STAT/ECE 695:
Sparse Modeling and Algorithms in Statistical Learning

Spring 2018

Lecture: MWF: 1:30-2:20pm, ME 1012

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Office Hours: By appointment.

Course Website: `https://engineering.purdue.edu/ChanGroup/ECE695.html`

Course Description: Machine learning and data analysis algorithms today can handle enormous amount of data with extremely high dimensionality. One of the key enabling factors is the concept of sparsity — while many data / signals are high dimensional, only a few of the dimensions are activated. Sparsity is the core to many statistical learning problems: regression, prediction, model selection, denoising, restoration, interpolation and extrapolation, compression, sampling, detection, recognition, etc. In this course, we will explore the fundamentals of sparse modeling. We will discuss various algorithms and their properties. Topics to be covered include: LASSO algorithms, optimization methods, group sparsity, matrix decomposition, graphical models, and dictionary learning.

Textbook:

1. Trevor Hastie, Robert Tibshirani, Martin Wainwright, *Statistical Learning with Sparsity*, CRC Press, 2015. `https://web.stanford.edu/~hastie/StatLearnSparsity/`
2. Michael Elad, *Sparse and Redundant Representations: From Theory to Applications in Signal and Image Processing*, Springer, 2010.

Grading: (Tentative, as of Feb 2, 2017)

- 10% Attendance
- 40% Readings. There are 7 reading assignments. You are required to read the papers, and write summaries. All reports should be typed in LaTeX with the template provided on the course website.
- 50% Project. (Teams of 1-2 students). If you choose to work as a team, then you need to show clear division of the labor. Regardless how many members in the team, each student should submit his/her own report.

Syllabus:

Part 1: Foundations of Sparse Modeling

The L_1 Problem
- What is LASSO?
- Cross Validation
- Shrinkage
- Properties of L_1 solution

Generalizations of Models
- Logistic Regression with Sparsity
- Multiclass Logistic Regression with Sparsity
- Log-linear Model with Sparsity
- Poisson Generalized Linear Model with Sparsity
- Support Vector Machine with Sparsity

Generalizations of LASSO
- Elastic Net
- Group LASSO
- Sparse Additive Model
- Non-convex Penalties

The L_0 Problem
- Mutual Coherence
- Spark
- Stability

Part 2: Optimization Tools

Convex Optimality
- KKT Condition
- Duality

Gradient Descent
- Subgradients
- Coordinate Descent

ADMM
- Algorithm
- Guarantee

Pursuit Algorithms
- Matching Pursuit, Orthogonal Matching Pursuit
- Basis Pursuit

Iterated Reweighted Least Squares

Part 3: Applications of Sparse Modeling

Matrix Decomposition
- Singular Value Decomposition
- Missing Data and Matrix Completion
- Other Matrix Decomposition Methods

Sparse Multivariate Methods
- Sparse PCA
- Sparse canonical correlation
- Sparse linear discriminant analysis
- Sparse clustering

Graphs and Model Selection
- Graphical models
- Graph selection via Penalized Likelihood
- Graph selection via Conditional Inference

Signal Recovery and Approximation
- Compressed Sensing
- KSVD

Academic Dishonesty:

We respect you as adults, and we expect that you are a responsible citizen. Therefore, we ask you to be honest and ethical in the course. In that respect, any action that might give a student unfair advantage on homework or exams will be considered dishonest. Examples include, but are not limited to:

- Sharing information during exam;
- Using forbidden material or device during exam;
- Viewing and/or working on an exam before or after the official time allowed;
- Requesting a re-grade of work that has been altered;
- Submitting work that is not your own. (You can discuss problems with your classmates. But you must write your own solution.)

All cases of academic dishonesty will be reported to the Dean of Student Office, and will result in punishment. Possible punishments include, but are not limited to, a score of zero on work related to the cheating incident, a failing grade for the course, and, in severe cases, expulsion from the university.

Emergency Procedure:

Purdue University is a very safe campus and there is a low probability that a serious incident will occur here at Purdue. However, just as we receive a "safety briefing" each time we get on an aircraft, we want to emphasize our emergency procedures for evacuation and shelter in place incidents. Our preparedness will be critical *if* an unexpected event occurs.

Purdue prepares for natural disasters or humancaused incidents with the ultimate goal of maintaining a safe and secure campus, but in the end, emergency preparedness is your personal responsibility. Lets quickly review the following procedures:

- To report an emergency, call 911. To obtain updates regarding an ongoing emergency, sign up for Purdue Alert text messages, view `www.purdue.edu/ea`.
- There are nearly 300 Emergency Telephones outdoors across campus and in parking garages that connect directly to the PUPD. If you feel threatened or need help, push the button and you will be connected immediately.
- If we hear a fire alarm during class we will immediately suspend class, evacuate the building, and proceed outdoors. Do not use the elevator.
- If we are notified during class of a Shelter in Place requirement for a tornado warning, we will suspend class and shelter in [the basement].
- If we are notified during class of a Shelter in Place requirement for a hazardous materials release, or a civil disturbance, including a shooting or other use of weapons, we will suspend class and shelter in the classroom, shutting the door and turning off the lights.
- Please review the Emergency Preparedness website for additional information. `http://www.purdue.edu/ehps/emergency_preparedness/index.html`

In the event of a major campus emergency, course requirements, deadlines and grading percentages are subject to changes that may be necessitated by a revised semester calendar or other circumstances. In such an event, information will be provided through the course website and through emails.

