Accelerated Stochastic Three Point Method

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Problem overview

Problem

We consider unconstrained minimization problem

$$\min_{x \in \mathbb{R}^d} f(x)$$

with smooth target function, that is bounded from below. We want to modify existing DFO algorithm **S**tochastic **T**hree **P**oints (STP), obtain better convergence guarantees and test it in practice.

$$y^{k+1} = \arg\min\left\{f(x^k), f(x^k + \gamma_k s^k), f(x^k - \gamma_k s^k)\right\}$$

$$z^{k+1} = \begin{cases} z^k & \text{if } y^{k+1} = x^k, \\ z^k + \alpha_k s^k & \text{if } y^{k+1} = x^k + \gamma_k s^k, \\ z^k - \alpha_k s^k & \text{if } y^{k+1} = x^k - \gamma_k s^k \end{cases}$$

$$x^{k+1} = \begin{cases} x^k & \text{if } y^{k+1} = x^k, \\ \tau_k z^{k+1} + (1 - \tau_k) y^{k+1} & \text{otherwise} \end{cases}$$

Current state and progress

Theory and proofs

Currently our algorithm is still in the development. It does converge in experiments if appropriate parameters are chosen, yet, there are no theoretical guarantees of convergence in the worst possible case. Becuase of that it is unclear how to choose parameters.
Developed theory would also allow to implement the main feature of linear coupling – restarting.

Practice and experiments

In practice out current implementation is competetive with other DFO algorithms such as SMTP, DDS and ZO variants of FO algorithms. It has the potential to outperform them.

Current state and progress

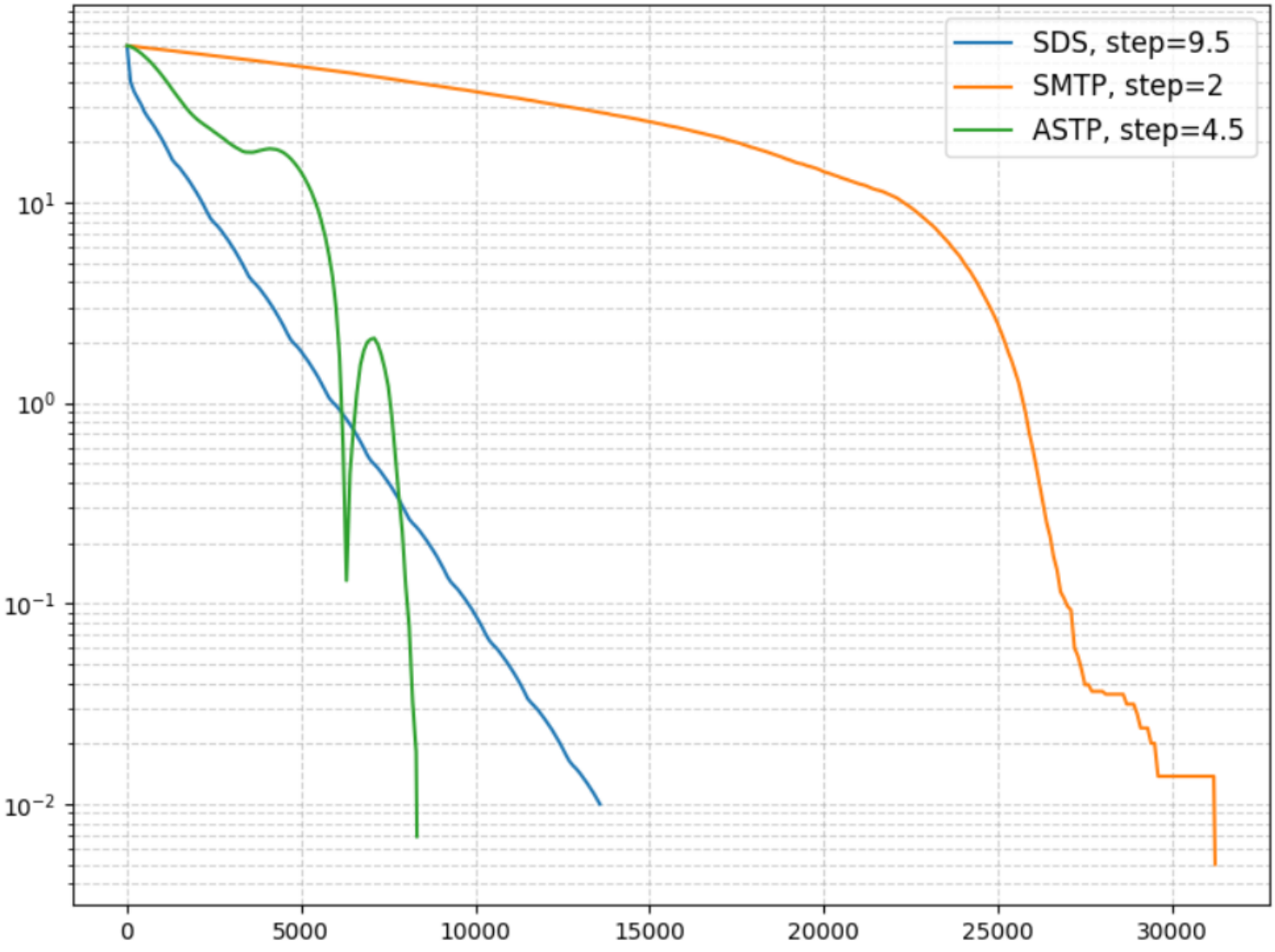

Figure: Comparison of the best case scenario for ASTP, SMTP and DDS. Parameter search was done on a unit grid

Current state and progress

Practice and experiments

We switched to more complex experiments involving fine-tuning LLM. In order to run those experiments I adapted code from [3], wrote computationally effective implementation using pytorch and ran dozens of experiments with various setups.

Pecularities of the experiments

1. All computation is performed on phystech's server
2. Each run takes at least 15 minutes to finish
3. Implementation of optimizers for LLM has its specifics
4. Results of fine-tuning are visualised with the help of WandB

Current state and progress

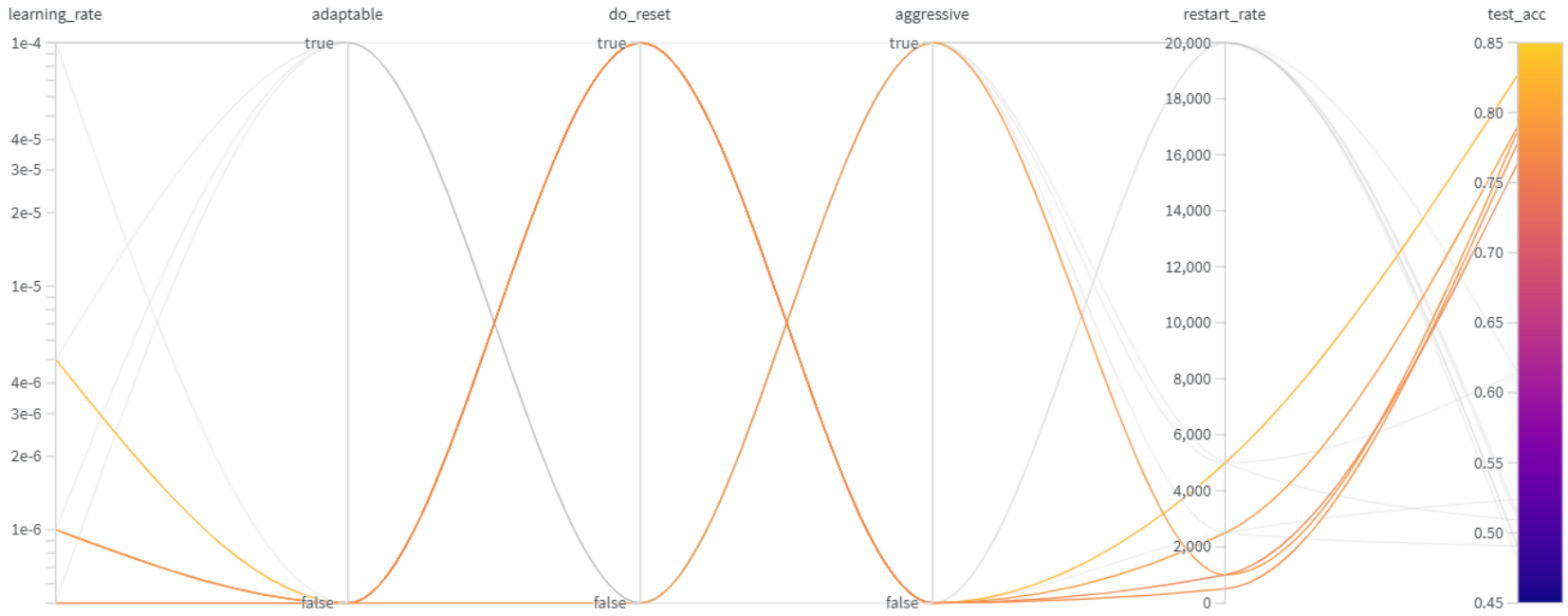

Figure: Visualisation for various setups in WandB

Plans and expectations

Incorporate Optuna framework

Optuna is a framework that is used to optimize hyperparameters search. My current goal is to add Optuna to the code and search for the best configuration of hyperparameters.

Do extensive benchmark

At this point I use facebook/opt-125m model for sentiment classification (SST task). We plan to benchmark performance of our algorithm and compare it to the performance of other DFO algorithms.

Proove convergence and test theoretical parameters

Theoretical proof would allow to implement restarting feature, it would also provide theoretical parameters with guarantees of convergence.

Bibliography

- [1] El Bergou, Eduard Gorbunov, and Peter Richtarik – *stochastic three points method for unconstrained smooth minimization*
- [2] El Bergou, Eduard Gorbunov, Peter Richtarik, Adel Bibi, Ozan Sener – *a stochastic derivative free optimization method with momentum*
- [3] Yihua Zhang, Pingzhi Li, Junyuan Hong, Jiaxiang Li and others – *revisiting zeroth-order optimization for memory-efficient LLM fine-tuning: a benchmark*
- github repository with code from paper above