Human-Machine Symbiotic Design of Complex Systems

Prof. Daniel Selva <d_selva@tamu.edu>
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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
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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

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

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

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

**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, \( w_0 = \text{beliefs}, \text{update with data} \)

```plaintext
while not converged do:
    f_i ← SelectModel(x_i; M)
    y_i ← ApplyModel(x_i; f_i)
    O_i ← SelectOperator(x_i; S)
    x_i ← ApplyOperator(x_i; O_i)
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