How to build Europe's largest eight-axes motion simulator

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Abstract *– This paper gives an overview of the new Stuttgart Driving Simulator for passenger cars which has been designed and realized in a joint effort of Stuttgart University and FKFS. The focus of the simulator is research upon driver's behaviour as well as design and testing of driver assistance systems.*

The simulator is based on a motion system with eight axes. In terms of motion space it is currently the largest motion simulator in Europe. As a special feature the simulator supports the integration and exchange of modified real passenger cars.

The paper describes the concept and the design of the Stuttgart Driving Simulator. An outlook on typical applications is given.

Key words: *motion simulator, eight axes, vehicle integration, driver assistance systems*

Introduction

Within the framework of the high-tech strategy and the IKT2020 research program of the German federal government, Stuttgart University started the interdisciplinary research project VALIDATE in July 2008 with the goal of reducing CO_2 emissions of road vehicles. The project was funded by the German Federal Ministry for Education and Research (BMBF) until December 2011. Further funding was granted by Ministry of Science, Research and Arts of Baden-Württemberg, in the context of a project named ElefAnt with the goal of optimizing electric vehicles and drivelines.

The funding enables the design and setup of a very sophisticated research platform for the design of electronic systems for energy reduction in a partial or complete virtual environment. Especially driver assistance and driver information systems, which indirectly lead to a reduction in energy consumption by supporting the driver in operation of the vehicle, are regarded [Pie1].

It is known that the individual driving style has an enormous impact on the vehicle's energy consumption [Rum1]. Therefore it was decided that a high-quality driving simulator should be part of the research platform. Such a simulator allows detailed investigation of the human driver's behaviour whereas unpredictable influences of traffic and weather can be suppressed.

Design of the Stuttgart Driving Simulator

Overview

Fig.1 shows the Stuttgart Driving Simulator. A new building with a dimension of 20 by 15 metres has been designed for the particular needs of the simulator.

The eight axes motion system consists of three parts:

- A gantry moves on three rails in the X direction and allows the simulation of longitudinal acceleration and braking.
- The gantry itself carries further rails. A sled moves on these rails in the Y direction and allows the simulation of lateral acceleration.
- The sled carries a hexapod system which allows translation and rotation with six degrees of freedom. It is mainly used to simulate pitch, roll and yaw motion as well as vertical movement. Furthermore, the hexapod supports the XY linear system in longitudinal and lateral acceleration simulation.
- The lightweight simulator dome is completely manufactured of carbon fibre and aluminium composite materials. The interior dome wall is used as a projection surface. Twelve projectors create a circumferential image.

Two doors in the dome allow persons to access the simulator vehicle from the driver's and co-driver's side. For this purpose the motion system moves the

dome to a parking position. Thereafter an access ramp, designed as a “flap bridge”, descends automatically and lets persons enter and leave the dome.

Fig. 1. Overall view and dome interior of the Stuttgart Driving Simulator

Scope of application

Both Stuttgart automotive research institutes IVK and FKFS have a long tradition of research on driver’s behaviour. Examples are the driver reaction under special aerodynamic conditions [Kra1] and the benefit of hybrid-electric propulsion for different driver types [Fri1].

IVK and FKFS have special experience in real-world test driving. This means that a sufficient number of drivers is recruited whose distribution of gender, age and yearly mileage reflect the population. These probands drive vehicles on selected routes in order to represent average driving in a particular region, e.g. Germany. By evaluation of measurements it is possible to identify potential improvements in vehicle technology with respect to fuel efficiency, safety or comfort [Rum2].

The results of such on-road studies are highly meaningful but cause substantial effort in terms of time and money. Furthermore it is neither possible to perform safety related driving manoeuvres with “normal” drivers nor doing this in real traffic. Furthermore, road testing does not provide reproducible traffic and weather conditions.

Hence, FKFS and IVK are tending to transfer road testing partially into simulation. The Stuttgart Driving Simulator has been mainly designed for the following scope of applications:

- Reduction of energy consumption by analysing and influencing the individual driving style and its impact on efficiency,
- design and investigation of driver’s reaction on new driver assistance systems and human-machine interfaces and
- research on future safety systems, mainly collision avoidance systems with a focus on the protection of pedestrians and children.

References

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