UMD FAIRNESS RESEARCH GROUP MEETING NOTES

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1. BILEVEL OPTIMIZATION PROBLEMS IN ML AND EFFICIENT SOLVERS (JUNE 15TH)

Led by Mucong Ding.

> **Definition 1** (Bilevel Optimization)
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> The **Bilevel Optimization** problem is
> $$\min_{v,\theta} f(v,\theta) \ \text{ s.t. } \ \theta \in \operatorname*{argmin}_{\theta'} g(v,\theta')$$
> where $\min\limits_{v,\theta} f(v,\theta)$ is the **outer function** and $\theta \in \operatorname*{argmin}\limits_{\theta'} g(v,\theta')$ is the **inner function**.

Note that the bilevel optimization problem can even be framed as a hyperparameter tuning problem in Machine Learning. The bilevel optimization problem can also be summarized as solving two interdependent problems where the outer problem depends on the inner problem.

Bilevel Optimization Problems in Machine Learning include the following:

(1) **Dataset Condensation/Distillation**: we want to learn a synthetic dataset such that the model trained on it has comparable performance to the model trained on the original dataset.
(2) **Coreset Selection**: similar to Dataset Condensation, but the learnable set is a subset of the original training set.
(3) **Targeted Dataset Poisoning**: modify the training data to cause reclassification of the unmodified test image.
(4) **Learnable Dataset Augmentation**: the learning of dataset augmentation can be formulated to minimize the loss of the trained model on the validation split.

> **Definition 2** (Efficient Solvers)
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> BO problems that enjoy convergence guarantee under mild conditions are **exact solvers**. The main approaches include Hypergradient descent methods, stationary, seeking methods, and value-function methods.

To summarize, Bilevel Optimization arises in many ML problems, each of which have unique setups and characteristics.

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