

Multi-objective optimization of the stability of a bicycle

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ABSTRACT

This article presents the implementation of a multi-objective optimization methodology for the design of a bicycle, considering some of its main geometrical characteristics as design parameters. The design process aimed at improving the stability of the bicycle, considering its modes of vibration. First, ten stability indices were introduced for representing the stability properties of the bicycle in each mode. Then, a multi-objective optimization based on surrogate techniques was used to analyse three different cases of multi-objective optimizations, where each case was constructed using different combinations of stability indices as objective functions. In order to reduce the computational cost without losing accuracy in the results, a strategy of inheritance of design points already evaluated was included. The results showed in a first instance the behaviour of the different indices when different design spaces were explored. After centring the attention on the modes of vibration that can be effectively unstable for some speeds, the results of the optimization cases shown that the use of global stability indices can generate feasible configurations of the bicycle, while the optimization cases based on single-mode indices can be preferred to investigate the trade-off between different modes of vibration. For the proposed optimization methodology, it was found that its use can reduce the computational cost required for the construction of the Pareto front for the Multi-objective under study. Moreover, the reliability of the results can also be improved referred to the results obtained with the other optimization methodologies considered as benchmark for this work.

Keywords: bicycle, stability, optimal design, multi-objective.

1 INTRODUCTION

The design of bicycles is in constant development. Currently, the modifications to geometrical and mass parameters of bicycles are defined through different strategies as, for example, the optimal design. Different works reported modifications that aim to improve characteristics as handling [1], comfort [2], stability [3]-[5], performance [6], [7] or even aesthetics [8]. Several efforts have been made to study the effect that changes in a bicycle parameter have on its different characteristics.

Regarding bicycle stability, the studies are usually focused on the analysis of the modes of vibration of the bicycles. Some of the studies reported in the literature address the behaviour of the weave and capsize modes of vibration, while others consider the wobble mode. For example, Bulsink et al. [4] performed an analysis of the effect that the type of tires, the inflation pressure,