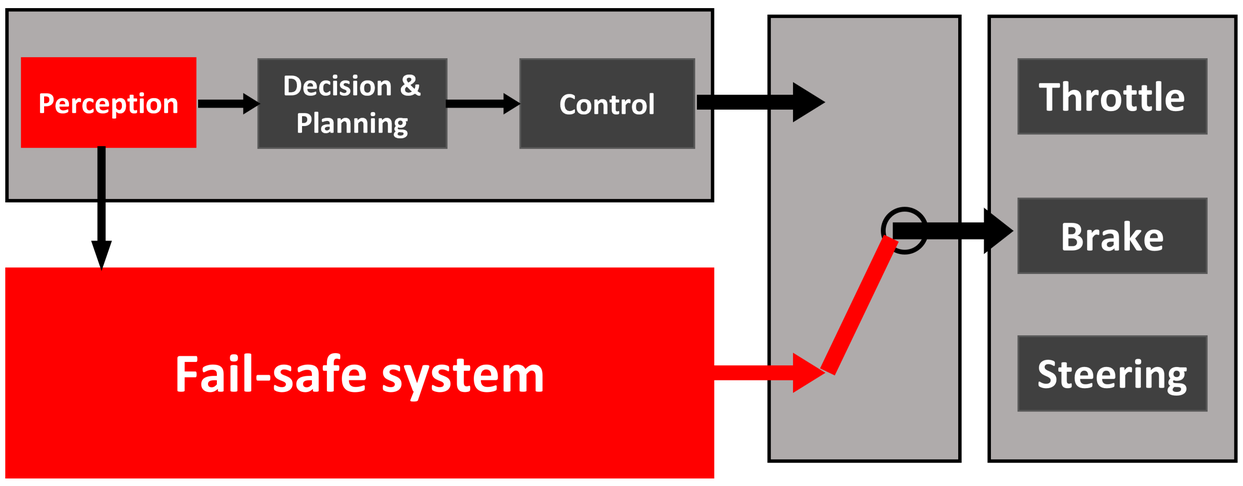
Model Predictive Control based Minimal Risk Maneuver Due to Perception Failure of Automated Vehicles

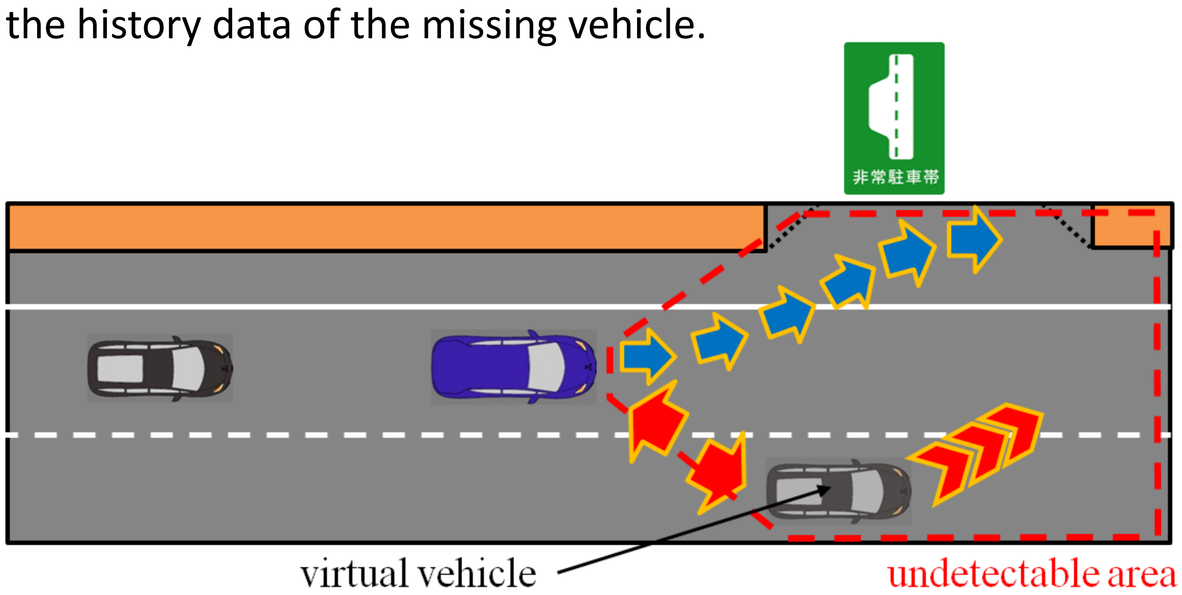
Introduction

This is an embedded fail-safe system, functioning when an automated vehicle encounters such severe perception failure that it cannot continue original driving task. The fail-safe system is supposed to take over the malfunction vehicle when sensor failure occurs. This research applies it in the fail-safe process on highway, during which the malfunction vehicle is instructed to leave for a safe stop. Validity is shown through numerical simulations.



Sensor malfunction and virtual lead vehicle scheme

Fatal sensor malfunction may cause a sight loss of detection. This research implements virtual lead vehicles to replace missing front vehicles. The virtual vehicle inherits the position and velocity from the history data of the missing vehicle.



To guarantee the safety, virtual vehicles are set to follow hazardous motion patterns to approach the ego vehicle. As shown above, a virtual vehicle (grey) is assumed to approach the host vehicle (blue) by decelerating while changing to the same lane with the host vehicle.

Safe inter-vehicle distance

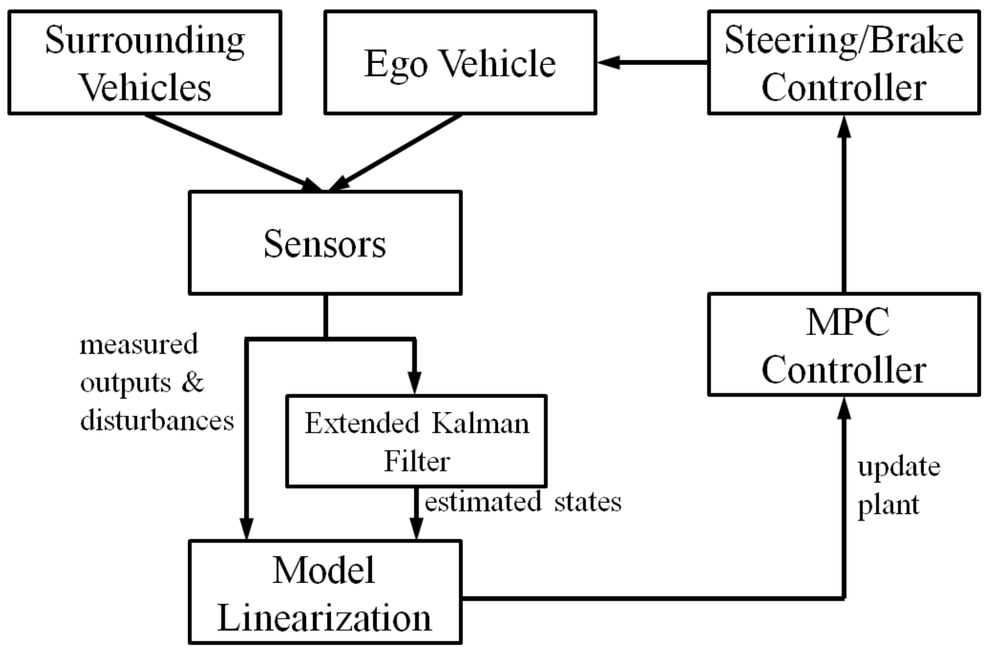
A practical Time-to-collision constraint requires that the inter-vehicle time space is regarded safe only when it is larger than the sum of driver reaction time (τ_f), brake function time (τ_r) and the least time required for deceleration ($\Delta v/a_m$, Δv: velocity difference, a_m: maximum acceleration).

$$TTC > \tau_r + \tau_f + \Delta v / a_m$$

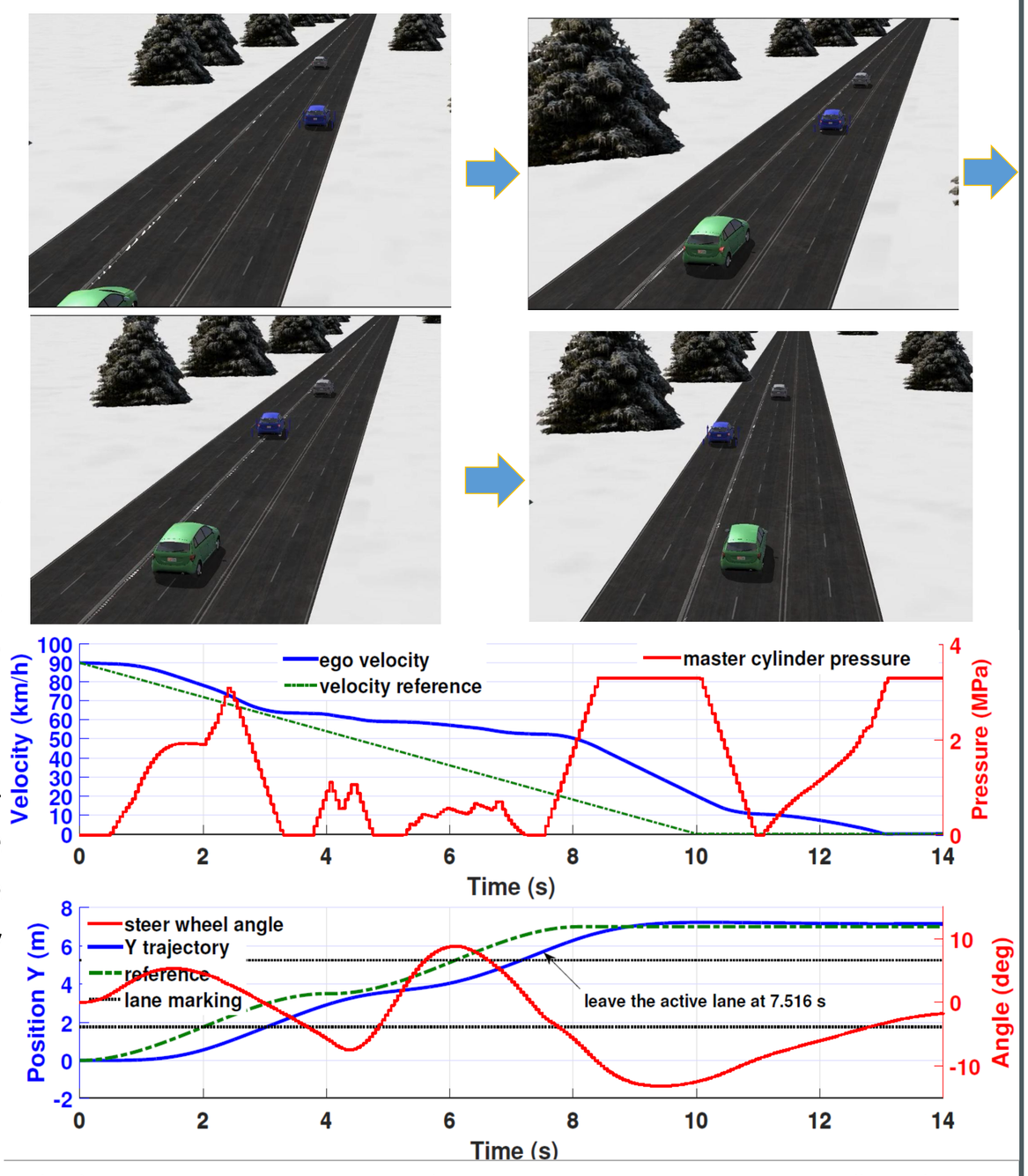
Movie of the fallback control process

Dynamic control algorithm

A linear vehicle model is constructed with the help of data collected by sensors, and states estimated by Extended Kalman Filter. Then the linearized model is used to update the vehicle plant embedded in the Model Predictive Control (MPC) at each iteration. Eventually MPC controller transports the optimized control input to the actuator to realize the optimal control.



Simulation results



Publications

W. Xue , B. Yang, T. Kaizuka, K.Nakano, "A Fallback Approach for an Automated Vehicle Encountering Sensor Failure in Monitoring Environment" in The 29th IEEE Intelligent Vehicles Symposium, Chang Shu, Jun. 2018.

Xue, W., Zheng, R., Yang, B., Wang, Z., Kaizuka, T. and Nakano, K. (2019), "An adaptive model predictive approach for automated vehicle control in fallback procedure based on virtual vehicle scheme", Journal of Intelligent and Connected Vehicles, Vol. 2 No. 2, pp. 67-77.

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