DESIGN AND OPTIMIZATION OF AUTONOMOUS VEHICLE SHUTTLE SERVICES FOR HIGH POPULATION CITIES

(Technical Paper)

ANALYZING THE RELATIONSHIP BETWEEN SOCIETY AND REGULAR CARS VS. SOCIETY AND AUTONOMOUS VEHICLES

(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

In crowded cities such as New York City or San Francisco, public transportation is a major mode of commute for the residents of the region. While it may be expensive to keep and maintain a car of their own, shuttle services and metro buses are available as alternatives to travel from one place to another. However, these modes of transportation usually require humans to drive the vehicle around every day, which can be tiresome and tedious. If these services are going along the same route each time, an autonomous vehicle could take its place, possibly allowing a more efficient and safer ride.

Technical Project Details

Introduction and Problem Description

My technical research project's main focus is to find an efficient route for an autonomous vehicle shuttle service in a city based on human mobility patterns present in the area. An autonomous vehicle is an automobile capable of sensing its environment and operating without direct human involvement (Synopsys, 2020). An autonomous car can go anywhere a traditional car goes and do everything an experienced human driver does. They tend to rely on sensors, actuators, complex algorithms, machine learning systems, and powerful processors to transport users from one place to another. This technology would eliminate the need of a driver to be present at the wheel. The shuttle service, therefore, would only require the autonomous vehicle to transport users across the city without a driver necessary.

Method Description

My current research focuses on finding an efficient route for the shuttle service to maximize usage and transport people in the city to common places they travel to. The dataset I am working with contains information such as various users, locations they travel to, the times they go there, and the speed at which they commute. All of this data is being analyzed through a computing program called Apache Spark. This system is an optimized engine used for processing and analyzing large amounts of data. It does this by distributing data across multiple machines and processing it in parallel. This computing engine is extremely advantageous to the project, as the human mobility dataset is quite large, and analyzing it in parallel would achieve greater efficiency. Additionally, Apache Spark also includes a way to easily transform data using functions such as grouping and sorting. For example, a transformation to group locations each user went to, and sorting those by time can give insight on which routes the users take on a day to day basis.

Once the data is analyzed, the locations need to be visually mapped to really observe which routes users take in the city. OpenStreetMap is a free editable map of the world with statistics for many regions. It also consists of a network with roads, trails, cafes, railways stations, and much more. This platform provides more information about the city and roads that can be used to get from one location to another. In addition, a python library called OSMNX is being used to graph the data on the maps returned from OpenStreetMap. The library allows the geographic area to observed as a graph in which routes can be further analyzed. For example, it can calculate the fastest road network to take when traveling from one location to the next, which can aid in creating the most efficient route for users of the shuttle service. Lastly, this research also consists of finding additional information about the city itself for the autonomous vehicle

shuttle to operate. Information such as the parking spots available in the city, speed zones, and locations of gas stations must be investigated.

Various stakeholders of this technical project include the physical artifacts mentioned above such as the datasets, autonomous vehicles, and computers for analysis. Software for the necessary computations are also required, such as Apache Spark, OpenStreetMap, and other python libraries (e.g. OSMNX). Lastly, the human actors involved include the researchers, the professor overlooking the project, and the humans whose mobility we are studying.

STS Project Details

Introduction and Problem Description

The STS research question I would like to focus on includes the analysis of the relationship between car users and the autonomous car itself, compared to regular cars. This question is very important to analyze as it investigates how potential users may respond to the autonomous vehicle shuttle service, and if they would prefer it over regular cars. For example, if people tend to mistrust autonomous vehicles more than services with drivers, this project may need to be consider that. Or, adjustments would need to be made if pedestrians fear autonomous vehicles more than regular cars.

In order to explore this question, an important STS topic to consider includes *technological momentum*. This theory observes the relationship between technology and society over time. The idea is that both are reciprocal and time-dependent – one does not determine the changes in the other, but both influence each other simultaneously (Definitions, 2020). This theory was formed by Thomas P. Hughes from two separate models of how society and technology interact. First is *technological determinism*, which claims that society is affected and

modified by the introduction of a new technology in an irreversible way. The other model is *social determinism*, which asserts that society controls how a technology is used and developed. Technological momentum combines these two models and adds time into the equation (Wikipedia, 2018). When the technology is young, society has more control over its use and scope. However, as the technology matures, it becomes integrated into society, achieving a technological momentum of its own, making it increasingly difficult to steer by users. In other words, at first, technology and society follow a social determinism model, but evolve into technological determinism over time, as the technology becomes more prevalent (Povlock, 2016). This STS theory is quite useful when applying it to the new autonomous vehicle technology. Some cities have recently introduced autonomous vehicles into their area, which has the ability to affect society in some way over time.

This technical momentum model can be applied directly to my research question. I would like to research how a user's relationship with their car may change through the switch to an autonomous vehicle, and this theory provides a new consideration. The user's relationship can change with time, and may even strengthen as the technology becomes more widely used. At first, the user may see the autonomous vehicles as a great convenience when travelling to work or parking in crowded areas. As time goes on, they may feel that they cannot operate on a day to day basis without their vehicle. This may cause cities to add more parking away from downtown as more people start using autonomous vehicles to send their cars to park. On the flipside, a user might find it hard to trust the autonomous vehicle as they cannot see a person or force operating the vehicle. With time, they may even fear all public transportation as most services would adopt the autonomous vehicle technology. The user may have to permanently change the way they travel because of this fear. It is very important to consider this STS theory, as the results I may

gather from surveys and interviews, may not tell the full story. Since the technology of autonomous vehicles is very new, the users can have a reaction now that is very different from later when the technology becomes more prevalent. It is important to consider how the immediate responses I collect, may intensify over time and cause a permanent change in the way the user lives and interacts in society. Therefore, I cannot determine the results of my findings as the finite answer to my question. I must consider that these answers can intensify over time to cause an irreversible mark in society.

So far, I have explored only looking at potential users of autonomous vehicles. However, another STS theory related to User Studies, explores that non-users of a technology are very important as well. Sally Wyatt is that author of the paper "Non-Users Also Matter: The Construction of Users and Non-Users of the Internet", where she goes into detail about users and non-users of the internet (Wyatt, 2003). At the beginning of the paper, however, she dwells on her own experience of choosing not to use automobiles, thus being a non-user of the technology, and asserting how much of a profound effect it has had on her life. Wyatt sees cars as a threat to her well-being and way of life, whether she is walking, riding a bicycle, or using public transportation. Wyatt uses this anecdote to make a point that non-users should be evaluated separately, to raise further questions and answers pertaining to non-use of the technology. For example, the reasons for why the technology falls short for some consumers may be answered. Wyatt goes on to discuss users and non-users of the internet. She emphasizes that certain people may decide not to over-complicate their lives by using internet if they have cheaper alternatives to fit their needs. This STS theory of User Studies, therefore, highlights that non-users should be separately observed in addition to getting user feedback on a technology (Wyatt, 2003). The

information received from non-users of a device, explaining why they choose not to use it, is equally as important as collecting information from users of the technology.

This theory should be applied to the STS research investigation in question, because it is important to consider the relationship between users and the new technology, but *also* non-users and the new technology. It is great to collect results on whether potential users would be interested in shifting to autonomous vehicles, but it is equally as important to decide how non-users of automobiles, such as pedestrians or cyclists feel about more autonomous vehicles being used around the city. For example, the non-users may feel more afraid of cars now that a person will not be directly controlling it, which is also a significant factor to consider. As both users and non-users will be affected by both technologies, it is important to gather data from both social groups to see how the potential effects of the technology on society.

Proposed Schedule of STS Research

To research this question, possible methods include the use of surveys and interviews in areas where the technology has been released. There have been multiple areas in the nation, where self-driving cars have been introduced. For example, the Aptiv autonomous vehicle has been introduced in Pittsburg, Las Vegas, and Boston. Another self-driving machine, Aurora, is being used in Palo Alto, San Francisco, and Pittsburg (Verger, 2019). To gather results on user and non-user interactions, I can conduct interviews and surveys in these areas to hear about what society feels has changed with the introduction to self-driving cars. In addition, I plan to be in touch with UVA's CSR Cooper Center to arrange surveys. Ideally, I am planning on researching the areas in more detail by the start of next September, reaching out to people by the end of that month, and collecting results by mid-October.

Conclusion

To recap, the STS research question I am trying to solve is: how does the relationship between a user with a normal car and a user with an autonomous vehicle differ? Would the user trust an autonomous vehicle more or less than a regular car? Will they value an autonomous car more or less than a regular car? Exploring this STS research question is extremely important and can provide valuable information. When a new technology is about to be introduced, it is extremely important to get society's reaction on the new product. Since this technology is most likely going to replace an older version, it can be very valuable to see how the relationship between society and the technology will change with the shift. If the relationship changes in a negative way, the product can be adjusted to accommodate for the people's worries. If it is bound to change in a positive way, the product can reinforce these points to make the technology better as a whole for society.

References

Definitions. (2020, April 15). Definitions for technological momentum. Retrieved April 22, 2020, from https://www.definitions.net/definition/technological+momentum

Povlock, Paul. (2016). "Environmental Ethics and The Electric Power Grid: A Case for Technological Momentum." *Ph.D. Dissertations (Open Access)*: 3-10

Synopsys. (2020). What is an Autonomous Car? – How Self-Driving Cars Work. Retrieved April 22, 2020, from https://www.synopsys.com/automotive/what-is-autonomous-car.html

Verger, R. (2019. June 6). Where to find self-driving cars on the road right now. Retrieved April 22, 2020, from https://www.popsci.com/self-driving-cars-cities-usa/

Wikipedia. (2018, October 17). Technological momentum. Retrieved April 22, 2020, from https://en.wikipedia.org/wiki/Technological_momentum

Wyatt, Sally. (2003). "Non-Users Also Matter: The Construction of Users and Non-Users of the Internet." *MIT Press:* 67-75