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SELF-BALANCING ELECTRIC MOTORCYCLE MODELLING AT LOW SPEED: PRELIMINARY RESULTS

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In the autonomous driving the main challenge is vehicle stabilization with electronic control systems - even when vehicle stops - which can enhance riders' safety. A mathematical model which captures its main dynamics is needed for control system design, but such models has not been thoroughly investigated at low speed.

In the work a validated model of the motorcycle dynamics has been derived with the specific goal of a model simple but able to capture all the dynamics relevant to the capsize motion of two-wheeled vehicles. For these purposes, the work presents a 4 degrees of freedom model dynamically similar to an inverted pendulum that considers both rear and front wheel driving torques instead of rear driving torque and steering one. Moreover, steering axis is initially set on a strictly positive steering angle and is constant over time. Front wheel driving torque actuation with a rotated steering axis helps balancing when steering torque is not actuated. The analytical equations of motion are given by the Lagrangian approach: the result is a nonlinear second order ODE system in four unknowns - roll and yaw angles and rear contact point coordinates.

The analytical model has been then validated by FastBike, a computer simulation multibody software for dynamic analysis of two wheeled vehicles which includes five bodies, a nonlinear tyre model and nine degrees of freedom. The software has been suitably modified for low speed range. In validation process a controller has been designed using the analytical model and then applied to the multibody one: the simulations show a good match in roll and yaw angles comparisons. This indicates that the analytical model captures the main dynamics and can be used for model-based control design.

REFERENCES

[1] C. Yang and T. Murakami, Full-Speed Range Self-Balancing Electric Motorcycles Without the Handlebar. *IEEE Trans. on Ind. Electronics*, Vol. **63**, Num. 3, pp. 1911–1922, 2016.

[2] D. J. N. Limebeer and R. S. Sharp, Bicycles, motorcycles, and models, *IEEE Control Systems*, Vol.**26**, Num.5, pp. 34–61, 2006