Stat 232B-CS266B:

Statistical Computing and Inference

in Vision and Image Science

MW 2-3:20 pm Spring 2013, Math Sci. Bldg 5203

[syllabus]

Course Description

This graduate level course introduces a broad range of advanced algorithms for statistical inference and learning on graphical structures. These algorithms could be used in vision, pattern recognition, speech, bio-informatics and data mining. Topics include heuristic search and relaxation algorithms, parsing algorithms, stochastic PDEs, advanced Markov chain Monte Carlo methods, hierarchical clustering methods for learning. These algorithms work on two types of underlying representations.

- *Flat graphs* where the nodes/vertices represent states of the same semantic level. E.g, constraint-satisfaction, relaxation-labeling, and Swendsen-Wang Cut, and C4.

- *Hierarchic graphs* where one level of vertices semantically generate the nodes at the level below. E.g. matching pursuit, heuristic search, language parsing (Earley, Inside-Outside), search on And-Or graphs, Data-Driven Markov Chain Monte Carlo, and compositional inference.

Prerequisites

- Basic statistics, linear algebra, MCMC, Stat232A or equivalence, programming skills (matlab, C++) for a project.
- Knowledge and experience on images will be a plus.

Reference books

The lectures will be mainly based on papers and book chapters.

- Mumford and Desolneux, *Pattern Theory: the stochastic Analysis of Real-World Signal*, 2010.
- J. Pearl, *Heuristics:Intelligent Search Strategies for Computer Problem Solving*, 1984.

Instructors

- Prof. Song-Chun Zhu, sczhu@stat.ucla.edu, 310-206-8693, office BH 9404. *Office Hours: Monday 3:30pm-5:00pm*

Grading Plan: 4 units, letter grades

The grade will be based on four parts

2 homework	20%
3 small projects	45%
Project 1: Matching pursuit and Least angle regression (15%)	
Project 2: Inside-outside algorithm for learning and inference on and-or tree (15%)	
Project 3: C4 for line drawing intepretation with positive and negative edges (15%)	
Final exam	35%

Tentative List of Topics [zip file for the reading_materials, 210M]

Chapter 1 Introduction [ch1.pdf]

1. Problems, objectives, and applications
2. Basics in algorithm design
   state spaces, operators, constraints, metrics and heuristics.
3. Algorithms on various graphical structures.

Chapter 2 Classical algorithms: heuristic search and relaxation [ch2.pdf]

1. Heuristic searches in and-or graphs (Pearl 84, 2.3-2.4)
2. Relaxation-Labeling for line drawing interpretation (Winston_AI, Ch12)

Chapter 3 Inference in the sparsity land [ch4.pdf]

1. Matching pursuit for image coding
2. Basis pursuit and Lasso (Least absolute shrinkage and selection operator)
3. Least angle regression (LARS)

Chapter 4 Classical algorithms: Parsing for grammars [ch3.pdf]

1. Bottom-ip/top-down parsing: CYK, Earley
2. Inside-Outside: inferring and learning SCFG

Chapter 5 Inference in the Gibbs fields [ch5.pdf]

1. Critria for finite state MCMC design
2. Data driven Markov Chain Monte Carlo for segmentation and parsing
3. Swendsen-Wang cut and its variants
4. C4 and Computing multiple distinct solutions

Chapter 6 Optimization by differential equations [ch6.pdf]

1. Region competition equations
2. stochastic diffusion and Langevins
3. Jump-diffusion

Chapter 7 Image parsing algorithms [ch7.pdf]

1. Top-down / bottom-up parsing of attributed grammar
2. Alpha-beta-gamma processes
3. Discussions on scheduling and decision policy
4. Multi-Armed Bandit problem: exploration vs exploitation

Chapter 8 Clustering and learning hierarchical models [ch8.pdf]

1. Structure Learning: Bi-clustering and Block pursuit
2. Disconnectivity graphs for neergy landscape
3. Curriculum design (discussion)