BOAT: Building Auto-Tuners with Structured Bayesian Optimization

Paper Authors: Valentin Dalibard, Michael Schaarschmidt, Eiko Yoneki
Presenter: Jiahao Gai
Background: Black Box Optimizer

Learning rate

Batch size

Neural network

Precision
Background: Black Box Optimizer

Input 1

...?

Input n

Target

Black Box Problem
Background: Bayesian optimization

*Bayesian Optimization builds a probability model of the objective function, which is used to select hyperparameters to evaluate in the true objective function.*
Background: Bayesian optimization

“Bayesian Optimization builds a probability model of the objective function”
Background: Bayesian optimization

“Bayesian Optimization builds a probability model of the objective function”

10 samples from the true objective function
Background: Bayesian optimization

“Bayesian Optimization builds a probability model of the objective function”

Initiate the surrogate model
Background: Bayesian optimization

“and use it to select hyperparameters”
Background: Bayesian optimization

Put it Altogether

**Algorithm 1** The Bayesian optimization methodology

**Input:** Objective function \( f() \)

**Input:** Acquisition function \( \alpha() \)

1: Initialize the Gaussian process \( G \)
2: for \( i = 1, 2, \ldots \) do
3: Sample point: \( x_t \leftarrow \arg\max_x \alpha(G(x)) \)
4: Evaluate new point: \( y_t \leftarrow f(x_t) \)
5: Update the Gaussian process: \( G \leftarrow G \mid (x_t, y_t) \)
6: end for
Background: Bayesian optimization

AKA. Sequential Model-Based Optimization
Problem Statement

unsuccessful at tackling optimizations in high dimensional space

1) Cannot accurately capture the objective function landscape after a reasonable number of iterations due to the curse of dimensionality

2) The numerical optimization algorithm, used in each iteration, fails to converge and find a promising point.
Structured Bayesian Optimization (SBO)

A novel extension of Bayesian optimization capable of leveraging bespoke probabilistic models to rapidly converge to high-performance configurations.
Structured Bayesian Optimization (SBO)

Figure 1: Procedure of Structured Bayesian Optimization
Two advantages of SBO

1. It captures the user’s understanding of the behavior of the system

2. Using such a model allows us to monitor runtime properties reflected in the model and use them for inference.
BOAT (BespOke Auto-Tuner)

Figure 3: Flow of data when using BOAT
Design of BOAT Framework

- Semi-parametric models
- DAG models
Evaluation

The evaluation focuses on quantifying two properties:

- **The benefits of auto-tuning**

- **The need for a bespoke auto-tuner.**

in two case studies:

- **Garbage collection**

- **Neural networks**
Evaluation

Comparison with other auto-tuners in two case studies

Garbage collection case study

Neural network case study
Pros
- Handling Complex Configuration Spaces
- Reduced Number of Iterations for Convergence
- Global Performance Portability

Cons
- Complexity in Building Probabilistic Models
- Potential Failure in Capturing Objective Function Landscape
Reverences

Questions?