JOHNS HOPKINS
WHITING SCHOOL
of ENGINEERING

Sparse Representations in Computer Vision and Machine Learning
EN.580.709
Fall Semester, 2019 (2 credits)

Instructor
Assist. Professor Jeremias Sulam, jsulam1@jhu.edu, https://sites.google.com/view/jsulam
Office: Clark 320B
Office hours: Tuesdays 10:00–11:00 pm, and by appointment

Meetings
Monday, 3:00–5:50 pm, Gilman 132

Textbook
Recommended:
- Elad, Michael. *Sparse and redundant representations: from theory to applications in signal and image processing*. Springer Science & Business Media, 2010.
- Hastie, Trevor, Robert Tibshirani, and Martin Wainwright. *Statistical learning with sparsity: the lasso and generalizations*. Chapman and Hall/CRC, 2015.

Online Resources
https://jsulam-jhu.github.io/EN.580.709/

Course Information

- **Prerequisites**
  Linear Algebra and Differential Equations (EN.553.291) or similar

Course Goals

Specific Outcomes for this course are that
- Students will identify the fundamental problems in sparse estimation in under-determined linear systems of equations.
- Students will learn different algorithmic alternatives to approximate the solution of the problems mentioned above, as well as identify their limitations and theoretical guarantees.
- Students will learn how to deploy sparse priors in the context of statistical learning, and their application.
- Students will learn how to obtain data-dependent sparse representations, and how they can be applied to regularize several inverse problems.

Course Topics

- Course introduction. Intro to underdetermined linear systems of equations, sparsity and math warm-up.
- Uniqueness and Stability.
- Greedy algorithms and their analysis.
- Basis Pursuit - success guarantees and stability. Compressed Sensing. Analysis and convergence of ISTA.
- Intro to statistical learning, sparse linear and logistic regression, variable selection.
- Lasso generalizations, elastic net, matrix and spectral sparsity and applications.
- Dictionary Learning - Early motivations, MOD, K-SVD, Online Dictionarly Learning, Double Sparsity.
- Computer Vision Applications: image denoising, inpaing, compression, MCA, Task Driven Dictionary Learning.
- Convolutional sparse coding and dictionary learning, and their application.
- MultiLayer sparsity based deep learning, theoretical guarantees and applications.

Course Expectations & Grading

The course will be organized in weekly lectures, and students are expected to actively participate in them. Grading will be assigned according to:

a) **Final exam** (40%), intended to serve as a fast check for contents presented in class.

b) **Course Project** (60%), to be carried out preferably in pairs, based on recently published papers. A list of candidate papers to choose from is given in the course online site (others can be accommodated upon request if relevant). Evaluation of the project will be based on a final report summarizing some of these papers, their contributions, and your own findings (open questions, simulation results, extensions, etc), as well as a short presentation to the class. Detailed project guidelines and evaluation criteria can be found in the course website.

Key Dates

The choice of your choice on paper(s) for projects is to be communicated no later than week 4 (09/23).
Projects Reports are to be submitted no later than the last day of classes (12/06).
Project presentations will be carried out during the last two classes (11/25, 12/02).

Ethics

The strength of the university depends on academic and personal integrity. In this course, you must be honest and truthful. Ethical violations include cheating on exams, plagiarism, reuse of assignments, improper use of the Internet and electronic devices, unauthorized collaboration, alteration of graded assignments, forgery and falsification, lying, facilitating academic dishonesty, and unfair competition.

Report any violations you witness to the instructor.

You can find more information about university misconduct policies on the web at these sites:

- For undergraduates: http://e-catalog.jhu.edu/undergrad-students/student-life-policies/
- For graduate students: http://e-catalog.jhu.edu/grad-students/graduate-specific-policies/

Personal Wellbeing

- If you are sick, in particular with an illness that may be contagious, notify me by email but do not come to class. Rather, visit the Health and Wellness: 1 East 31 Street, 410-516-8270. See also http://studentaffairs.jhu.edu/student-life/support-and-assistance/absences-from-class/illness-note-policy/
- All students with disabilities who require accommodations for this course should contact me at their earliest convenience to discuss their specific needs. If you have a documented disability, you must be registered with the JHU Office for Student Disability Services (385 Garland Hall; 410-516-4720; http://web.jhu.edu/disabilities/) to receive accommodations.
- If you are struggling with anxiety, stress, depression or other mental health related concerns, please consider visiting the JHU Counseling Center. If you are concerned about a friend, please encourage that person to seek out our services. The Counseling Center is located at 3003 North Charles Street in Suite S-200 and can be reached at 410-516-8278 and online at http://studentaffairs.jhu.edu/counselingcenter/

Classroom Climate

I am committed to creating a classroom environment that values the diversity of experiences and perspectives that all students bring. Everyone here has the right to be treated with dignity and respect. I believe fostering an inclusive climate is important because research and my experience show that students who interact with peers who are different from themselves learn new things and experience tangible educational outcomes. Please join me in creating a welcoming and vibrant classroom climate. Note that you should expect to be challenged intellectually by me and your peers, and at times this may feel uncomfortable. Indeed, it can be helpful to be pushed sometimes in order to learn and grow. But at no time in this learning process should someone be singled out or treated unequally on the basis of any seen or unseen part of their identity.

If you ever have concerns in this course about harassment, discrimination, or any unequal treatment, or if you seek accommodations or resources, I invite you to share directly with me. I promise that we will take your communication seriously and to seek mutually acceptable resolutions and accommodations. Reporting will never impact your course grade. You may also share concerns with the department Graduate Program Manager, Samuel Bourne (sbourne@jhu.edu) and the Assistant Dean for Diversity and Inclusion

(Darlene Saporu,dsaporu@jhu.edu), or the Office of Institutional Equity (oie@jhu.edu). In handling reports, people will protect your privacy as much as possible, but faculty and staff are required to officially report information for some cases (e.g. sexual harassment).