Math/CSE 555 Syllabus, Spring 2021

Instructors: Jinchao Xu (xu@math.psu.edu) and Jonathan Siegel (jus1949@psu.edu)

Location: https://psu.zoom.us/j/2753142495

Time: TR 12:05pm-1:20pm

Office Hours: TR 1:30pm-3:00pm

Prerequisites: Multivariable Calculus (Math 230), Linear Algebra (Math 220) and basic programming skills (Matlab or Python)

References:

1. Numerical Optimization, Nocedal and Wright; Convex Optimization, Boyd and Vandenberghe
2. Convex Optimization: Algorithms and Complexity, Bubeck
3. An Introduction to Optimization, Chong and Zak
4. Lectures on Convex Optimization, Yurii Nesterov
5. Typed Lecture Notes

Grading:

- 50% Homework (including programming assignments)
- 20% Take-home Midterm
- 30% Take-home Final

Description: This course covers the basics of constrained and unconstrained optimization algorithms and theory. We will cover selected topics with a particular emphasis on applications in machine learning. Topics will be selected from:

- Quadratic optimization problems
  - Gradient descent, Stochastic gradient descent method
  - Coordinate descent, methods of alternating corrections and subspace correction, Karmarcz algorithm
  - Conjugate gradient and preconditioning
- Unconstrained Optimization:
  - First-Order Methods: Smoothness and gradient descent
  - Second-Order Methods: Newton's method and variants
  - Quasi-Newton Methods: BFGS Method
- Constrained Optimization:
  - KKT conditions

  - Optimization on Manifolds
- Convex Optimization (First-Order Methods):
  - Basic theory of convex analysis
  - First-order forward methods for non-smooth problems: Gradient Descent, Dual Averaging
  - First-order forward methods for smooth problems: Continuous Dynamics, Gradient Descent, Conjugate Gradient, Accelerated Gradient Descent
  - Backward Methods for non-smooth problems: Proximal map, Proximal Point Method
  - Splitting methods: Forward-Backward splitting, Acceleration, Douglas-Rachford Splitting, ADMM, Augmented Lagrangian methods
  - Preconditioning: Mirror functions, Mirror Descent
  - Lower bounds on Complexity
- Convex Optimization (Second-Order Methods):
  - Convergence of Newton's Method
  - Interior Point Methods
  - Linear and Semi-definite Programming