Yunmei Chen
Department of Mathematics

MAP7436/C213–Seminar in Applied Mathematics

Introduction to Convex Optimization and Applications

Objective and Description of the Course:

The objective of this course is to continue our study on fast and accelerated 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 focus on the following topics. (1) Deterministic and stochastic or randomized primal dual gradient methods for a class of saddle point problems; (2). Deterministic and stochastic accelerated alternating direction method of multiplies (AADMM) for equality constrained convex optimization. (3). Fast and accelerated bundle level methods with inexact first order information for convex optimization (4). Fast and accelerated bundle level method based gradient sliding algorithm for a class of composite convex optimization problems. (5). Accelerated algorithms for convolutional sparse coding. We will study the iteration complexities and practical performance of those algorithms, as well as their applications. Students are expected to gain knowledge on mathematical theories, methods, and practical experience in solving convex optimization problems with applications to data analysis problems.

References:

- Introductory Lectures on Convex Optimization, by Y. Nesterov, Kluwer, Boston, 2004
- Convex Analysis, by R. T. Rockafellar, Princeton University Press, Princeton, NJ, 1970.
- 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 Faugera
- Related papers:

1. Beck and M. Teboulle, A fast iterative shrinkage-thresholding algorithm for linear inverse problems, SIAM J. Imaging Sci., 2 (2009), pp. 183– 202.
2. Beck and M. Teboulle, Gradient-based algorithms with applications to signal recovery problems. In: Convex Optimization in Signal Processing and Communications, Edited by Y. Eldar and D. Palomar, Cambridge University Press, (2010).
3. Y. Nesterov. A method for solving the convex programming problem with convergence rate O(1/k2). Dokl. Akad. Nauk SSSR, 269(3):543–547, 1983.
4. Y. Nesterov, Smooth minimization of non-smooth functions, Math. Program., 103 (2005), pp. 127–152.
5. Y. Nesterov, Gradient methods for minimizing composite objective function, http://www.ecore.beDPs/dp1191313936.pdf (2007).
6. P. Tseng, On Accelerated Proximal Gradient Methods for Convex-Concave Optimization, Technical report, Department of Mathematics, University of Washington, Seattle, WA; available online from http://www.math.washington.edu/~tseng/papers.html.
7. A. Chambolle and T. Pock. A first-order primal-dual algorithm for convex problems with applications to imaging. J. Math. Imaging Vision, 40, (2011), 120–145.
8. Y. Chen, G. Lan, and Y. Ouyang, Optimal primal-dual methods for a class of saddle point problems, SIAM J. Optim., 24 (2014), pp. 1779–1814.
9. G. Lan and Y. Zhou, An Optimal Randomized Incremental Gradient Method,Technical Report, Department of Industrial and Systems Engineering, University of Florida, July 7.
10. Y.Ouyang, Y.Chen, G.Lan and E.Pasiliao Jr., An Accelerated Linearized Alternating Direction Method of Multipliers, SIAM Journal on Imaging Sciences}, 8 (1) (2015), pp. 644-681.
11. S. Boyd, N. Parikh, E. Chu, B. Peleato, and J. Eckstein, Distributed optimization and statistical learning via the alternating direction method of multipliers, Foundations and Trends in Machine Learning, 3 (2011), pp. 1–122.
12. D. Jakovetic, J. Xavier, J. M. F. Moura, Fast Distributed Gradient Methods, arXiv.org > cs > arXiv.1112.2972.
13. Y.Chen, G.Lan, Y.Ouyang, and W.Zhang, Fast Bundle-Level Type Methods for Unconstrained and Ball-constrained Convex Optimization, http://arxiv.org/submit/1131766.
14. C. I. Fabian, Bundle-type methods for inexact data. Central European Journal of Operations Research, 8(1), 2000.

Meeting Time and Rooms:

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

Arrangement of the course::

- Unit 1: Accelerated methods for a class of saddle point problems (Tentatively weeks 1-5):

  1. Chambolle and T. Pock's united primal dual algorithm in reference 7;

  2. Nesterov's moothing techniques for minimizing non-smooth convex functions in reference 4;

  3. The accelerated primal dual algorithm in reference 8;

  4. The optimal primal dual method and randomized primal dual method in reference 9.

- Unit 2: Bundle level type methods (Tentatively weeks 6-8)

  1. Fast and accelerated prox level (FAPL) method and fast uniform smooth level (FUSL) method for solving ball constrained and unconstrained convex optimization problems and a class of saddle point problems: schemes, iteration complexity analysis and applications;

  2. Fast and accelerated bundle level method with inexact first order information for general convex problems and saddle point problems: scheme, iteration complexity analysis;

  3. FAPL based gradient sliding method for minimizing a summation of a smooth function and a non-smooth function.

- Unit 3: Deterministic and stochastic accelerated alternating direction method of multiplies (AADMM) and AADMM type methods for distributed optimization (Tentatively weeks 9-11)

  1. Deterministic AADMM with backtracking schemes, scheme and convergence analysis;

  2. stochastic AADMM scheme and convergence analysis;

  3. AADMM type methods for distributed computing;

- Unit 4: Convolutional sparse coding (Tentatively weeks 12-14)

  1. models for convolutional sparse coding.

  2. fast and accelerated algorithms for convolutional sparse coding.

- Unit 5: Applications of the above fast first order methods in large scale data analysis (Tentatively weeks 15-16)

  1. Applications in image reconstruction and segmentation.

2. Applications in neuron network computing.

3. Applications in multitask 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.

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