Project Title: Enhancing traffic safety and connectivity: A data-driven multi-step-ahead vehicle headway prediction leveraging high-resolution vehicular trajectories

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Research Priority: Promoting Safety

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Project Partners:

- City of Edinburg

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Project Description:

Vehicle headway, defined as the time elapsed between two successive vehicles passing a roadway point, is a key mesoscopic-scale measure in traffic flow theory with safety-critical transportation applications, such as preemptive collision avoidance warning systems as well as connected and autonomous vehicle (CAV) platoon control. Hence, it is crucial to accurately predict vehicle headway over sufficiently long future horizons (i.e., multi-step-ahead prediction) to be applicable for downstream safety-critical applications. This is a challenging task due to several random factors influencing headway, including inter- and intra-driver heterogeneity, asymmetric car-following driving behavior, and vehicle heterogeneity under mixed traffic of different vehicle classes. This becomes even more complicated under traffic congestion, which results in tangible inter-vehicle interactions and, thus, speed-dependent headways. The complex effects of the above factors on headway, along with the unprecedented amount of high time-resolution vehicle trajectory big data (e.g., datapoints recorded every 0.1 second), call for advanced data-driven headway prediction models. Deep learning architectures, particularly variants of Recurrent Neural Network (RNN), are promising candidates as they can "learn" highly nonlinear relationships from headway time-series data. However, recurrent networks are notorious for the vanishing gradient problem, which precludes learning long-term dependencies in time series data. To tackle, this proposed project will employ a state-of-the-art interpretable deep learning model for multi-step-ahead time series forecasting (e.g., next 5 seconds), which can accommodate reasonably long prediction horizons that can capture human/vehicle reaction time. Leveraging the vehicle trajectory big data from the USDOT's Next Generation Simulation (NGSIM) dataset, the model will be trained and tested to investigate the effects on headway of microscopic traffic measures, macroscopic traffic flow, vehicle class, and lane position.

Outputs:

The anticipated output of this research project includes a state-of-the-art machine learning method implemented on the vehicle trajectory big data.

Outcomes/Impacts:

The expected outcome of this research project is the capability enhancement in traffic safety (e.g., preemptive collision avoidance systems) and safe operations of connected vehicles (e.g., vehicle platoon control) through the application of the proposed method in the context of inter-vehicle headway prediction. The anticipated impacts of this research project are 1) improved computational technology in enhancing vehicle safety in car following scenarios when drivers are not completely attentive to the road environment, which can be of particular interest for auto manufacturers to incorporate it into preemptive collision warning systems embedded in smart vehicles; and 2) enlargement of the pool of trained transportation professionals at the nexus of transportation safety and machine learning.