

Mechanical Engineering Thesis Defense

Optimization of Multibody Dynamic Models and Their Controllers

School for Engineering of Matter, Transport and Energy

Marcus Gambatese

Advisor: Dr. Wenlong Zhang

Abstract

Multibody Dynamic (MBD) models are important tools in motion analysis and are used to represent and accurately predict the behavior of systems in the real-world. These models have a range of applications, including the stowage and deployment of flexible deployables on spacecraft, the dynamic response of vehicles in automotive design and crash testing, and mapping interactions of the human body. An accurate model can aid in the design of a system to ensure the system is effective and meets specified performance criteria when built. A model may have many design parameters, such as geometrical constraints and component mechanical properties, or controller parameters if the system uses an external controller. Varying these parameters and rerunning analyses by hand to find an ideal design can be time consuming for models that take hours or days to run. To reduce the amount of time required to find a set of parameters that produces a desired performance, optimization is necessary. Many papers have discussed methods for optimizing rigid and flexible MBD models, and separately their controllers, using both gradient-based and gradient-free algorithms. However, these optimization methods have not been used to optimize full-scale MBD models and their controllers simultaneously. This thesis presents a method for co-optimizing an MBD model and controller that allows for the flexibility to find model and controller-based solutions for systems with tightly coupled parameters. Specifically, the optimization is performed on a quadrotor drone MBD model undergoing disturbance from a slung load and its position controller to meet specified position error performance criteria. A gradient-free optimization algorithm and multiple objective approach is used due to the many local optima from the tradeoffs between the model and controller parameters. The thesis uses nine different quadrotor cases with three different position error formulations. The results are used to determine the effectiveness of the optimization and the ability to converge on a single optimal design. After reviewing the results, the optimization limitations are discussed as well as the ability to transition the optimization to work with different MBD models and their controllers.



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