The Insufficient Utilization of Advanced Technologies in Traffic Accident Prediction
(Technical Topic)

A Study of Public Resistance to Urban Planning Initiatives in Traffic Safety
(STS Topic)

A Thesis Prospectus
In STS 4500
Presented to
The Faculty of the
School of Engineering and Applied Science
University of Virginia
In Partial Fulfillment of the Requirements for the Degree
Bachelor of Science in Computer Science

By
Arjun Trivedi

April 2, 2024

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.

Signed: ____

Advisor
Kathryn A. Neeley, Department of Engineering and Society

Introduction

Every 27 seconds, a life is lost to a traffic accident, accumulating to approximately 1.19 million fatalities globally each year (World Health Organization, 2021). A traffic accident can be caused by a wide variety of factors, including cell-phone usage, poor decision-making, fatigue, vehicle defects, and road hazards (Ortega, 2021). While directly instructing drivers to improve their habits can mitigate some risk, the multifaceted nature of traffic accidents in the U.S requires a thorough analysis of such factors. The situation revolves around the ineffectiveness of current data analytics technology in studying traffic accidents (Cai, 2020). Current statistical methods focus on analyzing past incidents without recognizing patterns to be applied in preventing future incidents. This results in an observational rather than proactive strategy in traffic safety management. Moreover, the lack of trust between community members and urban planners caused by road change disagreements exacerbates these issues, inhibiting success in traffic safety.

The situation calls for attention and action to address the ineffectiveness of data analytics technology in studying traffic accidents. Over the past decade, the U.S has seen a 10% increase in road fatalities, contrary to other developed countries making improvements (Figure 1). If the situation is left unaddressed, the persistence of traffic fatalities will continue to impact public health, placing a large burden on the healthcare system (Zakeri, 2021). To stabilize the situation, this prospectus proposes two approaches that address different aspects of traffic safety management. The technical approach aims to discuss the possibility of using machine learning (ML) to improve the quality of traffic accident predictions through its ability in analyzing the complex relationships between traffic accident factors. The STS approach aims to promote trust between community members and local authorities through understanding how to positively view resistance in urban development.

Country	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Changes from 2019 (%)
Australia	1350	1277	1300	1187	1151	1204	1292	1222	1134	1186	1095	−8.31
Canada	2238	2023	2075	1951	1841	1889	1899	1856	1922	1762	1745	−0.97
Denmark	255	220	167	191	182	178	211	175	171	199	163	−22.09
France	3992	3963	3653	3268	3384	3461	3477	3448	3248	3239	2780	−16.51
Germany	3648	4009	3600	3339	3377	3459	3206	3180	3275	3046	2719	−12.03
Japan	5828	5535	5261	5165	4838	4885	4698	4431	4166	3920	2839	−38.08
New Zealand	375	284	308	253	293	318	327	378	378	352	320	−10.00
United Kingdom	1905	1960	1802	1770	1854	1804	1860	1856	1839	1752	1516	−15.57
United States	32999	32479	33782	32893	32744	35484	37806	37473	36560	36120	38680	6.62

Figure 1. Traffic Accident Statistics by Country. Other developed countries display improving numbers in fatality statistics over the past decade. The U.S is the lone country with an increase in fatalities from 2019, highlighting country-specific problems (Adapted from Ahmed et al., 2023, pg. 2).

Technical Topic: The Insufficient Utilization of Advanced Technologies in Traffic Accident Prediction

Current technology in traffic data analysis heavily relies on elementary statistical models that fall short in delivering the detailed insights needed for effective preventative measures. Elementary statistical models, which are fundamental to traffic data analysis, focus on basic descriptive statistics and simple correlations to understand trends and patterns in accident data. In fact, “[college] students would use statistics to learn regression only fits lines to linear data” (Matchett, 2023). Traffic accident models may use regression analysis to determine relationships between accident rates and variables such as time of day or weather conditions, helping identify high-risk scenarios. An example model output could indicate that drunk-driving is highly associated with driving at night (Jackson, 2011). In other words, the models are only capable of producing observations and facts to startle citizens, rather than concrete predictions that can be applied in future situations to create real change. These predictions could potentially be in the form of urban planning, such as lowering speed limits and widening specific driving lanes which are critical interventions designed to enhance road safety and prevent accidents before they occur (Cai, 2020).

Local authorities utilize traditional statistical models for analyzing traffic accidents, which were originally developed in the 1800s and have seen minimal changes since. While these models have historically provided a foundational understanding of accident dynamics, they now fall short in addressing the complexities of modern-day traffic incidents. This is because these outdated models are unable to process the multifaceted causes of today's accidents, such as the rise in cell-phone usage, the impact of substances like alcohol and drugs, and broader socio-economic factors including homelessness (Neale, 2022). While advanced technologies capable of processing these complex factors do exist, their application is often limited to private research and has not been widely adopted for nationwide use, a lengthy process. Specifically, “the National Motor Vehicle Crash Causation Survey data collected at crash scenes between 2005 and 2007 is used in [common] statistical analyses methods” (US Dept. of Transportation, 2010). As a result, the status quo often yields oversimplified data and if it persists, it will continue to fail to reflect the realities of current road safety challenges.

The gap in data analysis capabilities creates significant weaknesses in understanding the root causes of accidents, particularly in how variables like road design, traffic flow, and environmental conditions interact to escalate accident risks. For example, without a nuanced understanding of these factors, interventions such as the redesign of intersections or adjustments in speed limits may not be correctly aligned with specific peak times, overall showing no improvements (Cai, 2020). This oversight leads to a misallocation of resources and underperforming safety measures as the interventions fail to address the specific complexities of high-risk areas, leaving such areas vulnerable to persistent increasing accident rates (Goel, 2024).

To address the identified gaps in traffic data analysis and enhance the precision of safety interventions, this project proposes the possibility of adopting ML techniques, specifically feedforward neural networks (FNNs). The implementation of FNNs allows for the recognition of nonlinear relationships within large datasets, which traditional models often overlook (Vanitha, 2023). This capability enhances the accuracy of forecasts regarding accident conditions, allowing for timely and location-specific interventions. For instance, FNNs may be able to predict accident hotspots with greater accuracy by analyzing real-time data from various sensors and feeds, allowing more precise deployment of safety measures like adding longer transitions between traffic signals. The FNN model would be integrated into existing urban traffic control systems, enabling a proactive approach to traffic management by deploying targeted interventions based on the model's predictions.

This prospectus builds upon existing statistical model techniques by integrating FNNs to develop a more sophisticated traffic prediction tool. The deliverable will be a robust model tailored specifically for urban traffic management that can accurately analyze complex datasets encompassing real-time and historical factors like weather conditions, traffic density, and road types. However, key challenges remain in implementing such a solution, including the substantial computational resources required for training complex models, obtaining diverse high-quality datasets, and ensuring the tool's reliability across different urban environments.

STS Topic: A Study of Public Resistance to Urban Planning Initiatives in Traffic Safety

Urban planning and traffic safety initiatives have been implemented in cities for decades, aimed at improving road infrastructure and reducing accidents (Lewis, 2012). In terms of the sociotechnical system, urban planning for traffic safety involves multiple human actors, including local authorities, urban planners, technology developers, and community members, each with different priorities. While authorities and planners often focus on using new technologies to enhance efficiency and safety, community groups and residents are concerned about how these changes affect their daily lives, such as business disruptions or increased surveillance (Anthony Jr., 2023). For instance, adding new traffic cameras along a commercial corridor can prompt resistance from business owners worried about privacy and loss of customers during installation disruptions. It is crucial to find ways to balance technological solutions with protecting community interests and values to ensure successful implementation.

All the actors involved in urban planning are driven by passion and dedication for their community's well-being. From the government's perspective, initiatives like retiming traffic signals, adding cameras for enforcement, or constructing new road layouts are intended to reduce congestion and accidents. However, these efforts have sometimes faced pushback, like the public protests over privacy concerns when Chicago installed a widespread surveillance camera network in 2004 (Schwartz, 2013). The current negative view of community resistance challenges us to rethink the notion of 'resistance' not as opposition, but as a deeply rooted commitment to ensuring that changes reflect the community's values and needs (Rehman, 2021).

Urban resilience initiatives often start with high expectations, only to face skepticism as the complexities of real-world application emerge, as seen in Figure 2 below. This progression mirrors the Hype Cycle, “a theoretical model that maps the life cycle stages any new technology goes through, from overenthusiasm to eventual adoption and pragmatism” (Shamsuddin, 2020). Skepticism, or resistance, can be seen as an integral part of the Trough of Disillusionment, where the community's high standards challenge the implementation process. Urban planners focus on designing the technical solutions, but must balance functionality with minimizing community disruptions. Meanwhile, local residents prioritize having their values and needs reflected in any changes that affect their neighborhoods. These actors, whether they are traffic systems, urban planners, or local residents, form a network whose interactions and negotiations are important for moving beyond disillusionment to reach effective socio-technical solutions (Anthony Jr., 2023). It's through this critical phase that urban resilience efforts can evolve into sustainable practices that are embraced by the community.

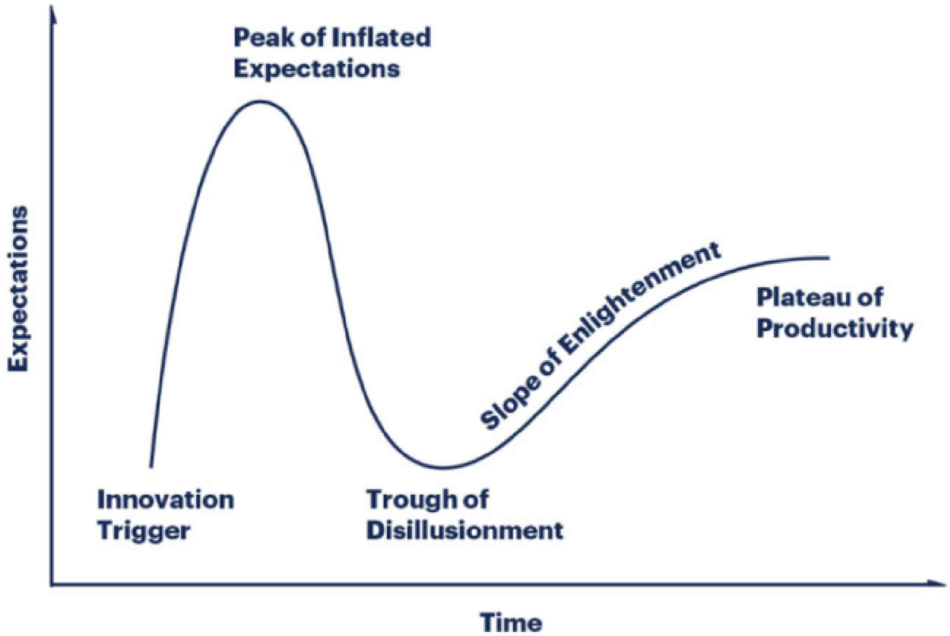

Figure 2. The Hype Cycle for Emerging Technologies. This model illustrates the typical progression of technological innovation from initial excitement through to widespread adoption, reflecting the journey of urban resilience initiatives as they confront community expectations (Adapted from Shamsuddin et al., 2020, pg. 2).

The consequences of overlooking the deep-rooted commitment that community members have towards urban planning initiatives are multifaceted. When this passion is misinterpreted as mere resistance, it can lead to a breakdown in trust between the public and local authorities, creating barriers to the successful implementation of traffic safety measures (Lewis, 2012). This misdirection can result in poorly adopted policies and the potential escalation of community protests, which may further delay critical safety improvements.

To address the redefined concept of resistance in urban planning, this research will explore how what is often perceived as resistance can actually be viewed as an informed and passionate engagement by community members advocating for their values. Building on STS research that examines conflict and cooperation within sociotechnical systems, this study will apply actor network theory (ANT) to systematically map and analyze the complex interactions, relationships, and flow of agencies among urban planners, local authorities, technology developers, and residents. The main challenge lies in effectively engaging with said stakeholders from various sectors, integrating their diverse perspectives into the planning process (Lemke, 2021). Through an in-depth examination of the dynamics driving these stakeholder interactions and resistance, the project aims to develop a comprehensive framework that redefines resistance as a valuable input and leverages community perspectives as a pivotal resource for enhancing traffic safety solutions and aligning them with community values and needs.

Conclusion

The anticipated deliverables of the technical work are the possible implementation of feedforward neural networks (FNNs) for advanced traffic accident prediction and analysis. The STS research aims to provide an improved understanding of how to leverage community resistance as a valuable resource in urban planning initiatives related to traffic safety.

If successfully implemented, these deliverables have the potential to contribute significantly to the resolution of the technical problem —the insufficient utilization of advanced machine learning techniques for traffic accident analysis — by integrating FNNs to enable more precise safety interventions. Additionally, they can address the STS problem of handling public resistance to urban planning initiatives by reframing resistance as valuable community engagement, developing a framework to foster trust and collaboration between stakeholders.

By addressing both the technical aspects of advanced traffic accident analysis and the sociotechnical aspects of stakeholder engagement in urban planning, this work has the potential to drive meaningful improvements in traffic safety initiatives, ultimately reducing traffic fatalities and the associated health burdens. **Word count: 1879**

References

Ahmed, S., Hossain, M. A., & Ray, S. K. (2023). A study on road accident prediction and contributing factors using explainable machine learning models: Analysis and Performance. *Transportation Research Interdisciplinary Perspectives*, *19*, 100814. https://doi.org/10.1016/j.trip.2023.100814

Anthony Jr., B. (2023). The role of community engagement in urban innovation towards the co-creation of Smart Sustainable Cities. *Journal of the Knowledge Economy*. https://doi.org/10.1007/s13132-023-01176-1

Cai, M., Hu, Q., Alamdar Yazdi, M. A., Mohabbati-Kalejahi, N., Vinel, A., Rigdon, S. E., Davis, K. C., & Megahed, F. M. (2020, February 18). *A review of data analytic applications in road traffic safety. part 1: Descriptive and predictive modeling*. MDPI. https://doi.org/10.3390%2Fs20041107

Goel, R., & Tiwari, G. (2024). Effectiveness of road safety interventions: An evidence and Gap Map. *Campbell Systematic Reviews*, *20*(1). https://doi.org/10.1002/cl2.1367

Jackson, C. K., & Owens, E. G. (2011). One for the road: Public transportation, alcohol consumption, and intoxicated driving. *Journal of Public Economics*, *95*(1–2), 106–121. https://doi.org/10.1016/j.jpubeco.2010.09.010

Lemke, A. A., & Harris-Wai, J. N. (2015). Stakeholder engagement in policy development: Challenges and opportunities for human genomics. *Genetics in Medicine*, *17*(12), 949–957. https://doi.org/10.1038/gim.2015.8

Lewis, C. W., & Gilman, S. (2012). *The Ethics Challenge in Public Service: A problem-solving guide* (2nd ed.). Jossey-Bass a Wiley Imprint.

Matchett, A. (2023). Elementary statistics projects using Covid Data. *PRIMUS*, *33*(7), 796–817. https://doi.org/10.1080/10511970.2023.2172750

Munappy, A. R., Bosch, J., Olsson, H. H., Arpteg, A., & Brinne, B. (2022). Data Management for Production Quality Deep Learning Models: Challenges and Solutions. *Journal of Systems and Software*, *191*, 111359. https://doi.org/10.1016/j.jss.2022.111359

Neale, J., Parkin, S., & Hermann, L. (2022). Substance use and homelessness: A longitudinal interview study conducted during COVID-19 with implications for policy and Practice. *International Journal of Drug Policy*, *108*, 103818. https://doi.org/10.1016/j.drugpo.2022.103818

Ortega, C. A., Mariscal, M. A., Boulagouas, W., Herrera, S., Espinosa, J. M., & García-Herrero, S. (2021). Effects of mobile phone use on driving performance: An experimental study of workload and traffic violations. *International Journal of Environmental Research and Public Health*, *18*(13), 7101. https://doi.org/10.3390/ijerph18137101

Rehman, N., Mahmood, A., Ibtasam, M., Murtaza, S. A., Iqbal, N., & Molnár, E. (2021). The psychology of resistance to change: The antidotal effect of organizational justice, support and leader-member exchange. *Frontiers in Psychology*, *12*. https://doi.org/10.3389/fpsyg.2021.678952

Schwartz, A. (2012). *Chicago's video surveillance cameras: A pervasive and poorly regulated threat to our privacy*. Northwestern Pritzker School of Law Scholarly Commons. https://scholarlycommons.law.northwestern.edu/njtip/vol11/iss2/4/

Shamsuddin, S. (2020). Resilience resistance: The challenges and implications of urban resilience implementation. *Cities*, *103*, 102763. https://doi.org/10.1016/j.cities.2020.102763

Vanitha, R., & Swedha, M. (2023). Prediction of road accidents using machine learning algorithms. *Middle East Journal of Applied Science & Technology*, *06*(02), 64–75. https://doi.org/10.46431/mejast.2023.6208

Zakeri, R., Nosratnejad, S., Sadeghi-Bazargani, H., Dalal, K., & Yousefi, M. (2021). The economic burden of road traffic injuries until one-year after hospitalization: A survey study. *Accident Analysis & Prevention*, *163*, 106459. https://doi.org/10.1016/j.aap.2021.106459