

# Multiobjective Optimization of Simulations with PARMOO

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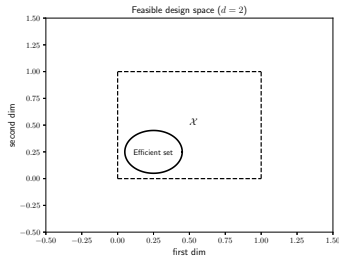
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# What is Multiobjective Optimization?

## Problem setting:

We can control input variables...



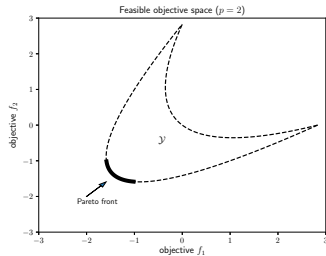
We can observe the response to inputs...

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



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

We want to minimize quantities of interest...



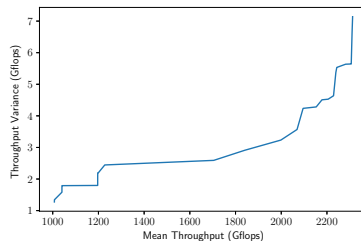
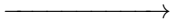
Solution is the *Pareto front* — a tradeoff surface balancing conflicting objectives.

# 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:  $\approx 1000$
- ▶ Software: Research codes

Very hard!

- ▶ Eval:  $\approx$  hrs
- ▶ Budget  $\approx 100$
- ▶ 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.

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(<https://bluejeans.com/580115580>)

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