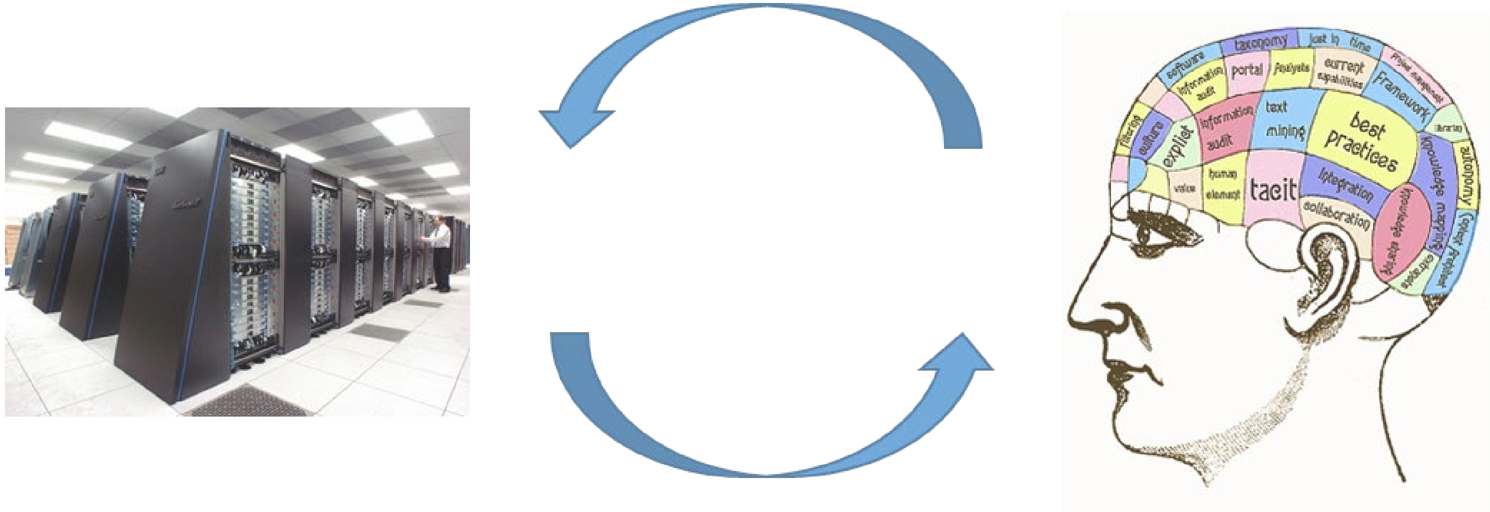
Human-Machine Symbiotic Design of Complex Systems

Prof. Daniel Selva <dselva@tamu.edu>

NSF EDSE Workshop

October 8 2019



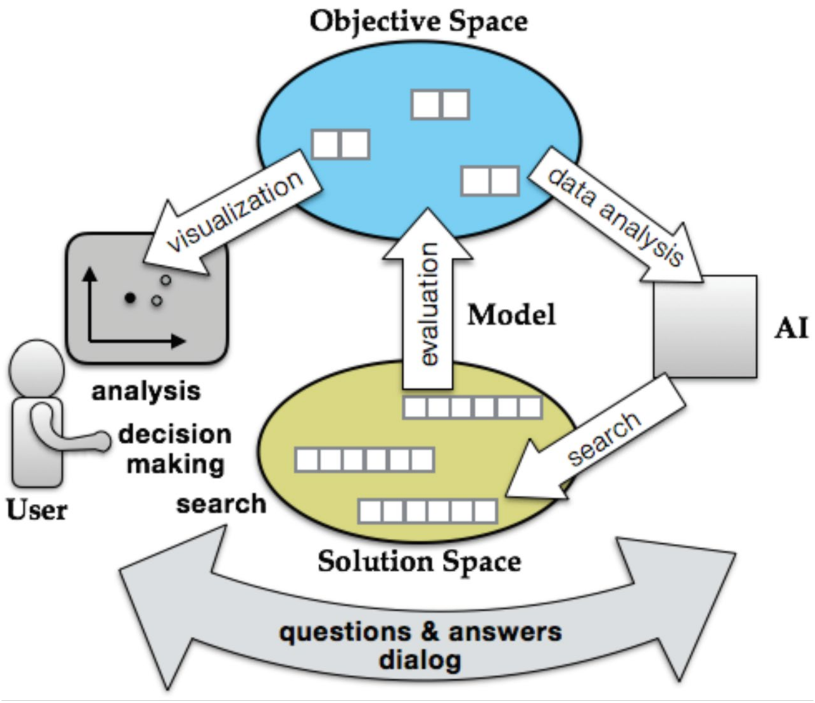
Co-PI: Guy Hoffman (Cornell U)
Co-I: So-Yeon Yoon (Cornell U)

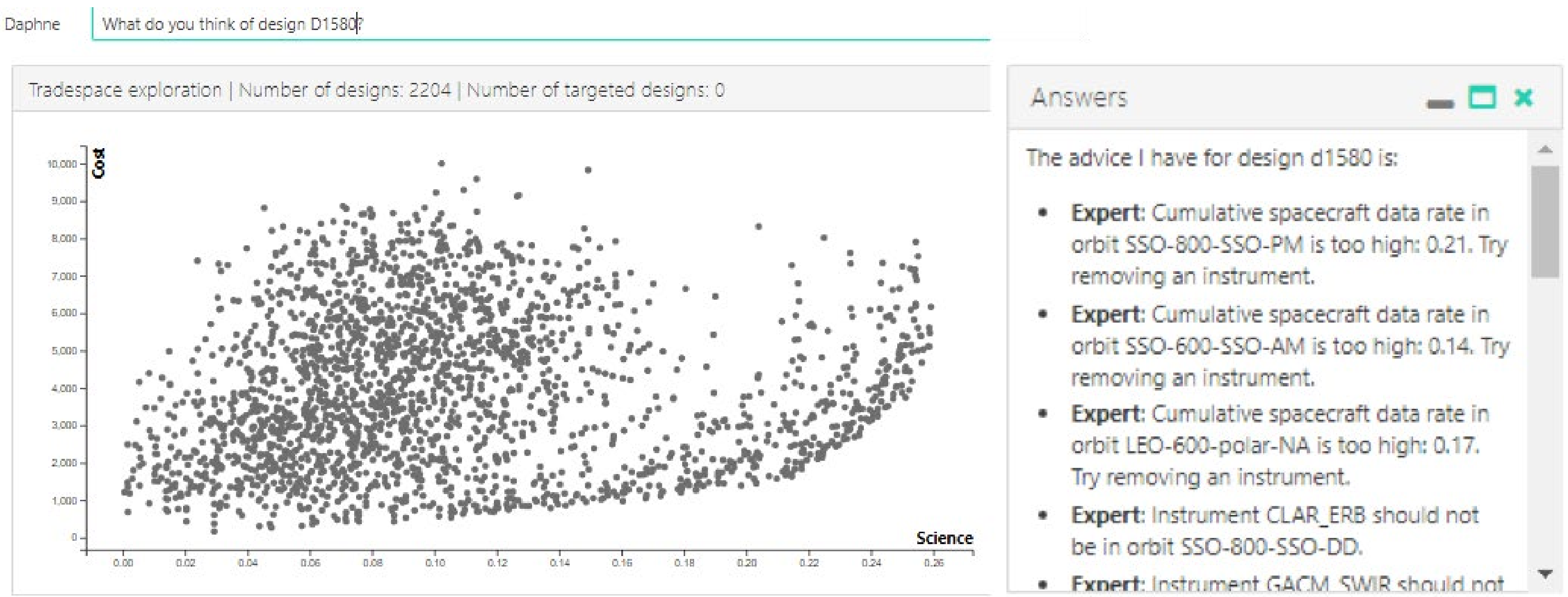
NSF CMMI #1907542

Co-PI: Meredith Silberstein (Cornell U)

NSF CMMI #1825521

Human-machine collaborative design space exploration





Human-machine collaborative design space exploration

Objective 1: Multiple agents and role allocation

- New roles (functionality and level of initiative) for design assistants (e.g., "Explorer" role)
- Effect of number of agents and role-to-agent allocation
- Effect of allowing agents to converse with each other
- **Measures**: design quality and diversity, designer learning, dialog structure, trust

Objective 2: Intent inference and anticipation

- Model and infer human intent in DSE using dynamic Bayes nets
- Model and infer agent optimal action (e.g., suggest design, criticize design) using MDP and reinforcement learning

Knowledge- and data-driven design of mechanical meta-materials

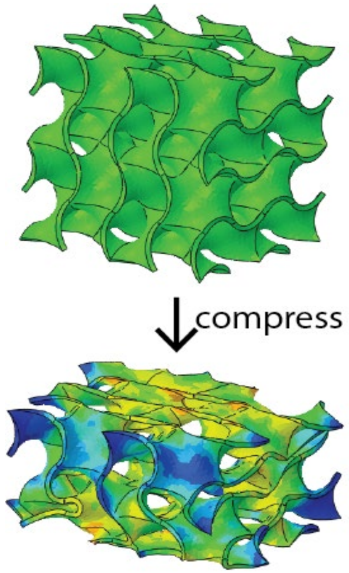
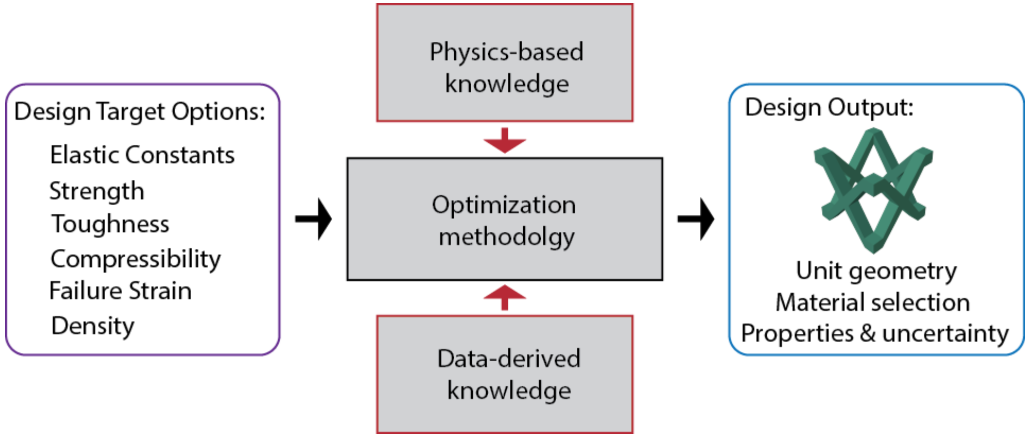


Figure 7. Gyroid before and after 50% strain. Contour shows Mises stress.



Research Objectives

1. Derive physics-based low computational cost models and design heuristics
2. Derive low computational cost surrogate models
3. Develop and evaluate strategies to combine expert knowledge and data-driven approaches to improve design space exploration

Expert knowledge:

- Physics laws
- Heuristics
- Beliefs

- **Scope**: 3D-printed lattice and minimum energy surface materials

Combining expert knowledge and data in design of mechanical meta-materials

Evaluate various strategies in benchmark and real-world problems and provide guidelines about when to use them

while *not converged* **do**:

$f_i \leftarrow SelectModel(x_i; M)$

$y_i \leftarrow ApplyModel(x_i; f_i)$

$O_i \leftarrow SelectOperator(x_i; S)$

$x_i \leftarrow ApplyOperator(x_i; O_i)$

Model selection

- Pool of models (physics-based model, FEA simulation, surrogate model, or human-as-model)
- Screening and clustering
- Select model w/highest expected accuracy in region
- Weighted average, w_0 = beliefs, update with data

Operator selection

- Pool of operators (domain-independent, based on heuristics, physics laws, learned from data, or human-as-operator)
- Bandit-based adaptive operator selection