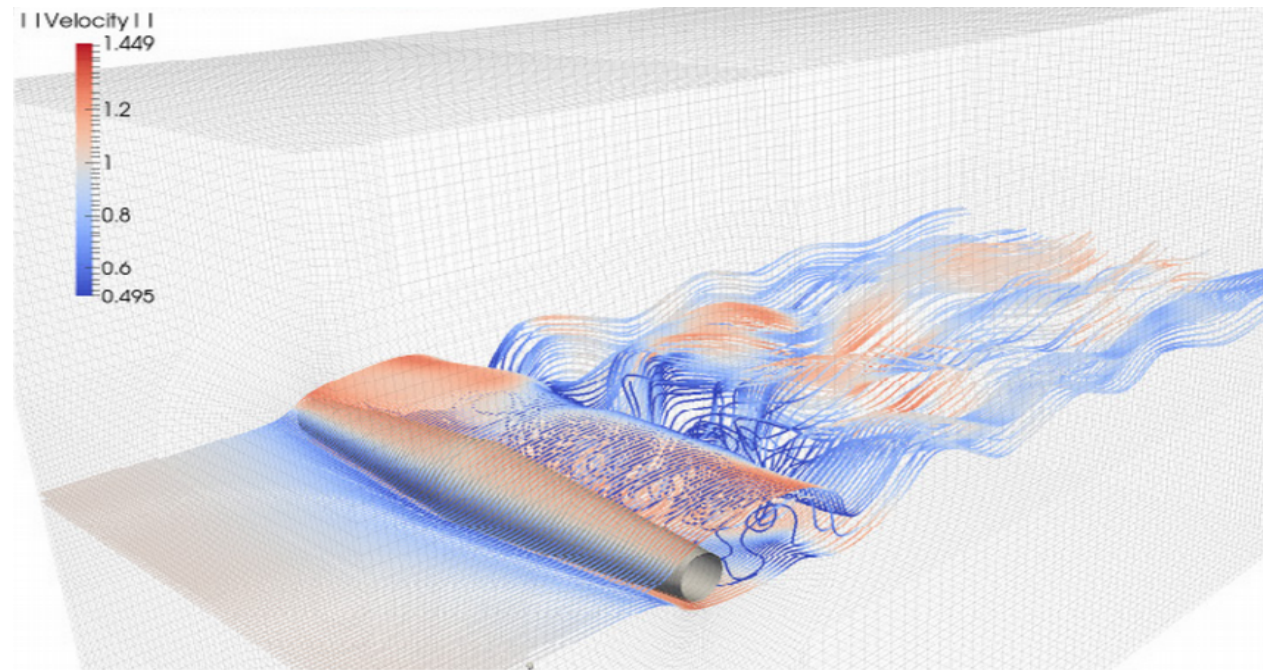


Control and Optimization in the Age of Data

DFG Round Table

Erlangen, 2nd May 2023

Anton Schiela



Klus/Geiß/Peitz/Schütte 2018



UNIVERSITÄT
BAYREUTH

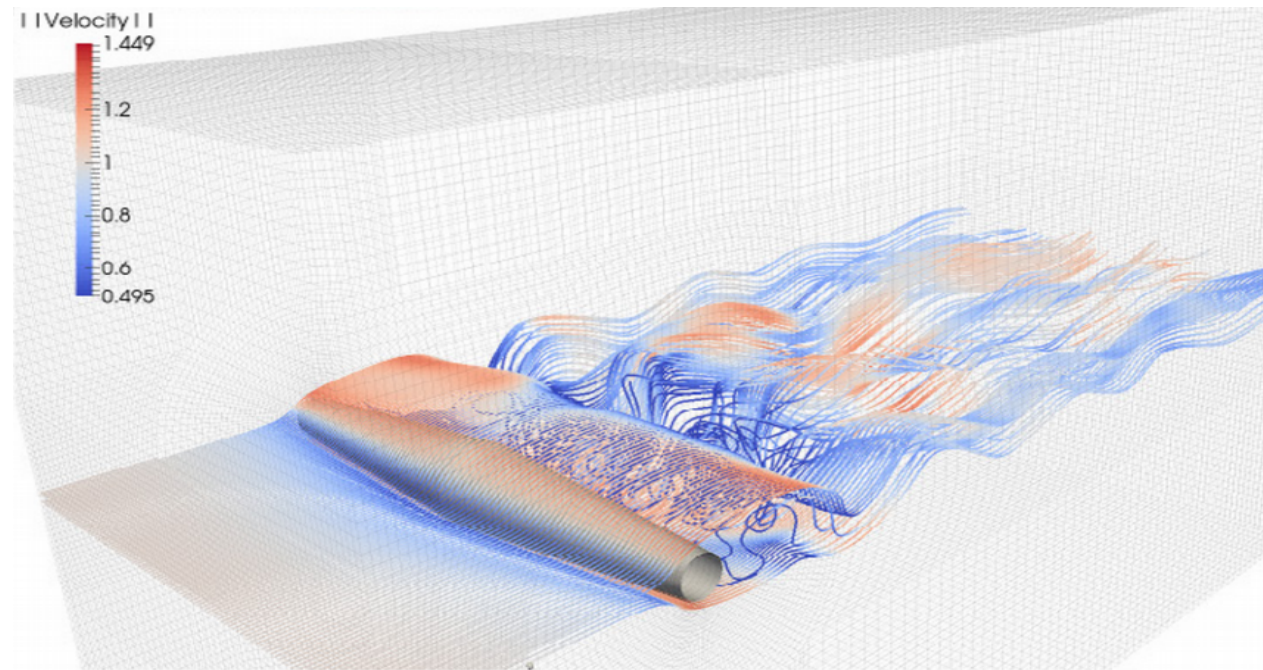
Control and Optimization in the Age of Data

Infinite dimensional approaches at the interface of control, optimization, and learning

DFG Round Table

Erlangen, 2nd May 2023

Anton Schiela



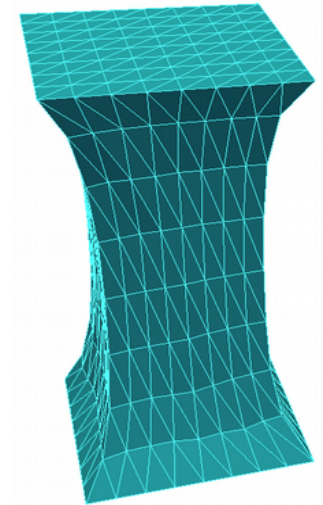
Klus/Geiß/Peitz/Schütte 2018



UNIVERSITÄT
BAYREUTH

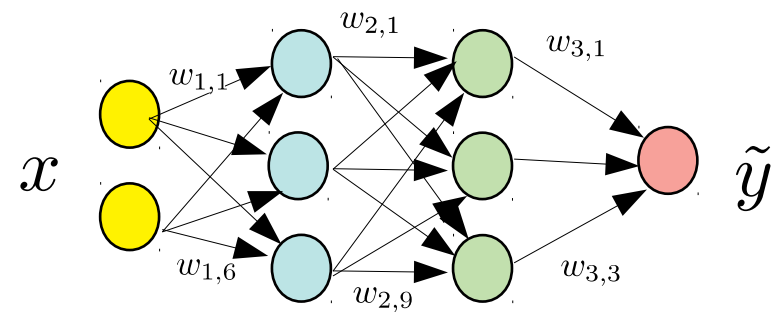
Classical „Modeling-Simulation-Optimization“:

- Requires accurate models, scientific insight
- Efficient algorithms exploit mathematical structure
- Performance guarantees, reliability

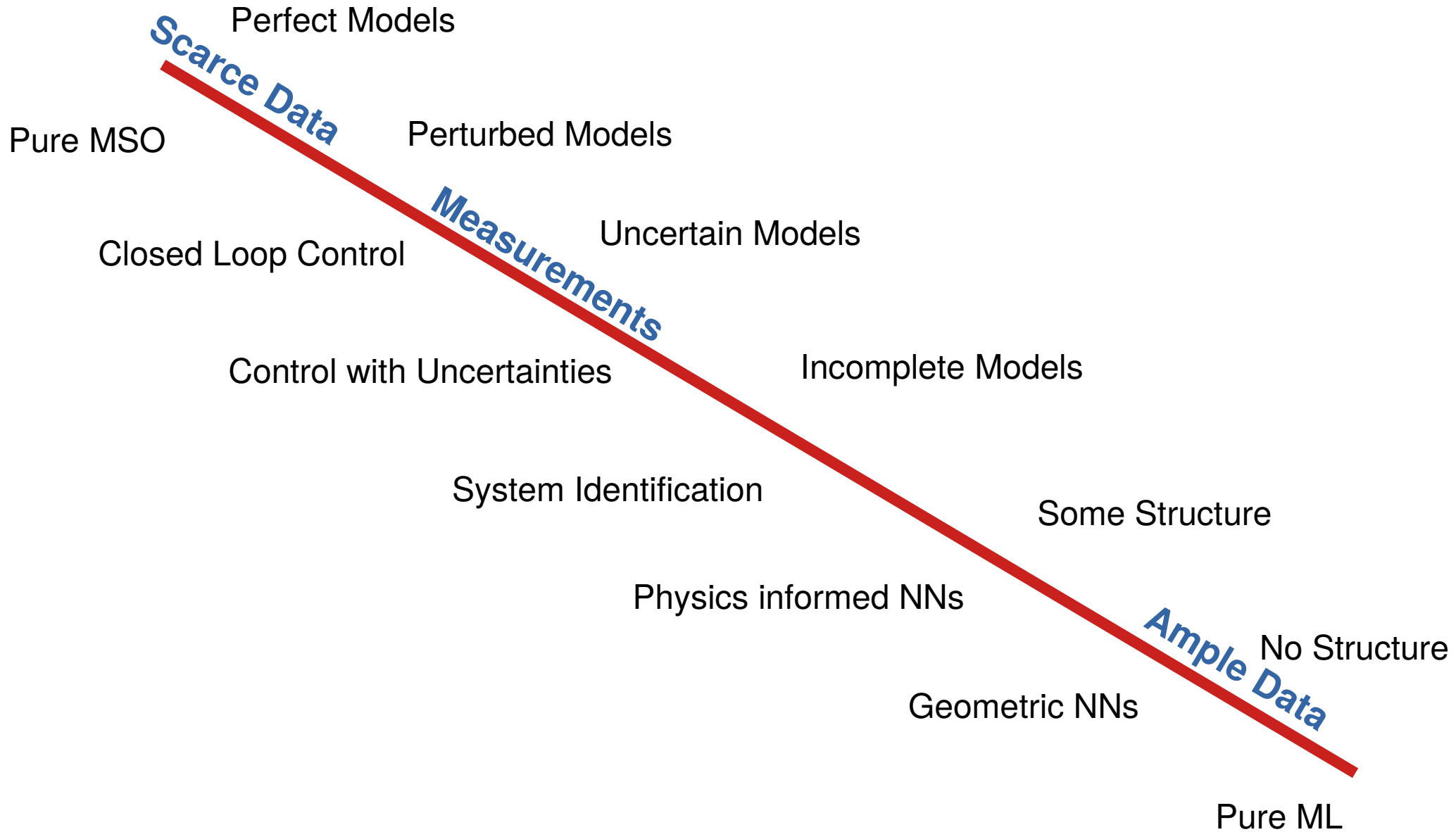


Classical „Neural network“:

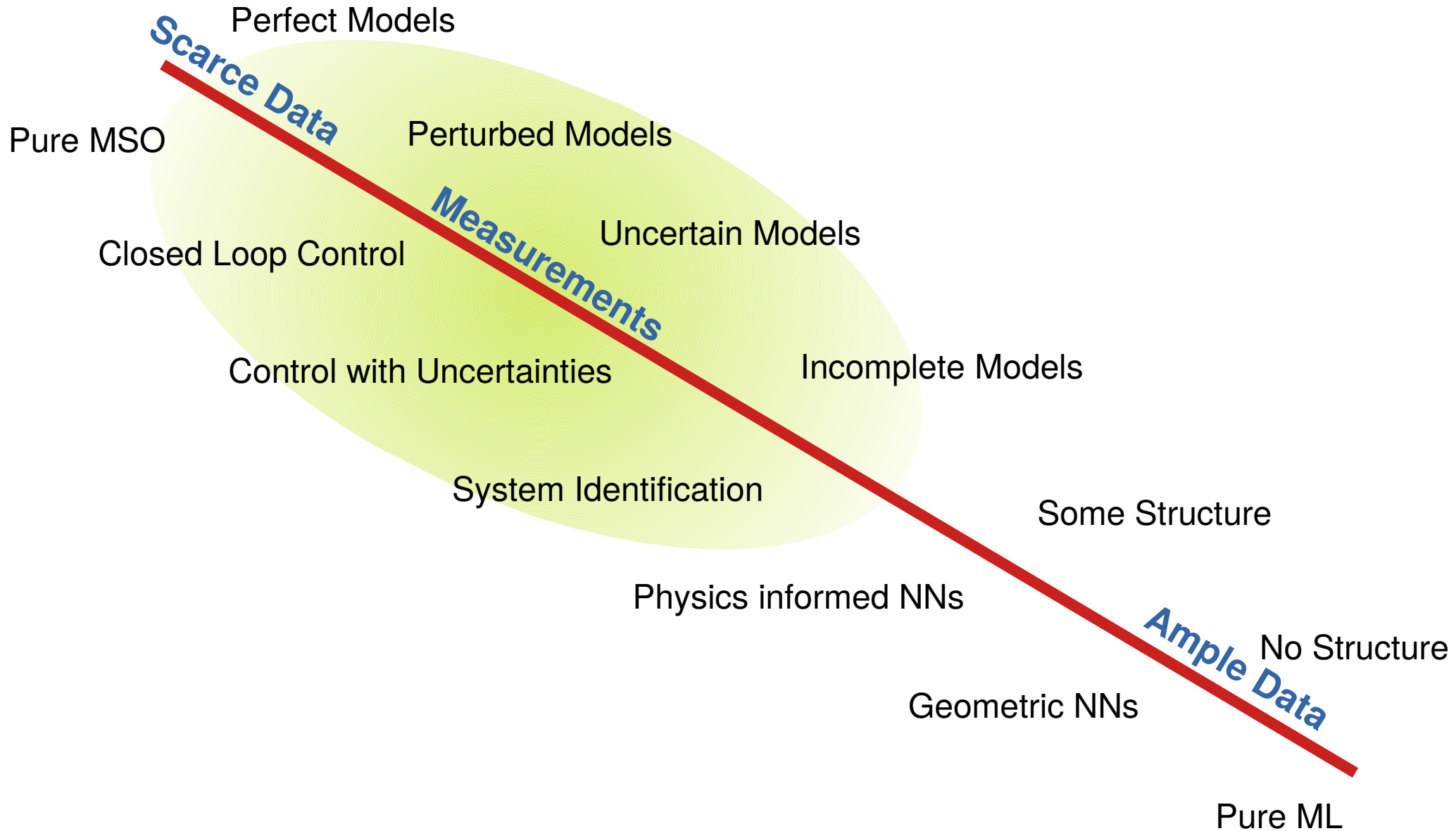
- Generic models, requires lots of data
- Special hardware for efficiency
- Lack of guarantees, adversarial examples



Spectrum: Models and Data



Scope of our SPP initiative



Analysis:

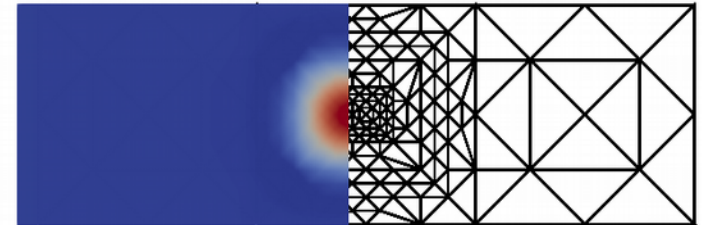
- Gain insight into class of problems
- Identify inherent mathematical structure

$$\min_{u \in H_0^1(\Omega)} \mathcal{E}(u)$$

$$\rightarrow 0 = \frac{d}{du} \mathcal{E}(u) \delta u \quad \forall \delta u \in H_0^1(\Omega)$$

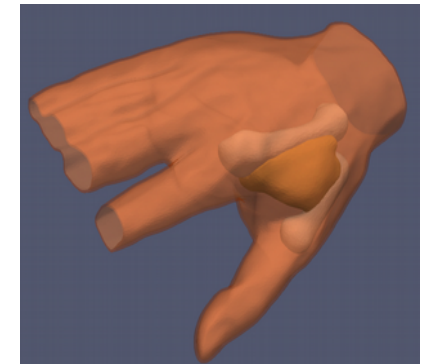
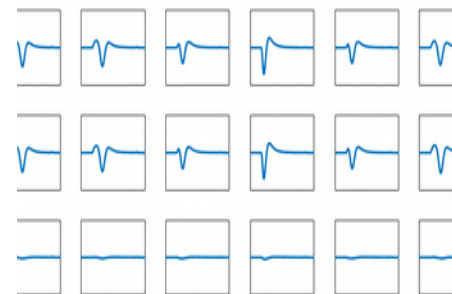
Algorithms:

- Efficiency by exploiting structure
- Provable reliability



Applications:

- Solve specific difficult problem
- Interdisciplinary cooperations



Establish mathematics in data-driven control & optimization of complex systems

Focus on:

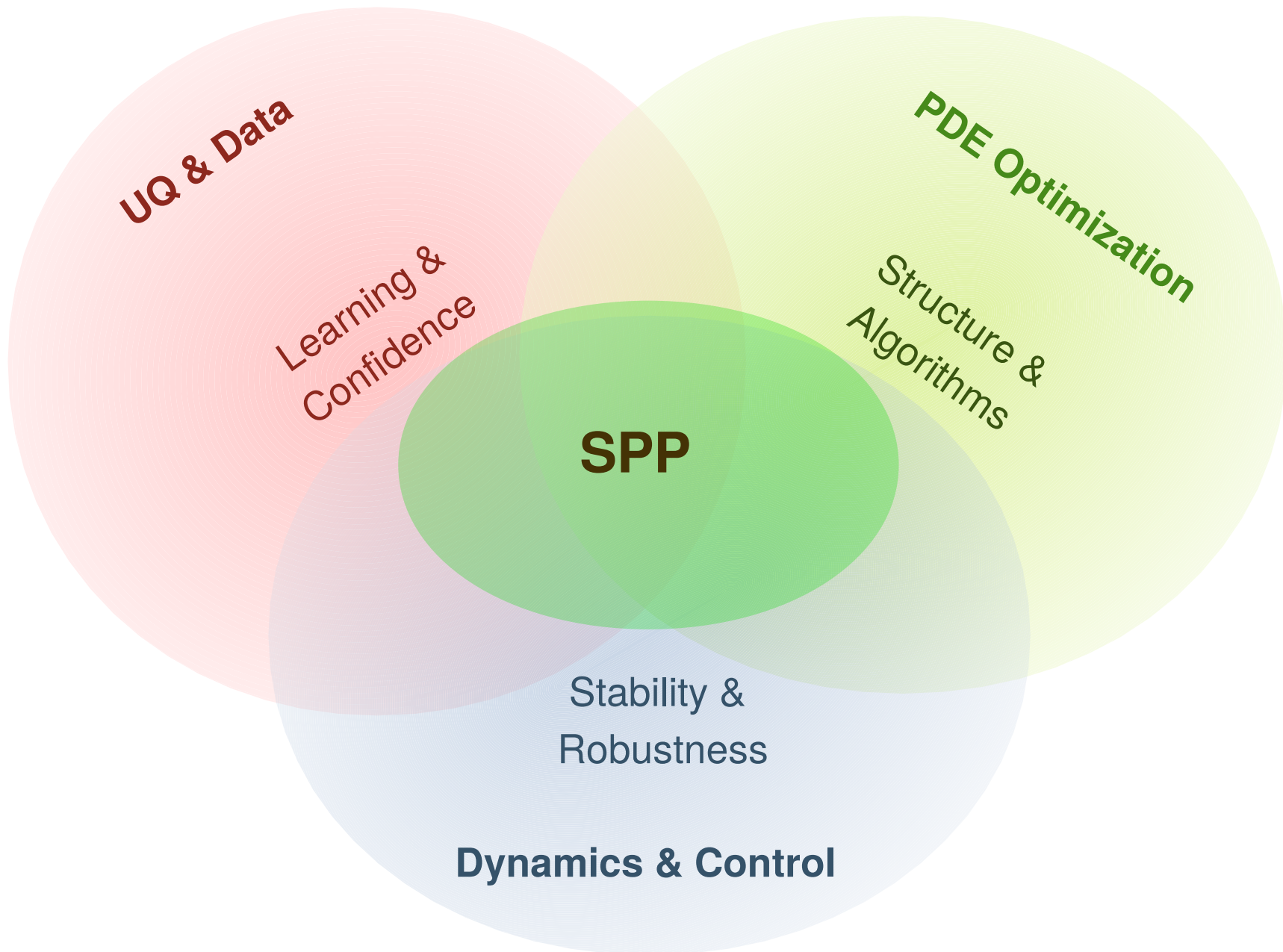
- Control and optimization
- Infinite dimensional systems: PDEs, reformulations of SDEs...
- Mathematically sound approaches and reliable algorithms
- Inherent structure of models and data

Example Topics

Control and optimization of infinite-dimensional systems with uncertainties

Theory and algorithms for data-driven optimal control

Enhancements of and alternatives to reinforcement learning



Control and optimization in Germany:

- Successful research tradition for many years
- Internationally leading senior and new generation of young researchers
- Steeply rising interest in data-driven and machine-learning techniques

Prerequisites for success:

- Understanding of infinite dimensional systems and PDEs
- Research spans the range from mathematics to applications
- Long experience with complex optimization algorithms

Joint Initiative in Applied Mathematics:

- PDE Constrained Optimization
- Closed-Loop Control and Systems Theory
- UQ, Data-Driven Modeling of Dynamical Systems

Timeline:

- Autumn 2022: first discussions, formation of initiative
 - May 2023: round table
 - Autumn 2023: planned submission of proposal to DFG
 - In case of success: Summer 2024: call for project ideas
- Summer 2025: start of SPP