloee et al., 2016). Consequently, autonomous vehicles may promote urban expansion in core areas, increasing the density of central business districts. Parking facilities occupy a significant portion of area in Central Business Districts (CBDs).

In summary, the long-term expectation with the introduction of level 4 autonomous vehicles is the emergence of denser urban centers, more construction and a reduction in parking places. Simultaneously, autonomous vehicles may facilitate increased dispersion of low-density development in metropolitan peripheral regions, since owners may partake in other activities while their vehicles navigate autonomously (Anderson et al., 2014).

Environment (energy and emission):

The environmental effect of AVs depends on three aspects, which can be either good or negative. Fuel economy of autonomous vehicles. Carbon intensity and life-cycle emissions of the fossil fuels utilized to power autonomous vehicles. The overall alteration in Vehicle Kilometers Traveled (VKT) attributable to the utilization of Autonomous Vehicles (AVs).

This section elaborates on the fuel consumption and efficiency of autonomous vehicles. Despite the advent of autonomous vehicles, innovations in vehicle design and engine efficiency have significantly reduced fuel usage. In one assessment, fuel usage for passenger automobiles was nearly reduced by fifty percent compared to the data recorded three decades’ prior (Alderson et al., 2014). The use of AV technology at Levels 1, 2, and 3 will result in enhanced driving efficiency and technology, referred to as eco-driving. Examples of fundamental technologies that facilitate eco-driving are cruise control and smooth, progressive acceleration and deceleration (NRC., 2010). Eco-driving demonstrates an improvement in fuel efficiency ranging from 4% to 10%. More optimistic forecasts have anticipated a rise in fuel economy of up to 39%. (Atiyeh., 2012). We have previously noted that autonomous vehicles may enhance travel capacity and decrease fuel consumption during traffic congestion. Autonomous cars facilitate communication of their maneuvers and actions with one another potentially decreasing idle time and enhancing both traffic flow and drive-cycle efficiency. Moreover, a platoon of closely positioned autonomous vehicles that infrequently halts or decelerates would resemble a train.

The outcome is anticipated to yield reduced peak speeds (enhancing fuel efficiency) while increasing effective speeds (Lu and Shladover, 2014). A distinct viewpoint is that the enhanced safety of autonomous vehicles may result in the development of lighter vehicles by automobile manufacturers. Indeed, safety initiatives are focusing on accident prevention rather than traditional crashworthiness in vehicles. Consequently, light cars are advantageous by-products of autonomous vehicle technology which significantly reduces fuel consumption. In traditional automobiles, safety-related features account for up to 20% of the weight. According to engineering principles, a 10-percent decrease in weight can result in a 6- to 7-percent decrease in fuel usage. Transitioning to electric vehicles from fossil fuel-powered cars enhances fuel efficiency. The efficiency of the changeover in fossil fuel vehicles compared to electric vehicles is established as 1–3 (Alderson et al., 2014).

Developing Countries:

Developing nations have challenges due to inadequate transportation infrastructure, including roads, bridges and public transit that hinder their economic advancement. The adoption of autonomous vehicles by these emerging nations may alleviate the expenses related to the expansion of capital-intensive infrastructure. A same scenario was observed when emerging nations advanced directly to mobile phone technology, therefore circumventing the costly landline infrastructure (Alderson et al., 2014).

Cybersecurity:

Since early 2012, swift advancements in cybercrime technology and methodologies aimed against infrastructure have led to an unparalleled increase in data breaches. Notwithstanding the significance of cybersecurity in autonomous vehicle technology, there remain concerns that have not been addressed in popular discourse or study (Pătraşcu, et al., 2014).

Societal Perception and Anticipating SEL Impact:

Lin's critiques of the safety argument have significant implications for the public utilization of the technology, public risk perception, and informed consent. Judging by media headlines like "killer cars," the issue of machine morality has already influenced public perception and risk assessment about the capacity of autonomous vehicles to make independent moral choices. If the premise by Gerdes and Thornton is validated, society's perception of autonomous vehicles will be the primary factor influencing the social and ethical implications of the technology. Their position prioritizes social perception and regards the assessment of autonomous technology as constrained by society's "ethical lens" (Gerdes and Thornton, 2016). Public risk perception is distinctly resistant to well publicized AV incidents, notwithstanding assertions of millions of kilometers driven safely. Nevertheless, while examining the myriad of news headlines and data derived from public questionnaires (Bonnefon et al., 2016) about autonomous vehicle safety and user perception, societal apprehensions correspond with the ethical dilemma and contradict the assertions of the safety argument. AV decisional capability reveals a fundamental challenge in the context of formulating decisions about AV and autonomous technologies. Autonomous cars embody an independent decision-making capability integrated inside one of the most dynamic and unpredictable elements of contemporary society as the human road network. This driving phenomena is known to provoke emotional responses even in the most reasonable individuals (Nash., 2017). Consequently, it occupies an unexpected emotional realm that autonomous vehicles must assess in many manners. For example, it argues that limited public tolerance for AV-related deaths may have unforeseen consequences for the parties engaged in technological development. The eventual success of AV will rely on a confluence of elements influencing societal perception including the ethical framework and risk assessment of the technology (Litman, 2017).

Conclusion

The autonomous vehicle is only one application of artificial intelligence technologies that significantly impact modern and future civilization. As AI implementations grow increasingly diversified and widespread, there will be a heightened necessity to comprehend the many contexts of decision-making applications. The consequence is that we should avoid pursuing a universal "One Size Fits All" model of artificial intelligence application, as no one framework can adequately include the myriad possibilities of machine decision-making applications. The conceptual framing is a fundamental component of an epistemic continuum that underpins governance and regulation. The strategic position consideration has in meaning chains that foster public discourse and is essential that such framing is subject to scrutiny. This study analyzes the insufficient scholarly focus on the essential process of conceptual framing within the realm of anticipatory governance.

The primary assertion is that conceptual framing influences subsequent discussions on the governance of automated vehicles. Another acknowledgment of the limitations of existing discussions is recognized, accompanied by a need for more accuracy in the formulation of such frameworks and ironically explains an investigation into the merits of reflective methods to conceptual framing. The intricacy and escalation of discussions on the societal impact of autonomous vehicles sometimes lead to a simplification of the argument for broader accessibility. This phenomenon is typical across several fields but is especially pronounced in the realm of new technology. For example, discussions on the hazards associated with nanotechnology reveal analogous deficiencies in early conceptual framing, resulting in regulatory inadequacies and extensive uncertainty among stakeholders. Reinstating clarity in conceptual framing, and acknowledging that conceptual frameworks have significant importance in any hermeneutic cycle might advance discussions on the implementation of autonomous vehicles.

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