A co-simulation environment for cooperative maneuvers among vehicles

Antonio Artuñedo, Rodolfo Haber, Fernando Matía

Center for Automation and Robotics (CSIC – UPM) Arganda del Rey, Spain
{antonio.artunedo, rodolfo.haber}@car.upm-csic.es

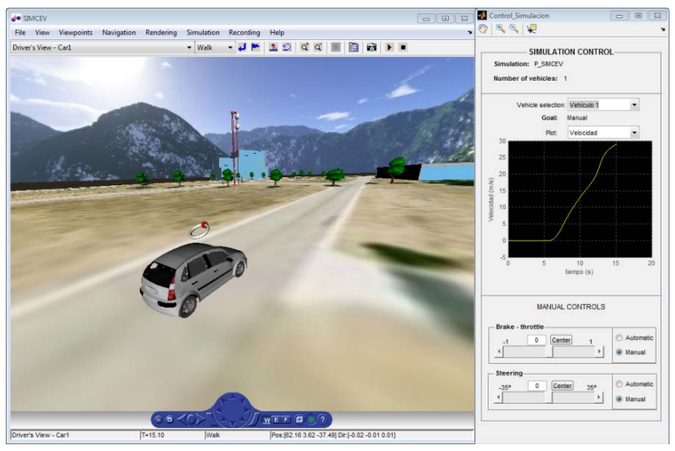
Abstract

In this work we propose a tool for simulation of cooperative maneuvers among autonomous vehicles in which virtual and real vehicles can conjunctively interact. It is a generic simulation platform where the user can define the desired scenario using a graphical user interface. This interface facilitates insertion of controllers and models for different parts of vehicles and some elements of the infrastructure. Furthermore, vehicle to vehicle (V2V) and vehicle to infrastructure (V2I) communications are available in the framework. The simulator also enables the 3D rendering of simulation and monitoring of several variables at runtime. The main advantage of the proposed framework relies on the use of hybrid simulation by combining real and virtual vehicles for studying their dynamic behavior and interaction without the need of real expensive equipment or vehicles. Therefore, the emulation of experimental tests based on data sets from the vehicle sensors serves as a powerful tool for designing and evaluation new ADAS.

Introduction

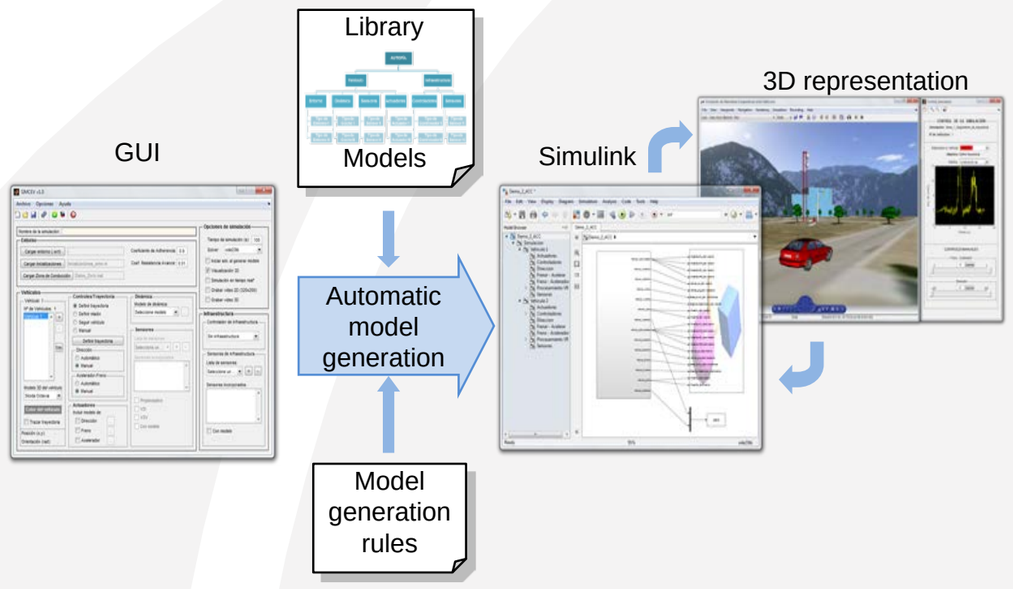
A tool for simulating a wide range of ITS applications is proposed in this work. This is a framework for simulating cooperative maneuvering among vehicles (real and virtual). The main goal is to address the new needs on ITS simulation such as ADAS, intelligent sensors simulation and testing of reliability and safety of controllers for autonomous vehicles, maintaining a balance between vehicle dynamics simulators and microscopic traffic simulators. Our proposal addresses the gap between traffic simulators and vehicle dynamics simulators allowing ITS researchers and developers to test on board vehicle equipment such as sensors, actuators or controllers, and cooperative transport maneuvers within urban realistic scenarios.

The real-virtual interaction allows to combine real vehicles with simulated scenarios, therefore it is possible to evaluate the performance of the real vehicle in critical situations without jeopardizing the vehicles or the infrastructure.

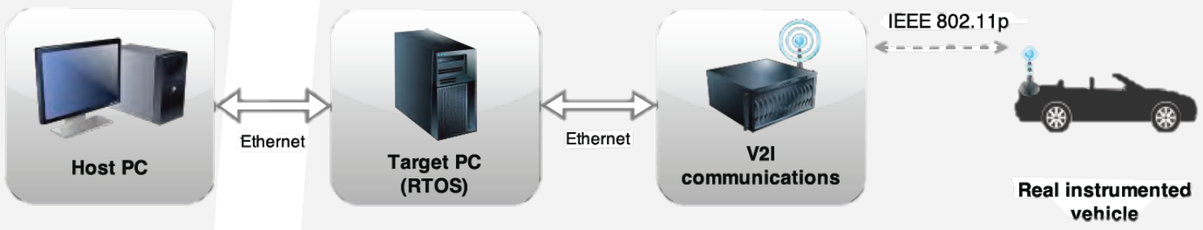


Framework description

It is a generic simulation platform where the user can define the desired scenario using a graphical user interface, generate automatically a simulation model and then simulate it. The interface facilitates the insertion of controllers and models for different parts of vehicles and some elements of the infrastructure, through a models library. Furthermore, the framework permits to implement V2V and V2I communication links among the entities that comprise the scenario (real or simulated).



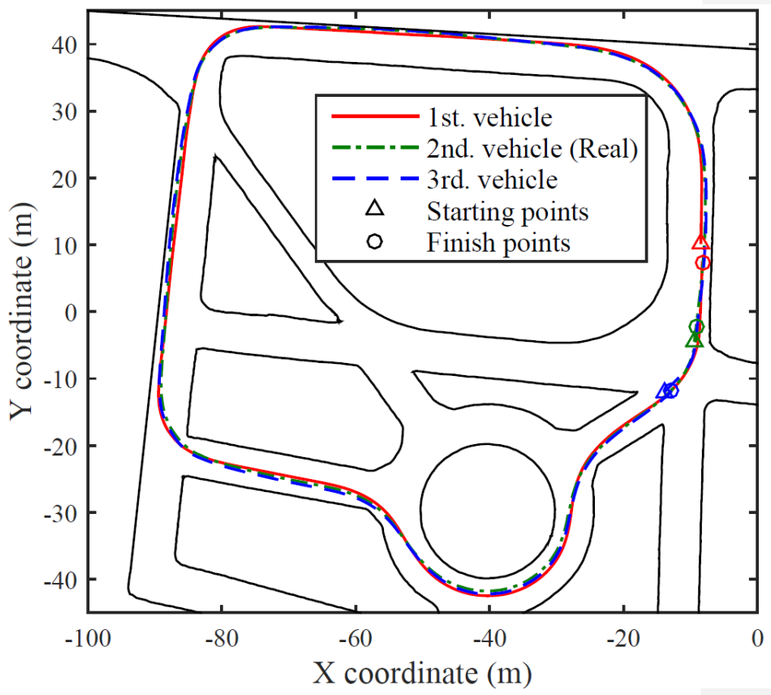
The simulator also enables the 3D rendering of simulation and monitoring of several variables at run-time. This tool uses hybrid simulation by combining real and virtual vehicles for studying their cooperative behavior without the need of real expensive equipment and vehicles. This tool also allows the recreation of experimental tests based on data sets stored from vehicle sensors. The real-virtual vehicles interaction provides new features and extends the capabilities of the framework.



Results

In order to analyze the result obtained with the simulation platform and validate the simulation model of the vehicle, several experiments were carried out. In these experiments a real car was used. The real vehicle is a Citröen C3 which has been adapted for autonomous driving, including several sensors such as GPS, camera and inertial measurement unit (IMU); and actuators for controlling the throttle, brake, steering wheel and gearbox. The vehicle also counts with an On-Board Unit (OBU), which is in charge of the control of the vehicle and an IEEE 802.11p communication system for V2I and V2V communications.

The results of the test demonstrated that the cooperation between simulation and real vehicles is possible, maintaining a good performance between the simulated and real systems.



Conclusions

As proven, the tool proposes a co-simulation framework for the development of applications on the autonomous driving field. The tool has a modular structure, allowing the user to implement several models and components at different levels of the simulation environment. The simulator also enables the 3D rendering of simulation and monitoring of several variables at run-time. It makes possible real-time interaction between real and simulated cars allowing them to cooperate. Also this functionality enables to use the simulation framework as a hardware abstraction layer between hardware and control systems. Ongoing research focus on the use of this feature for developing and testing Cyber-Physical Systems in the ITS scope.

Future work will be focused on improving models of vehicle, sensors, actuators and controllers as well as the simulation of wireless systems for V2X communication systems.