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Development of a Driving Simulator for Safe Driving Education to Prevent Rear-End Collisions and Hurried Driving

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In 2023, rear-end collisions accounted for approximately 30% of all domestic traffic accidents in Japan, making them the most frequent type of accident. Most of these occur while the leading vehicle is stopped. To prevent rear-end collisions, it is essential for drivers to maintain a following distance greater than the required stopping distance to allow for sudden braking. However, current surveys show that roughly 70% of vehicles fail to maintain an adequate distance. This study developed an experiential driving simulator (DS) for safety education, aimed at preventing rear-end collisions and mitigating hurried driving, which is recognized as a contributing factor to such accidents.

Traditional passive education methods, such as video observation, present difficulties for drivers in objectively assessing their own driving habits. Furthermore, exposing drivers to the risks of "hurried driving" on actual public roads is inherently impractical. To address these limitations, this DS utilizes the PLATEAU 3D City Model—provided by the Ministry of Land, Infrastructure, Transport and Tourism—to enable learning of the necessity of following distances and the inefficiency of hurried driving within a realistic urban environment. In this DS, a hazardous state is defined as any instance where the inter-vehicle distance falls below the required stopping distance. The experimental course consists of two distinct segments: a 1.0 km section featuring a single lane in each direction with five signalized intersections, followed by a 1.3 km section with two lanes in each direction and ten signalized intersections(Fig. 1). In the initial 1.0 km segment, learners are required to follow a lead vehicle. In the subsequent 1.3 km segment, the DS is designed to allow learners to perform overtaking maneuvers via lane changes. The DS is designed so that when the learner's vehicle enters a high-risk state for a rear-end collision, the lead vehicle performs an emergency stop, forcing the learner to experience the collision. Following the accident, a replay function visualizes the pre-crash footage alongside data such as inter-vehicle distance and steering/braking inputs. This allows for an objective review of why the collision became inevitable, thereby emphasizing the critical importance of maintaining adequate headway. Furthermore, to demonstrate the inefficiency of hurried driving, the DS allows learners to experience firsthand that there is no significant difference in arrival times between hurried and safe driving. This DS is predicated on the observation that many drivers unconsciously engage in hurried driving due to the cognitive bias that higher speeds significantly reduce arrival times. To optimize learning efficiency by minimizing the required number of trials, the DS defines the initial run (Fig. 2a), conducted prior to the instruction on maintaining adequate headway, as hurried driving. Conversely, the subsequent run (Fig. 2b), performed after the educational intervention, is defined as safe driving.

In a study evaluating the DS's validity with 15 university students, 11 participants experienced a rear-end collision under the predefined hazardous conditions. Following the subsequent educational intervention, all participants became capable of maintaining a safe inter-vehicle distance. Furthermore, the average difference in travel time between "hurried driving" and "safe driving" was a mere 7.6 seconds (with a maximum difference of approximately 40 seconds). These results suggest that the DS design is appropriate for its intended purpose. Future research should focus on verifying the long-term learning effects and retention rates when the DS is deployed among the general public.

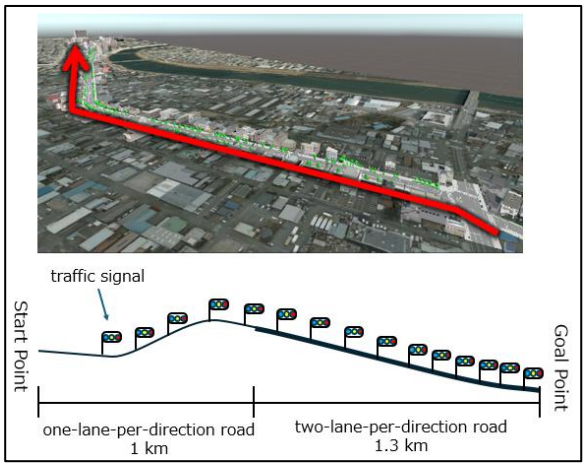

Fig. 1 Course generated using PLATEAU 3D Model.

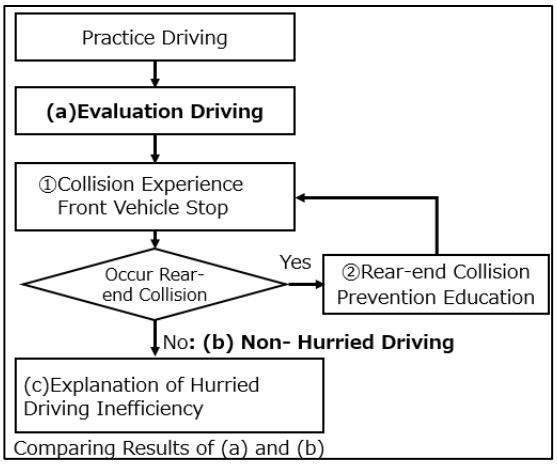

Fig. 2 Learning Steps Flowchart.