

Path Following Control for a Large Bus Based on a Vehicle Motion Model Considering Road Curvature and Cant

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KEY WORDS: Vehicle dynamics, Heavy duty vehicle, Motion control, Path following control, Automated bus (B1)

Automated buses are expected to contribute to sustainable public transportation. For practical operation, stable path-following performance is required, especially for large buses, which have larger mass, longer wheelbase, and slower steering response than passenger cars. Therefore, a steering control system based on a vehicle motion model considering these characteristics is important.

In this study, a model-based Path Following control system was designed using a large bus vehicle motion model considering road curvature, cant, and steering system dynamics. Road curvature was introduced as an input related to the required yaw motion, while cant was modeled as a lateral force caused by the gravitational component. The steering system model was also included to represent the dynamic relationship between the steering wheel angle and the front wheel steering angle.

The Path Following control system was designed to calculate the steering wheel angle as the final control input based on the vehicle motion model. Under the quasi-steady-state assumption, the steering wheel angle was derived as follows:

$$\delta_H = -\frac{Num_1}{Den}(\omega_r - K_2 e_2 V - K_3 \sin e_3) - \frac{Num_2}{Den} \dot{\zeta}$$

where ω_r is the target yaw rate, and Num_1 , Num_2 , and Den are coefficients derived from the quasi-steady-state vehicle model and determined by vehicle specifications, tire characteristics, steering system characteristics, and vehicle speed. The steering input was determined using lateral deviation, yaw angle error, vehicle speed, road curvature, cant, and control gains. The definition of lateral deviation e_2 and yaw angle error e_3 is shown in Fig. 2.

Simulations were conducted using designed road alignment, road curvature, cant angle, and target velocity as input conditions. The vehicle response was evaluated using lateral deviation e_2 , yaw angle error e_3 , steering angle, and sideslip angle β .

The simulation results for lateral deviation and yaw angle error are shown in Fig. 1. The mean absolute lateral deviation was 0.024 m, and the maximum lateral deviation was 0.44 m. The mean absolute yaw angle error was 0.23 deg, and the maximum yaw angle error was 2.53 deg. Although the deviation locally increased in sections with large curvature, cant variation, and relatively high vehicle speed, the vehicle remained within the lane when considering the vehicle width of 2.485 m and a general lane width of 3.5 m. These results confirm the effectiveness of the proposed Path Following control system based on the vehicle motion model. Future work will introduce the effects of sideslip angle and cant into the control law to improve control performance.

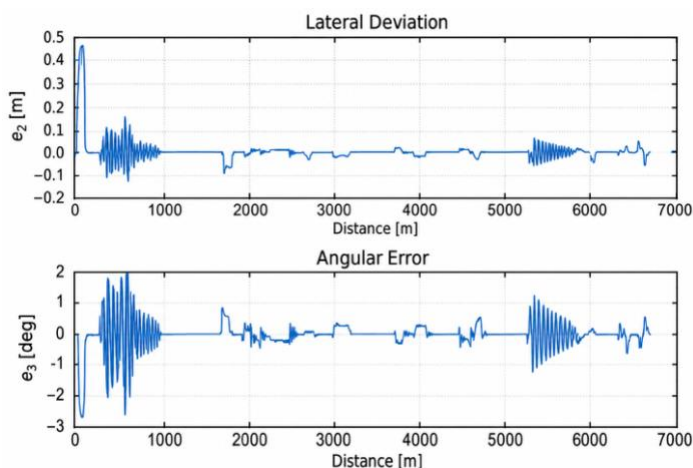


Fig. 1 Simulation results for lateral deviation and yaw angle error

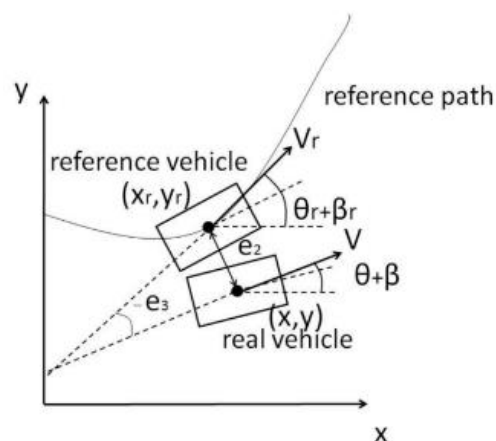


Fig. 2 Overview of Path Following control