SPACE SYSTEMS SYMPOSIUM (D1)
Interactive Presentations (IP)

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AN AUTOMATIC MULTIDISCIPLINARY DESIGN OPTIMIZATION FRAMEWORK AND ITS APPLICATION TO LAUNCH VEHICLE

Abstract

Launch vehicles is a typical multidisciplinary coupling problem. Especially with more and more complicated disciplines involved, it becomes a complex system contained with abundant disciplinary coupling relationship and complicated modeling and solving process. Multidisciplinary Design Optimization (MDO) is the specific techniques to optimize these complex problems. Lots of MDO solution methods are proposed to settle these complex problem, but there is no conclusion which one is more suitable for a given MDO problem. Trying every MDO solution method will spend a lot of time and resources. Meanwhile, developing new MDO solution method also need a comprehensive comparison to evaluate the performance and feature. So an automatic and standard MDO model and solving framework is essential to apply the ability of efficient MDO application. This paper proposed an automatic multidisciplinary design optimization framework with brief definition and clear process. The disciplinary relation matrix (DRM) is proposed to describe the coupling relationship according to disciplinary input/output variables, and the MDO definition has been reformulate to adopt the new interfaces. Based on these, a universal MDO solving procedure is proposed to establish an automated and efficient way for MDO modeling and solving. This is implemented by an object-oriented framework in C++ environment, which is called as Automatic Fast Solving Environment for MDO (AFSEMDO). And a X37B-like launch vehicle MDO problem is studied. Six disciplines are considered, there are geometry, aerodynamic, structure, trajectory, Mass and Control. The total mass is chosen as the objective function and the shape sizing, structural strength, trajectory path and stability are chosen as the constraints. Newton panel method is used as the aerodynamic solver. Nastran is used as the structure solver. GPOPS is used to optimize the launch trajectory. Other disciplines are some C++ or MATLAB code. These complex MDO problem of launch vehicle is modeled and solved in the proposed MDO framework. The result shows these MDO framework can evaluate MDO problem automatically and efficiently, and could provide a more simplified way to solve complex MDO problems.