High Fidelity Multibody Vehicle Dynamics Models for Driver-in-the-Loop Simulators

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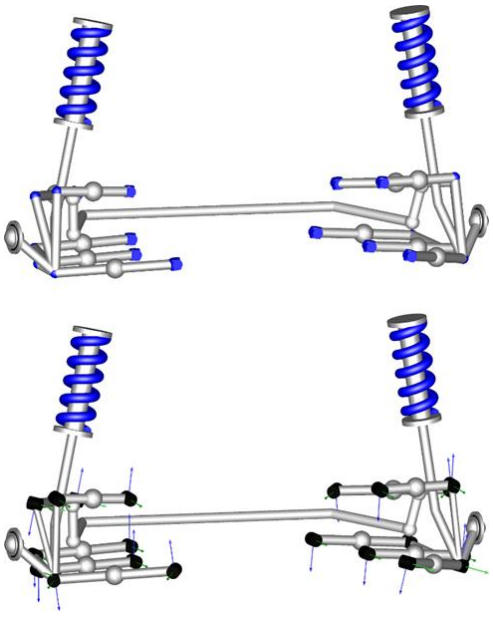
Modern Driver-in-the-Loop (DiL) simulators are sophisticated engineering tools that have been developed within Motorsport to support the development and optimization of race cars in Formula 1, NASCAR and Indycar. At the heart of the simulator is the vehicle model which has to accurately capture the behavior of the whole car. Modelica based vehicle models are used by many of the top teams because it enables a multi-domain vehicle model to be used in the simulators and support all the other simulation activities within the team. These technologies are now being deployed into road car applications which presents a number of additional challenges.

In the last few years driving simulators have been developed that can be used for more than basic procedural simulation such as driver training, evaluating human factors such as fatigue and stress, ergonomics and testing new man-machine-interfaces. The latest generation of systems make it possible to simulate a mathematical model of a car, over an exact replica of a road surface, with identical scenery and visual reference, with a *human* driver, in a safe, controlled, environment. These developments have been led by motorsport teams and organisations due to the restrictions in testing imposed by the governing bodies and the increasing complexity of the cars.

For Automotive OEM's the appeal of high fidelity driving simulators is that they can move the testing of new vehicle designs and parts into the virtual world and start the assessment of design decisions with professional drivers before committing to the production of a prototype.

There are many technological developments that have enabled the development of these engineering class of driving simulators including new software, new motion platforms, high fidelity real-time vehicle models and high precision track data. This paper focuses on the recent enhancements in the vehicle models and the related interface to track data.

A new interface to a system that can provide high fidelity road data, that is generated as a result of LiDAR scans, is presented together with the implications that the use of this data has on the tyre models and contact point calculations. The Modelica TerrainServer Library provides an interface between the Vehicle Dynamics Library and the rFpro TerrainServer enabling simulations in Dymola to use the same track data as the DiL system. To accompany this a new closed loop driver model has been developed to work with these tracks and to provide improved tracking performance.



New suspension models are introduced for road cars to support both kinematic and elastic suspenion models. These are being developed to support both offline and real-time simulation in a DiL system. New bush models have been developed that can capture the frequency and amplitude dependency in the damping characteristics of rubber bushes. The new multi-threading capabilities of Dymola are explored to enable the suspension models, with bushes, to be run in real-time as part of a DiL system.