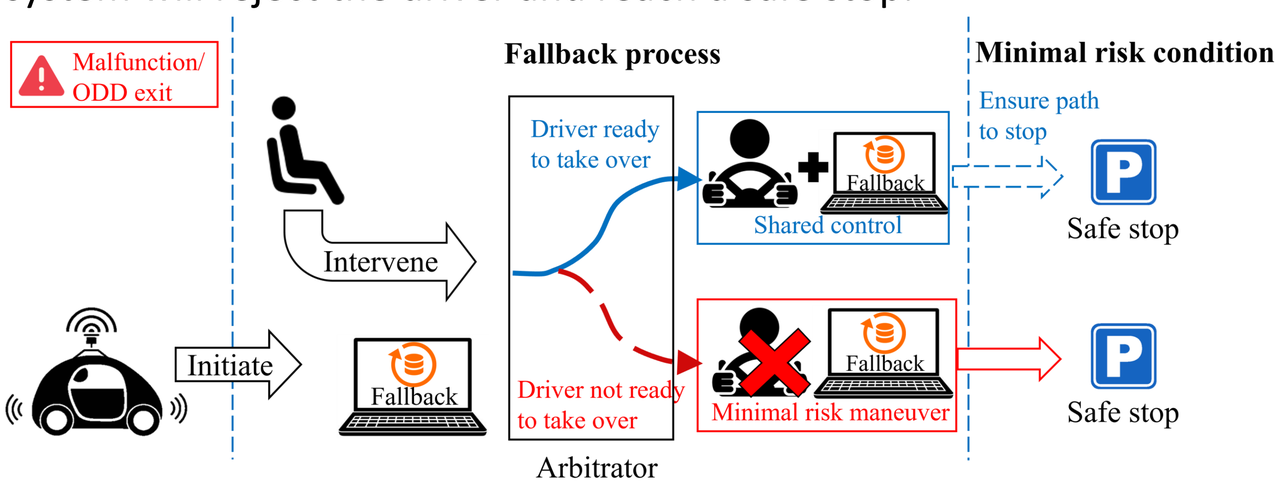
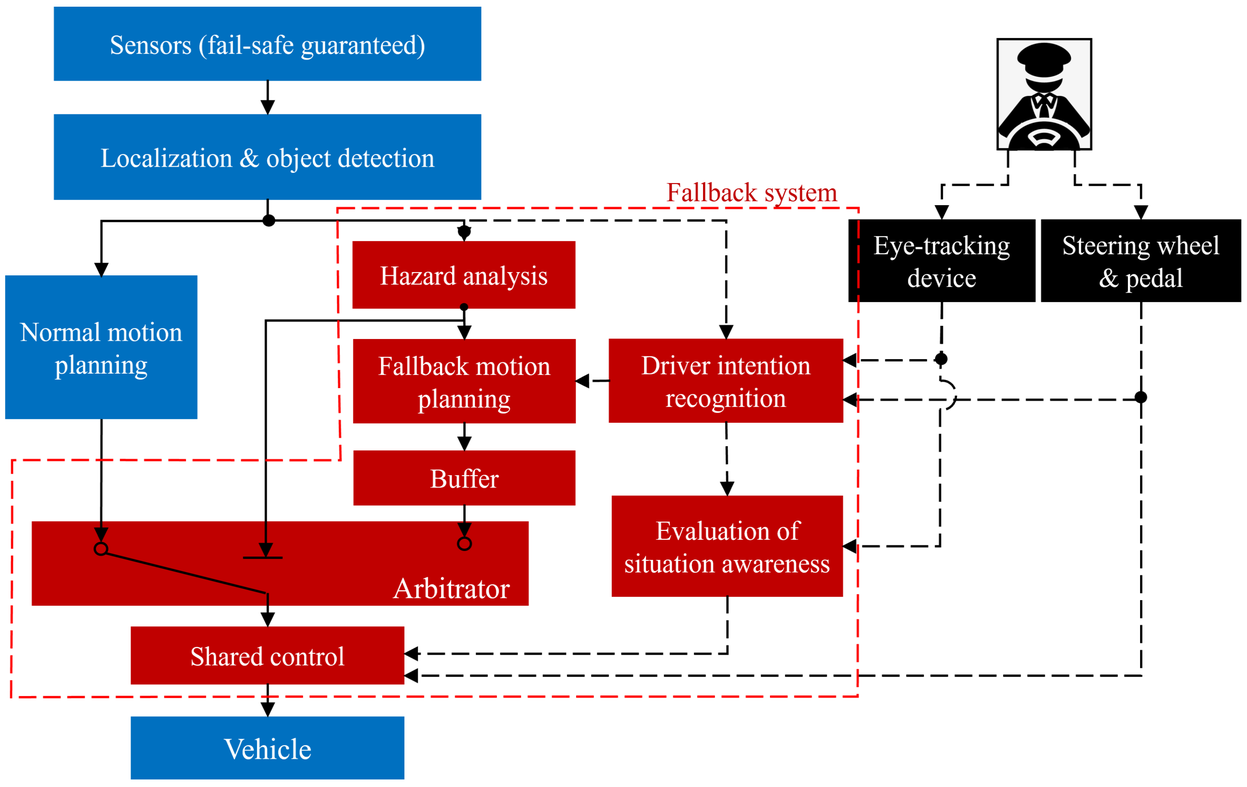
Fallback System of Automated Driving Vehicle Incorporating Potential Driver Intervention

Introduction

This is a fallback system that can guide a vehicle to a minimal risk condition while responding to potential human intervention in the event of system malfunction or exit from Operational Design Domain (ODD). When the automated vehicle encounters system malfunction or ODD exit, the fallback system can take over the vehicle, and then check if the driver is ready to take over. If the driver is ready, the system will assist the driver with shared control, while ensuring path to a minimal risk condition. Otherwise, the system will reject the driver and reach a safe stop.



System architecture

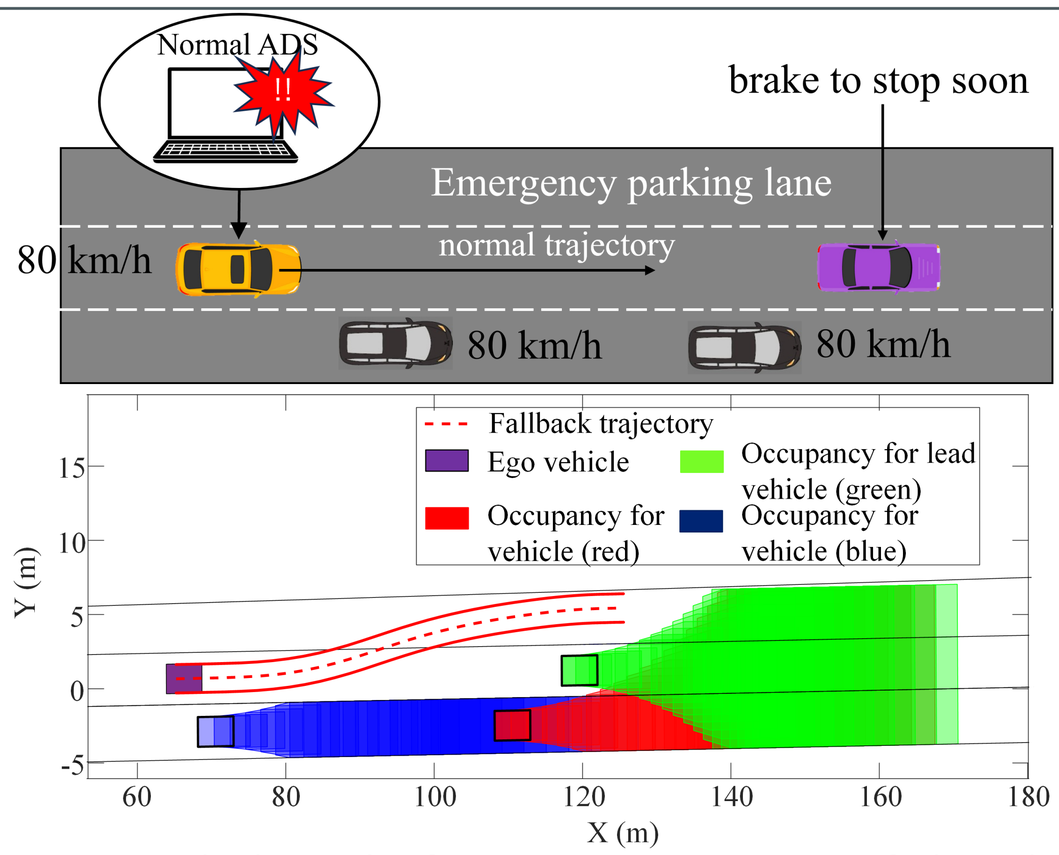


Fallback system is independent of the normal functionality. The fallback motion planning module aims at outputting a fallback trajectory ending with a minimal risk condition, which is then stored in the buffer for backup. Once the risk is higher than a predefined threshold, the arbitrator will select the fallback trajectory in the buffer and execute the minimal risk maneuver.

The driver intention recognition module estimates the driver's intention to affect the maneuver selection. The gaze information and control input are used to evaluate the status of driver, determining whether the driver is ready for takeover.

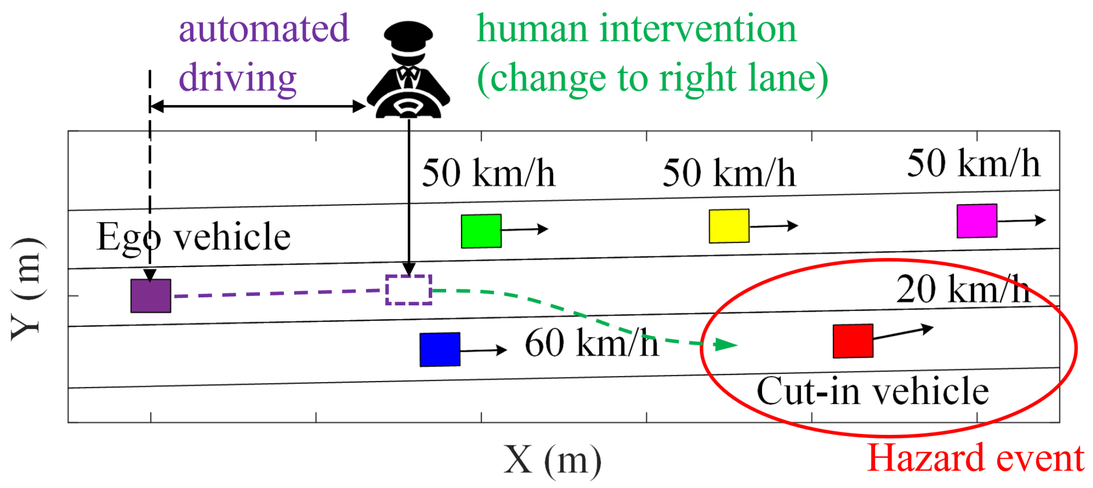
Fallback trajectory generation

Normal Automated Driving System (ADS) cannot avoid the front vehicle in hard brake due to system malfunction.



System calculates the future occupancy areas of obstacles and generate fallback trajectory to avoid the occupancy areas and steers the vehicle into the parking lane.

Simulation results



50 critical cases with a group of difference initial conditions for each takeover condition are tested. Two types of driver are simulated,

Panic driver: react late and behave in panic (delay and noise added in input);

Focused driver: react early and behave correctly.

Takeover condition	Accident rate	Rate of feasibility to a safe stop
Manual takeover by panic driver	58%	34%
Shared control with panic driver	24%	76%
Shared control with focused driver	0%	98%

Conclusion

- The fallback system decreases the accident rate and increases chances to achieve a safe stop in safety-critical situations compared with manual takeover.
- The safety is further improved when cooperating with a focused driver compared with a panic driver.

Publications

W. Xue, R. Zheng, B. Yang, Z. Wang, T. Kaizuka and K. Nakano, "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

W. Xue, Z. Wang, R. Zheng, X. Mei, B. Yang and K. Nakano, "Fail-safe Behavior and Motion Planning Incorporating Shared Control for Potential Driver Intervention," IEEE Transactions on Intelligent Vehicles, Vol. 8, No. 7, pp.3884-3897.

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