NTMATHEMATICAL PROGRAMMING MODELS AND ALGORITHMS FOR MULTIDISCIPLINARY DESIGN OPTIMIZATION

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Abstract. Multidisciplinary Design Optimization, MDO, "can be described as a methodology for design of complex engineering systems that are governed by mutually interacting physical phenomena and made up of distinct interacting subsystems". Modern design techniques require numerical models of each of the parts of the system and each of the interacting physical phenomena. These models were generally developed independently, as well as the simulation codes based on them. From a practical point of view, to be successful, MDO must be based on existing codes, as they are. It is not reasonable to ask engineers and scientists working in the different disciplines to modify their mathematical and numerical models and the corresponding computer codes to adapt them to MDO. MDO problems are naturally very large. They normally deal with a large number of design variables and include the state variables and constraints coming from all disciplines as well as the interaction between disciplines. Several techniques were developed to overcome this difficulty. Most of them try to decompose the problem into smaller sub problems or to work with reduced models for analysis and/or optimization. In this contribution we work with a model that considers the complete problem without reductions, decompositions or simplifications and present a numerical optimization algorithm for MDO. Our goal is very ambitious due to the size and complexity of the problems, but this can be a way to obtain strong and efficient tools for MDO. This model works with auxiliary variables and equality constraints to introduce the interaction between disciplines. In the classical approach for Design Optimization, the objective function and the constraints depend exclusively of the design variables and the state equations that represent the systems to be designed are solved at each of the iterations of the optimization process. Our approach also admits the Simultaneous Analysis and Optimal Design technique (SAND), which consists on adding the state variables to the design variables and including the state equation as additional equality constraints. Then, the state equation is solved at the same time as the optimization problem. FAIPA_MDO is based on FAIPA, the Feasible Arc Interior Point Algorithm. It takes advantage of the particular structure of MDO problems and allows classical or SAND optimization. The present algorithm includes several techniques for very large size problems, as an extension for constrained optimization of Limited Memory quasi-Newton method and iterative numerical techniques for the solution of the internal systems of FAIPA. In the case of SAND Optimization the size of the problem is reduced by a formulation that requires the solution of the tangent equilibrium equation. An important feature is that the internal solvers of Engineering Analysis Codes can be employed to solve these equations. In this way, FAIPA_MDO can interact with existing analysis codes to compute the state equation, the state sensitivity and to solve the tangent equilibrium equation.