Research Project Name: Reasoning and Mitigating AI Biases in Connected Vehicle-Infrastructure-Pedestrian Systems for Promoting Pedestrian Safety at Intersections

Recipient/Grant (Contract) Number: Florida A&M University; Stony Brook University

Center Name: Rural Safe, Efficient, and Advanced Transportation (R-SEAT) Center

Research Priority: Improving Mobility of People and Goods

Principal Investigator(s): Susu Xu

Project Partners: -

Research Project Funding: $97,106 (Federal request); $52,770 (Non-Federal cost share)

Project Start and End Date: 6/1/2023 to 12/31/2024

Project Description:

This project seeks to uncover, characterize, and mitigate the biases of AI models in connected vehicle-infrastructure-pedestrian systems by leveraging advanced statistical machine learning and representation learning techniques and real-world video data

Pedestrian safety remains a critical challenge in current transportation systems. In the US, fatal pedestrian crashes have increased by nearly 50% over the past decade. Data shows that children, the elderly, men, and people with low income are involved in far greater pedestrian-vehicle crashes compared to the general population. Autonomous Vehicles (AVs) are expected to effectively detect pedestrians and react to potential accidents. However, due to the constrained mobilities of vulnerable road users, data from vulnerable pedestrians, such as the elderly and children, is often limited. For example, children are more likely to exhibit unpredictable behaviors, and elderly pedestrians on average walk slower than the general population, as shown conceptually in Figure 1. The data scarcity and distinct distributions of these pedestrian groups will make their data minor ``mode" or even ``out-of-distribution" compared to the huge amount of training data from other pedestrian groups. This will lead to larger prediction errors for those groups during the testing stage. Error-prone detection and trajectory prediction of vulnerable pedestrians may cause decision-making that compromises their safety.

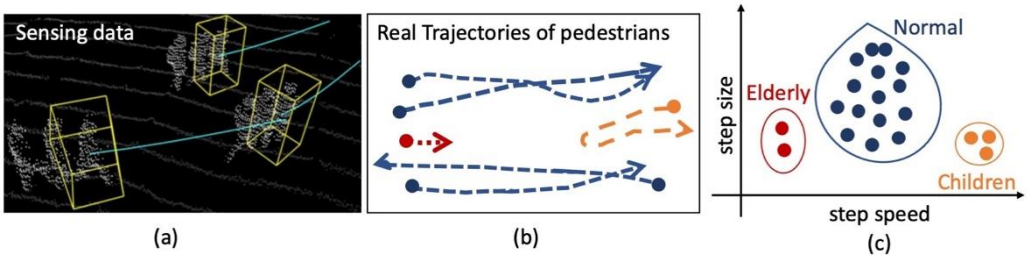

Figure 1 Concepts of out-of-distribution behavior patterns of vulnerable pedestrians. (a) Majority of pedestrian data are from normal pedestrians. (b) The vulnerable pedestrians such as elder/disabled (red) and children (orange) often have distinct crossing behavior patterns resulting in different trajectories. (c) Compared to data distribution of majority normal pedestrians, the data of vulnerable groups are often ``minor mode" or ``out-of-distribution".

US DOT Priorities: This project aligns with the USDOT the strategic areas of safety and transformation

Outputs:

- A draft project report that provides an adversarial on-manifold data augmentation scheme with approximated data manifolds of underrepresented pedestrians, and design fairness-aware loss function for algorithms that jointly optimizes general accuracy and differences between group-level prediction accuracy across different modalities
- Xue, Z., Zhang, X., Prevatt, D. O., Bridge, J., Xu, S., & Zhao, X. (2024). Post-hurricane building damage assessment using street-view imagery and structured data: A multi-modal deep learning approach. arXiv preprint arXiv:2404.07399

- Wang, C., Engler, D., Li, X., Hou, J., Wald, D. J., Jaiswal, K., & Xu, S. (2024). Near-real-time earthquake-induced fatality estimation using crowdsourced data and large-language models. International Journal of Disaster Risk Reduction, 111, 104680.
- Li, Z., Man, F., Chen, X., Xu, S., Dang, F., Zhang, X. P., & Chen, X. (2024, May). QUEST: Quality-informed Multi-agent Dispatching System for Optimal Mobile Crowdsensing. In IEEE INFOCOM 2024-IEEE Conference on Computer Communications (pp. 1811-1820). IEEE

Outcomes/Impacts:

- A novel fairness-aware multi-modal pedestrian safety system to enhance the quality of experience of pedestrians by leveraging connected vehicle-infrastructure-pedestrian (VIP).

Final Research Report: N/A