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Investigating the potential of a scenario catalogue for automated driving safety evaluation to cover real-world crashes

Marko Medojevic [1], Hisashi Imanaga [1], Jacobo Antona-Makoshi [1], Maki Kawakoshi [1], and Hideaki Satoh [2]

1) Japan Automobile Research Institute, Department of Automated Driving Safety
12530 Karima, Tsukuba, Ibaraki 305-0822 (E-mail: mmarko@jari.or.jp)
2) Japan Automotive Manufacturers Association
1-30, Shiba Daimon 1-chome, Minato-ku, Tokyo 105-0012

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ADS safety can not be evaluated on long distance driving strategies alone. This has motivated numerous countries to develop scenario-based approaches to ADS safety validation, as they represent a repeatable and reliable method of safety assurance [(1)]. Scenario-based approaches frequently incorporate traffic and crash data. Crash data has its limitations in ADS safety-relevant scenario development, as not all crashes represent ADS safety-relevant situations. However, crash scenario catalogues organize data into patterns, trends and crash frequency, resulting with Functional scenario generation. As such, crash data-based functional scenarios can be considered crucial for ADS safety-relevant scenario development.

This paper aims to verify the ADS scenario catalogue by establishing coverage over crash pattern-based scenario catalogues. To our best knowledge, few studies examine the coverage of crash pattern-based scenario catalogues by ADS scenario approaches. This paper focuses on Japan's maneuver pattern-based (traffic disturbance) scenario approach [(3)], developed by JAMA and SAKURA, and evaluates its potential to cover crash pattern-based scenarios. The ADS approach combines traffic disturbance scenario elements: road geometry, ego vehicle behaviour, surrounding traffic participant behaviour and position; and creates a scenario catalogue of 24 functional scenarios that cover all limited-access highway scenarios. We refer to this catalogue as the "maneuver pattern-based scenario catalogue"

From the crash pattern-based scenario catalogues, we selected two international crash pattern-based scenario catalogues: the 2007 NHTSA Pre-crash scenario typology for crash avoidance research, and the 2020 IGLAD Codebook. The manner of scenario generation differs between the catalogues. The NHTSA catalogue considers a national sample of about 6 million light vehicle crashes, and compresses the data into 37 scenario types, represented by a typical scenario description. While, the IGLAD catalogue considers about 8250 crashes from 12 countries. By examining the crash conflict type, IGLAD produces 311 scenarios. Both catalogues were proposed as functional scenario catalogues under the WP.29 activities (UN VMAD), and ISO expert discussions.

We compared crash pattern-based scenarios with maneuver pattern-based scenarios in order to establish the coverage status. First, we classified the crash pattern-based scenarios into 5 types: traffic disturbance, perception disturbance, vehicle control disturbance, functional safety-related, and human factor scenarios. Then we selected the target scenarios. The selection process excluded all out of scope scenarios, such as: other (lacking information), human factor, urban, and functional safety-related scenarios. The selection focused on highway traffic disturbance scenarios, including traffic disturbance caused by perception and vehicle control-related disturbances. Lastly, we carried out an individual scenario comparison. The coverage status was established through the examination of traffic disturbance scenario elements. We examined crash pattern-based scenario's traffic disturbance elements and matched them with elements described in the maneuver pattern-based scenario catalogue.

The results indicate comprehensive coverage of both NHTSA and IGLAD catalogues. Two of the maneuver pattern-based scenarios cover 12 selected from NHTSA, while seven cover the 69 scenarios selected from the IGLAD catalogue.

NHTSA's scenarios are covered by maneuver pattern based scenarios four and seven (Fig. 1). Both scenarios occur on the main roadway. The number four covers deceleration, while number seven covers acceleration scenarios.

IGLAD's scenarios are covered by number: 1, 4, 7, 15, 16, 20, and 23 (Fig. 1). Number one covers main roadway cut in scenarios. Scenarios four and seven are described in NHTSA coverage. Number 15 covers merge zone acceleration. Number 20 covers departure zone deceleration. Lastly, number 23 covers departure zone acceleration scenarios.

As the ADS enter the urban roads, further work is necessary to ensure safety and confirm capacity of ADS scenario-based approaches to cover crash pattern-based scenarios occurring in the urban environment.

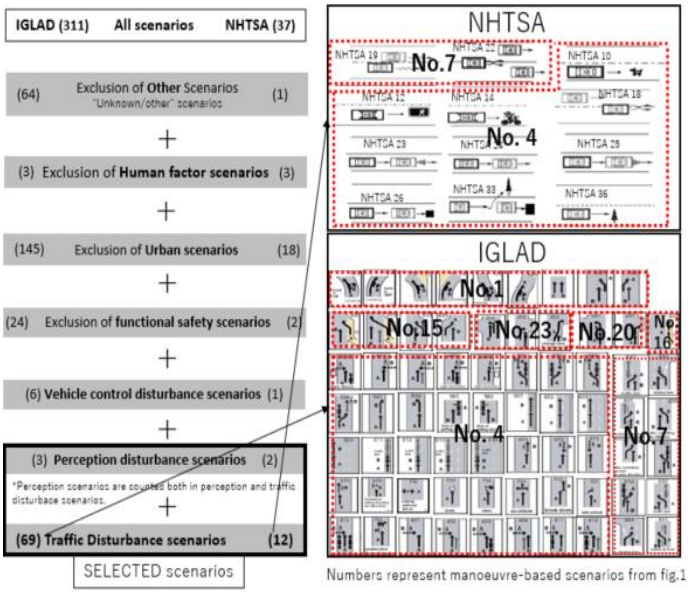

Figure 1. The selection process and comparison coverage results