

# Multi-agent Traffic Simulation For Human-in-the-Loop Cooperative Drive Systems Testing

## (Demonstration)

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### ABSTRACT

This demonstration presents the integrated multi-agent traffic simulation for human-in-the-loop cooperative drive systems testing. Its openness and flexibility supports a wide range of testing and validation possibilities for the researchers and developers in the field of autonomous vehicles, cooperative drive, driver assistants, and HMI design and development. The system is able to integrate various driving simulators, car control techniques, cooperative car coordination and user-driven vehicles. The usability of the system is demonstrated in various scenarios and configurations.

### Categories and Subject Descriptors

H.4 [Information Systems Applications]: Miscellaneous

### General Terms

Algorithms, Design, Experimentation

### Keywords

agent-based simulation, transportation, driving simulation

## 1. INTRODUCTION

Nowadays computer science, robotics and artificial intelligence are just some of overlapping areas that automotive industry may benefit from. The driver assistance systems or autonomous vehicles are examples of the applications aiming to improve road safety. Accident-free traffic or at least reduction of the number of accidents is an actual challenge in the related research areas. The recent achievements in autonomous cars development and advanced drive support systems arise research questions about user acceptance of such systems and their effectiveness from the traffic perspective in case of high penetration.

The development of next-generation car technologies relies on usage of drive and traffic simulations. The scale of the simulators used varies from high-end simulators based on large motion platforms providing realistic user experience or static cabin or seat equipped with visual projection to basic software simulation with no requirement of a special

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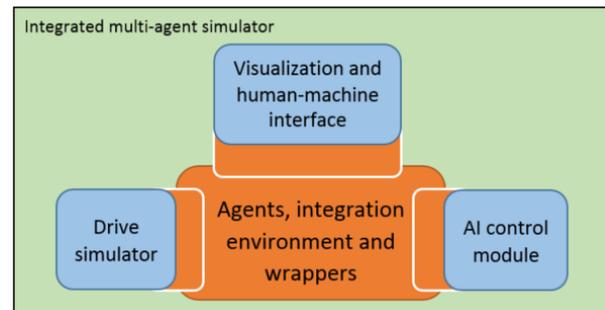


Figure 1: Schematic architecture of the integrated simulator.

hardware equipment. Such simulators are widely used to perform human in the loop tests of various in-car equipment.

This article presents a concept of integrated simulation platform enabling human-in-the-loop testing of integrated cooperative drive systems in the traffic perspective. It combines the features of realistic drive, AI controlled vehicles and flexible level of car simulation detail. The main advantage of the concept is the ability to mix various type of drive simulations with a wide range of AI methods controlling the vehicles (in fully autonomous mode or user-driven)<sup>1</sup>.

## 2. ARCHITECTURE

The presented simulation system targets for integration of driving simulator with a autonomous vehicle control modules equipped with collision avoidance mechanism. Such system is a key element for testing the behavior of autonomous cooperative vehicles combined with the user controlled one [4]. The drive simulator is responsible for realistic drive of all simulated vehicles controlled by both human and AI. AI-based vehicles execute instructions autonomously. The user driven vehicle visualize the instruction for a human driver using the human-machine interface (HMI). A schematic architecture of the system is depicted on Figure 1.

The integration module implementation is based on a simulation toolkit Alite [2]. The module performs a multi-agent simulation of all vehicles in the scenario. Each agent is responsible for controlling corresponding vehicle in the drive simulation and for implementation of the AI module and HMI integration. The multi-agent simulation allows to use

<sup>1</sup>The demonstration video is available at <http://agents.fel.cvut.cz/agentdrive/>.

distributed collision avoidance methods as well as the centralized ones. An agent in this context is specified as an entity that can perceive and act on the environment. The sensors and actuators respectively are used to provide interactions with the environment – a realistic drive simulator.

## 2.1 AI control module

The AI control module serves as an intelligent driver model. An inspiration for cooperative driver models can be found in the research field of collective robotics. The state-of-the-art approaches comprise of local or global collision avoidance or cooperative motion-planning. For the car safety perspective, we can consider both reactive collision (accident) avoidance techniques and (cooperative) motion/path planning for the vehicles. The main advantage of the AI control module in the presented system is its flexibility and openness, so the agents can use practically any techniques for avoiding collisions or drive enhancements, even a combination of different techniques for different agents. The control mechanisms used in this demonstration are based on variation of Optimized Reciprocal Collision Avoidance, safety distance based collision avoidance method [3] and cooperative trajectory planning algorithm for highway vehicles [1].

## 2.2 Drive Simulator

The integration of realistic drive simulator enables the simulation to validate control and coordination techniques on in the realistic environment. It can also support the human-in-the-loop validation of the system. Again, thanks to the openness and flexibility of the integrated simulator architecture, there is possibility to incorporate a wide range of drive simulators (assuming the ability to project external objects control into the simulator). The example of drive simulators integrated in this demonstration is open-source java based simulator OpenDS<sup>2</sup>. Figure 2 shows the basic setting for the OpenDS simulator running on regular laptop computer with gaming steering wheel. Another example is industrial stationary driving simulator with a SCANer<sup>TM</sup>simulation engine<sup>3</sup>. In principle, there is no conceptual problem to integrate any other drive simulator within the simulation. In fact, multiple simulators can be integrated in parallel to provide different levels of abstraction for different vehicles.

## 2.3 Human-Machine Interface

The Human-Machine Interaction Interface is designed to present the plan (or simply actions) proposed by the AI control module to the driver. The demonstrated simulator offers the possibility of implementing HMI in various ways. For example, for the OpenDS we have implemented simple augmented reality dashboard on the screen (see Figure 2 in the left part). The other possibility is to introduce hardware dashboard for stationary simulators. The development and validation of such dashboard is a strong research topic. An example of the dashboard used in this demonstration is on Figure 3.

## 3. CONCLUSIONS

This demonstration presents the integrated multi-agent traffic simulation for human-in-the-loop cooperative drive

<sup>2</sup>www.opens.eu

<sup>3</sup>www.scaner2.com



**Figure 2: OpenDS drive simulator installation (left) and industrial stationary driving simulator with a SCANer<sup>TM</sup>simulation engine (right). In the left part, the screen shows basic AI-based drive guidelines by the color projections (left blue lane represents change lane recommendation).**



**Figure 3: Example of the HMI dashboard for stationary driving simulator.**

systems testing. Its openness and flexibility supports a wide range of testing and validation possibilities for the researchers and developers in the field of autonomous vehicles, cooperative drive, driver assistants, and HMI design and development. The system has been validated in the various settings of the integrated driving simulator, HMI interfaces, and cooperative car control techniques. The demonstration supports the usability and validity of the simulation for future car systems.

## 4. ACKNOWLEDGMENTS

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