Computational framework for the optimal control of multi-reservoir systems under uncertainty

Design Optimization

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Problem Statement

- Real-time control of multi-objective and multi-reservoir systems imposes a significant challenge!

- Factors that raise complexity:
  - Multiple sources of uncertainty
  - Multiple objectives
  - Multiple reservoirs
  - A large number of constraints

- Real-time decision making needs:
  - fast and reliable results in few seconds
  - to incorporate uncertainty (robust solutions)
Approach & method

We combine three technological advances:

**Performance Graph Simulation**
- Ultra-fast simulation of unsteady flows

**Robust Optimization**
- Includes uncertainty information in the objective function

**Stochastic Collocation**
- Efficiently (parallel, non-intrusive) propagates uncertainty through systems
- Orders of magnitude faster than Monte-Carlo sampling
Current state of practice & research

Current limitations:

• Very slow
• Deterministic Optimization (no uncertainty)
• Local optimization methods
• Difficulty satisfying constraints
• Single-thread computation
Deliverables & benefits

- **Reliability** via improved decision making
- **Faster results** via parallelization
- **Money saved** via better informed decision making which considers uncertainties in the system
  - We intend to deliver a software implementation for decision making
Project plan

2013:
• Methods for Uncertainty Quantification
• Robust Optimization formulation

2014:
• Probabilistic constraint formulation
• Performance Graph simulation model

2015:
• Robust Hybrid Optimization for optimal control of reservoir systems
How ours is different

We aim to produce a framework which

- uses hybrid optimization for real-time operation of multi-objective and multi-reservoir systems
- is robust and computationally efficient (parallelizable)
- accounts for uncertainty and provides flexibility
Industrial relevance

- Improved relations with external agencies
- **Money saved** via better informed decision making which considers uncertainties in the system
- Techniques developed can be applied to complex systems in industry