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Active steering control strategy for articulated vehicles

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Key words: Articulated vehicle, Sharp curve, Lateral stability, Linear quadratic regulator

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Motivation

- The current research of active steering of articulated vehicles focuses mainly on improving the tractor or trailer's handling behavior. Little research presents an active steering controller for improving the maneuverability and stability behavior of both the tractor and the trailer.
- The current path-following control strategies are only applicable along gentle curves. There is a vital need for devising a control system not only applicable along gentle curves but also along sharp curves, especially the rectangular curves.
- The active steering controller based on linear quadratic regulator (LQR) theory is developed to improve the maneuverability at a low speed and lateral stability at a high speed of the whole tractor-trailer combination.

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Method

- A 3-DOF linear model of the tractor-trailer with steered trailer axles is built, and the simulated annealing particle swarm optimization (SAPSO) algorithm is applied to identify the key parameters of the model, thus providing the accurate desired reference yaw rate for the controller.

- By LQR method, the tractor and trailer active steering controller is designed to follow the desired yaw rate and minimize the side-slip angle of the tractor's CG and trailer's CG at the same time.

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Major results

- By our control strategy, the corner swept path width of the tractor-trailer has been greatly improved at a low speed. SPW without control is 4.8 m while it has been reduced to 4.2 m when it is fitted with active steering controller.

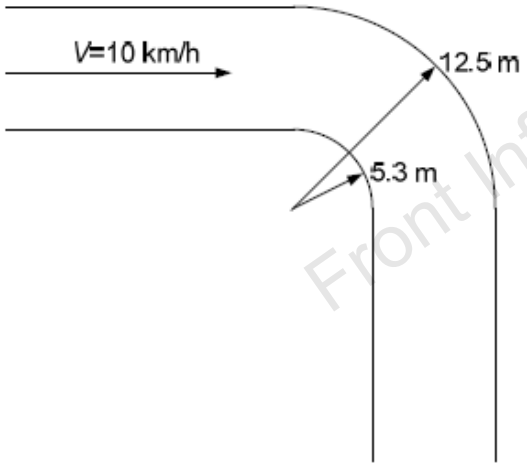


Fig. 12 Simulation road conditions

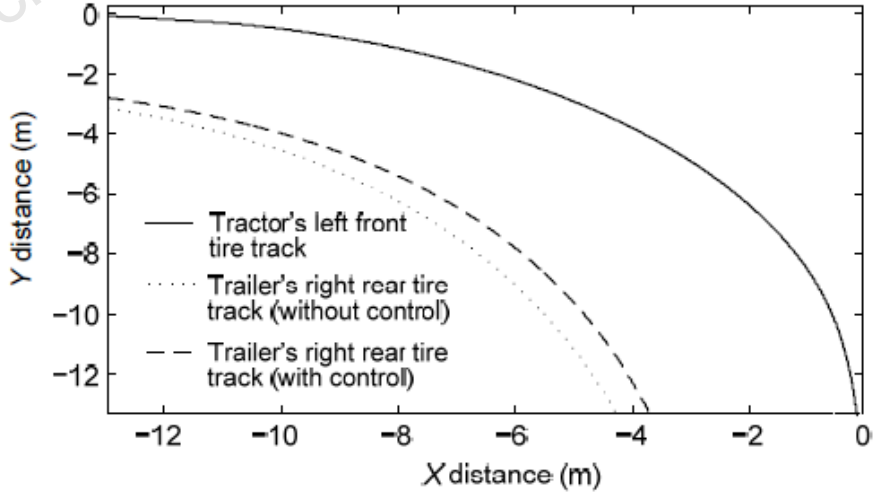


Fig. 14 Corner swept path width (SPW90)

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Major results (Cont'd)

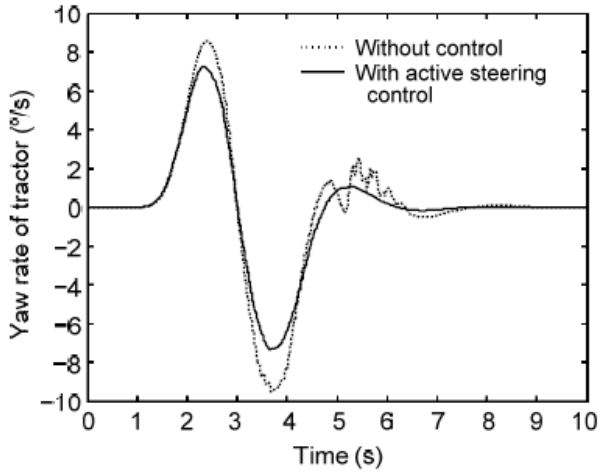


Fig. 18 Yaw rate of the tractor

- Compared with uncontrolled vehicles, the lateral stability and rollover indexes of the articulate vehicle benefit a lot from the active steering controller at a high speed.

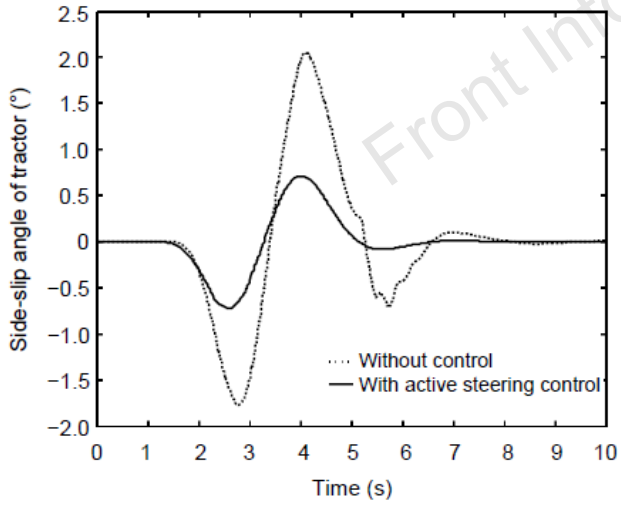


Fig. 22 Side-slip angle of the tractor

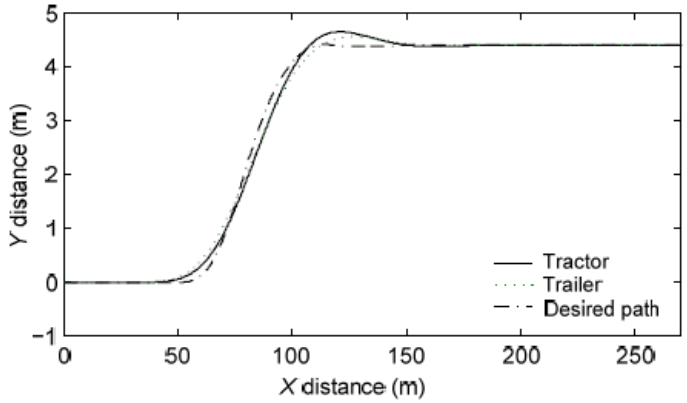


Fig. 21 The paths of the tractor and trailer with active steering control

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Conclusions

- The 3-DOF model of the tractor-trailer with steered trailer axles is built. The simulated annealing particle swarm optimization (SAPSO) algorithm is applied to identify the key parameters of the model under specified vehicle speeds and steering wheel angles, thus the key parameters of the simplified model can be obtained according to the vehicle condition by interpolation.
- The active steering controller for the tractor and trailer based on LQR is proposed. The tractor and trailer active steering controller is designed to follow the desired yaw rates of the tractor and trailer and minimize the side-slip angle of the tractor and the trailer's CG at the same time.
- The test results at a low speed show that the active steering controller can improve the maneuverability of the articulated vehicle along sharp curves (the rectangular curves).
- The results show that the stability indexes of both tractor and the trailer at a high speed are controlled in a low range simultaneously, which indicates the controller's significant effects in improving the lateral stability at a high speed for articulated vehicles.

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