Traffic heterogeneity with connectivity and connected automated vehicles

Research proposal

In the past decade, the increasing prospect of vehicle and infrastructure connectivity has appeared, as well as the introduction of the first automated vehicles, which build on decades of development of Advanced Driver Assistant Systems (ADAS). Much has been hypothesised about the potential influence of such technologies with a broad range of experimental (field testing and simulated) work being performed. However, there remains a lack of deeper theoretical understanding of the extent to which these technologies will influence the fundamental aspects of traffic heterogeneity, which is so key to traffic performance.

According to [Banks, 1999], traffic heterogeneity explains the data scattering on the flow-density plane and positive transferences within the congested phase (a transference is a line connecting adjacent points in the time series). This heterogeneity results from a traffic mixture, made up of various vehicles and drivers, or different traffic conditions such as meteorological conditions. Driver as a significant component of traffic system with unpredictable behavior, is usually regarded as a main cause to traffic accidents. In the context of mixed traffic, both AV design studies and traffic flow dynamics studies require us to build appropriate models to describe and simulate intersections between human drivers and CAVs. To this end, my research will focus on driver heterogeneity in an operational level, meaning that traffic heterogeneity in this project refers to driving heterogeneity.

The main goal of my research is to investigate and develop traffic theory on driver heterogeneity in mixed CAV traffic. The research includes three sub-sessions: modelling driving heterogeneity in full HDV traffic, modelling driving heterogeneity in mixed CAV traffic and heterogeneously modelling human driving behaviors in mixed CAV traffic. The framework of research topics is shown as Figure 1.

Firstly, I will focus on modelling human driving heterogeneity in full HDV traffic based on the accessible big datasets. Based on the current research, I will give a novel definition for driver heterogeneity and describe it in a mathematical way. The outcomes can be the references of identifying driving heterogeneity in mixed CAV traffic where limitations exist in current research due to the absence of big datasets. Second, I will develop a deep learning-based model to identify driving heterogeneity. Online Transfer Learning (OTL) will used to solve this problem. During the process, OTL aims to attack an online learning task on a target domain (driving behaviors in mixed CAV traffic) by transferring knowledge from some source domain (driving behaviors in full HDV traffic). By doing this, the impacts of CAVs on driver heterogeneity can be illustrated. Based on the pre-work, a novel human driving behavior model by considering driver heterogeneity in mixed CAV traffic will be developed. Several widely-used indicators, such as driving volatility(DV), time headway(THW) and time-to-collision(TTC), are going to be considered to evaluate the impacts on traffic heterogeneity. Standard deviation (Std), Mean Absolute Deviation (D_{mean}), Coefficient of Variation (C_v) and Time-Varying Stochastic Volatility (V_f) are the optional measurements.

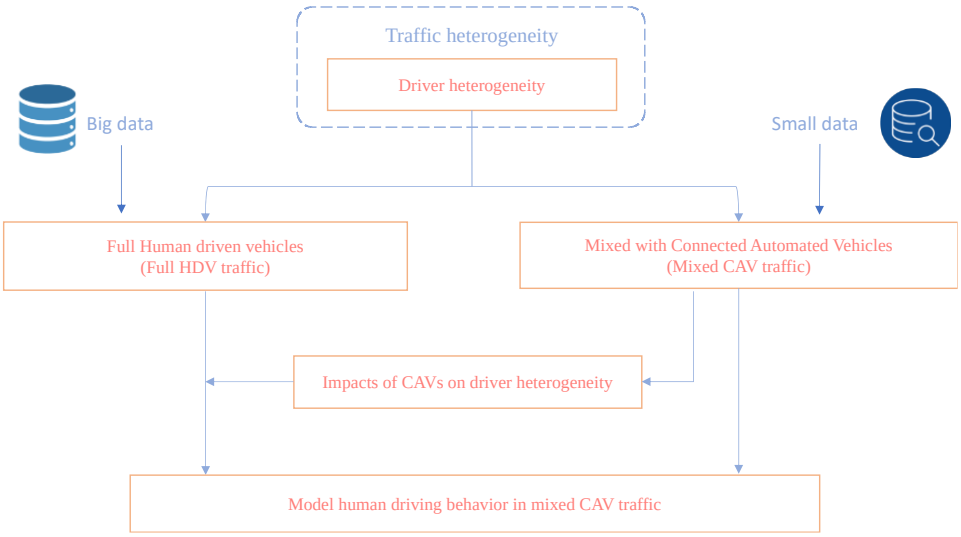

Figure 1: Framework of research topics

Reference

Banks, J. H. (1999). Investigation of some characteristics of congested flow. Transportation research record, 1678 (1), 128–134.