A Validation Methodology for the Minimization of Unknown Unknowns in Autonomous Vehicle Systems

Mohammad Hejase[1], Mathieu Barbier[2], Umit Ozguner[1], Javier Ibanez-Guzman[2], and Tankut Acarman[1]

***Abstract*— Deployment of SAE Level 3+ automated vehicles faces validation and certification challenges due to uncertainty and state space size of the operating domain. We propose a validation and testing methodology that aims to minimize unknown unknowns through minimization of scenarios that have not been accounted for, and scenarios that have not been identified due to modeling deficiencies. The methodology utilizes simulators with different levels of fidelity for residual risk handling, functional hierarchies for simplification of complex navigation tasks, and the Backtracking Process Algorithm to identify scenarios of risk significance. The methodology is demonstrated on a scenario with an intersection preceded by a traffic light. Through use of the testing flowchart, we were able to identify and remedy scenarios leading to undesirable events.**

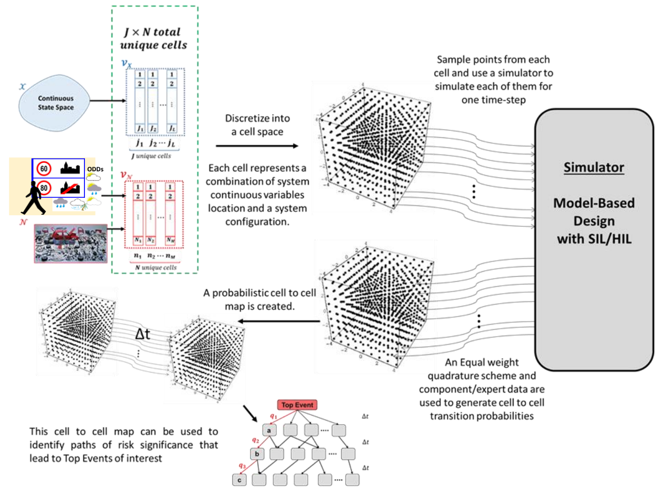

Fig. 1: The Backtracking Process Algorithm

I. Introduction

There are two main environments of operation to consider when driving: the vehicle system as a whole, and the surrounding environment related to the Operational Design Domain (ODD). Correct perception of the ODD and the subsequent decision making are among the biggest challenges for deployment of L3+ vehicles.

L3 systems are tasked with complete Object Event Detection and Response (OEDR) with the driver remaining in the loop in case intervention is necessary. The OEDR capabilities mean that the vehicle is tasked with perception and awareness of ODD states. This exponentially increases the number of scenarios a vehicle may encounter. Current testing techniques do not scale well to such systems. Scenario-based testing methods have been proposed in recent years to replace traditional testing methods. This has motivated efforts guided by government and industry institutes towards finding comprehensive approaches and frameworks for testing of L3+ systems [2, 7, 8, 10, 9]. The authors of this paper developed a methodology for the model-based validation of autonomous vehicle systems [3] that was submitted as a companion paper to the conference track of the 2020 Intelligent Vehicles Symposium. In [3] two main challenges are identified to increase testing effectiveness for L3+ systems: assurance of system coverage of the known space, and minimization of unknown unknowns. Within the first challenge, the proposed methodology in [3] aims to handle system model switching due to ODD variations and their effect at all instances of system operation. Within the second challenge, [3] aims to handle risks that were not identified in analysis and testing and scenarios composed of combinations of events that have not been accounted for or revealed in testing. A portion of the second challenge related to unknown unknowns as a result of modeling deficiencies and uncertainty was not addressed in [3]. This paper extends the proposed methodology of [3] and a demonstration of the validation process with emphasis on the minimization of unknown unknowns.

II. Challenges Related to Unknown Unknwons

As stated by [2] the Safety of the Intended Functionality (SOTIF) approach assumes three areas in which the system may operate in. The first is declared as known safe behaviors. This involves the known situations a vehicle operates in without any unacceptable system behaviors. The second includes known dangerous/undesirable behaviors during vehicle operation. The third is unknown and potentially dangerous behaviors, typically due to unforeseen combinations of events or risks that have not been accounted for.

During development of automotive technologies, the goal is the maximization of area 1 and the minimization of areas 2 and 3. For L1 and L2 systems, emphasis has always been placed on activities within area 1 , whereas for L3+ systems vehicles are expected to handle more unusual situations. It is particularly challenging to minimize the space of unknown unknowns due to the exponential increase in the number of scenarios a vehicle may be tasked with handling under increasing levels of automation. There are several key reasons for having scenarios that lie within the space of unknown unknowns, these are: **Risks that have not been identified**: If the risks that the system may encounter are not adequately defined, scenarios leading to these undefined risks

[1]Oztech Inc., 1170 Old Henderson Road, Columbus, OH. 43220. USA. uozguner@oztinc.com
[2] Renault S.A.S, 1 av. du Golf, Guyancourt, 78288, France