A Stochastic Quasi-Newton Optimizer for TensorFlow

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[1]CSE 592: Convex Optimization
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Problem overview

- TensorFlow is an open source framework for building neural networks.
- It provides an interface for creating new Optimizer objects which perform different minimization algorithms.
- Typical existing implementations are first order descent algorithms, but it lacks[1] any implementation of a BFGS-type algorithm.

[1] See: https://github.com/tensorflow/tensorflow/issues/446

Our contribution

- We implemented stochastic dampened (Sd) L-BFGS in `TensorFlow` following the work of Wang, Ma, Goldfarb, and Liu (2017).
- The approach is based on the iteration step:

$$x_{k+1} = x_k - \alpha_k H_k g_k,$$

- α_k is the step size,
- H_k is the L-BFGS approximate Hessian,
- g_k is a batch gradient defined as

$$g_k = \frac{1}{m_k} \sum_{i=1}^{m_k} g(x_k, \xi_{k,i}),$$

- m_k is the batch size,
- $\xi_{k,i}$ is randomly sampled training data.

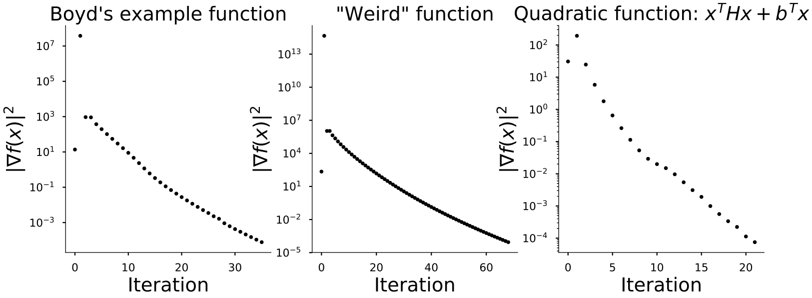
Our contribution

- The specific approach to approximating the Hessian differs from traditional L-BFGS implementations.
- Wang, et al showed that convergence (in expectation) is guaranteed by applying dampening at specific places in the approximation.
- Crucially, this holds even if the problem is **non-convex**.
- Their update, `SdLBFGS`, preserves the positive-definiteness of H_k even in non-convex situations.

Implementation

- Implementing L-BFGS proved challenging, and we discovered why it wasn't part of the library already!
- Following the advice from the discussion of Issue 446, we implemented L-BFGS as an `ExternalOptimizerInterface`.
- This allowed us to write `NumPy` code but "plug in" to `TensorFlow`.

Results: sanity checks



- Since our code is in `NumPy`, we could test it by running familiar homework functions.
- Here all gradients are deterministic.

Results: Higgs dataset