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The influence of frame compliance and rider mobility on the scooter stability

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This article investigates the effect of frame compliance and rider mobility on the scooter stability. Particular attention is given to the wobble mode, because it may easily become unstable in the vehicle speed range. This article includes a synthetic discussion of previous works, presents a new mathematical model, and discusses the results of both numerical and experimental analyses of the vehicle stability by varying the vehicle characteristics and motion conditions.

The mathematical model describes the out-of-plane dynamics of the scooter and consists of a twelve-degree-freedom linear model. It describes the main scooter features and, in particular, includes the frame compliance, rider mobility, and an advanced tire model. The torsion and bending compliance of both the front fork and swingarm are modelled using lumped rotational springs; similarly, the rider mobility is described by means of two soft springs which connect the rider body to the chassis. The tire model describes in detail the carcass geometry and its compliance. The full scooter model is available on the website www.dinamoto.it and has been derived using 'MBSymba', which is a package for the symbolic modelling of multibody systems.

The scooter stability has been investigated at both low and high speeds; in particular, the effect of vehicle compliance and rider mobility on the weave and wobble modes have been examined. Numerical simulations show that the bending flexibility of the front fork stabilizes wobble mode at high speed and has a contrary effect at low speed, whereas the torsion flexibility of the fork does not appear to have a remarkable influence; the bending flexibility of the swingarm slightly stabilizes the weave mode at very high speeds whereas the torsion flexibility of the swingarm has a contrary effect. The effect of rider mobility is to stabilize the weave mode at high speed and the wobble mode at low speed.

Several experimental tests have been carried out in the same speed range and a good correlation between simulations and tests has been found. The variation of some important vehicle parameters has been investigated; in particular, tests were repeated for different values of the rear-frame inertia, the rear-chassis stiffness, the front-tire characteristics, the normal trail, and the steer inertia.

Keywords: Scooter; Motorcycle; Vibration modes; Stability; Frame compliance

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