Development of an Autonomous Campus Vehicle
(Technical Paper)

Social Factors Affecting Autonomous Public Transit Adoption
(STS Paper)

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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

The concept of autonomous vehicles seeks to ultimately deliver roadways with fewer accidents, reduced pollution, and greater accessibility. In densely populated cities, people without their own cars could one day ride across town in autonomous shuttles. These vehicles, resembling the shape of a small bus, can usually hold up to six occupants and travel about 12 miles per hour. In the future, a fleet of such self-driving taxis will communicate with each other to reduce traffic in urban areas. Reduced traffic flow reduces time spent idling and wastes less energy. The vehicles will also park closer together than manned taxis when not in use, freeing up land ordinarily reserved for parking to be used for development projects. However, the success of autonomous public transit (APT) largely depends on public trust in the safety of the technology. City leaders are attempting to give transit riders personal experiences with autonomous vehicles and incentivize these new transportation methods. Even if autonomous vehicles are perfectly safe, relevant social groups such as riders, drivers, city officials, and public transit workers will need to negotiate the meaning of new technology before it can become widely used. As a response to these emerging technologies and the benefits that may follow, the technical project will focus on the development and testing of autonomous golf carts with a focus on safety and customer satisfaction. The STS topic will analyze the relevant social factors affecting adoption of APT systems through the Social Construction of Technology (SCOT) framework.

Technical Topic

All autonomous vehicles use sensors such as radar, lidar, sonar, GPS, and cameras to create a virtual map of the car's surroundings. Each of these sensors has its own set of advantages and disadvantages. For instance, lidar (light detection and ranging) sensors use numerous laser beams to detect obstacles with precision, but performance is severely limited in heavy rain and snow. Therefore, it is common practice to use multiple types of sensors in concert to provide redundancy in case a sensor is obstructed or stops working. Vehicles can also be fitted with actuators that are used to control steering, braking, and acceleration. Steering actuators have become so reliable and efficient that they are often implemented in modern production vehicles as part of a steer-by-wire system, where the power steering assistance is provided by a motor and not by traditional hydraulics. To control acceleration and braking, older vehicles can be fitted with actuators that physically move the pedals. However, it is common now for the pedals to send signals to a central computer instead of being directly connected to the drivetrain components. Modern vehicles are now shipping with complete drive-by-wire systems and even semi-autonomous capabilities, such as assisted braking, steering, and parking.

The capstone design team will be using golf carts as an experimental platform to develop vehicle autonomy. In past semesters, teams have been able to create a leader-follower system of golf carts. One cart was driven by a human, and another cart followed the first autonomously. This semester, we will expand upon previous work by integrating actuation and sensing systems in new carts and further tuning the control algorithms. Under the direction of our technical advisor Tomonari Furukawa, the team should prepare two fully autonomous carts that will drive along Engineer’s Way. The cart may also be stopped by a nearby student with a raised hand to allow for boarding. Once the cart reaches a destination, it should stop and allow the passengers to exit.

The existing autonomous golf cart systems are currently being examined and modified to meet the product development standards for safety and functionality. All provided carts are at various stages of completion and must be partially reconstructed. Because the braking and steering systems are entirely mechanical, actuators must be configured to physically move the brake pedal and steering wheel. One of the carts will use a geared DC motor and pulley system to move the brake pedal, while the second cart will use a linear actuator connected directly to the brake cables. The acceleration will be controlled electronically, and sensor data will be processed by a computing unit at the rear of the cart. The team recognizes that customer satisfaction is inseparable from the success of the project, and thus, various target specifications have been identified. In addition to the aforementioned goals, the control algorithms should be designed to steer around static obstacles and stop completely in the presence of moving objects. This will be the primary indicator of the system's safety. A display showing obstacles detected and the cart's projected path will be added to increase passenger comfort. During the initial weeks following winter break, the team will focus on integrating the necessary sensor systems. Implementation of braking, steering, and acceleration systems will be implemented shortly thereafter. The team anticipates outdoor testing of the vehicles by mid-April, and final testing on Engineer's Way by early May.

STS Topic

The Social Construction of Technology (SCOT) framework, introduced by Wiebe Bijker and Trevor Pinch in 1984, argues that new technology is given meaning by the societal context in which it is introduced. Social constructionists believe that human behavior shapes technological development and adoption. In addition, they believe the criteria that determines the acceptance of a technology is determined by affected social groups instead of the technical benchmarks typically established by engineers. Leading advocates Weibe E. Bijker and Trevor

Pinch describe SCOT as a ‘multi-directional’ model “in contrast with the linear models used explicitly in many innovation studies” (Pinch and Bijker, 1984). For any given social group, a number of problems are presented, each addressed by a number of different solutions. This type of analysis presents a web of relevant social groups and solutions that can be extremely useful in understanding why certain technologies succeed or fail.

SCOT can be summarized by four main tenets. First, interpretive flexibility highlights the development of numerous possible solutions to a given social problem. The social circumstances present during development cause negotiations between relevant social groups, who decide whether or not the technological artifact solves the social problem effectively. Development continues until all relevant social groups agree that the design does not pose any apparent problems, at which point closure and stabilization are achieved. Pinch and Bijker posit two examples of closure mechanisms – rhetorical closure, whereby a design is acknowledged as complete, and closure by redefinition, during which the design may be repurposed to solve a new problem. Additionally, sociologists often consider the sociocultural and political conditions surrounding technological development to gain a more complete understanding of group interaction dynamics. Each of these tenets will be used to examine the state of autonomous vehicle research and its possible outcomes under the assumption that success of the technology is socially driven.

APT Public Testing Initiatives

City officials were largely unprepared when ride hailing services such as Uber and Lyft ballooned in popularity about 10 years ago. As a result, public transit ridership dropped in 88 percent of major metropolitan areas in 2017 (Bliss 2019). Now, autonomous shuttle startups such as EasyMile are offering test vehicles to cities and transit agencies, who believe that "AVs could attract new riders to transit and reduce costs, positioning agencies for long-term success" (Zipper, 2020). Cities that have already planned for AV testing include Houston, Jacksonville, Las Vegas, Providence, and Frisco. Two types of vehicles were already tested in Columbus, Ohio, both of which encountered inconvenient technical problems. The first test, using vehicles supplied by May Mobility, ran on a 1.4-mile loop and exposed a major weak spot for AV technology – left-hand turns in traffic. The vehicles could not safely decide when to make the turn and a safety driver was required at all times. In a second instance of testing, vehicles from EasyMile were used to carry riders between a housing development and a nearby transit station. One vehicle made an emergency stop while travelling at 7.1 miles per hour, throwing a passenger from her seat (Marshall, 2020). The passenger experienced minor injuries and expressed publicly that she would never ride in an autonomous vehicle again. Incidents such as these are partially responsible for the public opinion of autonomous vehicles. A study of transit riders in Michigan found that about half of riders were "hesitant about riding in autonomous buses citing concerns over safety, no human, and distrust in technology" (Kassens-Noor, 2020).

Still, city officials believe that they can win over the public with continued testing. An autonomous shuttle called Relay is being tested in Northern Virginia, carrying up to a dozen passengers between the Dunn Loring Metro station and the communities in Merrifield (Augenstein, 2020). The proposed route is only 1 mile long and includes a traffic light on U.S. Route 29 that communicates its timing with the vehicle. Testing has received support from Fairfax County, Dominion Energy, the Commonwealth of Virginia, and real estate developer EDENS. All of these relevant social groups are working together with the common goal of increasing public acceptance of autonomous vehicles. Further STS analysis will explain how and why each of these social groups have a vested interest in the success of this technology.

Skepticism from Labor Unions

Labor unions representing transit workers have not hesitated to display their resistance to automation. John Samuelsen of the Transport Workers Union (TWU) personally led a protest of the AV shuttle tests in Columbus, Ohio. Though AV backers claim that APT will require its own set of new jobs, Samuelsen believes that vehicle attendants and backup drivers would never earn the wages that bus drivers do. In addition to the safety concerns shared with riders, he sees a possible "dehumanization" of transit. Without workers present to assist people with disabilities entering and exiting the shuttles, general accessibility of the technology will be greatly hindered. Additional research will examine whether or not the concerns of transport workers are being addressed by engineers during development.

Some AV companies certainly understand the influence that relevant social groups have on their success. May Mobility's business development lead Ben Thompson explains that it is "important for us to not just drop vehicles in a community and let them adapt, but work directly with communities" (Ahmed, 2018). Still, it will be difficult for transit labor unions to permit closure of APT without understanding what may happen to the jobs of the workers they represent. Engineers must consider the jobs, or lack thereof, that closure will yield in affected communities.

Future Research

Information for this study will be garnered primarily from existing journal articles on the topic, of which there are many. A review of this literature should provide more than enough background for a thorough STS discussion. If this is for some reason not the case, a series of interviews or questionnaires may be constructed to gain additional perspectives from potential users of the technology. The questions would primarily serve to gauge public interest and confidence in current or future autonomous vehicle technology.

Conclusion

As AV technology continues to develop, it remains to be seen how it will integrate with existing city infrastructures. The technical project seeks to explore the interactions between AVs and students on a small scale at the University of Virginia. This will be accomplished by first testing autonomous golf carts on the empty roads around OMERF laboratory, analyzing response to the presence of static and dynamic obstacles, and eventually testing carts on Engineer's Way with and without a human backup driver. The STS topic will further examine how public opinion of APT is shaped by analyzing the response of social groups to recent testing projects in large cities. It should also provide a thorough description of the state of the art through interpretive flexibility and a forecast of possible closure mechanisms. The study should ultimately inform the design of the technical project vehicles to ensure smooth integration into the operating environment on Engineer's Way, and the design of new autonomous public transit systems.

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