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A Literature Review of Autonomous Vehicle Technology:
The Readiness of Self-driving Cars to Be Integrated into Society

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Introduction

Each day, researchers and engineers bring fully-autonomous vehicle technology closer to becoming a reality. It is now commonplace for even semi-autonomous vehicles to have the ability to change lanes, stop at various traffic signals and signs, and even avoid potential collisions all without interference from a human driver. In the automobile industry, companies are racing to become the first to develop a vehicle that is capable of full self-driving. Researchers Katherine Rose Driggs-Campbell and Kai Holländer both share the belief that level-five vehicle autonomy (where the only interaction needed from the driver is the act of setting or changing a waypoint) is realistically achievable in the near future (2014, 2019). As a whole, however, this field, that the automobile industry is charging headstrong into, is still widely uncharted territory, and many questions revolving around the practical integration of fully-self-driving cars remain unanswered. Opinions on the readiness and practicality of the full integration of autonomous vehicle technology into the public sphere are contested because various researchers question whether or not the proper precautions have been taken.

Purpose of the Literature Review

The purpose of this literature review is to examine and gather information from various research studies that answer questions that I outline in my research proposal scope. Using my scope as an outline, I seek to answer my main research question: How would a homogeneous population of fully-autonomous vehicles impact traffic flow and safety

Questions that Remain about Self-Driving Cars

Integrating fully-autonomous vehicles into society would require communication pipelines at many different levels of the overall design. Researcher Katherine Rose Driggs-Campbell states that “little to no work [is] currently being done in autonomous-driver interactive situations” (Driggs-Campbell). This is in reference to vehicle-to-vehicle (V2V) communication, which Driggs-Campbell mainly focuses her research around. If fully-self-driving cars were to be fully integrated into everyday life, Driggs-Campbell argues, then some sort of interconnected communication framework would first need to be implemented. The question of how to solve this issue has taken a back seat to questions concerned with the actual self-driving vehicle technology itself. Similarly, Kai Holländer also examines the pace at which fully-autonomous technology in automobiles is approaching reality; Holländer claims that the “lack of communication [between pedestrians and their vehicular counterparts] is a direct side-effect of increasing automation” (Holländer). If such technology reaches deployment before the surrounding infrastructure or pedestrian collective has a chance to seamlessly integrate, then consequences will arise in the form of safety issues.

Just as Holländer highlights the lacking focus in pedestrian-vehicle communication, researcher Brian Mok (2014) also addresses how, in the autonomous vehicle field, there is a lack of “mental models” for autonomous cars. Mok states that researchers need to “understand what types of messages and behaviors [a] car should perform in order to increase the driver’s confidence and performance” (Mok). This is a large void that many researchers, including Mok and Holländer, fear will go unaddressed before full autonomy is developed and released. The lack of communication between a self-driving and pedestrians, or between the self-driving car and other manually-driven cars, if unattended to, could lead to many issues when trying to integrate autonomy into a larger backdrop such as a crowded city; in such a setting, many different actors would be interacting with self-driving cars, including pedestrians, cyclists, and other manually-driven vehicles. It is because of this reason that researchers such as Mok and Holländer feel mixed emotions about the readiness of self-driving cars to become fully integrated into society at large.

Before a self-driving vehicle of any ability (from the minimum, level-one autonomy, to the maximum, level-five autonomy) can enter a public roadway, it must go through countless different tests and preliminary safeguards. Here, a new question arises: since the time until a breakthrough in autonomous technology solutions is rapidly decreasing, are sufficient testing measures taking place? Furthermore, what *types* of testing are considered acceptable by researchers and engineers in the field of autonomous cars? José L. F. Pereira believes that researchers are now “more focused on the software challenges that such a complex system requires, as hardware itself is becoming more affordable” (Pereira). Despite advances in simulation tools, Pererira still believes such tools are being underutilized in the autonomous vehicle research field. In his paper, Pererira set out to contribute to the toolkit of the autonomous vehicle research community. More specifically, Pererira proposed an architecture that would combine both a traffic and robotics simulator. According to Pererira, this would allow other researchers to more accurately test self-driving cars in a contained and controllable environment (Pererira). Ultimately, this approach has the potential to aid the transition from a heterogeneous to homogeneous traffic environment.

The human brain is one of the most complex objects in the known universe. Its ability to make split-second decisions or interpretations is unmatched. If an automobile with level-five autonomy is supposed to have the same decision-making abilities as a human, if not better, then there may be a long way to go to true autonomy. Lars Müller explains that "some experts expect that it [could still] take more than 50 years to reach level-five automation" (Müller). From his research, Müller explains the subtleties of human and pedestrian interactions and how, if level-five autonomy is ever to become a reality, such intricacies will need to be translated into the mind of a machine. Lars claims that there is a "social dimension" to driving that is difficult for a computer to grasp with current technology (Müller). Some real-world examples of social subtleties include pedestrians walking faster across a crosswalk if a car is waiting, or polite drivers who signal for other cars to go first at a multiple-way stop. Autonomous vehicle designers and manufacturers, according to Müller, must look past their surface-level traits as machines, and look deeper into the human-like delicacies (Müller). Only once this facet of autonomous cars is fully understood can they be seamlessly integrated into the environment.

Along similar lines of integration, a new question emerges: will humans be able to fully *trust* an autonomous vehicle? This question, above all others, may be one of the most influential in the journey to achieve full autonomy. If users are not able to trust this "ghost in the machine," then no progress can ever be attained in the field. In the paper "Simulations and Self-Driving

Cars: A Study of Trust and Consequences," written by Bjarke Kristian Maigaard Kjær Pedersen et al., work is done to answer the previous question. The main focus of this study was to analyze trust. Additionally, the researchers aimed to decide whether or not the current simulation testing being performed in the autonomous vehicle field, like that done in the study by Pererira, can fully prepare society for the technology to come. In this paper, Bjarke Kristian Maigaard Kjær Pedersen et al. explain their study in which they had multiple groups of participants control a simulated self-driving car. One group was told that, upon a collision, they would be administered with an electric shock, while the other group was told that there would be no consequences following an accident in the simulator. Once the research had concluded, "results [showed] that participant behavior – in this study their willingness to assume control of the SDC – differed greatly depending on whether or not real-life consequences were applied to the simulation" (Kristian Maigaard Kjær Pedersen et al.). This conclusion brings an important realization about society's level of acceptance to light. Researcher Andrew Gambino also weighs in on the social outlook on the self-driving car industry. Specifically, Gambino outlines various predictors that an individual will, or will not, be favorable of self-driving car technology (Gambino). The different areas that Gambino collected opinions from were acceptance of the technology, the "coolness," danger, fun, and convenience factors, the "posthuman ability," and lastly the uncanny valley of self-driving vehicles (Gambino). Studies similar to Gambino's are a rarity in the autonomous vehicle research field; both Gambino and Müller believe that the social aspect of self-driving car development is not being given the needed attention. The reasoning for the lack of acceptance of fully-autonomous vehicles is still up for debate, but, as mentioned by other researchers such as Holländer, the reason may be due to pedestrians (as well as other drivers) feeling that there is a deficit in the communication skills of self-driving cars (Holländer).

Each day, technology becomes more and more complex, as it is integrated into the lives of humans; simultaneously, cyber-attacks and large-scale hacks are becoming increasingly commonplace. Sghiri Meryem outlines many of the different vulnerabilities that self-driving car engineers have to preemptively protect against (Meryem). Overall, Meryem does not comment on the readiness of autonomous vehicles to be fully-dispatched into everyday life. Rather, Meryem outlines the safety measures that software and hardware engineers will need to defend against. Meryem states that "all the technological developments that this evolution [of autonomous vehicles] [impose] will have a direct impact on the society where the motor vehicle, in a certain way, structured our way of life" (Meryem).

Although, as stated by multiple of the previously mentioned researchers, there is insufficient work being done in regards to communication between pedestrians and autonomous vehicles, the opposite appears to be true in terms of the potential of autonomous vehicles to maximize traffic flow. In the paper by researcher Kotagiri Ramamohanarao, titled "From How to Where: Traffic Optimization in the Era of Automated Vehicles (Vision Paper)," Ramamohanarao explains the future obsoleteness of "how" and its inevitable replacement with "where." In this context, "how" relates to a driver manually telling a vehicle where to go, or, in other words, making every decision while moving between a starting and stopping point; "where," on the other hand, explains how fully-autonomous (level-five) vehicles will only need to know the destination; no other aspect of the journey will need to be dictated by a human passenger (Ramamohanarao). According to Ramamohanarao, travel times could decrease by an average of 51% due to a new vehicle grouping pattern called "platoons"; platoons are "groups of cars synchronized in acceleration and deceleration" (Ramamohanarao). This explicitly explains how self-driving cars would impact traffic flow if implemented homogeneously on roadways. Jianjun

Wang et al. also sought to discover how the integration of self-driving cars would impact overall traffic efficiency. Wang et al. ultimately decided upon performing the fuzzy comprehension evaluation model as well a shortest path model utilizing various highway distances (Wang et al.). With these various models, the researchers could mathematically deduce what ratio of manually-driven to autonomously-driven was optimal, as well as what the optimal number of highway lanes for a given automobile journey would be (Wang et al.).

Answer to the Research Question

Following the examination of this literature review, it should be obvious that fully-autonomous vehicles will change society as we know it. *How* it will change society, however, is the more important question. After examining a multitude of different research studies, the following concord emerges: fully-self-driving vehicles will positively impact traffic flow, but such types of vehicles are not on track to make a smooth, safe transition into society.

Conclusion

The total sum of research in the autonomous vehicle field is rapidly growing each day and has done so *exponentially* since around the early 1950s. Humanity is now closer than ever to achieving full, level-five autonomous vehicles. In a Forbes article written by John Koetsier from earlier this year (July 2020), Koetsier tells of an account by Tesla CEO Elon Musk where Musk states that he “[remains] confident that we will have the basic functionality for level five autonomy complete this year,” and that he “[thinks] there are no fundamental challenges remaining for level five autonomy” (Koetsier). For Tesla, and the self-driving industry as a whole, this may come across as great news. However, among the researcher community, there may be a different opinion that is inscribed

Opinions surrounding the readiness of society for fully-autonomous vehicles remains contested. According to Hermant Bhargava, a professor at the UC Davis Graduate School of Management, the world is not ready for self-driving cars for multiple reasons (Bhargava). First, Bhargava states that “self-driving technology isn’t quite that good yet” and states that, on many accounts, he has had to take back control of his own self-driving vehicle when it began to act up (Bhargava). Bhargava also highlights the lack of “regulations and ethics” that exist in the world today (Bhargava). It is often the case when technology outpaces the law; such a thing happened when manually-driven automobiles were first introduced to the masses in the early 1900s.

Some researchers, such as Katherine Rose Driggs-Campbell and Kai Holländer, for example, have a slightly different outlook than Bhargava. They too believe that society (focussing on the infrastructure as well as on the pedestrians) is not ready for fully-autonomous vehicles. However, they do believe that the technology needed to produce such a vehicle is approaching fast. This idea is quite common among the research community and creates a worrying undertone compared to the whimsical feeling that accompanies technological progress. A disconnect between pedestrians and self-driving cars exists, and it is growing with each advancement that is made in the field.

Achieving a fully-homogeneous population of self-driving cars would drastically increase traffic flow and efficiency. Many sectors of business could reap the rewards (in the form of financial gain) from a technological breakthrough of this degree. However, if the current trends of self-driving car development continue, and ample attention is not given to research in the area of vehicle-to-pedestrian communication, then all of these gains will be achieved at the expense of the everyday people.

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