

Development of Foundational Technologies for Comprehensive Safety Evaluation Against Traffic Disturbances Encountered by Automated Vehicles

-Integrated Extraction of Traffic Laws and Traffic Disturbance Scenarios
Corresponding to Road Structures and Signs-

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1. Introduction

Safety evaluation of automated driving (AD) systems on general roads requires the traffic disturbance scenarios an AD vehicle may encounter to be evaluated systematically. In a companion paper⁽¹⁾, Pre-Logical Scenarios (Pre-LS) were defined as an intermediate layer between Functional and Logical scenarios, in which a traffic disturbance on a general road is represented by six elements: road geometry, ego-vehicle behavior, ego-vehicle position, and the behavior, position and direction of the other traffic participant. Because Pre-LS are generated exhaustively, they become numerous and include combinations that cannot occur physically or are not permitted by traffic law. This study proposes a three-stage constraint check for the generated Pre-LS, implements it as a prototype tool, and confirms its effectiveness through a case study.

2. Constraint check method

The inputs are the segment information of the target road (lanes, sidewalk and road shoulder, physical structures, road signs and markings) and the Pre-LS generated exhaustively as combinations of the six elements. The road is represented as a two-dimensional mesh map, and for each behavior of the ego vehicle and of the other participant, the set of mesh coordinates that can be traversed (the area of influence) is obtained. Three stages of constraint check are then applied.

(a) Road geometry: scenarios in which the areas of influence of the ego vehicle and of the other participant do not overlap are excluded because no risk of contact arises, as are behaviors whose area of influence extends outside the road, such as a lane change toward a nonexistent lane. (b) Physical structures: scenarios whose area of influence overlaps mesh coordinates adjacent to structures such as guardrails and center medians are excluded as unrealistic scenarios that would penetrate the structure, with the restricted participant types depending on the structure type. (c) Traffic laws: the conditions that restrict the position, direction and behavior of each participant type are organized from the Road Traffic Act⁽²⁾ as law data, and a law table is generated according to the segment information. Scenarios containing behavior that violates the law are identified together with the relevant provision.

3. Case study

A case study was carried out with the prototype tool on an example road without an intersection: three lanes on the ego-vehicle side and one oncoming lane, with a sidewalk and a road shoulder, a white broken line between the first and second lanes, a yellow solid line (no-lane-change marking) between the second and third lanes, and a center median with a guardrail. The other participants were four-wheeled vehicles and pedestrians. Table 1 gives the number of Pre-LS remaining after each stage; the exhaustive-generation count is a theoretical value computed from the combinations of the six elements.

Lane departures and U-turns toward the oncoming side, and pedestrian crossings that interfere with the center median (Article 6 of the Road Structure Ordinance⁽³⁾), are removed at the physical-structure stage. At the traffic-law stage, lane changes across the yellow solid line (Article 26-2(3) of the Road Traffic Act) are removed, leaving 87 of the initial 648 exhaustively generated vehicle scenarios after all three stages. For pedestrians, scenarios of walking on the roadway are removed by the duty to use the sidewalk (Article 10(2)), and 12 crossing scenarios remain. Removed scenarios are also classified and recorded with the applicable provision or structure, so that they can be included in the evaluation when compliance with traffic law is not assumed.

Table 1 Number of Pre-LS at each step of the three-stage constraint check

	Vehicle	Pedestrian
Exhaustive generation	648	288
Road geometry	163	64
Physical structures	135	29
Traffic laws	87	12

4. Conclusion

This study proposed a three-stage constraint check based on road geometry, physical structures and traffic laws, which selects the scenarios to be considered in safety evaluation from exhaustively generated Pre-LS for traffic disturbances on general roads, and implemented it as a prototype tool. The case study confirmed that these scenarios can be selected automatically, together with the provision or structure underlying each decision. Intersections, all participant types, and the detailed procedure will be reported in the lecture and a forthcoming paper. This work is based on the results of the SAKURA project (Ministry of Economy, Trade and Industry)⁽⁴⁾.

References (1) Miura, D., Yoshida, H., Hayashi, A., Mori, M., et al.: Systematization of traffic disturbance scenarios with explicit positional relationships among traffic participants on general roads, Proc. JSAE Annual Congress (Autumn), 2026. (2) e-Gov: Road Traffic Act (Act No. 105 of 1960). (3) e-Gov: Road Structure Ordinance (Cabinet Order No. 320 of 1970). (4) SAKURA Project, <https://www.sakura-prj.go.jp>, accessed August 19, 2026.