Transportation IoT Systems: Sensing & Data Science

Research Statement, Ziyuan Pu, University of Washington

**Vision:** Driven by the advancement of novel technologies, including data science and Internet of Things (IoT, as known as Cyber-Physical Systems under some context), the *fourth industrial revolution* broke out in recent decades, which empower transportation systems with the more powerful ability of sensing, interacting and controlling among passengers, vehicles, and infrastructures. Several challenging tasks of transportation engineering can be better addressed by the contribution of the new transportation systems, for example, the traffic status of urban areas and highways can be better predicted based on deep learning algorithms by learning huge amounts of phone app-based data generated by individual trips. However, the current transportation systems still have limitations on the technology side which has been threading the road users’ safety and restricting the traffic mobility, e.g. the frequent collisions involving autonomous vehicles caused by the malfunction of machine-vision-based sensing systems. In order to improve the safety and mobility of the current transportation system, the White House announced that 2.6 billion investment is initiated to support the development of autonomous vehicles and infrastructures in 2019, and a considerable part of the 200 billion investments in 2020 for supporting additional infrastructure development will keep pace with innovating emerging technologies such as autonomous vehicles and infrastructures. In light of such incredible opportunities, combining with my background and research experience, my long-term research goal is to **build a comprehensive transportation IoT system to form a fully perceptible and interactive network among vehicles, infrastructures and passengers for fulfilling the fully connected and autonomous transportation so that the traffic safety and mobility can be highly improved.**

**Background and research contribution summary:** In the transportation IoT system, data and algorithms are two main resources and tools, which data provides the essential measurements of transportation systems, and algorithms extract target parameters for supporting decision-making. My Ph.D. research mainly focuses on two parts, *novel traffic sensing technology and sensor networks development* and *advanced transportation data science.* The first part explored novel sensing methods and optimized sensor networks to improve the precision and efficiency of the edge-side. The second part aimed to build advanced data-driven algorithms for modeling, predicting, controlling, managing and visualizing. The main contributions of my Ph.D. research can be summarized in the following aspects. The detailed description of my Ph.D. research will be introduced in *Ph.D. Research Contribution I, II.*

- Developed the novel methods for pedestrian, passenger, non-motorized traffic flow, and road surface condition monitoring based on wireless communication technology and sensor-fusion algorithms.
- Optimized sensing and control systems considering deployment location of edge-side devices, computational efficiency, privacy protection, and communication security issues.
- Developed novel artificial intelligence-based short-term forecasting algorithms for handling spatial-temporal features and missing values in the dataset in traffic status forecasting and road surface condition prediction.
- Built data-driven algorithms for understanding, evaluating and improving traffic safety and urban mobility.

In the engineering field, I believe that the vision and ability to transfer research prototypes into real products to lead the development in the industrial area is one of the significant criteria to distinguish outstanding researchers. Thus, on the practical side, I developed two tools for demonstrating the practical values of my research and addressing engineering problems which are currently lack of solutions. Mobile Unit for Sensing Traffic Sensor (*MUST Sensor*) is a multi-source traffic sensing equipment and IoT system middleware. Multiple sensing modules are integrated to support the sensing functions, e.g. video and thermal camera, Wi-Fi and Bluetooth sensing, and environmental sensing (temperature and humidity). It has successfully been used by governments and universities for monitoring long-term motorized and non-motorized traffic flow and the status of road infrastructures under extreme environmental conditions. Digital Roadway Interactive Visualization and Evaluation Network (*DRIVE Net*) is a comprehensive platform for managing, processing, modeling and visualizing multi-source traffic data. Governments and transportation agencies have been using DRIVE Net for visualizing and creating daily traffic congestion and safety report to support traffic management and planning.