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Toward Establishing Methodology of Naturalistic Driving Simulator Experiment with Multi-agent Traffic Simulation

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In order to understand the phenomena and/or target objects, and design and develop useful artifacts (i.e., to predict the phenomena or behavior of objects), it is necessary to construct a "model" of those phenomena and nehavior of objects. This "understanding" and 'prediction' are not independent of one another; rather, we are engaged in a process of continuously improving the "model" by cycling through the loop shown in Figure 1.

In this loop, "observation" is not merely "seeing," but rather a process of accurately capturing objective facts and recording and analyzing them. In this context, data collection methods play a crucial role. In the field of automotive traffic systems to date, experimental observation has been the mainstream approach in the field of behavior observation, while naturalistic observation has not been widely utilized due to technical difficulties. However, the realization of realistic virtual traffic environments through multi-agent traffic simulation has enabled the conduct of naturalistic simulator tests, which is antithetical to condition-controlled simulator experiments. Accordingly, this paper discusses the purpose and role of naturalistic simulator tests, their differences from conventional simulator tests, acceptable interventions or operations in experiments, available and effective methods of experimental data analysis.

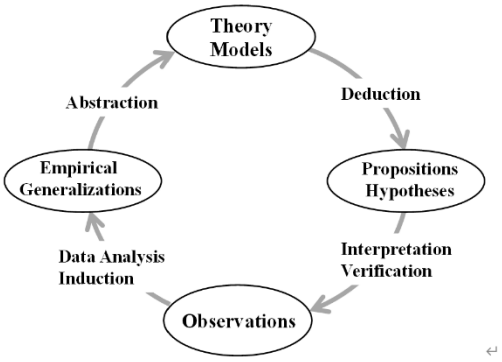

Fig.1 The wheel of science

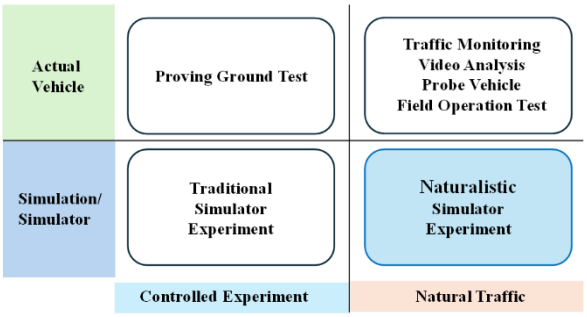

Fig.2 Positioning of Naturalistic DS Experiment

Given the vast range of traffic conditions that can occur in reality, it is natural to question whether limiting the conditions to a specific scenario and analyzing the resulting data truly leads to "solving real-world problems." Furthermore, one might reasonably ask whether introducing experimental manipulations creates unnatural situations that diverge from everyday behavior, thereby undermining the ecological validity of the findings. As a solution to this issue, one can consider nature observation using a driving simulator (naturalistic simulator testing = Naturalistic DS testing).

Figure 2 illustrates the positioning of naturalistic DS tests. It organizes the test methods along two axes: experimental versus natural observation, and use of actual vehicles versus virtual environments. Naturalistic DS testing is one of many data collection methods; it is not all-round and should be selected based on the specific objectives. For this reason, it is essential to clarify the characteristics of naturalistic DS testing. It should be noted that naturalistic DS testing is most effective for conducting observations related to traffic safety that are difficult to perform in real-world traffic conditions. It is also easy to imagine that naturalistic DS experiments will likely face criticism for lacking reproducibility, having insufficient data on the phenomena under analysis, and therefore not being scientific. Our stance is that if the data obtained from naturalistic DS testing is indeed the case, and if the data in question has the potential to generate new value in reality from the perspective of the "wheel of science" shown in Figure 1, then it should be respected.

The applications of naturalistic DS testing extend beyond the measurement of human behavior data to include evaluation tests aimed at improving product quality during development, as well as its use as an evaluation tool for enhancing safety in the development of autonomous vehicles. Furthermore, it can be utilized in such ways as generating the product concepts through experience of naturalistic DS and fostering communication within development teams by sharing those experiences.The practical application of naturalistic DS testing is still in its early stages, and we intend to publish the case studies in the future to contribute to the advancement of automotive transportation systems.