Optimizing Traffic Flow Through Autonomous Driving Systems

Enhancing Consumer Perception of Autonomous Driving Systems

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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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The Impact of Traffic on Everyday Drivers

Millions of drivers around the world waste precious morning hours in traffic causing significant delays, elevated stress levels, and an overall disgruntled start to the day. INRIX, a U.S.-based corporation that provides software-as-a-service analytics about traffic and road safety, cited in the 2022 release of the Global Traffic Scorecard that the typical American driver lost around 51 hours to traffic congestion in 2022, which is a 15-hour increase compared to the numbers from 2021. The hours lost translate to monetary losses of around $869 in 2022 ($564 in 2021) and around $546 ($412 in 2021) lost in fuel per urban American driver as illustrated in Figure 1.

In contrast, the COVID-19 pandemic had an opposite effect on traffic patterns, particularly in Central Business Districts, where shutdowns led to a drastic reduction in trips, almost eliminating time wasted in traffic congestion globally. Despite this temporary reprieve, the trend of increasing time spent stuck in traffic is expected to continue, resulting in greater inefficiencies and driver frustration, and the associated costs are projected to rise with the increasing number of vehicles on the road (Lutin, 2014, pp. 207-210). To address this issue, implementing autonomous systems that can communicate with and maneuver around nerby vehicles can smoothen traffic flow and reduce the likelihood of heavy traffic congestion and gridlock. However, the adoption of autonomous driving systems faces challenges related to public confidence, safety concerns, and ethical dilemmas. These societal factors must be carefully considered to ensure the successful integration of autonomous systems into existing transportation infrastructures. Addressing both the technical and societal aspects of autonomous driving systems can achieve a comprehensive approach to alleviating traffic congestion and driver frustration.

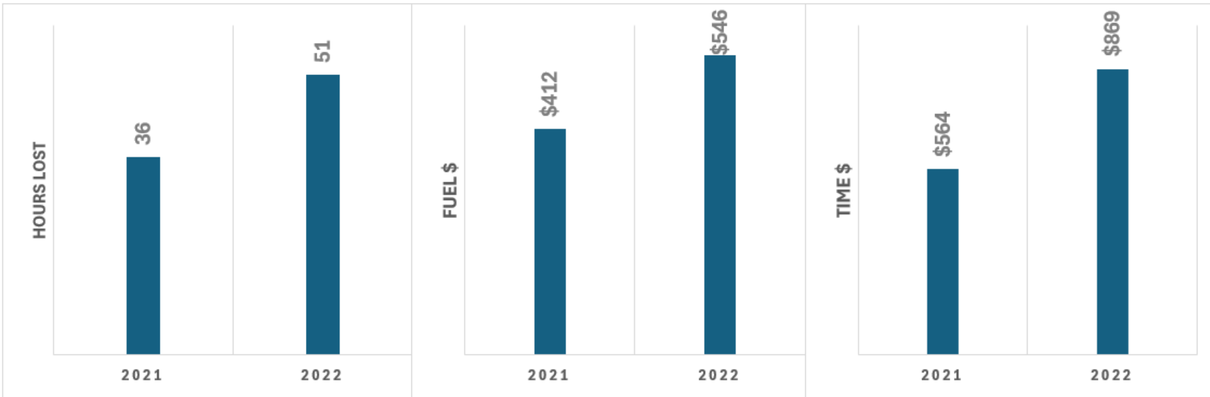

Figure 1: Comparison of hours, fuel money, and monetary value of time lost in traffic congestion for drivers in the United States in 2021 and 2022. As noted in the above paragraph, the number of hours lost increased the most in the United States along with money wasted in time and fuel, deplicting an increase between 2021 and 2022 (Adapted from Cookson, 2022, p. 4).

Technical Topic: Optimizing Traffic Flow Through Autonomous Driving Systems

Autonomous driving systems are revolutionizing transportation, relying on a complex interplay of hardware and software components. These systems utilize an array of sensors, namely LiDAR, GPS, gyroscope, and optical cameras, to gather data from both the autonomous vehicle, often referred to as an "agent", and its environment. LiDAR, which stands for Light Detection and Ranging, employs laser pulses to measure distances to objects in the environemnt, GPS, which stands for Global Positioning Systems, provides precise positioning information by using a network of satellites in space to determine the receiver's location on Earth, and cameras capture high-resolution images and videos of the vehicle's surroundings (Lutin, 2014, p. 207). Together, these sensors work in harmony to create a detailed and accurate 3D map of the vehicle surroundings, integrating precise location data from GPS with 3D spatial information from LiDAR and visual context from cameras.

The map data is processed by specialized software modules to enable real-time decision-making. The motion planning module analyzes the data to determine the optimal path for the vehicle, considering factors like traffic conditions and road layout. Meanwhile, the perception module interprets sensor data to identify objects and obstacles in the vehicle's environment, classifying them and assessing their distance and movement. Finally, the localization module, uses GPS and gyroscope data to determine the vehicle's precise position on the road (Sugimachi, 2013, p. 3).

Despite this advanced technology, current systems lack the capability for inter-agent communication, particularly evident in scenarios like planning traffic avoidance routes at intersections or on busy roads (Liu, 2021, p. 3). One of the most pressing issues facing modern transportation is the increasing number of vehicles on the road, leading to a rise in traffic congestion and wasted time. Drivers in populated urban areas are prone to facing gridlock traffic situations resulting in massive loss of productivity and adverse effects on mental well-being (Alawadhi, 2020, p. 7). As stated above, the average driver around the world wastes hundreds of dollars in fuel and time in traffic congestion year-over-year, indicating a challenge with no apparent solution.

To address these challenges, researchers worldwide are focused on enhancing the reliability of autonomous driving systems in real traffic environments. The goal is to achieve level 4 and level 5 autonomy, where vehicles can operate independently and safely without human intervention, so that a network of driverless vehicles can act freely to make the optimal driving decisions in the context of the surrounding vehicles and environment (Yurtsever, 2020, p. 3). My research aims to develop a communicate protocol that allows multiple autonomous vehicles to exchange information, coordinate their routes, and plan ahead for potential traffic congestion in an effort to optimize traffic flow.

STS Topic: Enhancing Consumer Perception of Autonomous Driving Systems

The essence of consumer mistrust in autonomous driving systems is apprehension about relinquishing autonomy to these systems. This fear stems from the desire for control over everyday life and especially in potentially perilous situations such as driving. A case study about trust in autonomous driving (Sheng, 2019, p. 1) revealed that human trust and system reliability are tightly correlated, and errors in the early stages of automation or on simple tasks have a severe negative impact on trust. Several cases of this mistrust can be observed in various real-world, For instance, an NPR article on the anonymous activist group called the Safe Street Rebels detailed how San Franciscan residents wearing dark colors stalk driverless vehicles and place a large traffic cone on the hood of the car, rendering the vehicle immobile until the cone is removed. The activist group rose in response to the numerous public health and safety incidents along with several accounts of driverless vehicles blockading first-responder vehicles (Kerr, 2023, pp. 2-6).

In response to these incidents, California's Department of Motor Vehicles suspended Cruise, a driverless subsidiary of General Motors, from deploying any of their driverless vehicles on Californian roads. The primary tipping point for state officials to take legal action was that Cruise allegedly withheld video evidence of an incident with a pedestrian, further deepening the chasm of mistrust between autonomous driving systems and consumers (Zipper, 2023, pp. 2-5). Such incidents further fuels the mistrust in autonomous driving systems and could potentially result in various other actors to oppose these systems. For instance, anti-driverless campaigns perpetuated by media corporations and lobbyists are likely to further sway public opinion and intensify the efforts against mass deployment, creating further obstacles for autonomous driving research and impeding the implementation of valuable research findings (Imai, 2019, p. 4).

To address these challenges, it is crucial to approach the deployment of autonomous driving systems with intentionality and open, clear communication and collaboration between all involved parties. Deliberate efforts between organizations involved in the development and deployment of this technology is the optimal method in overcoming these obstacles and ensuring mass deployment. Addressing anti-autonomous driving system lobbying requires adherence to ethical practices and a deep understanding of user acceptance that can be achieved through exploring research projects related to those fields. By focusing on these aspects, we can pave the way for the successful integration of autonomous driving systems into everyday life.

Conclusion

The key deliverable of the technical work will be software that is specifically designed to serve in either the perception and/or motion planning modules of the on-board computing system in an autonomous vehicle. The will be able to generate a trajectory (or set of trajectories) based on provided LiDAR and GPS data that includes other vehicles on the road as well. The STS work would consist of conflict resolution strategies for potential problems that may arise between the various organizations involved and will include methods of improving consumer trust.

The technical work will serve as a component of the on-board used in traffic situations where several autonomous vehicles need to communicate with each other. Specifically, it should play a role in the traffic avoidance mechanisms in intersections and other dynamic, agent-dense roads. Provided that there is a wide-scale adoption of the technical work, the total global man-hours spent in traffic should reduce and should save the average American drivers hundreds of dollars in time and fuel. The STS work would prepare organizations for the implications of a faulty initial deployment and provide alternative solutions or conflict resolution strategies when issues amongst the organizations arise. The STS work, along with a transparent technical design, will allow organizations to mitigate the negative implications on public mistrust and help build consumer confidence in autonomous driving systems.

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