

Multi-Body Simulation and Multi-Objective Optimization Applied to Vehicle Dynamics

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Abstract – This paper describes a demo application, where modeFRONTIER, a commercial software for design optimization, is coupled with a parametric 2D Multi-Body model of a touring motorcycle. The optimizer is asked to identify the characteristics of the front suspension (telelever scheme) that deliver more safety, more stability, and more riding comfort for a braking maneuver in straight running. All objectives are described through 4 scalar indexes, extracted from the braking kinematics.

As expected, results highlight that trade-off relationships connect the objectives. Only 13, among the 1900 tested configurations, are able to simultaneously improve the 4 indexes. Moreover, no design in this selection assures a decisive improvement of the stability. In order to accomplish this priority requirement, the best design is chosen accepting a slight reduction of stability.

Key words: Motorcycle Optimization, Braking Maneuver, Telelever, Multi-Objective Optimization, Design Optimization

1 Introduction

Dynamical performances of two wheeled vehicles largely depend on the response of each component. Among all components, tires and suspensions are the most important sub-systems, because their role is to modulate any force going from the road to the chassis [1, 2, 3, 4]. Therefore, a deep knowledge of such parts can be the turning key to develop better and safer motorcycles.

Multi-Body Simulation is the most suitable approach to perform vehicle dynamics investigation [5, 6, 7]. By creating parametric models, different configurations can be quickly evaluated, even at the earliest stage of the entire development process. From a business perspective, this means that wrong gateways can be dropped long before they lead to costly and useless real prototypes.

These benefits can be further increased by coupling the Multi-Body Simulation software with modeFRONTIER, which automatically plans and drives sets of simulations in order to perform complex tasks such as Design of Experiment, Parameter Sensitivity Analysis, and Multi-Objective Optimization.

This paper describes a demo application, where modeFRONTIER is asked to identify the parameters of a motorcycle front suspension to deliver more safety, more stability, and more riding comfort for a braking maneuver in straight running. Although the research is targeted to a very specific case, the proposed methodology can be straightforwardly extended to any user-defined running condition. Potentially, it is possible to build a single modeFRONTIER project to optimize different vehicle parts for various maneuvers.

As expected, results highlight that trade-off relationships connect the objectives, hence full optimization is almost impossible. Only 13, among the 1900 tested configurations, are able to simultaneously improve the 4 scalar indexes that have been previously defined to measure the objectives.

Moreover, no design in this selection promises a decisive improvement of the stability. In order to meet these primary requirements, the best design is chosen accepting a slight reduction of stability. The decision task has been totally supported by the Multi Criteria Decision Making tool implemented in modeFRONTIER.

2 The 2D Motorcycle Model

The Motorcycle is a complex multi-body system and special efforts are necessary to reliably simulate the overall dynamics. The broad range of literature available on this topic covers all simulation fields, such as time domain behavior [6, 7], optimal maneuver [8, 9], steady trim [10], frequency response [11], modal properties [5, 14, 15], tire dynamics [12], and so on. Since this research aims at highlighting the benefits of implementing an optimizer into the simulation chain, a detailed and validated model is not available. Model features have been implemented following state-of-art guidelines [13] to ensure sufficient result reliability.

As a simple test case, the vehicle behavior at braking during straight line motion is considered. In general, lateral dynamics plays an important role and a detailed 3D model would be recommended to perform thorough investigation. However, a 2D model includes enough features to study the influence of the front suspension on the braking distance, keeping the simulation complexity at reasonable level. Indirect considerations on stability and vehicle comfort can be made in any event by examining the variation of some in-plane quantities [4, 14].

The motorcycle model used in this research consists of 7 rigid bodies, such as chassis (which includes the rider), rear wheel, swinging arm, front wheel and three bodies for the front suspension with telelever scheme. Bodies are connected using proper joints to obtain the exact number of in-plane degrees of freedom.

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7th International Munich Chassis Symposium 2016 Prof. Dr. Peter E. Pfeffer, 2016-08-15 In chassis development the three aspects of safety vehicle dynamics and ride comfort are at the top of the list of challenges to be faced Addressing this triad of challenges becomes even more complex when the chassis is required to interact with assistance systems and other systems for fully automated driving What is more new demands are created by the introduction of modern electric and electronic architectures All these requirements must be met by the chassis together with its subsystems the steering brakes tires and wheels At the same time all physical relationships and interactions have to be taken into account *Computational and Experimental Studies* Y. Villacampa, G.M. Carlomagno, S. Ivorra, C. A. Brebbia, 2018-03-28 Comprising specially selected papers on the subject of Computational Methods and Experimental Measurements this book includes research from scientists researchers and specialists who perform experiments develop computer codes and carry out measurements on prototypes Improvements relating to computational methods have generated an ever increasing expansion of computational simulations that permeate all fields of science and technology Validating the results of these improvements can be achieved by carrying out committed and accurate experiments which have undertaken continuous development Current experimental techniques have become more complex and sophisticated so that they require the intensive use of computers both for running experiments as well as acquiring and processing the resulting data This title explores new experimental and computational methods and covers various topics such as Computer aided Models Image Analysis Applications Noise Filtration of Shockwave Propagation Finite Element Simulations **Proceedings of InCoME-VI and TEPEN 2021** Hao Zhang, Guojin Feng, Hongjun Wang, Fengshou Gu, Jyoti K. Sinha, 2022-09-17 This volume gathers the latest advances innovations and applications in the field of condition monitoring plant maintenance and reliability as presented by leading international researchers and engineers at the 6th International Conference on Maintenance Engineering and the 2021 conference of the Efficiency and Performance Engineering Network InCoME VI TEPEN 2021 held in Tianjin China on October 20 23 2021 Topics include vibro acoustics monitoring condition based maintenance sensing and instrumentation machine health monitoring maintenance auditing and organization non destructive testing reliability asset management condition monitoring life cycle cost optimisation prognostics and health management maintenance performance measurement manufacturing process monitoring and robot based monitoring and diagnostics The contributions which were selected through a rigorous international peer review process share exciting ideas that will spur novel research directions and foster new multidisciplinary collaborations **Fuzzy Systems and Data Mining V** Antonio J. Tallón-Ballesteros, 2019-11-15 The Fuzzy Systems and Data Mining FSDM conference is an annual event encompassing four main themes fuzzy theory algorithms and systems which includes topics like stability foundations and control fuzzy application which covers different kinds of processing as well as hardware and architectures for big data and time series and has wide applicability the interdisciplinary

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harry frederick ward jr 15 october 1873 9 december 1966 was an english born american methodist minister and political activist who identified himself with the movement for christian socialism best remembered as first national chairman of the american civil liberties union aclu from its creation in 1920 until his resignation in protest

tureng ward türkçe İngilizce sözlük - May 20 2023

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harry frederick ward papers 1880 1979 columbia university - Mar 06 2022

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harry ward linkedin - Apr 07 2022

education 1 1 2022 2025 activities and societies social secretary exeter uni athletics club 23 24 vice president uni yacht crew 23 24 volunteer experience volunteer disc disability

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harry ward has 15 books on goodreads with 19 ratings harry ward s most popular book is the yorkshire birdman memoirs of a pioneer parachutist

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view harry ward s profile on linkedin the world s largest professional community harry has 3 jobs listed on their profile see the complete profile on linkedin and discover harry s connections and jobs at similar companies

[harry ward to resign pdc tour card at the end of the season](#) - Jan 16 2023

sep 15 2020 harry ward has announced a shock decision to step away from the pdc circuit at the end of the 2020 season ward 21 secured a tour card at qualifying school in january 2019 and went on to win a players championship title just four months later

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harry ward is the author of the yorkshire birdman memoirs of a pioneer parachutist 5 00 avg rating 1 rating 0 reviews when fate summons 3 00 avg ra

[the radicalization of the social gospel harry f ward and the](#) - Oct 13 2022

jun 18 2018 this article examines the career of one representative figure from this protestant left the reverend harry f ward as a means of describing the evolving nature and limits of social gospel radicalism during the first four decades of the twentieth century

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now prince harry and meghan markle roasted by family guy - Sep 12 2022

19 hours ago harry and meghan appeared as characters voiced by series regular actors in the third episode of family guy s 22nd season which aired on sunday as part of a cutaway unrelated to the main plot

harry ward wikipedia - Jun 21 2023

harry ward may refer to harry ward athlete ca 1901 1965 american college and professional athlete and negro league baseball player in the 1920s and 1930s harry ward cricketer 1924 1993 australian cricketer harry ward darts player born

harry ward lyrics songs and albums genius - Aug 23 2023

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