COMPUTATIONAL MODELING OF VISUAL PERCEPTION

CSE6390D - PSYC6225A 3.0 (F)

James Elder
MW 13:00 - 14:30
Bethune 322

Enrolment limit: none

Purpose:
The goal of this course is to provide a framework and computational tools for modeling visual inference, motivated by interesting examples from the recent literature. Models may be realized as algorithms to solve computer vision problems, or may constitute theories of visual processing in biological systems. The foundation of the course is a treatment of visual processing as a problem of statistical estimation and inference, grounded in the ecological statistics of the visual world.

Topics include:

- Bayesian decision theory
- Principal components and factor analysis
- Graphical Models
  - Markov Random Fields
  - Conditional Random Fields
  - Belief Propagation
- Clustering
  - Mean Shift
  - Expectation Maximization
  - Spectral Methods (Graph Cuts)
- Sampling
  - Gibbs Sampling
  - Markov Chain Monte Carlo
- Classifiers
  - Support Vector Machines
  - Neural Networks

Course Format:
Each week will consist of two 1.5 hour meetings:
Meeting 1. A lecture by the instructor on a specific computational tool or approach
Meeting 2. A discussion, led by a specified student, of a selected computational vision paper in which this approach is applied to a specific problem.

In addition, each week a MATLAB software package will be provided that implements elements of the computational approach under study. Students will complete a short MATLAB homework applying the method to a simple example problem.

Two of these short assignments will be written up and submitted for grading.

Pre-requisites:

Experience with MATLAB or other high-level programming languages.

Basis of Evaluation:

In addition to student presentations of short computational vision papers, two short MATLAB assignments will be collected and graded. The final project will involve application and possibly extension of a technique studied in the class to a problem chosen by the student.

Class Participation	10%
Paper Presentation	20%
Assignment 1	20%
Assignment 2	20%
Final Project	30%

Main Texts:

- C.M. Bishop *Pattern Recognition and Machine Learning*. New York: Springer, 2006.
- S.J.D. Prince *Computer Vision Models*. Available in draft form at http://computervisionmodels.blogspot.com/

Additional Readings:

- Pearl J. (1988) *Probabilistic Reasoning in Intelligent Systems: Networks of Plausible Inference.* San Mateo, CA: Morgan Kauffman, 1988.
- Duda R.O., Hart, P.E. & Stork D.G. (2001) *Pattern Classification*, 2nd ed. New York: Wiley.
- Additional papers from the vision literature, to be determined.

Approximate Schedule:

Week	Date	Topic	Required Readings	Additional Readings	Application Paper	Presenter
1	M Sept 13 W Sept 15	Probability & Bayesian Inference Probability Distributions & Parametric Modeling	Bishop Ch 1.1-1.2.5 (29 pages) Bishop Ch 2.1-2.3 (skip 2.3.5) (43 pages)	Pearl Ch 1.4-1.6, 2 Howson & Urbach 1991 Prince Ch 1-4 Duda Ch 3.1-3.5		
2	M Sept 20 W Sept 22	Probability Distributions & Parametric Modeling (cntd.) Non-Parametric Modeling	Bishop Ch 2.5 (7 pages)	Duda Ch 4.1-4.5	Comaniciu & Meer 2002 (Mean Shift)	Ron Tal
3	M Sept 27 W Sept 29	Expectation Maximization	Prince Ch 5 (11 pages) Prince Ch 6.1-6.5, 6.8 (24 pages)	Bishop Ch 9	Stauffer & Grimson 1998 Weber & Perona 2000	Paria Mehrani
4	M Oct 4 W Oct 6	Linear Subspace Models	Prince Ch 6.6-6.7, 6.9 (12 pages) Bishop Ch 12 (40 pages)	Duda Ch 10.13-10.14	Tenenbaum et al 2000 Roweis & Saul 2000	Abdel-Hamid Ossama
	M Oct 11 W Oct 13	Reading Week				
5	M Oct 18 W Oct 20	Linear Regression	Bishop Ch 3 (36 pages)	Prince Ch 7.1-7.2	Moghaddam 2002 Cremers 2003	Junjie Zhang
6	M Oct 25 W Oct 27	Linear Classifiers	Bishop Ch 4.1-4.3 (34 pages)	Duda 5.1-5.8	Belhumeur et al 1997 Martin et al 2004	Brian Kim Tareq Mohammad Adnan (moved to Nov 1)
7	M Nov 1 W Nov 3	Non-Linear Regression & Classification	Bishop Ch 6 (29 pages)	Prince Ch 7.3-7.4	Toyama & Blake 2001 Grochow et al 2004	Anna Topol
8	M Nov 8 W Nov 10	Sparse Kernel Machines	Bishop 7.1 (20 pages)		Agarwal & Triggs 2006 Zhang et al 2007	Eduardo Corral Soto
9	M Nov 15 W Nov 17	Graphical Models: Introduction	Bishop Ch 8.1-8.3 (34 pages)		Freeman et al 2000 Shi & Malik 2000	Ravi Persad Xiwen Chen
10	M Nov 22 W Nov 24	Graphical Models: Inference	Bishop Ch 8.4 (25 pages)		Boykov & Funka-Lea 2006 He et al 2004	Chao Luo Anthony Calce
11	M Nov 29 W Dec 1	Graphical Models: Applications	Prince Ch 10-11 (56 pages)		Frey & Jojic 2005 Szeliski et al 2008 Friedman et al 2004	Wendy Ashlock
12	M Dec 6 W Dec 8	Sampling Methods	Bishop Ch 11 (32 pages)		Zhu 1999 Yuille & Kersten 2006	Calden Wloka

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