Pothole Detector

(Technical Paper)

The Societal Impacts of Micro-Mobility 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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I. Introduction

The accelerated growth in the general population and rapid urbanization in cities around the world has prompted many companies to enter the micro-mobility market. These companies are attempting to address the need for efficient and affordable transportation for individuals who live in a growing city; therefore reducing the dependency for personal vehicles and reliance on public transportation for the 'last mile' of the trip. However, micro-mobility may have unintended effects, especially with respect to the ethical, legal, and societal side. Research questions that may clarify some of these effects are when and why does micro-mobility become a pattern for future transportation, who are the stakeholders in the micro-mobility business, and what new ethical and legal concerns are raised with the growth of the micro-mobility market. Using the SCOT framework, I will look at stakeholders and how they influence the micro-mobility business, while proposing different research methods to aid in answering the research questions.

While cities are improving their public transportation network and companies creating micro-mobility vehicles, there is still a large demographic that have personal vehicles. These drivers depend on roads that have no little to no hazards that could damage their cars, which could end up being costly. For example, a study by the American Auto Association (AAA) has shown that "pothole damage has cost U.S. drivers $15 billion in vehicle repairs over the last five years, or approximately $3 billion annually" ("Pothole Damage Costs U.S. Drivers $3 Billion Annually", 2016). Given this information, this prospectus will introduce a solution that will mitigate potholes.

II. Technical Topic - Passive Data Collection on Potholes

The Pothole Detector is a device designed to detect potholes using accelerometers. This detection happens when a car drives over a pothole, triggering the accelerometer when a certain acceleration threshold is met. The custom printed circuit board will connect the Bluetooth chip, accelerometer, and MSP chip so that all the components will be able to connect as a complete unit. The MSP chip will filter and send the data to the smartphone application via Bluetooth. The smartphone will then use this data to plot on a map the location and severity of the pothole so other users can avoid the pothole ahead of time.

Our group decided to work on this project because of the prevalence of potholes in our everyday lives, and how it could allow the local government to fix certain roads quicker. Therefore, decreasing maintenance costs for vehicles and improving on the driver's experience. Another use case of our device is to better inform everyday drivers of road hazards, such as potholes and misaligned manhole covers. By giving driver's this information, they are able to avoid getting into accidents or risk damaging their personal vehicles. Overall, our product is designed to be added onto existing vehicles that do not have this feature, and should cost less than a maintenance fee for an average vehicle.

There are similar designs and concepts that attempt to detect and avoid potholes. This includes devices that use lidar and artificial intelligence/machine learning to avoid road hazards. However, our project is different from current methods because we are focusing our device on

the road hazards, specifically potholes, that cannot be avoided. This could be due to poor visibility, congestion, and other factors that take into account visibility and reaction time. A product that is similar to ours is Ford's active suspension system, which adjusts suspension to the rear wheel when the front wheel hits a pothole [Innovative Pothole Detection System Irons Out the Bumps for All-New Ford Focus Drivers, 2018], but does not plot the location of that pothole on a map to warn other drivers, which our device attempts to do.

Jaguar Land Rover is a company developing a pothole detection system using cloud technology, cameras, and sensors. Jaguar Land Rover's implementation will allow a vehicle to gather data about the location and severity of potholes, broken drains, and manhole covers. This feature will allow cars to send and receive warnings about these road hazards, allowing the driver to slow down or the car to adjust its suspension to reduce the impact [Pothole Detection Technology Research Announced]. They are utilizing cloud technologies to store the information about the hazard's severity and location to inform other drivers to avoid them and enable local authorities to repair those hazards quicker [Pothole Detection Technology Research Announced]. Additionally, they are working with Coventry City Council to understand how the information from the road that is collected by this technology can be shared with local authorities, and what data would be most useful for road maintenance teams to identify and prioritize repairs [Pothole Detection Technology Research Announced]. Although this project is similar to our system, their implementation is focusing more on Jaguar Land Rover vehicles and utilizes cloud technologies and cameras, which we do not use. Instead, we will be focusing on a device that any driver can add to their vehicle with the sensor system using accelerometers and Bluetooth connectivity, rather than cameras and cloud technologies.

The use of a smart pothole detection system depends on sensors and location services in a public and commercial setting. While our sensors and application will not communicate with each other on a global scale, local Bluetooth communications will be used to capture accurate location data. We decided to use Bluetooth in order to reduce the amount of time and effort the user of the product would need to get the system working on their vehicle, also taking into consideration the time delay to communicate between the sensor module and the smartphone device. Additionally, wireless connections ensures that if one sensor is damaged, the rest of the system will not be offline as a result. Finally, since we will need to use location services in order to plot data onto a map, we will need to ensure the customer that the location data they provide us will not be used for any other purpose. This could mean anonymity of each user's data to the central database or deleting data after the road hazard has been fixed. Overall, our final product will need to take into account user privacy and the device's integrity over a long period of time.

III. STS Topic - The Ethical, Legal, and Societal Impacts of Micro-mobility Vehicles

Introduction

Micro-mobility vehicles, which can be defined as on-demand, single-occupant vehicles, are changing the way people travel through city streets. These micro-mobility vehicle companies have "the potential to better connect people with public transit, reduce reliance on private cars, and make the most of existing space by 'right-sizing' the vehicle, all while reducing greenhouse gas emissions" (Zarif, Pankratz, Kelman, 2019). Critics, however, are concerned about the safety

of pedestrians and how these vehicles are implemented on the streets. As a result, the rapid expansion of these types of vehicles shows the need for regulation and how they could best be integrated with existing transportation methods. Research questions that may aid in clarifying the situation are when and why does micro-mobility become a pattern for future transportation, who are the stakeholders in the micro-mobility business, and what new ethical and legal concerns are raised with the growth of the micro-mobility market, specifically in Charlottesville.

Literature Review

Currently, there are a multitude of transportation methods where micro-mobility vehicles could develop and integrate with existing infrastructure. As such, it is important to discuss how these vehicles will be regulated and used with current forms of transportation. Through the use of bike sharing and electric scooters, these companies, such as Bird, claim that replacing cars with e-scooters "...may actually lower pedestrian deaths…" (Leefeldt, 2019). However, collisions between e-scooters and cars are responsible for over 20% of traumatic brain injuries, according to the CDC (Leefeldt, 2019). This shows that there is a tradeoff between lower amounts of pedestrian deaths, but at the cost of the severity of the injuries. However, findings from several studies demonstrate "...a common lack of good safety practices among e-bike riders, which include absence of protective gear (helmets), common practice of carrying other adults, running red lights…", showing that there is apathy for safety among users (Zuev, Urry, Tyfield, 2019). The conflict over these mobility options arise because we don't have a clear cost-benefit analysis for each and every application.

Furthermore, there are ethical and legal concerns when using micro-mobility vehicles, especially when it comes to geo-tracking and data security. Scooter rental companies' apps rely on network-based and GPS location data collected from users' smartphones, giving companies valuable information such as users' locations and travel routes. "Over time, these trip routes can paint a clear picture of a users' lifestyle and preferences," and companies sell this data or use it with malicious intent, then it can pose significant risks to users (Petersen, 2019). Additionally, poor privacy practices are a risk to underserved communities because of monetization. Since poorer communities are more likely to rely on relatively inexpensive and convenient transportation, such as micro-mobility, companies can monetize user data and activity logs by giving them to law enforcement, mental health professionals, and insurance companies (Petersen, 2019). Because micro-mobility companies are already giving data to local governments in order to secure contracts, it is a matter of time before data is misused or monetized.

Framework

Given the ethical, legal, and societal concerns of micro-mobility, the best framework to analyze the situation is SCOT. Relevant stakeholders in micro-mobility are the companies, the local government, and residents. Looking at companies, their primary goal is to make money from users of their product, but they are also looking to comply with local government regulations while keeping users satisfied. With respect to the local government of Charlottesville, they would like to see if micro-mobility could complement the current transportation infrastructure and how much regulation would these micro-mobility companies need in order to comply with existing laws and societal concerns. Residents of a city, such as Charlottesville, are

looking for affordable and reliable methods of transportation, and micro-mobility could aid with the 'last mile' of a trip. However, if safety and privacy concerns are not addressed successfully, then they could complain to the local government to have these vehicles removed. In order for micro-mobility to have a meaningful impact in the community, there needs to be demand, but also communication among private companies, the local government, and residents.

Methods

To aid my research questions and analysis of SCOT, I propose looking at a case study in China, specifically on electric bicycles (e-bikes) and how they affected residents in cities across China, and looking at data and information from Charlottesville's pilot program on micro-mobility. Looking at China's dockless bicycle program could allow me to compare the two programs, and why e-bikes were pulled in China and if the same could happen in Charlottesville. If possible, I would be able to gain access to each micro-mobility company's usage data to see micro-mobility's effect in Charlottesville. Additionally, I can conduct interviews with Charlottesville's transportation officials on the effectiveness of the pilot program, send out a survey to the University of Virginia's student population for their thoughts on micro-mobility, and conduct interviews with community members that are not students on their opinion about micro-mobility and the impact it has so far. This would allow me to gain insight from the relevant stakeholders and help me answer the research questions proposed.

Discussion and Next Steps

To answer the questions of when and why does micro-mobility become a pattern for future transportation, who are the stakeholders in the micro-mobility business, and what new ethical and legal concerns are raised with the growth of the micro-mobility market, the comparison of case studies and interviews with stakeholders are necessary to understand micro-mobility. Comparing the cases of e-bikes in China and the scooter pilot program would allow necessary insight and foundation on the ethical and legal impacts of the two programs. Additionally, conducting interviews with the city transportation officials and local residents on the effectiveness of the micro-mobility program would give necessary relevant stakeholder opinions. Finally, looking into the legal and ethical concerns of micro-mobility overall would be conducted by a literature review. The goal is to answer the questions laid out, while understanding micro-mobility's role in the current transportation infrastructure, specifically in Charlottesville.

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