Enhancing Intersection Safety: Detecting and Mapping Vehicular Movement Through Intersections
Driver Behavior and How it is Shaped by Social Constructs of Masculinity

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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 recent years, the United States has experienced a concerning rise in fatalities at intersections (Larson, 2023). This increase underscores a critical issue in road safety that demands urgent attention. The purpose of this proposal is to bridge this gap by introducing a comprehensive system to address the complexities of intersection safety.

The core problem revolves around the surge in deaths at intersections, a phenomenon that poses a significant challenge to existing road safety measures. To establish a more concrete connection between the overarching problem and the proposed technical solution, it's crucial to delve into the specifics of the issue at hand. Through a closer examination of intersection-related fatalities, it becomes evident that current approaches may be falling short, particularly in scenarios involving young and inexperienced drivers.

To address this challenge, I propose a targeted technical solution designed to enhance intersection safety. This solution leverages pre-existing hardware and software technologies to detect vehicle presence at traffic lights. By accurately predicting and mapping vehicle movement through intersections, emergency services can navigate these complex scenarios more efficiently. This technology not only aims to reduce response times during critical emergencies but also plays a pivotal role in promoting overall intersection safety, with a particular emphasis on the unique challenges faced by young drivers.

Simultaneously, the Science, Technology, and Society (STS) project investigates the behavioral patterns of young male drivers on the road. Specifically, we explore how societal constructs of masculinity influence drivers differently, seeking to understand the underlying reasons behind impulsive decisions made by young male drivers.

The synergy between the technical and STS projects forms a feedback loop. Technological advancements reshape EMS interactions, influencing the development of behavioral norms for road users. These evolving norms, in turn, guide the implementation of future technology variations for the benefit of all users.

Technical Topic: Enhancing Intersection Safety: Detecting and Mapping Vehicular Movement Through Intersections

Currently, intersections across the United States uniformly have copper inductive wires to detect vehicle presence and traffic light cameras to monitor traffic situations as they develop. This project would utilize the inductive wiring system to determine the volume of vehicles present at distinct points in the intersection and couple that with vehicular image analysis using the traffic light cameras. The image analysis component would help determine the vehicle type,

its current travel path, and its current velocity to predict its exact movements in real-time which would then be mapped onto a GPS service for EMS. The mapping system will constantly update with the changing traffic conditions to provide the most accurate data to EMS as they respond to emergencies.

For vehicular image analysis, I will utilize two prebuilt open-source Python libraries, OpenCV and YOLO. Fine-tuning the models generated by these libraries will result in a system being able to calculate any vehicle's current and anticipated velocity. This is necessary for predicting its future location. These libraries specialize in vehicular detection, which allows me to identify the type of vehicle (i.e. sedan, SUV, truck) and estimate its mass. I will then take the generated information of velocity and mass and use the linear kinematic formula $\Delta x = v_i + \frac{1}{2}at^2$ to predict the location of a vehicle. To map the predicted vehicle paths, I will be looking into the Google Maps API and researching other mapping services. The linear kinematic formula is restricted to predicting linear movement; however, at times vehicles can experience parabolic movement when taking a turn. To account for this, I will also use an angular kinematic formula $\Delta \theta = \omega_i + \frac{1}{2}\alpha t^2$. This formula is similar to the linear version, but it considers the angular aspect of travel which includes the curvature in movement.

OpenCV and YOLO libraries are pre-built and have code blocks that create bounding boxes in video feeds. Bounding boxes are boxes placed around an object to bound the object so it can be tracked by a Convolutional Neural Network to identify where in the picture the object is (IBM, 2021). YOLO has defined methods to create bounding boxes for images, as they are passed into a model. We can then use the bounding box information by going through a frame-by-frame process, where we identify the Euclidian distance between past bounding boxes. This tracks the vehicle through the intersection and can be expanded upon to predict future travel paths.

Understanding and predicting driver behavioral patterns is crucial for improving road safety and developing targeted interventions. A fundamental part of this project is the LSTM, Long-Short Term Memory, a model that will detect trends in driver behavioral patterns. Since the LSTM is one of the most trusted predictive models for sequential inputs, it will help improve predictions over time by analyzing driver movements. The pattern recognition will be coupled with the Euclidian distance to enhance predictions. An LSTM model operates by learning from past inputs and using long-term dependencies to predict sequential data behavior (Saxena, 2023). The overall machine-learning architecture will be as follows: OpenCV/YOLO image analysis for kinematic equations passed into an LSTM to learn and predict travel paths based on kinematics and sequential vehicles for behavioral analysis.

Once viable predictions have been made, the projected travel paths for vehicles in intersections will need to be plotted geo-spatially. This requires some form of a mapping service,

such as the Google Maps API, to enable plotting multi-vehicular travel paths. This portion of the project requires more research, as it is less common for map services to plot more than one travel path. However, it would be simpler to implement a Python solution, compared to other development kits, due to the machine-learning aspect utilizing a Python framework. By mapping the predicted travel paths of vehicles in an intersection, EMS will be able to use the information to identify the safest/quickest possible path to pass through the intersection. This will help create a standardized interaction between intersection users and EMS during a high-stress moment as EMS responds to calls.

STS Topic: Driver Behavior and How it is Shaped by Social Constructs/Cultural Norms

A vast majority of vehicular accidents involve young/inexperienced drivers, which contributes to the rise in traffic accidents across the United States. These accidents are also more likely to be fatal, as the leading cause of death for those under the age of 25 in the United States and Canada is car crashes (Porter, 2011). Many studies have examined these accidents, looking at a variety of factors involved. To name a few there are gender, age, driving experience, etc.

In particular, it has been found that men exhibit less risk aversion than women, especially when with male peers (Tian, Guo, Lu, Liu, Lu, 2022). Additionally, men tend to overestimate their own driving abilities and may require intervention as safety precautions (Bannach and Bianchi, 2021). Numerous studies consistently highlight that young male drivers are more prone to traffic violations and crashes compared to other social groups, with a higher likelihood of violating traffic rules (Alver et al., 2014). The prevalent conclusion among these studies raises questions about the root cause of such behavior.

The link between violations and distracted driving behavior, where drivers are not fully attentive to road conditions, exists and has been studied by Stavrinos and colleagues. This is because performing multiple tasks at once takes away from our cognitive resources to perform either task at a high level (Stavrinos, Pope, Shen, Schwebel, 2017). The critical question emerges: is the tendency for violations, particularly among young male drivers, rooted in constructs of masculinity that lead to overestimation of their driving abilities?

This inquiry delves into the societal perception of masculinity, seeking to understand whether overestimation is a personal characteristic or a learned behavior. It also prompts reflection on how the concept of 'distracted driving behavior' aligns with and potentially contributes to these observed patterns. By examining the connections between learned individual traits, social constructs of masculinity, and distracted driving, we aim to gain a more nuanced understanding of the factors driving violations and crashes on the road.

These questions prompt an investigation into how young men and other social groups analyze risks in driving scenarios. It was found that men are more likely to participate in some form of distracted driving behavior, with younger men(Millennials) engaging in distracted behavior more than their older counterparts (baby boomers) (Gardner, 2017).

New technological advancements, exemplified by Apple CarPlay, were designed with the intention of minimizing distractions caused by using phones directly. However, paradoxically, these innovations can contribute to driver distraction. Apple CarPlay, while facilitating access to maps or music, can divert attention away from the immediate driving conditions. Nevertheless, in comparison to the direct use of a phone, Apple CarPlay is considered a safer alternative, allowing drivers to keep their hands free (Apple, 2023). This is because Apple CarPlay, and its counterpart Android Auto, serve to eliminate manual distractions while driving (Storrar, 2022). However, they do not remove the visual distractions, as drivers spend roughly 16 seconds looking at the screens in their cars instead of the road when interacting with the technology.

This example highlights a feedback loop in technological evolution. Initially, technology is developed to address certain concerns and that creates new interactions between the users and the technology. Subsequently, further innovation is prompted to simplify these interactions or resolve issues in the interactions if necessary, creating a continuous cycle of technological development and societal response. In the context of distracted driving, this loop demonstrates how technology designed to mitigate one issue may inadvertently introduce new challenges to driver attention and safety.

From 1991 to 2008 distracted driving fatalities have increased significantly, yet the ratio of male to female distracted drivers remained relatively similar with ~72% of men consistently being distracted drivers (Wilson & Stimpson, 2010). In this timeframe, hand-held devices were utilized more, as cell phones became more prominent. Additionally, since 2008 2 out of 5 drivers who were involved in fatal distracted driving accidents were younger drivers, and roughly half of the distracted drivers were young men.

The evidence shows that young male drivers are more likely to be involved in accidents, however, it does not provide a justification for why young men are more likely to be distracted drivers involved in accidents. This STS project aims to investigate how cultural expectations of masculinity, influenced by the integration of smartphones in-car technology, contribute to the prevalence of distracted driving incidents among young male drivers using an Actor-Network Theory approach. In this project we have human actors that include drivers, EMS/first responders, and other intersection users. Non-human actors include the various vehicles, pre-existing technologies the technical project uses, as well as the algorithms and applications that detect and map vehicular movement. I will examine how the norms of human actors influence the non-actors and how they are influenced by non-human actors. This examination will be

broken down to separate human actors by age and gender, to provide a closer investigation into the STS project.

For the STS project, I will gather evidence by conducting interviews with UVA students. These interviews are designed to provide a comprehensive understanding of the complex dynamics surrounding distracted driving, its cultural implications, and the role of technology. By interviewing UVA students, especially those in the age group prone to distracted driving incidents, we aim to gain insights into their behaviors, attitudes, and perceptions related to driving. Understanding how personal technology influences their choices and how societal norms may shape these behaviors is essential. Additionally, exploring how UVA students perceive and assess risks in driving scenarios will shed light on their decision-making processes. This can provide valuable information on the intersection of individual ego, societal norms, and distracted driving.

Faculty members from the engineering department can provide insights into the development and impact of technological products. Understanding their perspectives on the unintended consequences of technological innovations, such as Apple CarPlay/Android Auto, can deepen the analysis. Through interviews, surveys, or collaborative discussions, we can collect evidence on their views regarding the unintended consequences of technological innovations, such as Apple CarPlay. Engineers have expertise in understanding unintended consequences due to their involvement in the design, development, and assessment of technologies, allowing them to evaluate risks, consider ethical implications and engage in continuous improvement, ultimately contributing to public safety and the responsible advancement of society. This evidence collection process will enrich the analysis by incorporating the perspectives of experts who understand the intricacies of these technologies. Exploring how engineering faculty members view the interaction between humans and technology in the context of driving can contribute to the examination of non-human actors within the Actor-Network Theory framework.

Conclusion

To summarize, the proposed technical project to enhance intersection safety through the detection and mapping of vehicular movement offers a unique solution to address the increasing number of intersection-related accidents and improve the efficiency of emergency medical services (EMS) response times. By utilizing existing technologies, such as OpenCV, YOLO, and traffic infrastructure, this project aims to predict and map vehicle movements in real time, providing relevant information regarding traffic conditions to EMS for faster response times during emergencies. Additionally, by using an LSTM model the technical project aims to self-

learn and improve predictions over time by using memory of pattern analysis in new predictions. This novel approach aims to enhance intersection safety, by providing EMS with advanced information regarding an intersection's conditions before approaching it, in order to determine the safest route possible.

The STS project delves into the relationship between societal views of masculinity and the use of car technology, shedding light on why young male drivers are more prone to accidents. By exploring how societal constructs of masculinity influence behavior, we aim to understand the reasons behind their increased susceptibility to traffic violations and distracted driving, culminating in accidents. The examination of these constructs, with a primary focus on exploring how societal notions of masculinity may contribute to distracted driving, underscores the intricate interplay between human and non-human elements; particularly, technologies such as Apple CarPlay, shaping driver behavior. This interdisciplinary approach, framed within Actor-Network theory, offers a comprehensive perspective on the intricate sociotechnical dynamics influencing road safety. The blend of technical innovation and sociocultural analysis strives to cultivate a safer and more informed environment for all road users.

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