Effect of crosswind on bicycle with or without rider control

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ABSTRACT

Crosswind has significant impact on safety, stability and performance of a cyclist. Despite the occurrence of fatal accidents due to crosswind (Fintelman, 2014), very limited work has been conducted in this area. The current research work aims to simulate the effect of crosswind on a bicycle in stable and unstable speed ranges, with or without rider control actions. This study is the first step in understanding the crosswind effect, which would help improve safety of cyclists and equipment, as well in defining guidelines for cycle lane infrastructure.

In this work we adopt the benchmark bicycle model developed by Meijaard et al. (2007), the rider model as identified by Schwab et al. (2013), and the experimentally obtained aerodynamic forces by Fintelman et al. (2014). The rider is modelled as a PID controller obtained by Schwab et al. (2013), wherein the gains are estimated by using system identification techniques during a set of lateral perturbation experiments on a narrow treadmill. Wherein, the rider senses roll and steer angles with their higher derivatives, and applies a steer torque. It is also assumed that the rider maintains a constant speed, and therefore only side force, yaw moment and roll moment due to crosswind are taken into account.

The simulations show that the rider-controlled bicycle has transient manoeuvres before it stabilizes at an equilibrium configuration, with a near zero heading angle and a small resultant roll angle. The controller steer torque is notably higher at the unstable speed, concluding that the rider puts extra control efforts to stabilize the system at that speed. In another situation of hands free bicycle, the bicycle tends to align with the wind direction while sustaining small oscillations, which requires future investigation.

Keywords: Crosswind, bicycle, control, stability, system identification.

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