Prospectus

Design of Weatherproof Sensors for Autonomous Vehicles
(Technical Topic)

Analysis of a Fatal Driverless Tesla Crash in Texas, 2021
(STS Topic)

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

Since the 1950's, from the introduction of cruise control to today's use of lane/breaking assists, car designers have looked for a way to make driving simpler and more comfortable for the average consumer (NHTSA, n.d.). Autonomous features have been present in vehicles for 70 years and continue to become more prevalent in the car industry. One of the current challenges that developers face is the difficulty of using sensors for autonomous features on AVs during inclement weather; the particles in the air cause inaccurate readings that interfere with decisions made by the vehicle (Half Fast Chicago, 2018). My team will develop a design with the use of different sensors and mapping that will remove the issues faced by a self-driving vehicle during bad weather, hoping to advance the progress being made to having fully autonomous cars on the road.

However, simply creating a more advanced autonomous vehicle will not fully accomplish the task at hand. Since I am proposing the continuation of a shift from human control of cars to automated control, this new network in the car industry continues to change. If the roles of humans and non-humans are not carefully considered in the development of this technology and the interactions between the two that must occur to promote safe usage of AVs, then a series of negative consequences can make this fragile network collapse. Developing these sensors solely for the creation of a better self-driving vehicle and not carefully examining the actors playing their roles in the newly developed network, will cause severe technological and social failures in the future.

To create the best overall autonomous vehicle, both technical and social components must be examined. The technical component will be addressed by a new design that will incorporate current sensors used on AVs with new radar sensors and mapping technology to improve performance in inclement weather. For the social component, I will assess the failures of certain actors in a fatal Tesla self-driving incident from 2020 to fully understand how the network broke down. This analysis will focus on both human and non-human actors to ensure all factors in the Tesla network are fully considered.

Technical Problem

Within the past decade an increasing number of autonomous features have been introduced to everyday cars, such as autopilot, park/brake assist, and lane departure (NHTSA, n.d.). These simple additions proved to be the first step in the growing industry of AVs. With a projection of over 12% of registered vehicles worldwide being autonomous by 2030 (Khvoynitskaya, 2020), manufacturers look for the most effective way to create fully self-driving vehicles. AVs already make appearances on roads, and the technology behind them only continues to improve.

For an autonomous vehicle to safely function on the road, it needs to employ the use of various sensors to “see” its surrounding environment. Two of these components, LiDAR (Light Detection and Ranging) and cameras, are crucial aspects to mapping out a 360° view for the vehicle as it needs to make decisions while driving (D’Allegro, 2021). LiDAR can create a 3D visualization for the vehicle using millions of pulsations from microscopic lasers that are measured by the time it takes to bounce off objects and return to the sensor (Waymo, n.d.). This allows an autonomous vehicle to have the luxury of an aerial view of its surroundings regardless of the time of day. Cameras on the car provide an encompassing view of all traffic conditions, which lets the vehicle take note of all traffic lights, construction scenarios, pedestrians, etc., as it makes intelligent decisions on the road (Waymo, n.d.). These sensors have been essential to the rise of the AV industry and are a large part of the success behind the increasing developments being made for these types of cars today; over 1,400 self-driving cars are being tested in the US today (Kopestinsky, 2021).

On the other hand, an autonomous vehicle using LiDAR and cameras does have crucial limitations. First, LiDAR is made using a rare earth metal that makes the sensors extremely expensive to produce, so any company working to develop autonomous cars using LiDAR sensors must have adequate financial capital to develop such vehicles; any customer that wants such a car will have to pay more for the product (Half Fast Chicago, 2018). The main concern with the two sensors is that both cameras and LiDAR begin to have issues during inclement weather, such as rain, snow, or fog, as the droplets distort the readings on the instruments (Labios, 2020). The result of this shortcoming is that when only these two sensors are used on an AV, usage is not safe during bad weather, which makes it nearly impossible to pass safety inspections for mass production. The functions of the two technologies that make them so useful during a sunny day also result in severe malfunctions as poor weather causes incorrect readings in the software.

The purpose of this technical project is to find a way to allow autonomous vehicles to effectively "see" the road in all types of weather conditions. There are two different technologies that will be utilized to find the best combination of sensors on a self-driving car that allow it to function in the most efficient and safest way possible. These sensors, radar and computer mappings, are intended to give the vehicle a different perspective to visualize its surroundings even during inclement weather (Mitchell, 2021). The proposed methodology for this experiment will involve a common vehicle used by the average consumer in the United States, with the addition of radar sensors and a computer system used for satellite mapping to test the proposed technology. These sensors will display their visualizations under varying weather conditions (clear, rain, snow, fog) to test the extent that these components are useful for an AV in all environmental situations.

The task of this proposal is to compare the data recorded from radars and computer mapping on a vehicle to those of LiDAR and cameras under similar conditions. The data comparison will tell us if these different sensors prove to be crucial components to an autonomous vehicle or if an alternative route will need to be taken to make these cars usable during inclement weather. Testing the use of LiDAR will demonstrate its efficaciousness in multi-sensor navigation of AVs.

STS Problem

As companies such as Tesla continue to introduce new autonomous features on their vehicles, they attempt to ensure that proper safety guidelines are followed by all drivers that exercise the use of the new technology. In addition to an Autopilot feature, Tesla offers six different "full self-driving capability" options that create easier driving scenarios for a driver (Tesla, 2019). As a result, Tesla strongly encourages consumers to read fully and follow all safety guidelines when not being in full control of the wheel as an effort to protect both the people in the vehicle and anyone on the road.

Unfortunately, Tesla's goal for safe self-driving failed when two people were killed in a crash with no humans behind the wheel near Houston, Texas in mid-April 2021. Officials dictated that the incident occurred partly because "no one was driving the vehicle" when it crashed (Pietsch, 2021). This horrific accident is a glaring example of the potential dangers of AVs, especially when full control is not instantly obtainable by a human operator. Even though

Tesla clearly states that there must be an attentive driver behind the wheel even while using self-driving features, an incident disregarding such instructions followed. If further analysis of what led to this accident is not made, then such tragedies will only increase in occurrence and Tesla, among other companies introducing these features to their cars, will face severe backlash from the public (Biondi, 2020). Furthermore, we could see a severe pushback from many people against having AVs if human fatalities become a significant side effect of self-driving usage and only add to the amount of lives lost on the road each year; this would severely damage the bright future of driverless vehicles.

Some fatal oversights were made that led to the accident in Texas in 2021; scientific procedure and a misunderstanding of the way that humans behave in certain situations caused an inaccurate representation of how the autonomous features in a Tesla need to be utilized. In this instance, I argue that Tesla design engineers' perspective of humans in a self-driving car was miscalculated; a human did not have to be present in the driver's seat for autonomous features to work and was the ultimate cause of the accident. The result of such an oversight in this system led to a consequence that exposed the misconceptions between design and usage. My analysis of the driverless Tesla wreck will draw on the concept of actor-network theory (ANT), which considers both human and non-human elements as equal actors working together in a complex network to accomplish an overarching goal (Cressman, 2009). In ANT, it is important to note that there are both human and non-human actors, because for this specific incident, one of the actors at fault is the self-driving system developed by Tesla. These networks tend to fail when actors within the network do not follow their proper role as the software, Tesla engineers, and consumers all did not accomplish their purpose in safely using Tesla's autonomous features. To further understand the roles that the engineers play in the development of self-driving components in a Tesla car, I look to Michel Callon's interpretation of engineers as sociologists in a network. Callon discusses how engineers perform as sociologists during the development of a network and how they mold the societal consumption of their product, which I see as a direct connection to the development of Tesla's autopilot feature that led to the fatal accident (Callon, n.d.). I will use Callon's argument on engineers as sociologists and its connection to ANT to support my argument on the failures of actors within the Tesla autonomous features network and find the correct roles that all actors need to fulfill to promote self-driving Tesla cars.

Conclusion

To develop the next advancement for autonomous vehicles, I will perform two different procedures. First, I will develop a design for an AV that will include radar sensors and mapping to improve car decision making and vision in inclement weather. Then, I will analyze the shortcomings of both human and non-human actors in the Tesla vehicle network from the site of the Texas incident in 2021 to further understanding the fragility of developing a self-driving car. Using the knowledge gained from both a technical and social analysis, design engineers will have a clearer path to developing self-driving cars. Using a socio-technical analysis rather than viewing just one of the two components allows for a better understanding of the complex network that is formed in this scenario. Technology cannot be forced onto society by engineers whose sole purpose is to create the best piece of machinery; social implications must come into consideration to ensure an efficiently working network of both humans and technology. The future of autonomous vehicles will be propelled by a successful analysis of the relationship between both social and technical factors.

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References

Advantages And Disadvantages Of Autonomous Car – Half Fast Chicago. (2018, May 3). http://www.halffastchicago.com/advantages-and-disadvantages-of-autonomous-car/

Biondi, F. (2020, November 30). *Who's to blame when a self-driving car has an accident?* The Conversation. http://theconversation.com/whos-to-blame-when-a-self-driving-car-has-an-accident-150941

Callon, M. (n.d.). *Society in the Making: The Study of Technology as a Tool for Sociological Analysis*.

Cressman, D. (2009). *A Brief Overview of Actor-Network Theory: Punctualization, Heterogeneous Engineering & Translation*.

D'Allegro, J. (n.d.). *How Google's Self-Driving Car Will Change Everything*. Investopedia. https://www.investopedia.com/articles/investing/052014/how-googles-selfdriving-car-will-change-everything.asp

Khvoynitskaya, S. (2020, February 11). *3 types of autonomous vehicle sensors | Itransition*. https://www.itransition.com/blog/autonomous-vehicle-sensors

Kopestinsky, A. (2021, April 29). *Self driving car statistics for 2021| Policy Advice*. https://policyadvice.net/insurance/insights/self-driving-car-statistics/

Labios, L. (2020, November 21). *Upgraded radar could let autonomous vehicles see in bad weather*. The Robot Report. https://www.therobotreport.com/updgraded-radar-autonomous-vehicles-see-bad-weather/

Mitchell, C. (2021, January 8). *How can self-driving cars "see" in the rain, snow and fog?* Abc10.Com. https://www.abc10.com/article/weather/accuweather/self-driving-cars-radar-inclement-weather-rain-fog-snow/507-0438604e-ef32-4c0a-9634-99a6ec71fa12

NHTSA. (n.d.). *Automated Vehicles for Safety | NHTSA* [Text]. https://www.nhtsa.gov/technology-innovation/automated-vehicles-safety

Pietsch, B. (2021, April 18). 2 Killed in Driverless Tesla Car Crash, Officials Say. *The New York Times*. https://www.nytimes.com/2021/04/18/business/tesla-fatal-crash-texas.html

Tesla. (2019, February 13). *Autopilot and Full Self-Driving Capability*. https://www.tesla.com/support/autopilot

Waymo Driver. (n.d.). Waymo. https://waymo.com/waymo-driver/