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Exploring Public Perceptions of Autonomous Vehicles Through Waymo

Introduction

The advancement of computer technology in self-driving vehicles over the last decade has been staggering. The Google Self Driving Car Project, now known as Waymo, started all the way back in 2009 after successes in the Google X Lab. In 2020, Waymo became the first fully autonomous ride service in Phoenix, Arizona and is looking to expand its serviceable area across the United States (Waymo 2023). Despite successes in autonomous technology driven by tech giants such as Google, Microsoft, and Uber, the general public is generally untrusting of autonomous vehicles. The Pew Research Center reports that 44% of Americans are against the widespread adoption of autonomous vehicles, while only 26% hold a positive view, supporting the idea that autonomous vehicles are beneficial (Rainie et Al 2017). This begs the question of why a majority of Americans are opposed to riding in an autonomous vehicle. What is the difference between a human driving the car as opposed to an autonomous system? My thesis will explore the concept of trust in relation to autonomous vehicles and examine how it plays a role in shaping public attitudes and the adoption of autonomous systems.

Discussion of Literature

As far as technology is concerned, the vehicle perceives many times more information than a human can and can make decisions in fractions of a millisecond (Greenblatt, 2016). In an ideal world, autonomous cars would be safer, as they theoretically have plenty of advantages over a human driver. A properly programmed system would always follow law, would never tire, would never get intoxicated, and would have inhuman reaction speed. In a simulation run by Google, researchers estimated that the Waymo system could prevent 82% of collisions (Scanlon et al., 2021). Despite the developments in autonomous technology, there are still reasons for concern over their use. Machine learning and algorithms used by autonomous vehicles are difficult to understand, and challenges with the technology lead to questions about the system's

ability to handle real world events. Despite its shortcomings, the rapid pace in innovation of autonomous vehicles as well as the potential benefits make a compelling case for not dismissing the technology outright. The potential benefits of autonomous autonomous vehicles are numerous, yet their adoption is generally opposed. This comes down to a lack of trust in the technology.

Part of the lack of trust in this technology is a lack of knowledge about autonomous vehicle technology itself. When discussing autonomous vehicles, the idea of a "trolley problem," wherein an actor must decide to sacrifice an individual for the greater good, inevitably arises in the discussion. A popular example of this approach is the MIT Moral Machine (Awad et al., 2018), which polled users to make decisions for a theoretical car to hit one group of individuals over another. This creates several issues, as the trolley problem assumes a deterministic set of actions, whereas the consequences of actions are not entirely certain (Nyholm 2018a). As a model, it is easiest to reduce the problem to this simple binary dilemma as opposed to how current autonomous systems operate. Current technologies currently rely heavily on machine learning models to determine the course of the autonomous vehicle. Machine learning uses algorithms to calculate probabilities of future events, then uses these probabilities to predict the best course of action. At the current stage of artificial intelligence, we cannot instruct a binary morality system; rather machine learning uses previous data to predict future outcomes. Machine learning is great at handling a majority of complex situations, where the most probable course of action is constantly changing and updated.

However, machine learning has limitations that raise issues with trust. Machine learning is somewhat of a "black box," wherein humans are unable to understand exactly which calculations are being done to determine the predictions. We can see the outcomes of the predictions and tune the algorithms to be more precise, but we cannot change the internal algorithms themselves (Goodall 2016). This makes the idea of the trolley problem largely incompatible with machine learning training. Therefore when an accident does happen, it is difficult to understand the "thinking" of an autonomous system. In the case of the fatality in Arizona, the car's sensors were unsure if the pedestrian walking a bike was a vehicle, a pedestrian, or a bicycle (Pavia 2023). In this incident the autonomous braking system was disabled while a human driver oversaw. We may be able to understand that the algorithm was

unable to figure out what the pedestrian was doing, but the internal algorithms that the car used to come to that decision are obstructed.

Another cause for a lack of trust is a lack of data in niche situations. Machine learning uses past data to predict future events, and accident data is relatively uncommon compared to available datasets of normal everyday driving. Accidents happen in a matter of seconds, and out of millions of cars on the road, only a mere fraction of them experience crashes, and of those only a few are equipped to record that data into a usable format for machine learning. It is much easier to tell the car what to do in normal operation such as driving around the city than what to do in the case of a potential accident. The ambiguity around how these systems make decisions is understandably concerning, as transparency around the decisions being made is necessary to gain trust. A human explaining the reasons for their decisions is much more approachable than an engineer explaining that the algorithm simply did not work for an unknown reason.

Transparency around the companies developing these autonomous systems is another area where trust can be formed. In a paper put forth by Waymo, they argued that autonomous vehicle safety regulations should be a collaboration between lawmakers and self-driving car companies and urged that other companies follow suit (Favaro et al., 2023). This sets forth a positive precedent for developing transparent communications around how these systems are being developed and tested. However, as a company, Waymo is still a for-profit initiative, and has also decided to sue the California DMV to protect its crash data, citing trade secrets as well as user data privacy as reasons for their lawsuit. As one of the largest private companies in the world, there is reason for trust and distrust to arise from the general public. On one hand, one could argue that being one of the largest companies in the world would give them the resources they need to ensure safety for their consumers, but on the other hand, their primary interest as a company is profit.

Another reason for lack of trust around autonomous vehicles is a lack of clear accountability when an accident occurs. When two human drivers crash, all parties give statements to what occurred, and the situation is determined. Once the situation is determined, blame is assigned to the parties who acted in violation of the law. Except in the case of catastrophic failure, autonomous vehicles by their very nature gather large amounts of data

during their operation. This collection of data can reproduce the scene of the crash in detail far exceeding the ability of a human. This can reduce uncertainty in determining the details of the situation drastically (Goodall 2016). While we may not entirely understand the algorithms behind the decision making of the car, the data collected is useful for a human juror to weigh judgment. Through sifting through the data, a human can gain understanding to how the accident occured as well as the "reasoning" behind the car's actions. The data can also be used to discover who was at fault legally to a more accurate degree. While the collection of data can resolve the details of legality and blame, it still remains unclear as to who the blame falls to in the case that it was in fact the autonomous vehicle's fault. In the case of a fully autonomous system, the precedent for blame likely falls to the manufacturer. In the case of accidents caused by a faulty mechanical component, blame falls to the manufacture of the vehicle. Like any system, the autonomous portion of the car could be treated as a component in the system. In the US legal system, suing the company responsible for the system failure usually falls under punitive damages, or damages that exceed compensation for the victim and are awarded to punish the defendant, are relatively common in the United States. These costs are much higher than settlements between two human drivers, which gives manufacturers even more incentive to improve safety (Greenblatt, 2016).

Finally, the trust in autonomous systems must stem from our expectations of these systems. When asked about the largest advantages of autonomous cars, safety was not seen as one of the biggest advantages; rather, the prospect of arriving at the destination while doing other activities or relaxing was seen as the greatest advantage. When asked about how often they would use the theoretical car, they would use it primarily for short drives for convenience (Nielsen and Haustein, 2018). This frames the automated car as a luxury device, rather than a safety device. I believe that this demonstrates that autonomous vehicles are generally perceived as unsafe.

Additionally, expectations of autonomous vehicles are much higher than that of regular vehicles, with 87% of Americans polling that driverless vehicles should be tested using a higher standard (Rainie et Al, 2017). This shows distrust in the safety of the technology as one of the foremost issues with the adoption of autonomous vehicles. This is to be expected; as a new technology enters society, it is first met with skepticism, but if it performs well it is generally

accepted (Hughes, 2012). Most people have not been driven by an autonomous vehicle, so they do not trust these vehicles and are impressed when they can complete the same tasks as a human. As this technology becomes more prevalent, public opinion will improve if the technology continues to perform positively.

Discussion of Case

The Google Self Driving Car Project, now known as Waymo, started in 2009 after successes in the Google X Lab. Headed by Sebastian Thrun, the team continued to develop autonomous car technology until being publicly unveiled in 2010. In 2016, the Google Self Driving Car Project became a subsidiary of Google under Alphabet and was renamed Waymo. In 2022, Waymo became the first fully autonomous ride service in Phoenix, Arizona and is looking to expand its serviceable area across the United States (Waymo 2023).

Since its inception, Waymo has been one of the industry leaders in autonomous vehicle technology and development. As a subsidiary of Alphabet Inc., Waymo has huge backing through Google and access to virtually limitless resources. Waymo can collaborate with other Alphabet subsidiaries such as Google DeepMind and leverage previous Google innovations such as Google Street View, giving Waymo a huge advantage over other autonomous vehicle companies. Google DeepMind is an artificial intelligence subsidiary of Alphabet, and like Waymo, is one of the largest players in its respective field. As current autonomous technologies rely heavily on artificial intelligence and machine learning algorithms, this is a huge boon to Waymo's success. Additionally, Google's global reach and scale gives Waymo huge brand recognition as well as opportunities for partnerships with other tech giants and automobile manufacturers. Waymo has partnered with Uber to provide their services in the LA region and has manufacturing partnerships with well known brands such as Mercedes-Benz, Jaguar, and Volvo.

Waymo has been careful in its marketing and its expansion. Currently Waymo only operates in San Francisco and Phoenix, but is looking to expand to Los Angeles and Austin. Their incremental expansion seems to serve two main purposes. Firstly, machine learning technology must be trained and tuned on large datasets. These datasets have millions of parameters that must be carefully tuned to ensure proper performance and safety. Data such as spatial mapping of roads and buildings, vehicle flow in the area, and traffic signals must be

meticulously mapped for proper operation. It is in Waymo's best interest to increment slowly to allow time for the vehicles to be properly calibrated to the expanded area. Secondly, their slow expansion allows for the expansion of brand recognition and trust. Autonomous vehicles are subtle but strikingly different when seen in person. From afar, they appear to be regular cars, but on closer inspection one can see there is no driver and the vehicle is outfitted with arrays of sensors and cameras surrounding the vehicle. Partnerships with other entities in the automotive industry helps build trust and familiarity. With partnerships with automobile manufacturers, they can retrofit existing known and trusted vehicles with their autonomous technology. Partnerships with existing ride share apps such as Uber adds a seamless transition between an existing product that many people already use and incentivizes use of Waymo. While they are currently an irregular sight, gradual expansion of the operable territory will make them more commonplace. Over time, Waymo hopes to change the perception of autonomous vehicles from being extraordinary to commonplace through gradual expansion.

Waymo's primary marketing comes down to three principles that are proudly listed on their homepage: "Convenient. Consistent. Safe." Their strategy of gradual expansion helps build an image of consistency and safety. These principles are important for their marketing as it addresses both the use case and concerns with autonomous driving technology. Currently, no company is selling these fully autonomous vehicles for personal use. By confining it to select areas and platforms, Waymo can more effectively maintain an image of safety and consistency. Waymo's marketing materials strongly push safety as one of their top concerns and even tout that their cars are safer on average than human drivers. This commitment and emphasis on safety quells one of the biggest criticisms and sources of concern towards autonomous vehicles. As mentioned before, Waymo is one of the industry leaders in the field of autonomous vehicles and has published several articles on their safety methodology and reports. While their underlying technology remains guarded, their safety methodology and risk management is relatively open. This transparency further contributes to their image of safety, but also to their place as one of the leaders of autonomous innovation.

While the company has made significant strides in advancing the safety and reliability of its autonomous driving systems, it has not been immune to accidents or incidents. Recently, a Waymo car collided with a bicycling pedestrian, luckily ending only in minor injuries. As the image of safety is paramount to the success of these vehicles, Waymo has a vested interest in

preventing as many crashes as possible. Other incidents of concern are the more “non-human” behaviors that the autonomous system exhibits. These include difficulty interpreting construction sites, inability to interpret human signals, and bizarrely routing upwards of 50 cars a day down a dead end. These behaviors are extremely detrimental to the perception of these technologies, as they are disruptive and inexplicable to a human driver. While their safety methodology is largely transparent, they have sued the California Department of Motor Vehicles to prevent data on driverless crashes from being released to the public. Despite vocal criticism from the public, Waymo has cited disclosure of trade secrets would occur if crash data was to be made public. Other detractors include the San Francisco transportation and planning agencies, who cite the car's erratic behavior as concerns for further expansion in San Francisco. While Waymo promotes a sense of transparency through their press releases, they contradict this through not releasing key information such as crash reports. Withholding this information undermines trust in the public.Without this information it becomes difficult for the public and policy makers to determine risks associated with autonomous vehicles.

Analysis

The relationship between autonomous vehicles, producers of autonomous vehicles, and consumers can be described using a producer consumer model. Autonomous vehicles are a disruptive technology that aim to fundamentally change transportation as a whole. Within this network, producers of these autonomies have a great deal of influence on the network as a whole. The producers not only create the physical vehicle but also the social-technical systems that govern their use and integration into society. The producers of autonomous vehicles are motivated by profit incentives, driving their efforts to ensure the successful adoption and continued acceptance of these technologies. Despite inherent uncertainties and risks, the industry demonstrates a degree of confidence in autonomous systems, as evidenced by their gradual deployment to the public, albeit within controlled and regulated environments.

However, the success of autonomous vehicles ultimately hinges on consumer trust and acceptance. Producers rely on cultivating consumer confidence in the safety, reliability, and benefits of autonomous technologies to drive market expansion and profitability. The technological systems that producers create also have a huge influence. Machine learning, a technology central to autonomous vehicles, is highly reliant on past data and operation. The context in which data is collected and utilized reflects societal norms, values, and power

structures. These autonomous systems aim to replace human actors, and therefore are extremely disruptive. Consumers are another important actor within the system, their attitudes towards autonomous vehicles drive market forces and demand for autonomous vehicles. Their attitudes are shaped in part by producers, and in turn, changes in consumer demand may change producer priorities and market strategy.

Conclusion

In conclusion, the apprehensiveness around the adoption comes partly from a lack of knowledge about autonomous vehicles and their operation. As autonomous vehicles are an entirely new field, the unfamiliarity with their intricate systems and decision-making processes contributes significantly to public skepticism. Unlike traditional automobiles, which are familiar to the average consumer, autonomous vehicles rely on new technologies that consumers are unfamiliar with. This lack of familiarity with the underlying technology can lead to skepticism. Questions about how autonomous vehicles perceive and respond to their surroundings, how they prioritize safety, and how they handle unforeseen circumstances often remain unanswered for many individuals. Waymo fosters that trust through releasing safety information and presenting themselves as safe and reliable. However, the refusal to release comprehensive crash reports raises doubts about the completeness of their transparency efforts. While Waymo may share certain safety statistics and highlight successful aspects of their autonomous vehicle technology, the absence of crash reports deprives the public of insights into incidents and their causes.

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