Dynamics and Control of an Unmanned Bicycle

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ABSTRACT

In this report, the equations of motion of a bicycle are developed by using Lagrange ’ s equations for quasi-coordinates. The pure rolling constraints between the ground and the two wheels are considered in the dynamical equations of the system. For each wheel, two holonomic and two nonholonomic constraints are introduced in a set of differential-algebraic equations (DAE). The constraint Jacobian matrix is obtained by collecting all the constraint equations and converting them into the velocity form. Bicycle equilibrium, an algorithm for searching for equilibrium points of bicycles and the associated problems are discussed. Formulae for calculating the radii of curvatures of ground-wheel contact paths and the reference point are also given. To solve the DAEs of motion and ensure numerical accuracy in simulation of the bicycle system, computational methods for constraint handling are also discussed. From the developed dynamic model, PID and fuzzy controllers creating steering torque are derived to recover the balance of the bicycle from a near fall. After that, another fuzzy controller is added for controlling the bicycle to a desired equilibrium point. The bicycle can track a given roll-angle while retaining balance. Further more, ground-path following control for the unmanned bicycle is accomplished by taking the shortest distance from the vehicle to the given path and its heading direction into account. The effectiveness of the control schemes is proven by simulations. Finally, a new genetic algorithm is used to train fuzzy viitracking and path-tracking. Simulation shows that this algorithm is very efficient in the sense of fast-training time, small number of generations and good control performance. controllers for various control tasks such as: self-balancing, roll-angle

Keywords : Bicycle Dynamics, Multibody, Numerical Stability, Fuzzy Control, Path-tracking, Bicycle Stabilization, Genetic Algorithm.

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