EE641 - Model-Based Image and Signal Processing
Fall 2013

Instructor: Charles A. Bouman
Office: MSEE 348
Phone: 49-40340
E-mail: bouman
Course Hours: MWF 2:30 to 3:20
Course Location: BME 1083
Office Hours: after class or by appointment
Course Web Page: https://engineering.purdue.edu/∼bouman/ee641/
Lab Web Page: https://engineering.purdue.edu/∼bouman/grad-labs/
Email address for off-campus homework submission: hwbouman@gmail.com

References:

1. R. Chellappa and A. Jain, *Markov Random Fields: Theory and Application,* Academic Press, 1993.

2. S. D. Silvey, *Statistical Inference,* Chapman & Hall, 1975.

3. A. K. Jain, *Fundamentals of Digital Image Processing,* Prentice-Hall, 1989.

4. A. Rosenfeld and A. Kak, *Digital Picture Processing,* volumes 1 and 2, Academic Press, 1982.

5. R. Kindermann and J. L. Snell, *Markov Random Fields and their Applications,* Providence: American Mathematical Society, 1980.

6. W. Briggs, *A Multigrid Tutorial,* Society for Industrial and Applied Mathematics, Philadelphia, 1987.

7. A. Tikhonov V. Arsenin and F. John, *Solutions of Ill-Posed Problems,* V. H. Winston & Sons, 1977.

This course will cover topics in image processing at the level of current research. Reference material will be primarily in the form of journal publications. The course will include computer homework assignments, computer projects, one midterm and a final. Final grades will use the following weighting.

Homework and computer projects	30%
Midterm #1	30%
Final exam	40%

Course Outline

1. Introduction
    a. Random variables
    b. Estimation
    b. Whitening
2. Autoregressive Processes
    a. 1D, 2D
    b. Matrix Representations
    c. Computing optimal predictors
    d. Order estimation
3. Gaussian Random Fields
    a. Gauss-Markov Random Field
    b. Simultaneous AR
4. Image Restoration
    a. GMRF
    b. Optimization
        i. ICD
        ii. Gradient Search
        iii. Convexity
    c. MAP vs. MMSE
5. EM algorithm
    a. Derivation
    b. Clustering
    c. Convergence
    d. Order estimation
6. Markov Chains
    a. Matrix Representation
    b. Parameter estimation
7. Hidden Markov Models (HMM)
    a. Dynamic programming
    b. EM algorithm for training
8. MRF's
    a. Gibb's Distributions
    b. Hammersley Clifford Theorem
    c. Simmulation
9. Segmentation
    a. Bayesian Model
    b. Simulated Annealing
    c. MPM
    d. Multiscale Techniques
10. Emission/Transmission Tomography
    a. Derivation of model
    b. EM algorithm
    c. MRF prior
    d. Influence functions
11. Diffusion Tomography
    a. Nonlinear inverse problems
    b. Frechet derivatives and adjoint differentiation
    c. Multigrid optimization
12. Magnetic Resonance Imaging (MRI)
    a. Derivation of system model
    b. Functional MRI (fMRI)
    c. Open problems
13. Nonlinear prediction
    a. Classification/regression trees
    b. Training and order estimation
12. Multiscale Stochastic Models
    a. Stochastic Trees
    b. Estimation-ML,MPM,SMAP
    c. Fast algorithms
14. Image Search and Query
    a. Similarity measures for images
    b. Tree search and pruning