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A Virtual Rider for Reproducing Experimental Manoeuvres

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Abstract

The control of two-wheeled vehicles represents a challenging task. Indeed the stability of a bike is characterized by vibration modes which significantly change their behaviour with speed and acceleration and may become unstable under certain motion condition, see e.g. [1]-[3].

Different control strategies have been proposed in the past years, and the control of single-track vehicles remains an open research field. Nonlinear optimal control theory has proven successful, [4]-[5], but computational reasons make this approach not appealing for complex multi-boby model. PID approaches have demonstrated effective for constant speed or slowly varying manoeuvres, [6],[7]. Optimal linear time invariant controllers have been used for constant speed manoeuvres [8] and speed control [9]. The linear optimal control theory designed on a very simple motorcycle model has been used to control a complex multiboby code in [10]. A recent discussion on linear predictive control for motorcycle with constant speed simulations is devised in [11].

It is worth noting that most of the works available from literature deal with constant speed or slowly varying speed manoeuvres. On the contrary, this paper presents a virtual rider which controls the vehicle with both (strong) longitudinal and lateral accelerations. This is achieved by updating at each instant the control action based on the information of the approaching road section and the current vehicle state. This approach mimics the real rider behaviour, who looks ahead, learning a portion of the track, continuously using this information to decide when/how to steer and accelerate. In more detail, the approach is based on the predictive control theory framework. At each step the virtual rider computes the control action using an appropriate linear model which is derived from the full nonlinear multiboby model, see Figure 1.

As an example of application, the virtual rider is used to reproduce a lap of the Adria circuit (Italy): real bike speed and roll angle are used as target motion by the virtual rider, which controls the vehicle with longitudinal acceleration up to 1 g and roll angle up to 50°. In particular, in Figure 2 the roll and speed of the real vehicle (circles) are depicted together with the roll and speed of the multiboby model (solid line) ridden by the virtual rider. It is worth noting that the tracking is almost perfect, both in terms of speed and roll angle.

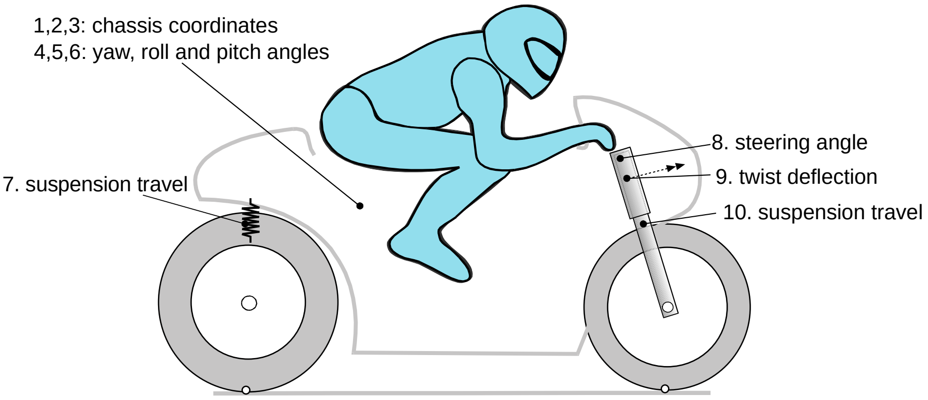

Figure 1. Degrees of freedom of the motorcycle model used for simulation.

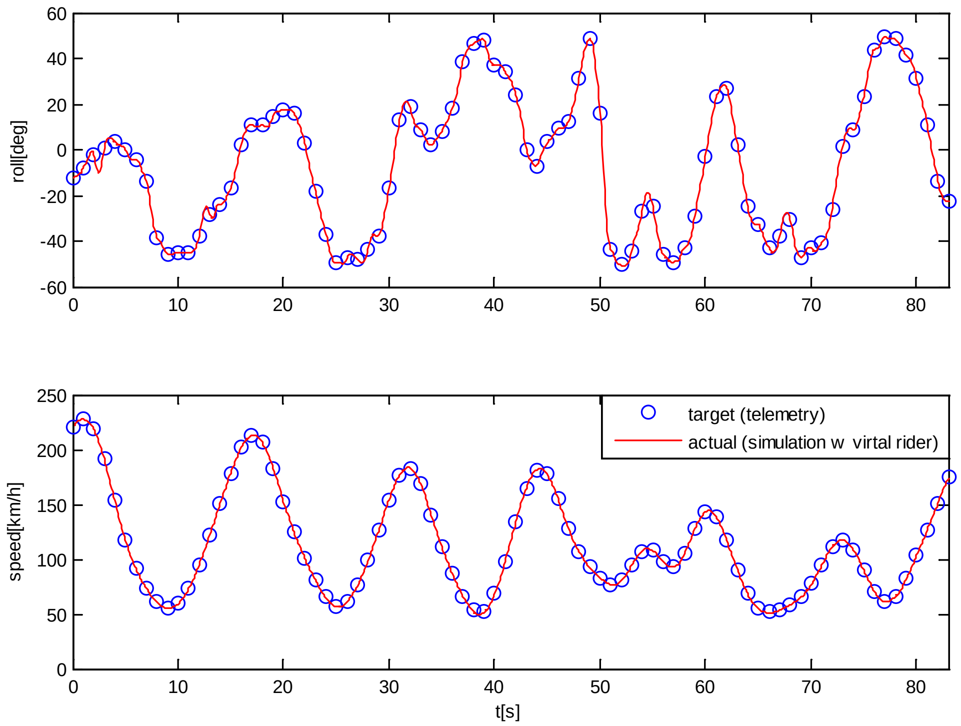

Figure 2. Comparison between simulation results (multiboby model with virtual rider, solid red line) and telemetry logged at the Adria circuit (blue circles).

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