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Practical Advances in Optimal System Design: What Method Should be Used When?

James T. Allison – Doctoral Student – University of Michigan
Panos Y. Papalambros – Professor – University of Michigan

Decomposition-Based Optimization

- Design of complex systems, such as automobiles and airplanes, is difficult because of the numerous system components that interact with each other.
- Decomposition-based optimization allows a design problem to be split into smaller, more manageable parts.

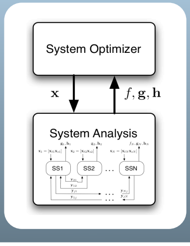
Research Objective

Show under what conditions the Individual Disciplinary Feasible (IDF) approach to decomposition-based optimization is preferable to the traditional Multidisciplinary Feasible (MDF) approach.

What is MDF?

Multidisciplinary Feasible Approach

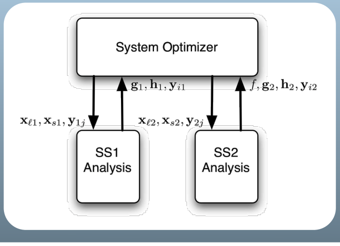
- System analysis performed for every optimization iteration
- Success dependent on system analysis
- Sequential: analyses cannot be executed in parallel



What is IDF?

Individual Disciplinary Feasible Approach

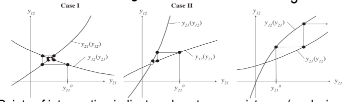
- Alternative method: optimizer helps perform system analysis
- Auxiliary constraints ensure system components agree
- Analyses can be executed in parallel



What Can Go Wrong With MDF?

Fixed point iteration is commonly used to perform the system analysis for MDF. FPI is easy to implement, but MDF inherits its problems:

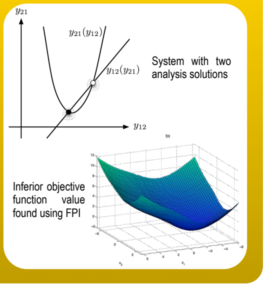
- May diverge or converge very slowly
- May not find the best of multiple analysis solutions



Points of intersection indicate subsystem consistency (analysis solution)

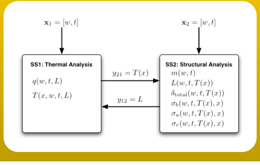
IDF Finds Hidden Designs

- Hypothesis: IDF can find optima that correspond to repelling fixed points
- Experiment: Use both IDF and MDF to solve a problem with multiple fixed points.
- Results:
  - MDF solution: -0.244
  - IDF solution: -975.7
- IDF found the superior solution
- MDF proven incapable of finding superior solution



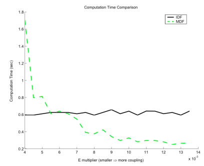
Turbine Blade Design

Thermoelastic design of a turbine blade: minimize heat transfer subject to constraints on temperature, stress, deflection, and mass.



IDF vs MDF: IDF Faster for Strong Coupling

- Coupling strength of turbine blade problem varied
- MDF computation time increases with coupling strength
- IDF is insensitive to changes in coupling strength



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BiomedicalEngineering University of Michigan
MichiganEngineering
KAIST
Lawrence Livermore National Laboratory
Macromolecular Science and Engineering Center
Materials Science and Engineering
Mechanical Engineering at the University of Michigan
Rackham
Schlumberger