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Lane Change Decision and Trajectory Planning for Intelligent Cars in Curved Road Scenarios

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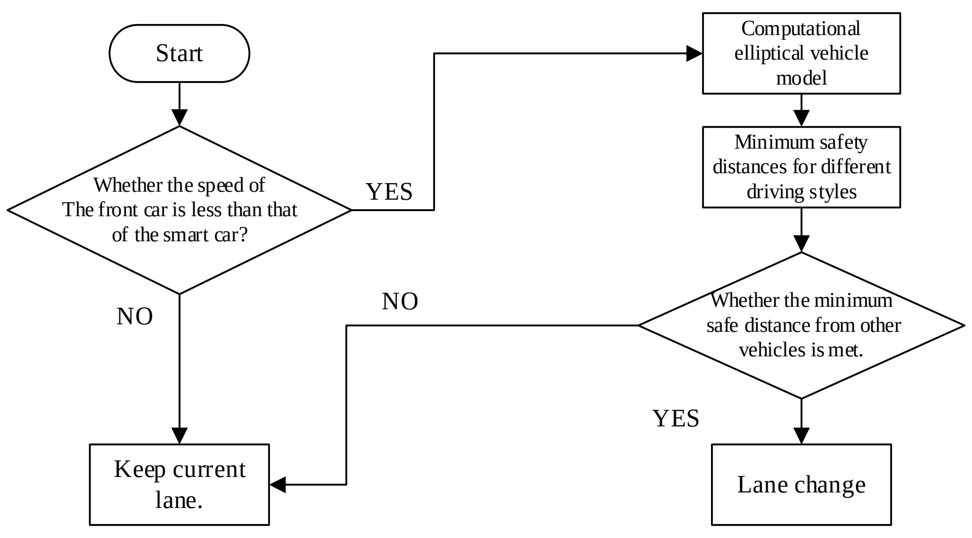
Introduction

In order to improve the efficiency of curved road passage and the safety of lane changing, the curved road section is used as the research object, and the curved road lane changing model is established by analyzing the lane changing decision and trajectory planning of intelligent vehicles. In the lane change decision, the influence of different driving styles, curved road radius, car type and other factors are considered, and the improved car ellipse model is proposed and applied to the minimum safety distance for free lane change of intelligent vehicles. In terms of trajectory planning, different lane change executable regions are proposed for drivers with different driving styles, and the optimal lane change trajectory within the lane change executable region is obtained by filtering the trajectory clusters under the Frenet coordinate system through the evaluation function. MPC control is used for trajectory tracking. Finally, the validity of the intelligent vehicle curved road lane change model is verified through Carsim and Simulink simulation.

Decision

- **Lane Changing Decision**

According to the vehicle speed and the minimum safe distance based on the elliptical car model, and meet the requirements Conditions, the vehicle performs lane change operation.



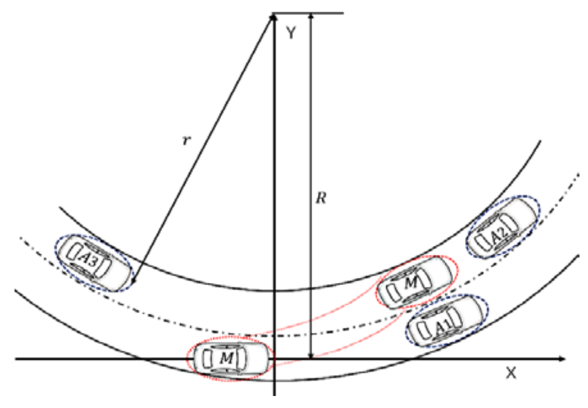
- **The Improved Elliptical Car Model**

In order to make the elliptical car model closer to the actual situation, the model is improved considering the characteristics of curved roads, vehicle types and other factors.

$$L_X = \left[L + (1 - T_S)^{\frac{W}{L}} \cdot \frac{V_R}{V_F}\right] K\sigma + \gamma$$

- **Minimum Safety Distance**

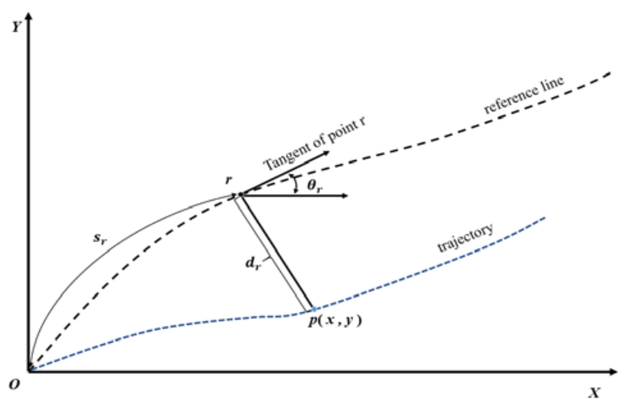
Through the variation of the long semi-axis of the elliptical model, the minimum safety distance can be obtained under different driving styles.



Trajectory Planning

- **Frenet coordinate**

Transform cartesian coordinates into Frenet coordinates.

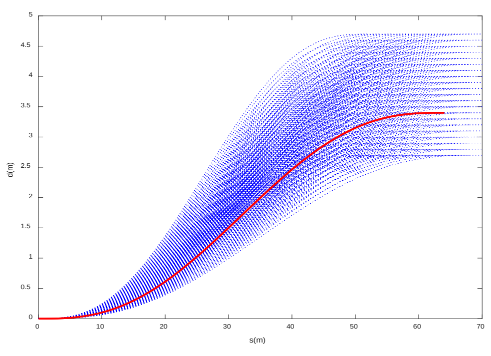


- **Generation of Trajectory Cluster**

The executable area of lane change consists of lateral displacement space and lane change time of drivers with different driving styles.

- **Constraints and Evaluation Functions**

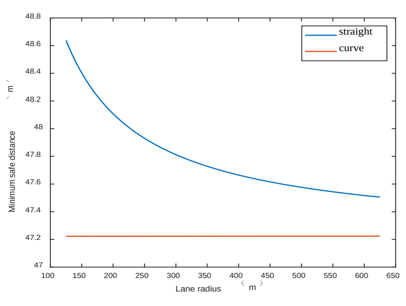
The trajectory cluster is screened by constraint conditions, and the current optimal lane-changing trajectory is obtained by calculating each trajectory evaluation function in the trajectory cluster.

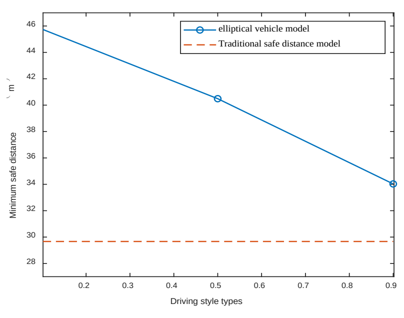


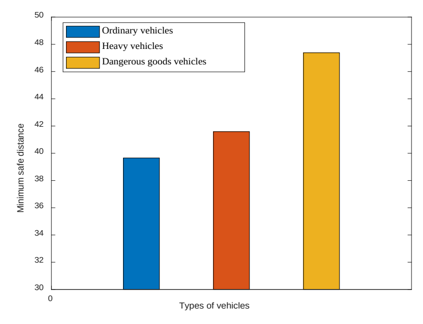
Results

- **Influence of Different Factor on Minimum Safety Distance**

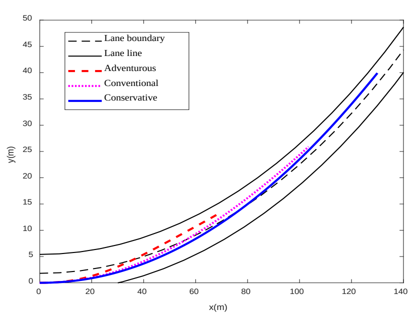
Factors such as driving style, curved road radius and vehicle type have the following effects on the minimum safe distance.

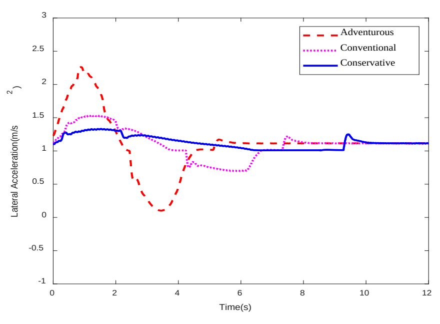






- **Influence of Driving Style on Lane Changing Trajectory**





The optimal trajectory under different driving styles is tracked by MPC control, and the lane changing trajectory output by Carsim and the lateral acceleration of the vehicle are collected.

Conclusion

The elliptical vehicle model is improved and introduced into the minimum safe distance model considering the influence of driving style, hazard factor of vehicle category, relative speed of vehicles in front and behind, etc.

Different lane change executable regions are established for drivers with different driving styles, and the optimal lane change trajectory within the lane change executable region is derived by filtering through evaluation function pairs to make the process of lane change more humane.

The process of lane change on curved roads of intelligent vehicles is jointly simulated by Carsim and Simulink to verify the reliability of the lane change model and analyze the influence of various factors on the results.