Multidisciplinary design optimization

Researchers in academia, industry, and government continue to advance multidisciplinary design optimization (MDO) and its application to practical problems of industry relevance.

Delft University is defining high-level primitive "building blocks" to support conceptual design of aircraft from a multidisciplinary perspective. Tel Aviv University extended the topological design method for optimal actuator placement to reduce acoustical noise of vibrating surfaces. Technion-Israel Institute of Technology developed structural reanalysis models for dynamic and nonlinear problems and obtained accurate results for very large design changes.

The University of Pretoria applied its gradient-based optimization algorithms to design off-road vehicle suspensions. The University of New Castle finalized a large-deformation shell formulation for shape optimization, which is being coupled with a total Lagrangian beam element to analyze stiffened panels with geometric imperfections and residual stress capability.

The European Active Aeroelastic Aircraft Structures project tests an adaptive aircraft design concept with a wingtip leading-edge device developed using MDO in the 7-m-diam wind tunnel at TsAGI.

SGI and Ford are collaborating on massively concurrent high-performance computing for rapid visualization of design alternatives and steering, including advancements in mesh morphing for shape design changes. Penn State's Applied Research Lab has been collaborating with JPL and Lockheed Martin Space Systems to develop methods for visualizing multidimensional data sets and identifying Pareto frontiers.

RPI is developing surrogate models with reduced computational requirements to tackle larger problems more easily and develop more competitive designs. Sandia National Labs developed new second-order-accurate surrogate-based optimization methods, uncertainty quantification capabilities, and reliability-based design optimization methods, which are deployed through the publicly available DAKOTA toolkit for use by the Dept. of Energy, other U.S. government labs, and various commercial partners.

The University of Iowa is working with the Army on vehicle durability and reliability to support weight minimization initiatives in Stryker and Future Combat Systems. MDO is part of the aeroelastic design of high-altitude long-endurance concepts in support of the AFRL SensorCraft program. The University of Michigan investigated the impact of uncertainties in design optimization of hierarchical multilevel systems and applied analytical target cascading to simulation-based building design and integrated engineering/marketing decision-making.

Northwestern University is linking enterprise-level business decision-making with engineering decision-making to facilitate the design of large-scale artifacts that involve multidisciplinary efforts in marketing, product development, and production.

The University at Buffalo extended provable convergence conditions for m-discipline decentralized MDO problems to large nonlinear constrained problems. Clemson is targeting complexity and integration in design problems by studying coordination strategies, representation techniques, and multicriteria optimization on problems such as configuration design in transportation systems. MIT researchers are investigating the impact of new technologies as well as the tradeoffs between noise and engine emissions vs. performance and operating costs for commercial aircraft fleets. They are also developing techniques for optimally staging the evolution of satellite constellations over their life cycle, taking into account uncertainties in future coverage and usage patterns.

Wright State University investigated 3D preform shape design in forging problems using reduced basis concepts for extremely large-scale nonlinear plastic deformation problems. The University of Missouri-Columbia used MDO to incorporate the effect of materials processing on a product's material properties when designing short fiber-reinforced polymer composites. The University of Oklahoma improved displacement-based multilevel structural optimization by combining parallel subsystem-level optimizations with a substructuring approach for parallel system-level optimization. Penn State is developing and implementing coarse- and fine-grain parallelism in gradient- and nongradient-based MDO involving topology, shape, and sizing design variables.

Purdue is expanding the scope of MDO to "systems of systems" that require understanding the interfaces between diverse knowledge domains so that effective design algorithms can be developed for future transportation systems. NASA-Langley is developing a roadmap for a research effort in the analysis and design of novel transportation topologies that combines traditional operations research methods and innovative methods for complex adaptive systems.

by **Timothy W. Simpson**