MAP7436/C213–Seminar in Applied Mathematics

Introduction to Convex Optimization and Applications

References:

- Mathematical Problems in Image Processing – PDE and the Calculus of Variations by Gilles Aubert and Pierre Kornprobst.
- The Handbook of Mathematical Models in Computer Vision by Nikos Paragios, Yunmei Chen, and Olivier Faugeras.

Related papers:


Meeting Time and Rooms:

- MWF 5:30 at LIT 233
- Office Hours: MWF 4 or by appointment

Objective and Description of the Course:

The objective of this course is to introduce several popular classes of the first order methods for solving large scale convex optimization problems arising from image analysis, machine learning, neuron network computing, and related data analysis problems. In this course, we will review Nesterov’s fast gradient methods for smooth convex optimization and Nesterov’s smoothing techniques for non-smooth optimizations. Then, we will study the generations of Nesterov’s for minimizing composite convex functions and some recently developed accelerated first order methods that adopted the main idea of Nesterov’s fast gradient methods. They are the accelerated primal dual methods for solving constrained convex problems; the accelerated alternating direction method of multipliers (ADMM) for solving certain classes of convex optimization problems with equality constraints; the accelerated bundle level (BL) type methods for solving certain classes of smooth and non-smooth, constrained and unconstrained convex optimization. Then, we will study the related data analysis problems. In this course, we will review Nesterov’s fast gradient methods for smooth convex optimization problems arising from image analysis, machine learning, neuron network computing, and related data analysis problems. We will also consider some recent developments in convex optimization and related data analysis problems. The objective of this course is to introduce several popular classes of the first order methods for solving large scale convex optimization problems arising from image analysis, machine learning, neuron network computing, and related data analysis problems. In this course, we will review Nesterov’s fast gradient methods for smooth convex optimization and Nesterov’s smoothing techniques for non-smooth optimizations. Then, we will study the generations of Nesterov’s for minimizing composite convex functions and some recently developed accelerated first order methods that adopted the main idea of Nesterov’s fast gradient methods. They are the accelerated primal-dual methods for solving constrained convex problems; the accelerated alternating direction method of multipliers (ADMM) for solving certain classes of convex optimization problems with equality constraints; the accelerated bundle level (BL) type methods for solving certain classes of smooth and non-smooth, constrained and unconstrained convex optimization. Then, we will study the related data analysis problems. In this course, we will review Nesterov’s fast gradient methods for smooth convex optimization problems arising from image analysis, machine learning, neuron network computing, and related data analysis problems. We will also consider some recent developments in convex optimization and related data analysis problems.

Arrangement of the course:

- Unit 1: Nesterov’s Optimal Gradient Methods (Tentatively weeks 1-4)
  1. Optimal gradient methods for minimizing smooth convex functions;
  2. Smoothing techniques for minimizing non-smooth convex functions;
  3. Generalization of Nesterov’s accelerated gradient methods for minimizing a class of composite convex functions consisting of a smooth function and a simple non-smooth function, such as the fast iterative shrinkage/thresholding algorithm (FISTA);
- Unit 2: Bundle Level Type Methods (Tentatively weeks 5-9)
  1. Bundle level type methods and accelerated bundle level methods: schemes, iteration complexity analysis;
  2. Fast accelerated bundle level method and its variants for solving unconstrained convex optimization problems: schemes, iteration complexity analysis, comparisons and applications;
  4. Gradient splitting method for fast accelerated bundle level method for minimizing a class of composite convex functions consisting of a smooth function and a non-smooth function.
- Unit 3: Alternating Direction Method of Multipliers (ADMM) and Accelerated ADMM (AADMM) for distributed optimization (Tentatively weeks 10-13)
1. ADMM and AADMM: schemes, and convergence analysis;
2. Deterministic and stochastic AADMM in distributed optimization;
3. General form consensus optimization and sharing;
4. Comparisons with FISTA based distributed optimization methods.

Unit 4: Applications of the fast first order methods in large scale data analysis (Tentatively weeks 14-16)

1. Applications in imaging.
2. Applications in neuron network computing.
3. Applications in machine learning.

Grading:
Students will be required to present one to two papers and the projects related to the course content. These projects may be related to problems of particular interest to the individual student. Grades will be assigned on the basis of the presentations or projects. Current UF grading policies can be found from the following link:
http://www.registrar.ufl.edu/catalog/policies/regulationgrades.html

Teaching Evaluation:
Students are expected to provide feedback on the quality of instruction in this course based on 10 criteria. These evaluations are conducted online at https://evaluations.ufl.edu.

Academic Honesty:
The course will be conducted in accordance with the University honor code and academic honesty policy, which can be found in the student guide.

Accommodation for Student with Disabilities:
Students requesting classroom accommodation must first register with the Dean of Students Office. The Dean of Students Office will provide documentation to the student who must then provide this documentation to the instructor when requesting accommodation.