Computing Science Course Outlines
2022 Fall

CMPT 409 - D200 Spec.Topics/Theoretical Cmpt

Instructor(s): Sharan Vaswani

Calendar Objective/Description:
Spec.Topics/Theoretical Cmpt

Instructor's Objectives:
This course (Optimization for Machine Learning) introduces the foundational concepts of convex and non-convex optimization with applications to machine learning. It will give the students experience in 1. Proving theoretical guarantees for optimization algorithms, 2. Analyzing machine learning (ML) problems from an optimization perspective and 3. Developing and analyzing new optimization methods for ML applications.

Prerequisites:
see go.sfu.ca

Topics:
- Basics: Subdifferentials, Optimality conditions, Conjugates, Lipschitz continuity, Convexity
- Machine Learning Basics: Linear/Logistic regression, Kernel methods, Deep learning
- (Non)-Convex minimization 1: (Projected/Proximal) Gradient Descent, Nesterov/Polyak momentum
- (Non)-Convex minimization 2: Mirror Descent, Newton/Quasi-Newton/Gauss-Newton method
- (Non)-Convex minimization 3: Stochastic gradient descent (SGD), Variance reduction techniques
- (Non)-Convex minimization 4: Adaptivity for SGD, Coordinate Descent
- Applications to training ML models (logistic regression, kernel machines, neural networks)
- Online optimization 1: Regret minimization, Online to Batch, Follow the (regularized) leader
- Online optimization 2: Optimistic Gradient Descent , Adaptive gradient methods (AdaGrad, Adam)
- Applications to Imitation learning, Reinforcement learning
- Min-Max optimization 1: Primal-dual methods, (Stochastic) Gradient Descent-Ascent, Proximal point
- Min-Max optimization 2: (Stochastic) Extragradient, Acceleration, Variance reduction
- Applications to GANs, Robust optimization, Multi-agent RL

Grading:
There will be a couple of assignments with the major evaluation components being a paper presentation and a final project. The details will be discussed in the first week of classes.

Reference Books:
Convex Optimization, Boyd and Vandenberghe, 2004, 9780521833783
Numerical Optimization, Nocedal and Wright, 2006, 9780387303031
First-order Methods in Optimization, Beck, 2017, 9781611974980
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