Autonomous Vehicles: Machine Learning and Its Algorithms (Technical Report)

Public Policy on Road Safety for Autonomous Vehicles in the United States (STS Report)

A Thesis Prospectus

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By

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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Introduction:

In the evolution of American urbanization, a prominent pattern emerges. That is the undeniable dependence on personal vehicles, particularly in areas without ample public transportation. This trait, predominantly witnessed outside urban cities like New York City or Philadelphia, serves as a testimony to the United State's weaknesses in infrastructure. The construction of additional roads, while serving the immediate need, triggers a cyclic issue: induced demand. As roadways proliferate, so does traffic, immersing regions in the so-called "self-reinforcing dynamic of car dependence" (Mattioli et al., 2020, p. 7). The historical trend of Anglo-American suburbanization further aligns this automobile dependency with privatization, boosting a collective taste and necessity for personal vehicles (Mattioli et al., 2020, p. 8). The historical trend of suburbanization in the UK and US has seen people moving from urban to more spacious suburban areas, significantly influencing modern lifestyles and urban development. This shift to suburban living has led to increased reliance on private vehicles for transportation, as the suburban lifestyle often makes public transport less feasible or practical.

Unfortunately, as the necessity of private transport increases, so does the danger surrounding it. An unfortunate testament to this is the fatal human cost of road accidents in the United States. The year 2020 had approximately 40,000 fatalities and about two million emergency room visits as direct results of vehicular incidents, translating to an estimated financial cost of $430 billion (Ahmed et al., 2023). In response to this challenge, several researchers view autonomous vehicles as a potential solution to reduce these fatalities. A new study from the AAA Foundation for Traffic Safety forecasts the potential life-saving benefits of these systems, estimating that in addition to preventing traffic-related deaths, ADAS (advanced

driver assistance systems) will prevent 37 million collisions and 14 million injuries from 2021 through 2050 (Zukowski, 2023).

Autonomous vehicles once envisioned as futuristic dreams, have now made significant strides, evolving into tangible realities with functional achievements ranging from levels L0 to L3. However, there remain notable challenges to overcome before fully realizing the highest levels of autonomy. They span a range of autonomy, going from L0 to L5, with the latter representing complete self-reliance in navigation and operation (WEVOLVER, 2020). The development of autonomous vehicles, utilizing advanced technologies such as LIDAR, thermal cameras, and complex machine learning algorithms, suggests a potential evolution in societal transportation perceptions. This indicates a collaborative interplay between technology and social change, rather than technology solely driving societal shifts. Leading this revolution are companies like Tesla and Volvo, who are breaking barriers between human and machine-driven transit. Looking at DataMyte's observations, while semi-autonomous vehicles demand partial human intervention, their fully autonomous counterparts operate independently, belonging to L4 or L5 of the Society of Automotive Engineers' scale (Muscad, 2023). DataMyte is a provider of integrated quality management solutions for manufacturing, offering software, hardware, and services. The potential benefits of these innovations are extensive, from mitigating traffic bottlenecks to introducing safer transportation modes and democratizing mobility for the disabled and elderly (Muscad, 2023).

But, as with all massive societal shifts, the rise of autonomous vehicles warrants severe scrutiny. This research aims to explore the multi-dimensional impacts of artificial intelligence and autonomous vehicles on society. A detailed analysis of the positive implications and drawbacks of AI technology in human society is necessary (Khogali & Mekid, 2023). An ethical

line of questioning comes from a social theory perspective. Considering AI's designed and structured nature, how does its emerging role in society intersect with existing social behaviors and norms? For example, self-driving vehicles may also show biased results during the classification and detection of women and mobility-impaired individuals, as the datasets, especially the validation set, lack such representation of classes (Katare, 2020). The epistemic uncertainties surrounding novel technologies make safety failures likely, and the impact of failures cannot be foreseen with certainty (Hemesath & Tepe, 2023).

In my research, I aim to investigate the acceptance of autonomous vehicles through a socially ethical lens, recognizing the crucial role of comprehensive datasets and robust ethical frameworks in addressing potential biases and concerns. This approach acknowledges the importance of aligning technological advancements with societal norms and values, particularly in terms of fairness, equity, and privacy. To thoroughly understand this topic, we will utilize contemporary scholarly databases, with a special focus on the most recent data that reflects the dynamic nature of AI and autonomous systems. Platforms like Google Scholar will be significant in ensuring the accuracy, validity, and relevance of the case studies and datasets used in the study. By doing so, I strive to provide insights that are not only technologically sound but also ethically and socially responsible.

The technical topic is the development and implications of autonomous vehicles in the United States. Along with that, the STS topic is the societal and ethical impacts of integrating artificial intelligence and autonomous vehicles into urban infrastructure and society.

Technical Topic:

The advancement of technology and the endless pursuit of efficiency are leading sectors of the world with access to these innovations into an era where machines and algorithms are increasingly taking over tasks traditionally performed by humans. This shift is more pronounced in regions with the infrastructure and resources to implement such technological advancements. An emerging knowledge base of human performance research can provide guidelines for designing automation that can be used effectively by human operators of complex systems (Parasuraman, 2000). Among these advancements is the development of autonomous vehicles (AVs). The United States, with its vast landscapes and intricate highway systems, stands at the forefront of this transportation shift. However, the transition from human-driven vehicles to autonomous ones is full of complexities and implications.

Urban centers in the United States are grappling with challenges like traffic congestion, increased vehicular accidents, and environmental implications of mass car usage. These growing concerns call for a solution that not only addresses the immediate issues but also paves the way for a sustainable transportation future. Autonomous vehicles promise a solution to these multifaceted problems. Research indicates that AVs have the potential to significantly reduce traffic collisions attributed to human error. Essentially, by optimizing routes and reducing unnecessary accelerations or decelerations, AVs could reduce traffic congestion and the associated environmental impacts. Urban expressways are a promising starting scenario for eLanes, because this environment is well structured, and thus automated driving could be handled by state-of-the-art sensors and automation technology (Toffetti et al., 2009).

Alongside these promising outcomes, come significant challenges. The integration of AVs into the current infrastructure presents a reevaluation of the urban design, regulatory frameworks, and public perception. Potholes, unclear lane markings, and complex traffic

scenarios can hinder the operation of AVs. Moreover, cybersecurity threats to these vehicles open a new avenue of concern. The most pressing challenge is deterring criminal behavior in both the physical and cyber realms through the adoption of CAV (Connected and Automated Vehicles) cybersecurity protocols and regulations (Khalid Khan et al., 2023).

Given the potential of AVs to revolutionize transportation and the inherent challenges they present, the central research question that arises is: How can the United States effectively integrate autonomous vehicles into its transportation ecosystem, ensuring safety, efficiency, and public acceptance, while addressing the associated challenges?

To address the research question, the study will follow a multifaceted approach. An exhaustive review of existing literature will be conducted, focusing on the development, capabilities, and challenges of AVs. The resources from reputable sources will be instrumental in understanding the current state of AV technology. Drawing insights from (Khalid Khan et al., 2023), the research will delve into potential cybersecurity threats to AVs and propose mitigation measures. Analyzing existing regulations surrounding AVs and identifying gaps or areas for improvement. The research by (Pillala et al., 2023) and (Gibson & University of Kentucky Transportation Center, 2017) will be pivotal in this segment. Lastly, there will be a review of global best practices. For instance, the European model of AV integration, as presented in the article, “Challenges for Urban Planning in European Cities” (Gavanas, 2019), can offer valuable lessons.

STS Topic:

The complex relationship between technology and society is now being showcased in the development and deployment of autonomous vehicles (AVs). Though, beyond just societal ethics

and technological advancements, public policies play a crucial role in shaping the direction of such innovations. Science, Technology, and Society (STS) studies offer a viewpoint to scrutinize how technological advancements, like AVs, are influenced by, and in turn, influence public policy.

Public policies are not just executive decisions. They reflect a society's collective values, priorities, and aspirations. In the context of the United States, the car-centric culture combined with technological enthusiasm has steered the nation towards embracing AVs as a potential solution for numerous transportation challenges, such as traffic congestion and vehicular accidents (Mattioli et al., 2020). However, public policy around AVs doesn't just concern itself with technological feasibility but also grapples with societal implications, including safety, equity, employment, and urban planning. Although the widespread use of fully connected and autonomous vehicles is still several years away, it is nonetheless critical that legislators, policymakers, and regulators understand how the presence of these vehicles will restructure the operation of roadway networks (Gibson & University of Kentucky Transportation Center, 2017).

Additionally, while AVs present potential benefits, the algorithms that drive them are shaped by societal data, carrying the risk of inheriting societal biases. Katare (2020) highlights a case where object detection algorithms in self-driving cars were unable to accurately identify certain user groups due to unidentified racial groups. This issue arose because the AI models were trained on datasets predominantly composed of images of caucasian individuals, which excludes individuals from other racial backgrounds from being equally considered in the dataset for training. With innovations like AVs, public policy doesn't merely respond to technology; it actively co-constructs it. Regulations, standards, and policies guide research directions, market deployments, and societal interactions with such technologies.

The STS-oriented research question in the context of public policy and AVs asks how policy at the federal level, particularly in road safety, influences the development and deployment of autonomous vehicles in the United States.

In my research, I will examine public policies, regulations, and guidelines at both the federal and state levels concerning autonomous vehicles (AVs). This will include an in-depth analysis of California's legislative transcripts, selected for their stricter state-level regulations compared to federal standards, as indicated by Fox-Sowell (2023). My goal is to understand the underlying motivations, considerations, and impacts of these policies. I plan to investigate the National Highway Traffic Safety Administration's (NHTSA) position on AVs, as understanding their stance is important. I will engage with policymakers, industry leaders, and public advocacy groups in hopes that it will offer diverse perspectives, highlighting their views, concerns, and goals related to AV policy. Further, I will analyze the datasets and algorithms utilized in AV systems, evaluating them in the context of current or future policies. A key aspect of this analysis will be exploring how these policies address potential biases and ethical issues in AV technology. I will also compare AV policies from various countries to gain insight into different regulatory approaches and their results. This could reveal best practices and possible policy directions for the U.S. Lastly, I will document how initial AV policies in the U.S. have evolved, adapting to technological advancements and societal feedback. This will help to illustrate the iterative process of policy-making in an era of rapidly advancing technology.

Conclusion:

Throughout my research, the technical portion will display an improved design for autonomous vehicles, integrating the latest algorithms and safety measures. This design aims to

harness the true potential of AVs, ensuring they are efficient, safe, and ethically calibrated. The STS deliverable will offer a detailed analysis of existing public policies regarding autonomous vehicles (AVs), providing recommendations to align them with the values, ethical standards, and technological advancements as perceived and upheld by the American populace. This alignment will particularly focus on fostering the overall wellness, ethical considerations, and safety of Americans in environments where autonomous vehicles operate and interact with people.

Once completed, these findings can significantly reduce existing transportation challenges. The improved AV design would offer safer, more efficient roads and ease traffic congestion. Also, the refined public policies, informed by the STS analysis, would provide a strong framework that fosters technological innovation while protecting societal interests. Together, these findings have the potential to pave the way for a balanced integration of autonomous vehicles into society, balancing technological progress with human values.

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