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GEOMETRIC PROGRAMMING FOR SPACECRAFT CONCEPTUAL DESIGN OPTIMIZATION

Abstract

A solid conceptual design from pre-phase A and phase A of a spacecraft project is critical for it to further grow, or even for it to ever leave the paper. An important part of this phase is understanding the key trades of the project, which today come either from experienced systems engineers, or some level of optimization of very crude models. Both offer their limitations, especially optimization in the traditional way it is done, as the number of interfaces across disciplines is very large, and the number of parameters required to better model the system soon becomes too large for the optimization algorithm to solve. Recent advances in convex optimization, also known as geometric programming, have lead to extremely fast solvers that can solve large optimization problems(variables and constraints on the order of 1000) in sub-second time. Additionally the solvers require no initial guesses or tuning of solver parameters, and guarantee globally optimal solutions. These benefits come at a price: all mathematical models that describe spacecraft design relations and physical constraints, must be expressed within the restricted functional forms of geometric programs. As shown by Hoburg et al. in the paper *Geometric Programming for Aircraft Design Optimization*, this is not as big a challenge as expected, as a large set of physics based models used for the early conceptual design satisfy the form required by geometric programs. Furthermore, for models that do not satisfy this form, Hoburg et al. have developed a set of general methods for generating surrogate models that accurately approximate the original models. Hoburgs results for aircrafts are here extended to spacecraft, through the conceptual design of a simple Earth orbiting satellite, illustrating optimization through geometric programing and its general application to the conceptual design phase in space systems engineering. Promising advantages of this method are also presented in more detail: the ability of building model libraries that can easily be plugged and played into new designs, thus significantly speeding up future design studies. Finally this work concludes with a section showing how geometrical programming enables rapid spacecraft architecture enumeration and exploration.