EE 599: Mathematics of Data
Fall 2015

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Lectures: Mondays and Wednesdays 3:30-4:50 PM GFS 118.

Office Hours: Mondays and Wednesdays 5-6:30 PM EEB 432 (Prof. Kyriakakis's office).

Catalog Description: modern developments in data representation/analysis, convex optimization, efficient first-order algorithms for smooth and non-smooth optimization, iterative algorithms and non-convex optimization, non-asymptotic random matrix theory, randomized numerical linear algebra, sketching, dimensionality reduction, clustering, low-rank models, inverse problems, applications in computational imaging, signal processing, machine learning, computer vision and neuroscience.

Prerequisites: EE 441 and EE 503. Familiarity with a numerical solver such as MATLAB, R, or Python is required. Familiarity with basic convex analysis and optimization is a plus but not required.

Course Overview: Modern data sets are noisy and unstructured and often contain corrupted or incomplete information. At the confluence of optimization, signal processing, statistics and computer science a new discipline is emerging to address these challenges. In this course we will explore the foundations of this area. The main goal is to expose students to modern methods that model data through vectors and matrices, efficient algorithms for representing and extracting information from such data as well as new theory explaining the success of these algorithms. A special focus will be on novel methods and mathematical tools that allow us to glean useful information from seemingly incomplete data sets.

Course covers:

1) Fundamental theoretical and mathematical tools.

2) Efficient techniques to collect and analyze data and deal with nuances (such as noise, missing information, outliers).

3) Sample applications from computational imaging, signal processing, machine learning, computer vision and neuroscience.

Required Texts: None.

Grading (subject to change):
- %10 Lecture scribes
- %40 Homework
- %50 Final Projects

Course Outline (subject to change):

- **Week 1:** Introduction to mathematics of data, sample applications, Optimization basics.
- **Week 2:** Optimization for modern data analysis I: first order methods, accelerated schemes.
- **Week 3:** Optimization for modern data analysis II: sub-gradients and non-smooth optimization, incremental and stochastic schemes.
- **Week 4:** Basics of concentration of measure and high dimensional probability.
- **Week 5:** non-asymptotic random matrix theory and matrix concentration.
- **Week 6:** Dimension reduction, sketching, and applications.
- **Week 7:** Fast and randomized methods for numerical linear algebra.
- **Week 8:** Clustering I: Matrix perturbation theory.
- **Week 9:** Clustering II: Spectral algorithms, application in community detection.
- **Week 10:** Linear inverse problems I: Compressive sensing and sparsity.
- **Week 11:** Linear inverse problems II: Recommender systems, matrix completion and low-rank modeling.
- **Week 12:** Optimization basics: convexity, linear and semidefinite programs, convex relaxations.
- **Week 13:** Linear inverse problems III: recovery of fine-scale data from coarse-scale measurements: applications in deblurring, fluorescence microscopy, wireless communications, medical imaging and computer vision.
- **Week 14:** Modern theory of linear inverse problems; Iterative algorithms and non-convex optimization; Phase retrieval and computational imaging.
- **Week 15:** Learning representations, sparse coding, "shallow" and "deep" learning.

Statement for Students with Disabilities
Any student requesting academic accommodations based on a disability is required to register with Disability Services and Programs (DSP) each semester. A letter of verification for approved accommodations can be obtained from DSP. Please be sure the letter is delivered to me (or to TA) as early in the semester as possible.
DSP is located in STU 301 and is open 8:30 A.M.-5:00 P.M., Monday through Friday.
Website and contact information for DSP:
sait.usc.edu/academicsupport/centerprograms/dsp/home_index.html
(213) 740-0776 (Phone), (213) 740-6948 (TDD only), (213) 740-8216 (FAX), ability@usc.edu (email).

Statement on Academic Integrity
USC seeks to maintain an optimal learning environment. General principles of academic honesty include the concept of respect for the intellectual property of others, the expectation that individual

work will be submitted unless otherwise allowed by an instructor, and the obligations both to protect ones own academic work from misuse by others as well as to avoid using anothers work as ones own. All students are expected to understand and abide by these principles. SCampus, the Student Guidebook, (scampus.usc.edu) contains the University Student Conduct Code (see University Governance, Section 11.00), while the recommended sanctions are located in Appendix A.

Emergency Preparedness/Course Continuity in a Crisis

In case of a declared emergency if travel to campus is not feasible, USC executive leadership will announce an electronic way for instructors to teach students in their residence halls or homes using a combination of Blackboard, teleconferencing, and other technologies.