A self-organizing approach to the design of complex engineered systems

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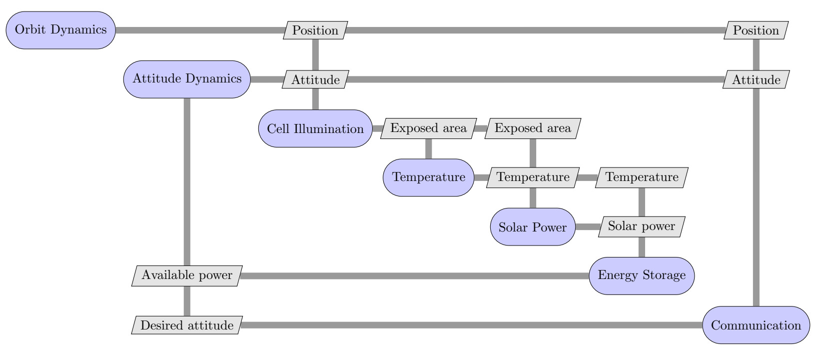
Motivation

Engineering systems often involve many coupled disciplines.



Optimization exploits the coupling and finds unintuitive designs.

Gradient-based optimization can handle O(1000) design variables,

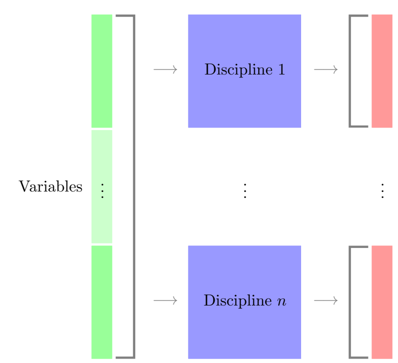
However, it is difficult to implement.

Project objective

To develop a self-organizing method to couple multidisciplinary models for optimization.

Theory

We mathematically formulate the multidisciplinary computational model as a nonlinear system:



$$R(u) = 0$$

This formulation leads to an equation that unifies all methods for computing discrete derivatives.

$$\frac{\partial R}{\partial u}\frac{\mathrm{d}u}{\mathrm{d}r} = \mathcal{I} = \frac{\partial R}{\partial u}^T \frac{\mathrm{d}u}{\mathrm{d}r}^T$$

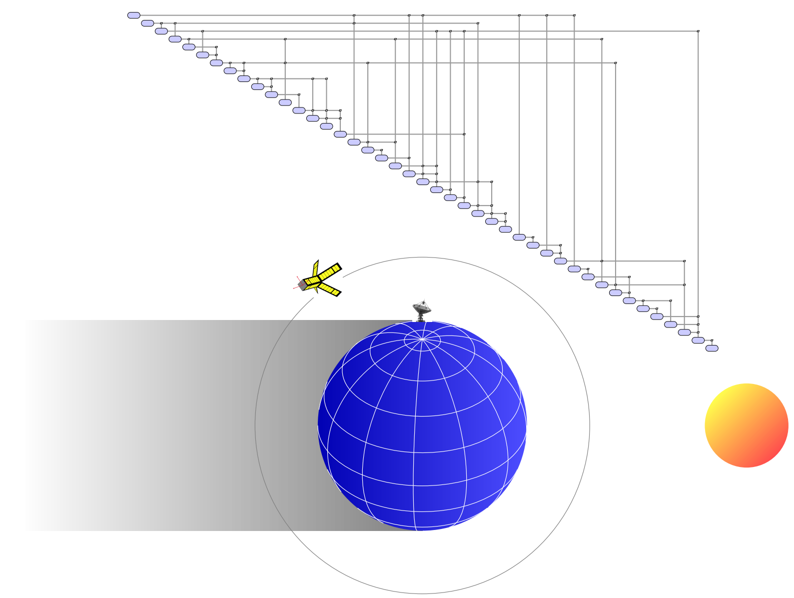
Parallel framework

We have implemented these equations in a parallel framework for multidisciplinary optimization.

They have also been adopted in NASA's OpenMDAO framework.

Application

This framework has been applied to several engineering problems including nano-satellite design.



Self-organizing approach

We are now developing ways to optimally order and group the disciplines for efficiency and robustness.