Assessing Safety Hotspots using Vehicular Telematics Data

Examining the Current Decision-Making Capabilities of Self-Driving Systems

A Thesis Prospectus
In STS 4500
Presented to
The Faculty of the
School of Engineering and Applied Science
University of Virginia
In Partial Fulfillment of the Requirements for the Degree
Bachelor of Science in Systems Engineering

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November 30, 2023

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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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Overview:

The automotive industry stands on the brink of a transformative revolution, with self-driving systems emerging as the focal point of innovation. These autonomous systems promise to enhance road safety, reduce traffic congestion, and provide greater mobility to individuals with disabilities, among numerous other benefits. Currently, the leading cause of death in the United States for those aged 1-54 is from traffic incidents (CDC, 2023) This illustrates a clear need for improvement, in terms of safety, in the world of automobiles. However, the widespread adoption of self-driving vehicles hinges upon their ability to make complex and nuanced decisions in real-world scenarios that humans do as they drive their cars every day. As we stand on the cusp of this autonomous revolution, it is imperative to examine the current decision-making capabilities of self-driving systems critically in order to ensure the complete safety of these vehicles. This goal goes hand-in-hand with my capstone project, which attempts to identify safety hotspots within the University of Virginia campus using telematics data from Facilities Management vehicles. The rest of this prospectus will be divided into sections that further examine the capstone project, as well as the STS research question in more detail.

Assessing Safety Hotspots using Vehicular Telematics Data:

For my senior capstone project, I am a part of a team led by Professor Brian Park in the Department of Systems and Information Engineering. The rest of the team consists of Transportation Operation and Fleet Manager Mike Duffy, fellow Systems Engineering students Sunho Oh and Goirick Saha, as well as members of the Computer Science Department at Virginia State University: Ahmed Mohammed, Terence Blunt, Jihad Turner, and Joon Lee. Given that safety is one of the primary concerns of Facilities Management at the University of

Virginia, the goal of this project is to identify potential safety hotspots on the grounds of the University of Virginia using telematics data from UVA Facilities Management Fleet vehicles.

This project is a continuation of past projects in collaboration with UVA Facilities Management, with the same goal of improving road safety and sustainability. For this project, the team will explore surrogate measures related to road safety such as harsh acceleration, harsh braking, harsh cornering, and speeding, in addition to their geo-location to investigate locations with potential safety hazards for drivers. These locations will then be compared to historical crash data for validation. However, it is important to note that since crashes are a rare occurrence at the university, the identified safety hotspots might not show any actual crash data. Despite this, these identified safety hotspots are still important as they identify areas for potential safety improvements, which can prevent future accidents.

The telematics data used to identify our surrogate measures as well as their geo-location are from GeoTab devices, where the data can be accessed through GeoTab's website. GeoTab is an onboard device that is installed in over 270 University of Virginia Facilities Management vehicles that report various vehicular statuses, including all the surrogate measures listed earlier. One downside, however, is that the geolocation data from these GeoTab devices is inadequate as they only update every 15 seconds, which can result in inaccurate location tags for the surrogate safety events. To prepare for this, the project team plans to utilize the Internet of Things (IoT) network to obtain more accurate geo-location data from select Facilities Management fleets using LoRaWAN gateways that have been installed across the grounds of the University of Virginia. This part of the project will be managed by the Virginia State University side of the project team.

Based on the findings from the capstone project, we hope to be able to develop recommendations to improve road safety in identified safety hotspots across from the University of Virginia. In addition, there is hope that the University of Virginia will become one of the leaders in utilizing its fleets' telematics data for improving safety as well as sustainability through the completion of this project.

Examining the Current Decision-Making Capabilities of Self-Driving Systems

The landscape of autonomous driving technology has been rapidly evolving in recent years, with various companies and researchers around the world working tirelessly to advance the capabilities of self-driving cars. However, determining the current state of autonomous driving is a challenging task, primarily due to the conflicting and often sensationalized information presented by the media. This help with this, SAE International has defined six levels of driving automation to help track the progress of self-driving development (USEPA, 2023). The levels are defined as:

- Level 0 – The car has no driving automation. The driver is always in full control of the car, although the car might have the ability to send safety warnings.
- Level 1 – The car as driver assistance. This means that the car can control either the speed or steering, but not at the same time. Examples include adaptive cruise control and lane assist technology.
- Level 2 – The car can control both speed and steering, but only in certain conditions. This includes when the car is in slow-speed situations, such as parking assistance.

- Level 3 – The car has “conditional automation” capabilities. The car can control the speed and steering, as well as monitor its surroundings. The driver still needs to be paying full attention while behind the wheel (ex. Traffic Jam Assist).
- Level 4 – The car is highly automated and can self-drive in normal conditions. Human drivers will need to take over in uncertain circumstances such as extreme weather.
- Level 5 – The car is fully automated. The car is capable of driving itself in all conditions.

Currently, self-driving systems level 3 and below are widely produced, with level systems gradually developing (Wang et al, 2021). Nonetheless, developing level 4 and level 5 systems presents a much greater challenge than the first three levels. So far, the decision-making capacity of self-driving systems has been based on scenario-driven and task-driven approaches that enable the car to perform specific tasks without the need for human intervention (Ulbrich et al, 2017). We can see this through the current features that can be automated: Active Cruise Control (ACC), Lane Departure Warning System (LDWS), Lane Keep Assist (LKA), Park Assist (PA), Traffic Jam Assist (TJA), etc. This concept of automation has enabled the automotive industry to progress relatively quickly through levels 1-3 of automation.

However, this method of development fails to achieve the ultimate goal of producing fully automated cars (Level 5). The current scenario-driven concept means that manufacturers would have to come up with an infinite number of scenarios in order to achieve a fully automated car. For my research, I plan on investigating the gap between the current automated systems against what is expected from a fully automated level 5 system. Specifically, I want to answer the following question: “What are the current decision-making capabilities of self-driving systems”. This includes investigating current self-driving systems such as Tesla’s Autopilot, Ford’s BlueCruise, Cadillac’s Super Cruise, Mercedes-Benz’ Driver Assistance, etc; to see where they currently stand and the steps each are taking as they continue to advance in the automation of their vehicles (Monticello, 2023).

Given this, I plan to utilize the Actor-Network Theory (ANT) for my research. The Actor-Network Theory emphasizes the interconnectedness and relationships between various actors, both human and non-human, in a technological system. It will allow me to explore how self-driving systems interact with human drivers, pedestrians, policymakers, and other elements in the environment. Overall, using ANT, I can investigate how these autonomous systems are integrated into society, how they influence human behavior, and how societal factors shape the development and implementation of self-driving technology.

This research is important as there are a multitude of benefits that come from the automation of driving (NHTSA, 2023). First and foremost, self-driving cars have the potential to significantly decrease the number of accidents caused by human error, which remains a leading cause of fatalities on the roads. Additionally, self-driving cars can optimize traffic flow by communicating with each other, minimizing congestion, and promoting more efficient use of roadways. This can lead to reduced travel times and fuel consumption, which in turn is better for the environment. Moreover, this technology can enhance mobility for individuals who are unable to drive due to disabilities or age-related issues. In essence, self-driving cars have the potential to revolutionize transportation, making it safer, more efficient, and environmentally friendly.

The benefits that come with having fully automated cars are undeniable. However, as previously mentioned, we are still a bit away from achieving this groundbreaking goal. There are still shortcomings in this field, which I will continue to learn about as I continue my research on this topic. In the future, I intend to use literature to analyze recent work being done with regard to driving automation as we progress closer to the development of full automation.

References

Centers for Disease Control and Prevention. (2023, January 10). *Global Road Safety*. Centers for Disease Control and Prevention. https://www.cdc.gov/injury/features/global-road-safety/index.html

The main argument of "Global Road Safety" revolves around the alarming statistics related to traffic injuries and fatalities worldwide. By highlighting the significant toll of traffic incidents, the report underscores the need for advancements in road safety. This ties in to my project as the advancement of self-driving systems promises to improve the safety of roads. Having this source enables me to present how pressing the issue of road safety is and why the idea of self-driving systems is relevant to society.

Monticello, M. (2023, October 17). *Ford's BlueCruise remains CR's top-rated active driving assistance system*. Consumer Reports. https://www.consumerreports.org/cars/car-safety/active-driving-assistance-systems-review-a2103632203/

This article provides an insightful overview of the current landscape of self-driving systems, focusing on the functionality and safety aspects of active driving assistance systems. It discusses current systems such as Ford's BlueCruise and Tesla's Autopilot, emphasizing its capabilities in hands-free driving and the collaboration between adaptive cruise control and lane centering assistance. The article highlights the widespread adoption of these systems, with over 50% of 2023 model cars having such technologies. Additionally, the paper evaluates and ranks all the existing systems. This source contributes valuable insights into the practical implementations, strengths, and challenges of existing self-driving technologies, helping to inform my assessment of the current state of these systems.

National Highway Traffic Safety Administration. (n.d.). *Automated vehicles for safety*. NHTSA. https://www.nhtsa.gov/technology-innovation/automated-vehicles-safety

This source discusses the ongoing evolution of automotive technology, focusing on the potential safety benefits of automated vehicles. The text highlights the transformative safety opportunities that may arise with mature automated driving systems. More specifically, the safety benefits are emphasized, particularly in removing the human driver from situations that could lead to crashes. The article also goes over potential societal benefits of having automated driving systems, including increased mobility for seniors and the disabled, expanded transportation options for underrepresented communities, improvements in traffic congestion, and also improvements in air quality. This source is helpful as it provides a comprehensive overview of the safety and societal considerations associated with the evolution of automated driving systems.

Ulbrich, S., Reschka, A., Rieken, J., Ernst, S., Bagschik, G., Dierkes, F., … Maurer, M. (2017). Towards a functional system architecture for automated vehicles. Retrieved from http://arxiv.org/abs/1703.08557

This paper presents a functional system architecture for automated vehicles, offering a comprehensive structure across vehicle projects. The architecture is designed to be independent of specific implementations, providing a versatile framework. It draws inspiration and validation from a real-world automated driving implementation called the "Stadtpilot Project" by Braunschweig University of Technology. This paper is instrumental in understanding the foundational elements required for the successful implementation of automated driving systems. This source can contribute essential

insights into the structural and functional aspects of automated vehicles, assessing the current state and potential future developments of autonomous systems.

United States Environmental Protection Agency. (2023, May 18). *Self-driving vehicles*. EPA. https://www.epa.gov/greenvehicles/self-driving-vehicles

This source defines the levels of automation with regards to self-driving cars, which is a comprehensive framework for understanding the evolutionary trajectory of autonomous vehicle trajectory. This categorization, ranging from level 0 (no automation) to level 4 (full self-driving), offers a structured perspective on the progressive integration of autonomous vehicles, which is useful for my STS project as it provides a way to track the current state of self-driving systems. It is a useful tool for evaluating the current state of self-driving systems, examining the advancements made and challenges encountered at each level of autonomy.

Wang, Jianqiang & Heye, Huang & Li, Keqiang & Li, Jun. (2021). Towards the Unified Principles for Level 5 Autonomous Vehicles. Engineering. 7. https://doi.org/10.1016/j.eng.2020.10.018.

The primary purpose of this paper is to address the challenges and conceptual gaps in the development of level 5 autonomous vehicles. The paper contends that the prevailing task-driven and scenario-specific approaches used so far in automation are not effective in reaching level 5 automation. The authors then proposed a framework which could help bridge the gap to achieve full automation. This paper contributes valuable insights into the challenges and potential solutions associated with level 5 autonomy, offering a conceptual framework that analyzes the current state and future trajectory of self-driving systems.