

Multiobjective Optimization of Simulations with PARMOO

Tyler Chang^a and Stefan Wild^a

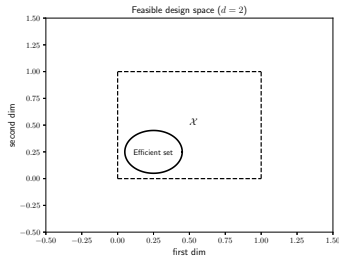
^aMathematics and Computer Science Division,
Argonne National Laboratory

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What is Multiobjective Optimization?

Problem setting:

We can control input variables...



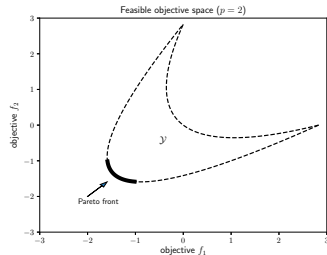
We can observe the response to inputs...

Numerical simulation?
Real-world experiment?
Build a prototype?
Run a test?



$$F : \mathcal{X} \rightarrow \mathcal{Y}$$

We want to minimize quantities of interest...



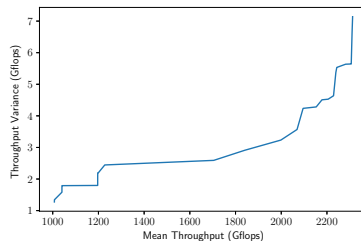
Solution is the *Pareto front* — a tradeoff surface balancing conflicting objectives.

An Example in HPC System Performance

Want to manage tradeoff between performance variability and mean performance in HPL linear system solver on HPC system Bebop at Argonne

- ▶ Adjust 5 configuration settings for HPL
- ▶ For each setting, run HPL 30 times on 4 nodes of Bebop, and compute the mean and standard deviation of throughputs

Use multiobjective optimization to maximize mean & minimize std dev



[1] Chang, Larson, and Watson. *Multiobjective optimization of the variability of the high-performance LINPACK solver. To appear in Proc. 2020 Winter Simulation Conference.*

The Spectrum of Computational Expense

Reasonable!

- ▶ Eval: \approx secs
- ▶ Budget: $\approx 10,000$
- ▶ Software: Genetic algorithms

- ▶ Eval: \approx mins
- ▶ Budget: ≈ 1000
- ▶ Software: Research codes

Very hard!

- ▶ Eval: \approx hrs
- ▶ Budget ≈ 100
- ▶ Software: ??

Computationally cheap —————> expensive

Our solver is PARMOO — A flexible framework for solving multiobjective optimization problems all accross the expense spectrum

- ▶ In order to solve problems of varying expenses and with varying amounts of available domain knowledge, we support interchangeable solvers, search strategies, problem types, and varying amounts of information
- ▶ We will also leverage the `libEnsemble` library for extreme scale parallelism

Continued Work

- ▶ We are working on adding solvers and features to support widening classes of problems
- ▶ We are also looking into the integration with `libEnsemble` [2]
- ▶ We are looking for new problems to test our solvers on and and widen our support for new problem types!

[2] Chang, Larson, Watson, and Lux. Managing computationally expensive blackbox multiobjective optimization problems with `libEnsemble`. In *Proc. 2020 Spring Simulation Conference (SpringSim '20)*. SCS, Fairfax, VA, USA, Article No. 31, 12 pages.

Email: tchang@anl.gov

BlueJeans Q&A Room: 580 115 580
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