Modeling traffic flow thanks to real time communication between vehicles

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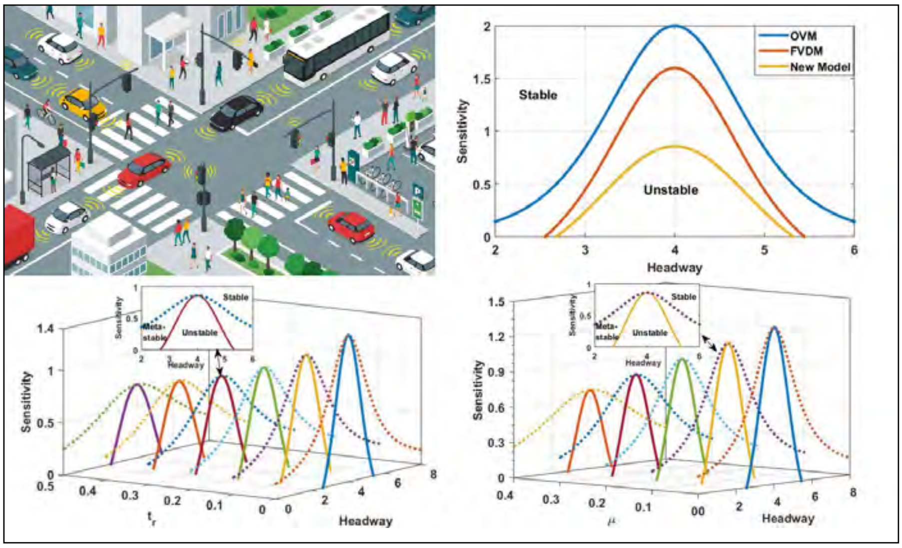
Since quite few years, automotive manufacturers have implemented vehicular communication systems such as V2X technology enabling communication from the vehicle-to-many entities such as infrastructures, networks, other vehicles, pedestrians or devices.

As such, V2X technology plays a pivotal role in intelligent transportation systems by providing real-time updates on nearby vehicle movements, helping drivers in maintaining traffic flow difference between actual and anticipated traffic information. Moreover, drivers in the traffic system manage vehicles and need some time to judge and decide the driving state of the vehicles in front of them. Then, V2X systems provide information to the driver with real-time status of the traffic flow and an advance reaction time before the vehicle in front starts moving. Also, the optimal velocity in real traffic reflects the driver's expectations about traffic behavior, which obviously has a significant influence on traffic flow.



▲ Top left: V2X environment with vehicle-to-many communication in yellow; Top right: Comparison between the new model with existing models; Bottom: headway phase diagrams in model parameters space with *t*, the driver's advanced reaction time and μ the response coefficient corresponding to optimal velocity deviation.

Although it has not been examined in earlier car-following models, there is always some difference between the stable optimal speed and the driver's optimal speed which is referred to as the optimal velocity deviation effect. Drivers may not consistently maintain their ideal speeds because of several factors, including traffic, erratic weather and personal preferences. The driver's optimal speed refers to the optimal speed chosen drivers based on their perception of the headway distance to the vehicle in front and it is often influenced by factors such as safety, comfort and the desire to maintain a reasonable distance from the lead vehicle. This speed is subjective and can vary from one driver to another. On the other hand, the stable optimal speed represents the speed that would lead to a stable traffic flow and minimise congestion when all drivers in the traffic stream follow the same car-following model and react similarly to the traffic conditions. Thus, drivers typically observe and respond to the behaviour of vehicles ahead, thereby influencing traffic dynamics. With the aim of optimising traffic flow in a general set-up and better understanding the effect of these two parameters, we propose a car-following model which makes use of this observation by considering the driver's advanced reaction time and optimal deviation within a V2X setting (Figure 1, top left).

The integration of driver reaction time and optimal velocity deviation has proven to be crucial for predicting traffic variations and making timely speed adjustments, resulting in a smoother traffic flow with fewer unexpected interruptions. Indeed, this approach promotes safe driving conditions by allowing vehicles to anticipate potential risks and optimize their path accordingly. Our study[1] focuses on the driver's perception of running speed influenced by the optimal velocity deviation effect and introduces a novel car-following model that incorporates the driver's advance reaction time in both optimal and local velocity variations within a V2X environment. By comparing this model with conventional OV [2] and FVD[3] models, the research highlights a significant enhancement in traffic flow stability. Linear and nonlinear stability analyses are conducted to determine the neutral and coexisting curves and the stability condition of the model. Results indicate that increased optimal velocity deviation and advance reaction time contribute to improve traffic stability leading to a notable reduction in congestion, as demonstrated in numerical simulations, which align closely with theoretical predictions (Figure 1).

Ultimately, this research contributes to advancing intelligent transportation systems, offering insights into optimizing traffic flow dynamics and mitigating congestion challenges. ■

References

[1] S. Yadav *et al.*, *EPL* **143**, 52004 (2023) .

[2] M. Bando *et al.*, *Phys. Rev. E* **51**, 1035 (1995).

[3] R. Jiang *et al.*, *Phys. Rev. E* **64**, 017101 (2001).