Human-machine interactions when visualizing datasets beyond 3D

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Background: The human eye is well equipped to understand 2D and 3D datasets but this is insufficient for capturing the complexities of 'real' problems we face. From correlations in medical treatment procedures to engineering design variables, many complex systems require a large (i.e., greater than 3) number of critical variables. In my laboratory, we regularly are trying to understand trends in 5 and 6 dimensions when we design new energy materials.

As part of the NSF Institute for Data-Driven Dynamical Design, a $16M institute centered at Mines, we have been considering how humans interact with such complex datasets and make decisions when given guidance by machine learning algorithms (e.g., Bayesian optimization with Gaussian processes). However, a consistent barrier has been how to communicate to the human the rational underlying the machine learning suggestions. We thus have a specific goal of communicating Gaussian process uncertainty in spaces ranging from 4D – 6D. We are equally excited about the inverse problem where domain users navigate 4D-6D spaces to offer expert feedback to active search algorithms.

Project Goal: The overarching goal is to create a package that facilitates dataset visualization in 4D-6D and is responsive to user navigation and feedback. To achieve this goal, critical subgoals include:

- Explore approaches to high dimensional visualization and identify target visualization approaches (e.g., time, color, dimensional reduction).
- Develop backbone mathematical code to handle transformations into the visualization space.
- Craft a user-friendly visualization front end for displaying data.
- Develop input functionality for incorporating user feedback from mouse clicks.

Stretch goal: Incorporate user feedback into uncertainty in Gaussian process.

Skill sets: Flexible; experience in python and visualization is a plus

Team size: Three to four students is probably appropriate.

Location: CSM