

# A Review of The Application of VTD Simulation Software in Intelligent Driving

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**Abstract:** This paper mainly introduces the importance of the driving simulation system, establishes a simulation platform, explains the main operation of VTD simulation software, and uses specific cases to carry out practical operation. Secondly, the application of VTD simulation software in intelligent driving assistance system is summarized, and how to perform co-simulation with other software is the difficulty in the use of VTD simulation software. Finally, the application scenarios of VTD are analyzed, and the development prospect of VTD in intelligent assisted decision-making is prospected.

**Keywords:** Virtual Test Drive, Intelligent driving, Co-simulation.

## 1. Introduction

Before the ICV can be implemented, it needs to go through a large number of real-world road tests. At present, it is considered in the industry that an autonomous driving system needs to be tested for 11 billion miles before it is ready for mass production [1]. This is not only costly, but also difficult to debug and modify new algorithms, which is well solved by the emergence of driving simulation systems. In the simulation software, the proposed intelligent driving assistance decisions can be simulated by building real road scenarios, and dangerous scenarios that are difficult to verify in real vehicles can be verified. In this paper, the basic operation of VTD is introduced according to the VTD simulation simulator built by the research group, and then the literature on VTD application is searched to study the use of VTD simulation software in intelligent driving assistance decision-making.

## 2. Basic Overview

VTD (Virtual Test Driving) It is a complete tool chain

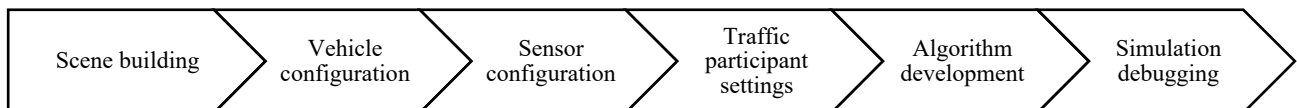


Figure 1. Simulation flow chart

VTD GUI: In this interface, you can open the road construction interface and scene construction interface from the toolbar, and in the user interface, you can set the driving perspective, sensor, weather, and road adhesion coefficient.

ROD: An interactive road network modeler that creates complex road networks with multiple types of lanes, including undulating pavements, roadside buildings, traffic lights, and other traffic signs, with customizable 3D models and texture libraries.

SE: Traffic scene modeling, monitoring and simulation module, which can automatically run or manually intervene in traffic operation when visually simulating the traffic scene

simulation software for intelligent driving, and is the main product of VIRES company in Germany, which contains a complete 3D model of various types of simulation environment and simplified physical model sensors, which can be used to build complex traffic scenarios and provide a complete high-fidelity intelligent driving test program. VTD can be used for SiL, DiL, HiL, ViL, and is compatible with third-party customers' models and packages, and its open and modular design makes it very interactive and integrated, with very good flexibility. VTD can provide the underlying data to help the development of intelligent driving algorithms, and provide a development basis for image recognition, intelligent control, and sensor development. The overall consists of three parts: VTD GUI, ROD (Road Designer), SE (Scenario Edit). This structure realizes the upstream and downstream or pipelined functional design through the invocation of multiple small software within the large software, which can be called the "V" shaped development process in more technical terms. For example, the project is modeled and simulated according to the following ideas:

designed by the user.

### 2.1. VTD simulation software driving simulation platform

According to the VTD simulation software driving simulation platform, it is composed of a computer host equipped with VTD simulation software, a simulated driving input device, and a high-definition curved large screen. The driving simulation input device is Logitech G27, including steering wheel, accelerator pedal, brake pedal, etc., and the control feeling of the accelerator, brake pedal and steering wheel is very close to that of a real vehicle, which can meet

the needs of simulated driving experiments. During the experiment, the RDB-Viewer tool provided by the VTD simulation software can visually analyze the experimental data, collect and save the experimental data in real time, and finally process and analyze the data everywhere.

## 2.2. VTD basic operations

(1) Build a static scene, through ROD, you can build the road, the width of the road, the altitude, the green plants next to it, traffic signs, street lights, etc.

(2) In the dynamic scene setting (SE), you can set the vehicle, pedestrian, vehicle running trajectory, running rules, traffic participants or obstacles required in the traffic scene, as well as the control (trigger, action) of the traffic light and the vehicle.

(3) After setting the scene and vehicle operation rules, the simulation can be carried out on the driving simulation platform. In this step, the VTD needs to be switched to Joystick mode by executing the script selectSetup. At this time, the scene in the VTD will be displayed on a large curved screen, and external devices can be used to control the vehicle.

(4) Finally, some data in the simulation process can be read through RDBSniffer, such as the steering wheel angle, brake pedal opening and other data are collected, and finally the data are exported for integrated analysis.

## 3. VTD Application in Intelligent Decision-making

### 3.1. VTD Practical application

This section describes the practical application of VTD.

(1) Create a virtual scene that is close to the real road. No matter what kind of simulation is carried out with VTD, the first thing is to build as realistic a scene as possible and restore the real road conditions, so that the intelligent car can be truly intelligent and in line with the complex road conditions in the real scene. Ref. [2] proposes a technical route for building scenarios using VTD for the common landing scenarios of L3 autonomous driving, and creates urban roads and ring highways in the nine-square grid area.

(2) Collection of datasets. The simulator can be used to analyze the driver's behavior, which lays the foundation for the development of driver assistance systems in the future. Using VTD enables a large number of skilled drivers to use

the driving simulator to drive in different scenarios and situations, and finally form a dataset of skilled drivers, so that the decisions proposed will be more relevant to daily life rather than paper. Wang et al. used VTD to analyze the behavior of human drivers, and finally concluded that when encountering obstacles in front of them, 92% of the results were to brake and change lanes to avoid obstacles [3].

(3) Verification of the personality driver model. VTD can also analyze different styles of drivers, and after proposing a personality driver model in Ref. [4], 15 sets of data from each of the different styles of drivers were obtained by VTD, and they were classified into three types: mild, moderate and aggressive, so as to verify the proposed model. When testing a car, the same should be done with different styles of drivers.

After collecting the driver's behavior, the real reflection of the skilled driver under the same working conditions is formed, or the behavior of the driver of different styles, the model can be trained, so that the model has diversity, and can make some independent decisions on the basis of driving assistance, and it is closer to the actual situation of China's roads, as well as the actual situation of different styles of drivers, which is also of great significance to the landing of intelligent vehicles.

### 3.2. Co-simulation with the rest of the software

When simulating the auxiliary functions of autonomous vehicles, it is often necessary to combine multiple software, so as to give full play to the advantages of each software, and make the simulation more accurate and realistic. Many researchers in China have used VTD to conduct driving assistance research, and the following examples give examples of different scholars using VTD in intelligent assistance decision-making research.

(1) Lane change decision model: Ref. [5] is a study of the lane change decision model, in the simulation process, Matlab/Simulink is used to quickly build lane change decision and lane change control, and at the same time, VTD software is used to quickly build road scenarios and configure surrounding vehicles, as well as vehicle dynamics models and on-board sensors (VTD contains many types of sensors, such as cameras, millimeter-wave radar and GPS systems, as well as corresponding advanced driver assistance systems). Data is transferred between the two software via UDP and thus controlled vehicles change lanes. Figure 2 shows the framework.

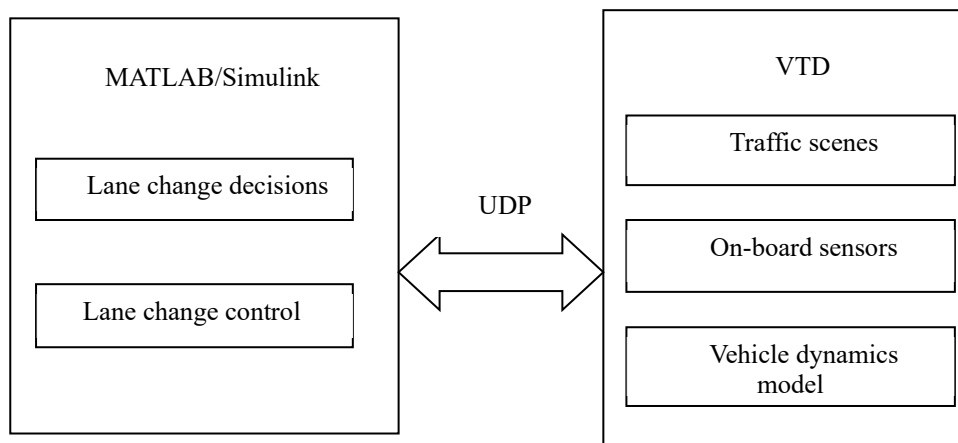


Figure 2. VTD and MATLAB/Simulink co-simulation architecture

(2) Research on adaptive cruise control in corners: In Ref. [6], a driver-in-the-loop system was built, and a control algorithm was designed to test and verify the adaptive cruise control algorithm in corners. The real driver controls the vehicle direction and cruising speed through the driving simulator, adjusts the driving style and cruising speed, and then inputs the control signal to the dynamic model, and then outputs the latest dynamic information of the vehicle to the ACC vehicle in the VTD, so as to complete the construction of the driver-in-the-loop system and the algorithm test. VTD is used to build the scene and the real driver, veDYNA is used to build the dynamic model, Matlab/Simulink converts the dynamic model into a dll. file, and the input and output are

connected in Veristand.

(3) Evaluation of traffic congestion assistance system: Ref. [7] This paper integrates the ASCL vehicle dynamics model with the VTD to replace the built-in vehicle dynamics model of the VTD, and replaces the ASCL with the image system of the VTD. The image system of the driving simulator uses the TJA system (Intelligent Vehicle Traffic Jam Assist System) that comes with Matlab as the measurement method, and builds a test scene of the TJA system in VTD, and the tester enters the driving simulator to experience the control effect of the TJA system, and then scores according to the subjective evaluation, and collects the state data of the vehicle itself, and finally comprehensively analyzes it.

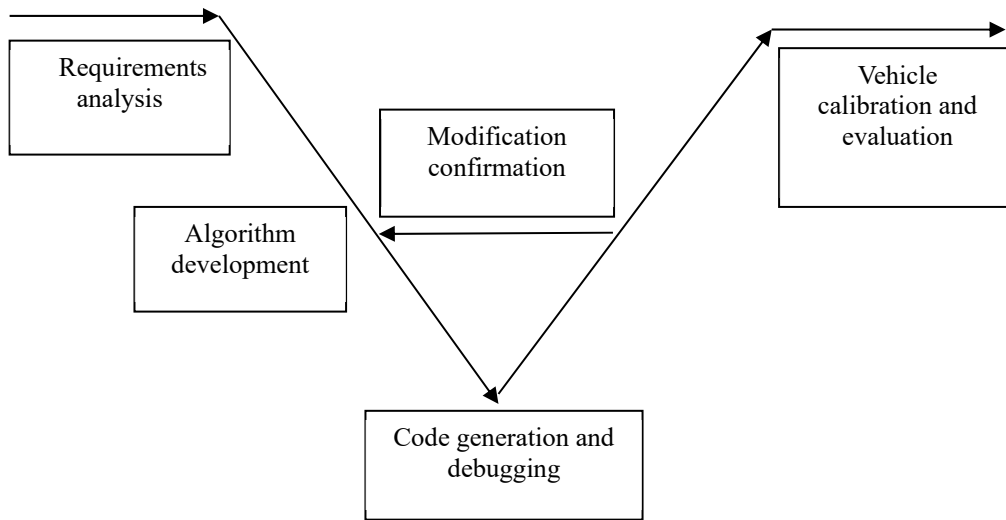


Figure 3. The V-shaped development process of the TJA system

(4) Research on the development of virtual test scenarios for straight-line driving conditions on highways: Ref. [8] VTD is used to build virtual scenes, veDYNA is used to build vehicle dynamics models, and VeriStand is used for NI real-time hardware configuration I/O channels, data recording, excitation generation, and host communication. Collect real driver data and analyze driver characteristics as a control model of the vehicle in the virtual test scene environment, so as to develop the virtual test scenario.

(5) Research on driving behavior modeling methods: In order to improve the authenticity and diversity of virtual test scenes, NGSIM real vehicle trajectory data is used to analyze the driver's style, establish a motion model considering the driver's style characteristics, and apply it to the traffic vehicle in the virtual scene to make the traffic vehicle reflect different driving style characteristics. The path of the vehicle is set according to the motion preview model, and Simulink outputs the motion status of the car to the VTD.

Based on the summary analysis of the existing research, it can be found that VTD and Matlab/Simulink co-simulation occupy the mainstream, and Matlab/Simulink is generally used to build models, and then build scenarios in VTD for simulation and testing. There are also studies that use other specialized software, such as veDYNA (Vehicle Dynamics Simulation Software), to replace the internal models, dynamics models, and sensors in the VTD.

## 4. Conclusion

Through the analysis of some existing studies, it can be known that the scene built by VTD not only restores some situations encountered on the road as realistically as possible, but also collects and analyzes data from different drivers through driving equipment. At the same time, VTD can be used to combine with other software to verify the proposed decision-making algorithm, and can also make subjective evaluations through real drivers using driving simulators to participate in traffic scenarios. However, VTD and many other driving simulators are only convenient in the development process, not a substitute for real car simulation, and it is an inevitable step for the driverless car to be simulated on the road before it lands.

VTD also has many development scenarios in intelligent driving assistance decision-making:

(1) Most of the current research is to use VTD to simulate and test a single intelligent networked vehicle, which can also be simulated and evaluated in the following of multiple vehicles.

(2) The driving intention dataset of various styles of drivers can be established, which can provide a basis for the development of some assisted driving decisions, and the model can be trained according to the collected data set, so that the model can finally make decisions independently.

(3) It can be used for V2X (Vehicle to X), X stands for Infrastructure, Vehicle, Pedestrian, etc., and X can also be the

R&D and application of any possible "Person or Thing" (Everything).

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