Design Space Exploration: Advanced Topics

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Outline

• Multi-objective Optimization
• Constrained Optimization
• Prior Injection
Outline

• Multi-objective Optimization

• Constrained Optimization

• Prior Injection
Multi-objective Optimization

• Some applications have multiple objectives
Multi-objective Optimization

• Some applications have multiple objectives
• The objectives are often conflicting:
  • Improving one makes the others worse
Some applications have multiple objectives

The objectives are often conflicting:
- Improving one makes the others worse

Goal is to find the Pareto front
- Set of solutions that cannot be improved without making at least one objective worse
Multi-objective Optimization

Objective 1

Objective 2

Samples

Pareto Front
Multi-objective Optimization

Objective 1
Objective 2

threshold
threshold

Samples
Pareto Front
Multi-objective Optimization

- Demo example 4: HyperMapper on DLTZ1
Outline

- Multi-objective Optimization
- Constrained Optimization
- Prior Injection
Constrained Optimization

- Some applications have feasibility constraints
  - E.g. Spatial’s constraints on FPGA resources
Constrained Optimization

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  • E.g. Spatial’s constraints on FPGA resources
• Goal is to find the best \textit{feasible} solutions
Constrained Optimization

- Some applications have feasibility constraints
  - E.g. Spatial’s constraints on FPGA resources
- Goal is to find the best feasible solutions
- HyperMapper predicts which solutions will be feasible

```json
"feasible_output": {
  "enable_feasible_predictor": true
},
```
Constrained Optimization

Graph showing the relationship between cycles (log) and logic utilization (%) for GDA Benchmark.
Constrained Optimization

HyperMapper not using the model for the feasibility constraint
Constrained Optimization

HyperMapper using the model for the feasibility constraint
Constrained Optimization

About 2x in Cycles, 10% difference in Logic
Constrained Optimization

GDA Benchmark

Wasted samples
Constrained Optimization

- Demo example 5: HyperMapper on Chakong-Haimes
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Prior-injection

- Users have an idea of which parameter values will be good
  - Example: How many threads on a CPU with 4 cores?
  - Gaussian-shaped around 4
Prior-injection

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  - Priors help converge faster
Prior-injection

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  • Example: How many threads on a CPU with 4 cores?
  • Gaussian-shaped around 4
• Prior helps guide search towards good solutions
• HyperMapper combines the prior with BO model
  • Priors help converge faster
  • Still converges if priors are wrong
Prior-injection Example

![Graphs showing comparison between shallow CNN, deep CNN, and MD Grid.](image)

- **Shallow CNN**
  - Random Sampling
  - Expert Configuration
  - HyperMapper
  - HyperMapper + Prior

- **Deep CNN**

- **MD Grid**

Cycles (log) vs. Number of Evaluations
Prior-injection Example

**Shallow CNN**
- **Cycles (log)**: 24,154,953 to 4,197,501
- Number of Evaluations: 0 to 50

**Deep CNN**
- **Cycles (log)**: 24,154,953 to 1,202,604
- Number of Evaluations: 0 to 50

**MD Grid**
- **Cycles (log)**: 8,886,111 to 22,026
- Number of Evaluations: 0 to 140

**Convergence**
- **Deep CNN** converges 1.4x faster
- **Shallow CNN** converges 1.58x faster
- **HyperMapper** and **HyperMapper + Prior** compared to **Random Sampling** and **Expert Configuration**
Prior-injection Example

- **Random Sampling**
- **HyperMapper**
- **Expert Configuration**
- **HyperMapper + Prior**

**Shallow CNN**

- Cycles (log) vs. Number of Evaluations

**Deep CNN**

- Cycles (log) vs. Number of Evaluations

**MD Grid**

- Cycles (log) vs. Number of Evaluations

1.28x speedup
Prior-injection Example

- Under review at NeurIPS 2020
- Open-source + arxiv version in 2 weeks!
The HyperMapper Framework