Efficient Multidisciplinary System Design Optimization at the Mission Level

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Presentation Overview

• Introduction

• Current projects
  — Multidisciplinary design optimization (MDO) architectures
  — Multifidelity optimization (MFO)
  — Mission-level optimization (MLO)

• Future research
MDO Introduction

- Geometry
- Aerodynamics
- System Model
- Structural Analysis
- Performance
Research Introduction

• Optimizing complex system models is computationally expensive

• Efficiency can be improved with the right MDO architecture and/or MFO method

• Optimizing for mission success, rather than system performance, may better align with stakeholder needs
MDO problems can be formulated in different ways; this work compares two common architectures.

**Multidisciplinary Feasible (MDF)**

Optimizer → CFD → FEA

\[
\begin{align*}
\text{min}_x & \quad f \\
\text{s.t.} & \quad g \leq 0
\end{align*}
\]

**Individual Discipline Feasible (IDF)**

Optimizer → CFD → FEA → FEA

\[
\begin{align*}
\text{min}_x & \quad f \\
\text{s.t.} & \quad g \leq 0 \\
& \quad y - \hat{y} = 0
\end{align*}
\]
MDO Architectures Results

- Architectures optimized 15 times using surrogate-based algorithm
- MDF finds better optima but takes more time – confirming predictions found in the literature
- MDF has a more straightforward set up
- IDF can take advantage of parallel processing and may be more suitable for siloed work structures
- IDF coupling constraints can hinder algorithm convergence

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Multifidelity Optimization

Low-fidelity Model
Faster run time, less accurate results

High-fidelity Model
Slower run time, results accurate enough for application

MFO:
Accurate enough results, significant time savings
Models used in MFO Study

• Simplified models
• Projection-based models
• Surrogate models
• Experimental data

This project uses a coarsened mesh and a surrogate model for the two lower-fidelity models.
Multifidelity Optimization Results

- Multifidelity model management strategy did not save time
- Time and effort to create MFO routines needs to be considered

Mission-Level Optimization

• MLO is an alternative to system-level optimization

• Can leverage mission scenario simulations to improve communication with key stakeholders

• MLO combines several challenging aspects of optimization
• Highly stochastic UAS/counter-UAS search mission

• Sampled using definitive screening design and created surrogate models for mission success and two “intermediate” variables
Mission-level Optimization Results

- Solution improved over other designs with no crashes
- Intermediate variables provide opportunities and difficulties
- Capability to run simulation faster than real time is important

Future Research

• Extend and validate MDO architecture and MFO work with new models currently under development

• Conduct an in-depth literature review of mission-level modeling and define and test a new strategy for MLO

• Combine MDO architectures, MFO methods, and MLO strategy to efficiently optimize a more complex mission scenario
Questions

Thank you for your time!

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