# CHAPTER 7
# SCENARIO GENERATION FOR SAFETY TESTING

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## 7.1 INTRODUCTION

Autonomous vehicle (AV) has become the priority inspection in the automotive industry with the continuous development of modern vehicles. As the development of automobile has drawn massive attention to the world, progressing to higher degrees of driving with the aid of technology brings forth extraordinary challenges and contradictions. Nevertheless, the blueprint for the development of AVs has become increasingly composite in respect of software and hardware. Kalra and Paddock (2016) carried out survey analysis to investigate the safety of driving an autonomous vehicle. Several questions have been raised whether developers can acquire enough data to develop a safe autonomous vehicle just by test driving. In order to statistically prove the safeness of an autonomous vehicle, automotive researchers performed statistical analysis and measurement throughout the study to calculate failure rates based on vehicle driving mileage. However, it can be noted that millions of actual vehicles driving mileage are required. Therefore, a longer period in terms of years is required mainly to collect driving data to sum up their findings. Hence, researchers suggested alternative safety testing methods such as virtual testing and simulations to boost

the practicality of testing the capability of an autonomous vehicle before actual deployment.

Several research works have been established to focus on safety testing focusing on verification and validation of autonomous vehicle using scenario-based testing method. This is one of the crucial assessments of the quality and performance of AV behaviour with respect to safety, comfort, and efficiency (de Gelder et al., 2020; Li et al., 2023; Rosengerger et al., 2019). Scenario-based testing has been proposed as one of the methods as a solution to evaluate the capability and safety of the vehicle. This method also proposed as a solution to minimize public road tests because expensive and time consuming (Shibuya et al., 2023). With a scenario-based testing approach, the response of the system-under-test is assessed in many scenarios and for the variations of these scenarios that occur in the real world. One of the advantages of a scenario-based testing approach is that the assessment can focus on the more challenging situations by selecting scenarios that are challenging for the system-under-test. As a source of information for the assessment scenarios, real-world driving data has been proposed, thereby guaranteeing that the scenarios represent real-world driving conditions (Haixia et al., 2022; Yang et al., 2022).

In general, scenario-based testing allows the tester to execute a wide variety of scenarios, which are often considered inefficient, risky, and/or infeasible to be tested physically. This can include many rare scenarios that may not occur very frequently in real life. Each scenario can cover multiple scenario categories (Tulpule et al., 2022), with a diversity of activity parameter sets per class. The term scenario can be referred as description of a situation that can happen or has happened in the real world. Moreover, scenarios are used to describe any type of situation that a vehicle in operation can encounter during its lifetime. The set of scenarios described by the scenario categories will not fully cover all possible situations that can occur in reality (de Gelder et al., 2022). Furthermore, each scenario can be parameterized to form concrete test cases. Each test case includes a set of parameters that are assigned specific values. The combinations of applicable parameters add on to

the diversity and volume of the tests required to cover the desired safety goals (Piazzoni et al., 2021; Ploeg et al., 2021). Many of these scenarios may also involve a high level of risk, making physical tests infeasible. Due to the above reasons, it is imperative to test these variety of scenarios through virtual testing and selected relevant scenarios for the physical testing.

This chapter is organized by firstly presenting related work in Section 7.1. Section 7.2 describes the related to scenario-based testing for safety testing and validation of autonomous vehicle. Section 7.3 explains the development of 3D virtual environment using IPG CarMaker. Section 7.4 discusses the scenario test cases development and Section 7.5 explains the optimization of test manager to automate the test cases. Section 7.6 explains about interfacing IPG CarMaker and Simulink Controller and finally, Section 7.7 of this chapter provides the conclusion on the study.

## 7.2 RELATED WORKS

Virtual safety testing during any vehicle development process is quite normal in the automotive industries before proceeding with physical testing. Generally, virtual testing was focused on the component level testing of the vehicle and vehicle integrated system level testing. However, this is not sufficient to ensure the safety and credibility of the autonomous vehicle to be safely deployed on mixed and complex traffic environment. Therefore, integration of virtual-based testing with scenario-based testing approach (Aparow et al., 2022; 2021; de Gelder, 2022;) is used as a first layer of safety testing of autonomous vehicle. In order to perform virtual safety testing of the autonomous vehicle, a subset of the relevant scenarios is selected through a selection process based on the autonomous vehicles' ODD. Then, the autonomous vehicle is tested using virtual safety testing which emphasizes the scenario definition and test case generation, vehicle dynamics, traffic behaviours, road environment model, motion and path planning control and sensors perception.