Multi-Objective Bayesian Optimisation: Optuna, Ax and RayTune

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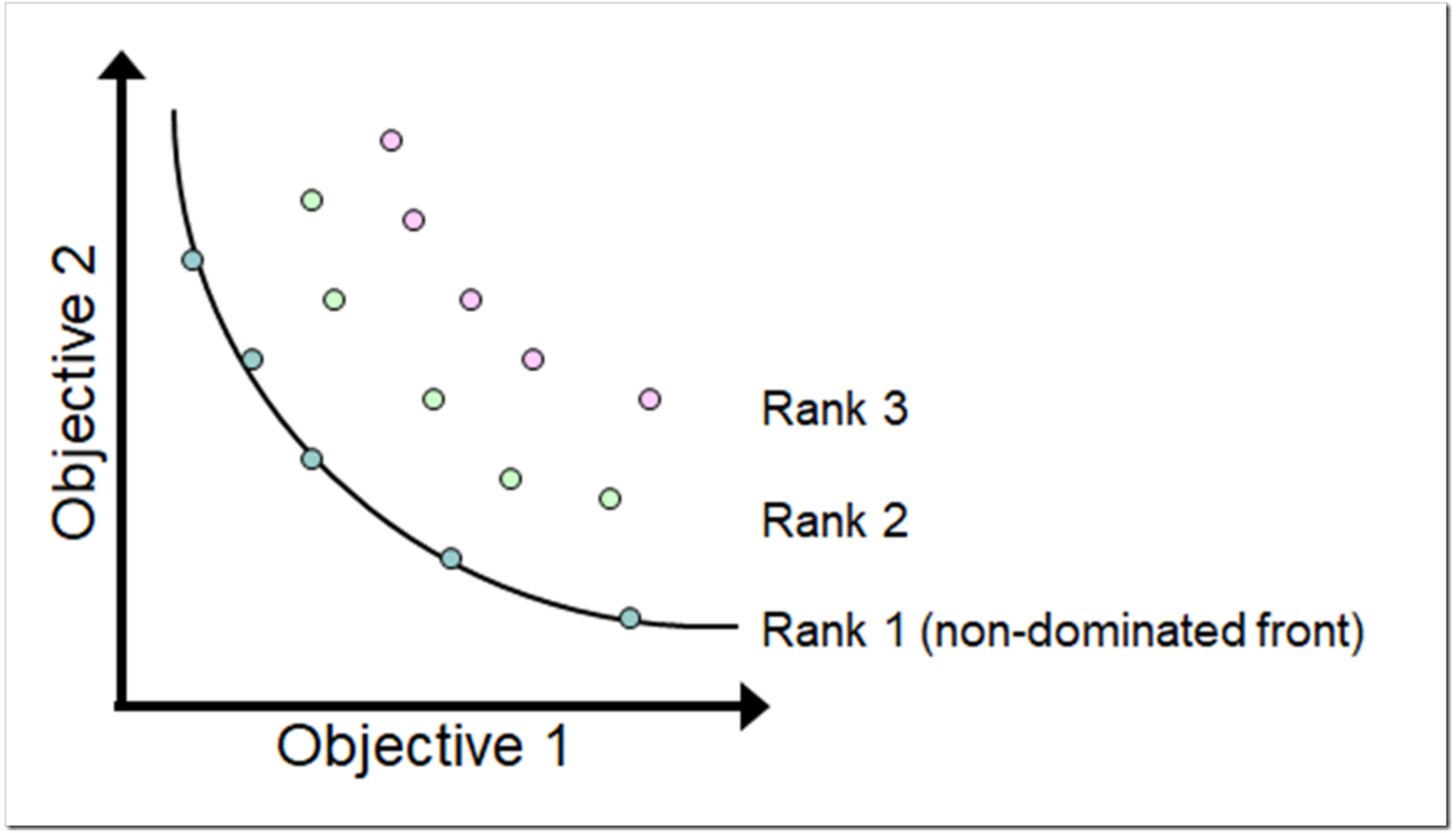
Parameter Optimisation Is a Big Thing!

- Test every combination — how to traverse fast?
- Used for:
  - Hyperparameter Tuning
  - Neural Architecture Search
  - Reinforcement Learning
  - List goes on

Multi-Objective Optimisation

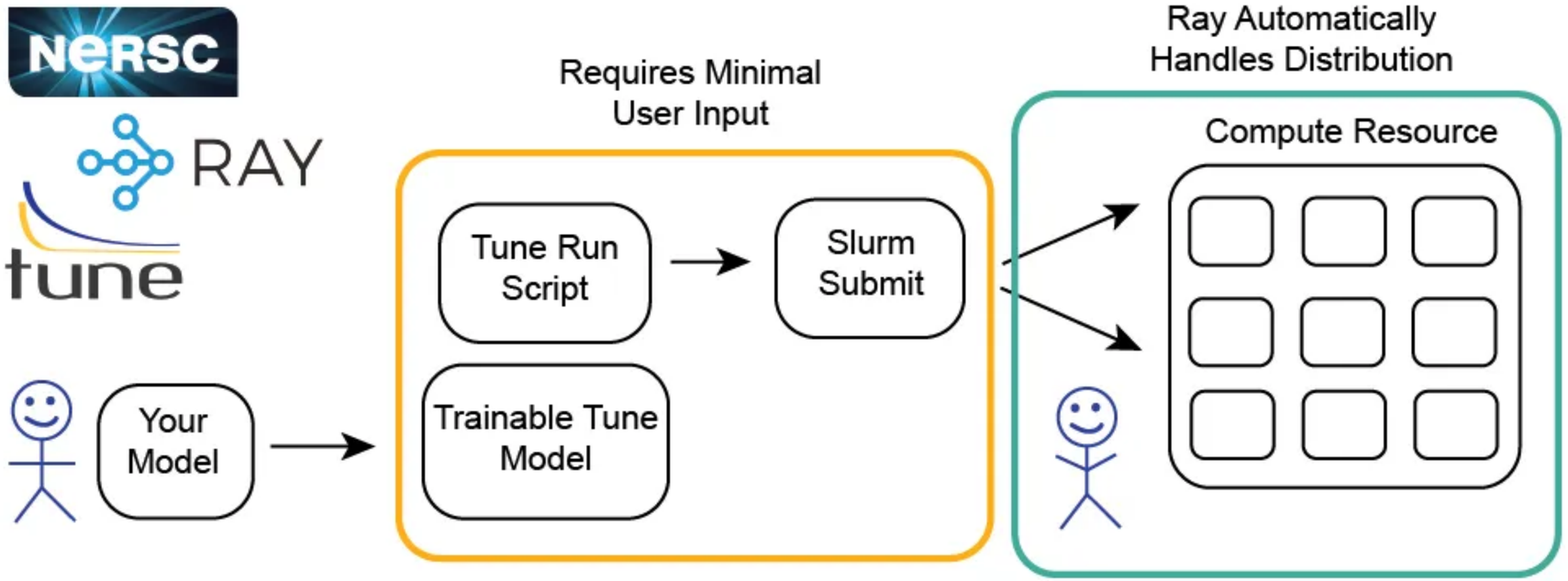


Current State

Multi-Objective Bayesian Optimisation can be done using:

- BoTorch (via Ax)
- Hebo (Huawei’s thing)
- Optuna
- SMAC3
- Smaller tools like Dragonfly

Using Ray as a distributed backbone

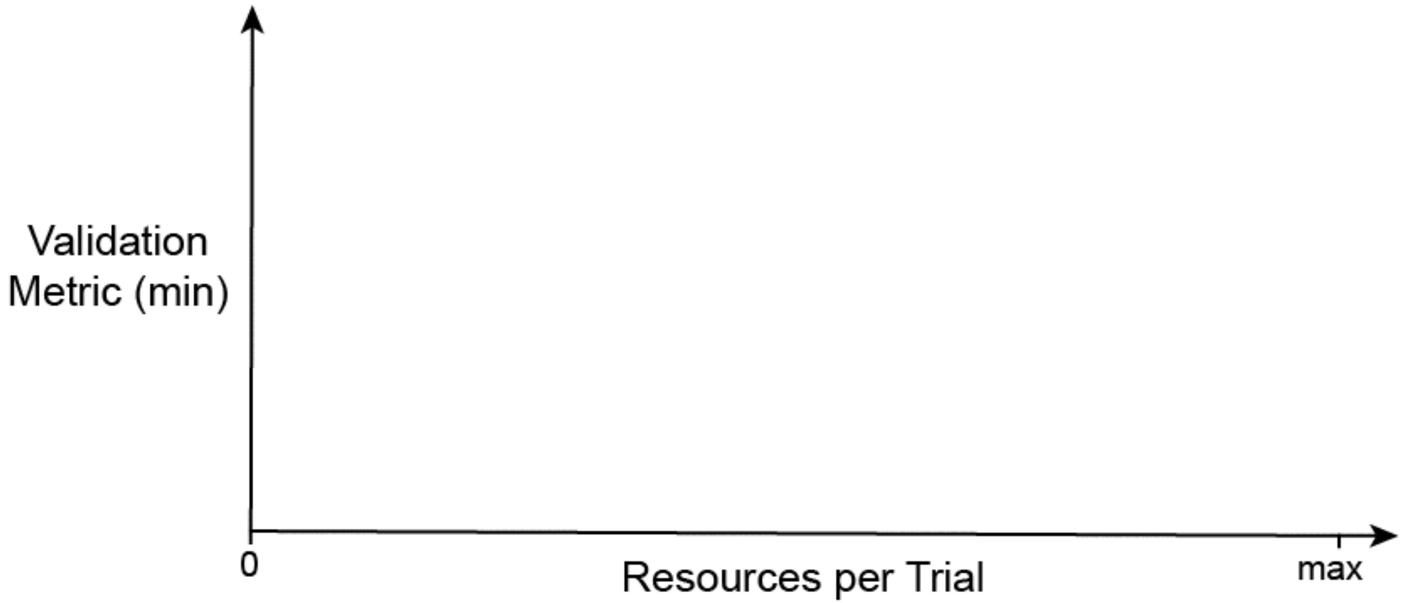

NERSC
RAY
tune
Your Model
Requires Minimal User Input
Tune Run Script
Slurm Submit
Trainable Tune Model
Ray Automatically Handles Distribution
Compute Resource

RayTune integrates with both Ax and Optuna but:

1. **For Ax** - MO not supported when used with RayTune

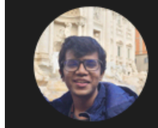
2. **For HEBO** - MO not supported when used with RayTune

3. **For Optuna** - RayTune MO works, but schedulers like ASHA do not work with multiple objectives



ASHA - Allocate a small budget to each configuration, evaluate all configurations and keep the top 1/η, increase the budget per configuration by a factor of η, and repeat until the maximum per-configuration budget of R is reached

Request for Implementation Code of Multi-Objective ASHA



Sidharrth Nagappan <sn666@cam.ac.uk> Today at 9:40 PM

To: rschmuck@cs.cmu.edu; donini@amazon.com; zafamuh@amazon.com; +2 more

Dear Dr Schmucker, Dr Donini, Dr Zafar and team,

By way of introduction, my name is Sidharrth and I am a graduate student at the University of Cambridge. I am currently working on schedulers for Multi-Objective Bayesian Optimisation and I came across your paper that extends ASHA to MO settings.

I was wondering if there is a codebase available for the paper, as it will greatly assist my research!

Thank you, and I'm looking forward to hearing from you!

Best Regards,
Sidharrth

richardliaw commented on Apr 17, 2020 Contributor

For existing schedulers, I have no immediate plan to support multi-objective optimization. However, I'm happy to take any contributions. Note that this is not hard to do - adding multi-objective optimization does not require any lower-level modifications to the framework.

I'll close this for now, but feel free to reopen if you have any questions.

bitosky commented on Nov 9, 2021 Author

> were you able to get this to work? **@bitosky**

@aswanthkrishna I didn't solve it directly. I wrote my own scheduler and analyzer to deal with multi-objective optimization problems. It was not easy for me, And I spent quite a while to do that.

“If you don’t specify a scheduler, Tune will use a first-in-first-out (FIFO) scheduler by default, which simply passes through the trials selected by your search algorithm in the order they were picked and does not perform any early stopping.”

RayTune’s Docs

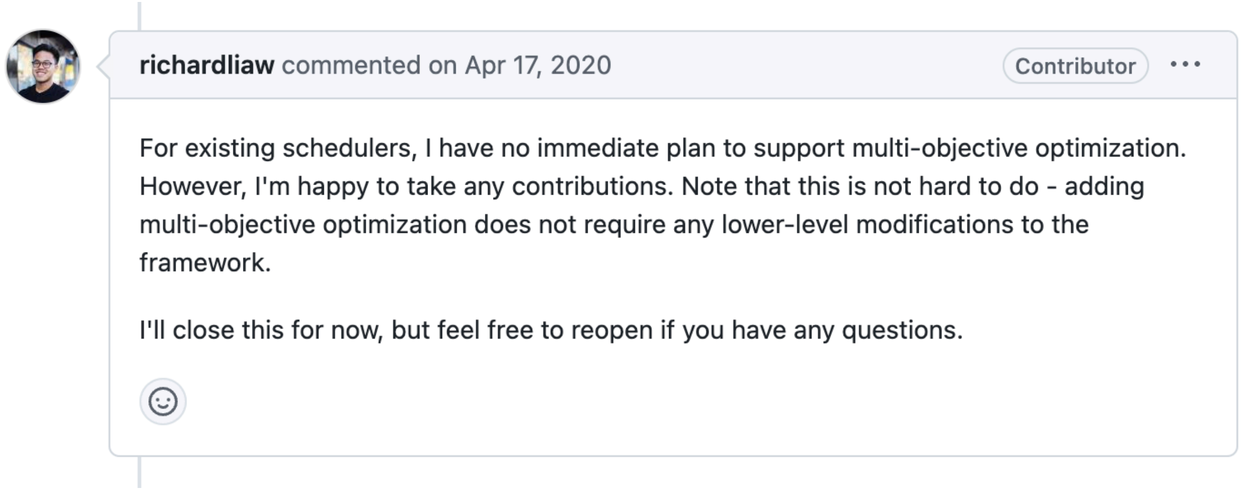
Limitations in Literature

- Limited work compares modern MO BO methods — very niche area, especially when used for pruning / NAS / hyper parameter tuning
- RayTune doesn’t integrate well with MO BO search methods
  - Either doesn’t support multi-objective at all
  - Or cannot use RayTune’s scheduler with the MO BO method

3 mini-projects over Christmas!

My Plan

- Explore RayTune, Optuna, Ax
- Explore HEBO
- Compare, evaluate, critique MO BO algorithms on hyperparameter tuning and elementary NAS *(has not been done before)*
- MAYBE: *If I have the time (may not happen or even work)*, improve RayTune's ASHA scheduler to speed up multi-objective, incorporate Pareto front, speed up Optuna + RayTune



Done So Far

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- Explore HEBO
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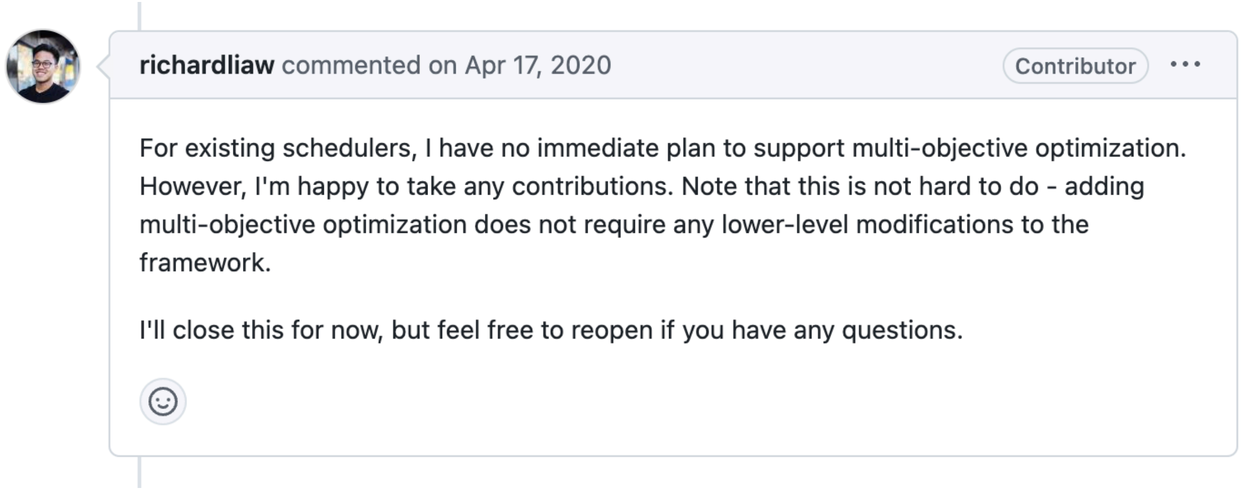

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Questions?