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Motion Analysis of a Motorcycle Taking Account of Rider's Effects

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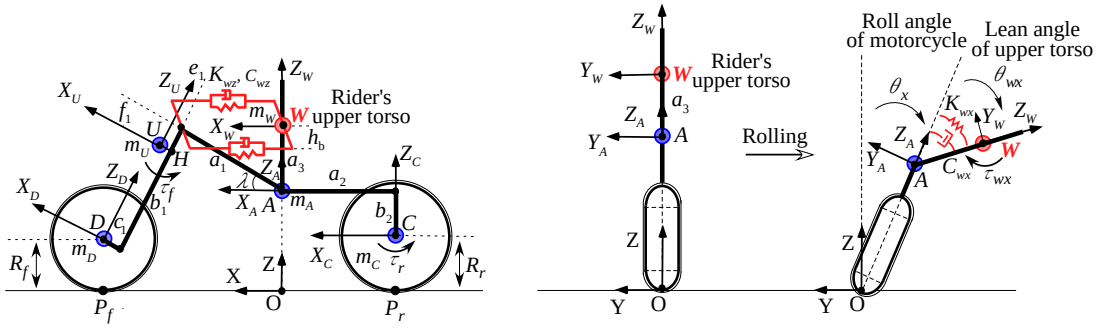
Abstract

In this paper, to analyze rider's effects on the motion of a motorcycle, we model a rider-motorcycle system taking account of the lean motion of the rider's upper torso [1], [2] and the rider's arm [3]. Figure 1 shows the dynamical model of the rider-motorcycle system, where the rider's upper torso can rotate around the roll axis and the rider's arm is connected to the handle from the upper torso with a spring and a damper. In addition, we introduce the nonlinearity of the tire force to the tire model with taking account of the cross-sectional shape, the elastic deformation and the tire-ground contact area[4], [5]. In Reference [6], we have already designed a front-steering assist control system [7], [8] to stabilize the motorcycle on the basis of the dynamical model including the lean motion of the rider's upper torso without the rider's arm.

In this study, by carrying out simulations, not only the effect of the lean motion of his/her upper torso but also that of the rider's arm in steady-state turning are analyzed. The constant steering torque from the rider is directly applied about the handle axis. In simulations, we have a rider lean in, lean with and lean out the motorcycle roll angle by applying the lean torque to the rider's upper torso. Figure 2 shows the simulation results of the steady-state turning taking account of rider's effects at 35 km/h. The friction coefficient of the road surface is originally 0.8 and suddenly decreases to 0.6 from 2 s to 7 s. The constant steering torque about the handle axis is - 9 Nm. The lean torque to the rider's upper torso is 20 Nm to have the rider lean in. In case of the rider model with arms, when the rider's upper torso leans in the same direction of the roll angle and keeps the lean angle of 5.6 deg at the steady-state, the roll angle of the motorcycle increases to about 26 deg. In case without arms, the lean angle, the roll angle and the steering angle become larger than those of the rider model with arms. Also the friction coefficient change severely affects the motorcycle motion and causes the roll angle vibration comparing to the rider model with arms. It is seen from Figure 2 that effects of the rider's arm and the rider's posture to motion analysis of motorcycles are large.



(a) Side view (b) Rear view

Figure 1. A dynamical model of the rider-motorcycle system

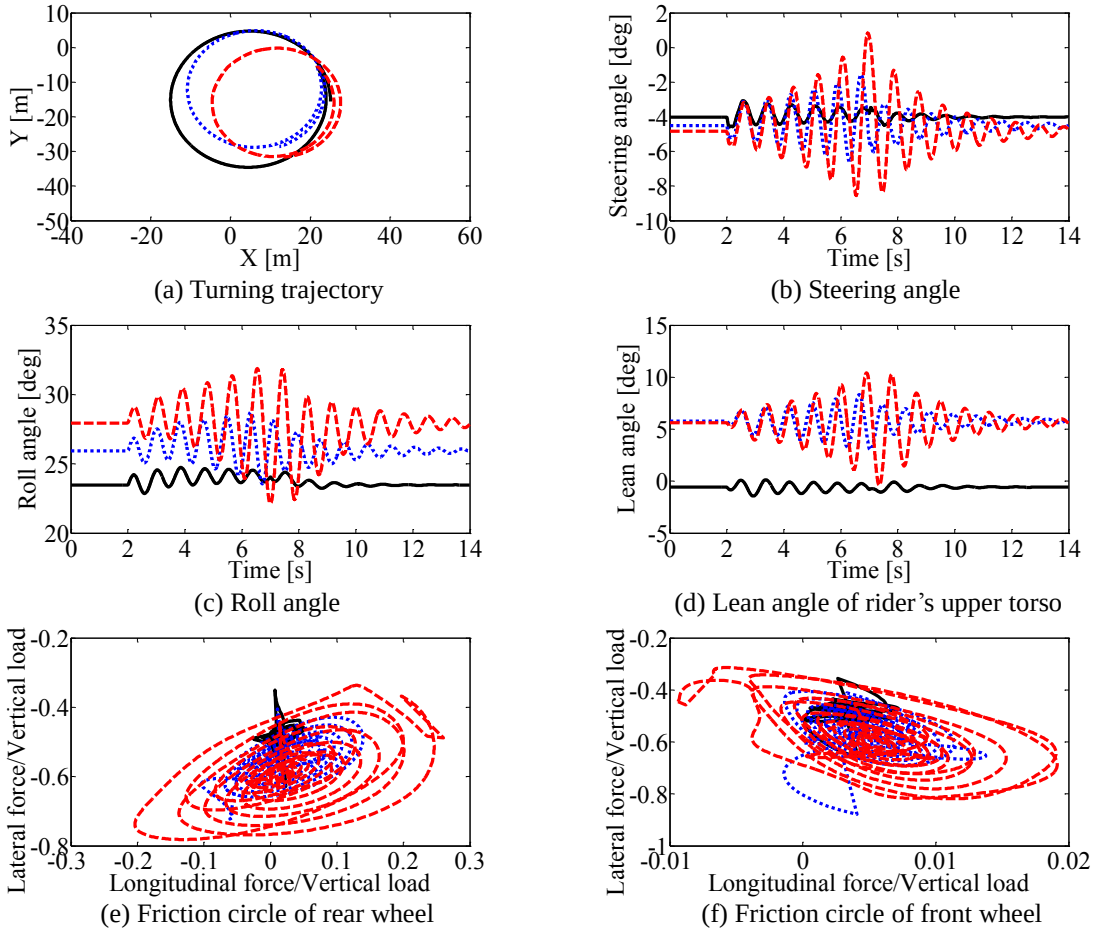


Figure 2. Simulation results of steady-state turning taking account of rider's effects at 35 km/h (0 s - 2 s: μ=0.8, 2 s - 7 s: μ=0.6, 7 s - 14 s: μ=0.8)

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