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Bicycle dynamics: modelling and experimental validation

Abstract

This dissertation explores bicycle dynamics through an extension of the Whipple bicycle model and validation of the model equations equations of motion through the implementation of a robotic bicycle. An extended Whipple bicycle model is presented which makes uses of a unique set of physical parameters based on cylindrical gyrostats. The nonlinear equations of motion for this model are derived, linearized, and validated against a set of benchmark model parameters. A general formulation for the linearization of a system with configuration and velocity constraints is presented, and is demonstrated on an idealized rolling disk. The method of linearization is directly applicable to the equations of motion which result from the application of Kane's method. The linearization procedure is used to formulate the linear state space equations of motion for the bicycle model, which are then used as the plant model to design the robotic bicycle control system. The mechanical, electrical, and software aspects of the robotic bicycle are presented, along with representative results from a set of experiments.