Determining the rider induced roll torque on a dynamic motorcycle riding simulator

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Introduction

During the project DESMORI (Development Services for Motorcycle Rider Interaction) a dynamic motorcycle riding simulator is developed. Its main task is the investigation of rider behaviour under the influence of additional tasks like the operation of informing assistance and infotainment systems (e.g. radio, navigation systems, etc.).

While [Gut15] addresses the motion cueing of the simulator, this contribution discusses the challenge of using the rider’s movement as an input to the vehicle lateral dynamics, which is a key issue to increase immersion.

Motivation

Following a planned trajectory in a two track vehicle is almost solely dependent on the driver’s steering input (neglecting e.g. throttle control of over or under steering). However, on single track vehicles there are two main rider inputs to control lateral dynamics: Steering and rider’s leaning motion.

Fig. 1 shows the interdependencies between rider and vehicle as well as between the vehicle’s subsystems themselves.

Approaches

Position tracking

Optical 3D tracking devices are widespread and have proven to be a technology which is affordable and easy to implement and use. Thus, one of the DESMORI prototype simulators is fitted with an according system, as shown in Fig. 2.

In order to facilitate correct rider inputs (blue arrows) on the simulator, both the feedback cues as well as the dynamic coupling within the vehicle (grey arrows) need to be modelled and provided to the rider.

While undoubtedly the rider leaning input – in most cases – will not be used solely for following a given trajectory, it has a vast influence on steering forces and handling of powered two wheelers (PTW) due to the bidirectional steer-roll-coupling. Thus, to increase the immersion and rideability on a motorcycle riding simulator, the rider’s body movement is an essential input to the vehicle dynamics calculation.

Figure 1. Interdependencies between rider and vehicle regarding lateral dynamics

Figure 2. Optical 3D rider position tracking

Alongside its simplicity there comes a limited potential to use the rider’s position as an input to the vehicle dynamics simulation, since this approach vastly simplifies the system dynamics.
Roll-torque determination

In order to increase the level of detail in the modeled rider-vehicle-coupling and to enable additional functions to increase immersion (e.g. balancing in standstill), a second approach is being developed, which takes any rider motion and any response of the rider’s body to vehicle induced motions into account.

The basic idea is, to determine the so called “rider induced roll torque”. This includes any static torques (due to the rider’s COG position relative to the PTW’s) or dynamic torques (due to reaction forces between rider and vehicle) that are applied on the motorcycle’s rear frame by means of a leaning motion or support forces on the foot pegs, knee pads etc.

Therefore, on the second DESMORI prototype simulator (Fig.3), the motorcycle is mounted on an additional roll axis which allows for a rotation relative to the motion platform. The mockup is attached to a load cell which determines the roll torque relative to the platform.

Isolating the rider motion signal

The main task of the abovementioned method is to isolate the torque signal induced by the rider’s motion from the signal’s disturbances due to the motion of the 6-DOF platform. Therefore, a multi body simulation (MBS) is performed, that models the simulator with a fixed rider mass. The roll torque calculated by the simulation serves as an expectation value for a scenario with a non moving rider. Differences between this calculated torque and the torque which is measured online while performing tests on the simulator give information about the rider induced roll torque. Fig. 4 shows how this torque is determined and used as an input to the vehicle dynamics simulation (VI-grade, BikeRealTime) in an online simulation.

Results

The upper diagram of Fig. 5 shows the measured force of the load cell with rider motion (blue) and the calculated expectation value with a fixed rider mass (green) with a random platform excitation. The difference between these two signals thus can only follow from the rider’s lateral movement and is proportional to the rider induced roll torque around the longitudinal axis of the vehicle (green in lower plot). Fig. 5 shows that this torque correlates well with the rider’s lateral position (dashed blue line).

Outlook

The introduced method of determining the rider induced roll torque is currently being implemented on the simulator. Studies to compare the usability and functionality of both abovementioned methods are part of future research. Also the differences in rider movement between riding in real life and on the simulator (e.g. due to the lack of lateral acceleration) need to be investigated.

References