# E E 2 9 5 Image Processing

**Spring Semester 2008**
**Tue., Thurs. 12:30 - 1:45 pm**
**(Votey 361)**
**Wed. - TBA**
**Instructors: Mirchandani, Oughstun, Snapp**

**EE 295, Image Processing,** 4-credit hours, is being designed to replace EE 276, Image Processing & Coding. It has a reduced prerequisite and covers a wider range of topics. Course lectures will be team taught. Lectures will cover the theoretical aspects of image processing topics described below, with the physical aspects illustrated in the Labs. and homeworks. A tentative syllabus is given.

**Description**
The course will cover the fundamentals of digital filter and transform techniques for image processing and feature extraction. Also covered is the image reconstruction problem under the unifying framework of inverse problems and Bayesian models for image processing.

**Prerequisites**
EE-171 Signals and Systems. Knowledge of Probability Theory and Linear Algebra at the undergraduate level will be assumed. A short introduction to digital signal processing methods will be given in the first 4 lectures.

**Intended Audience**
Besides EE students, the course may be of interest to other students with an applied math., statistics, physics or engineering background who have a serious interest in image processing. In particular, those with such interest in Medical Imaging, Computer Vision, Remote Sensing and Computed Imaging (Tomography, MRI, Radar Imaging).

**Syllabus**

**1. Review of 1-D Deterministic Digital Signal Processing** *(4 Lectures - Mirchandani)*
Signals & Systems: Linear, continuous-time systems. Time-domain analysis and convolution.
Continuous-time Fourier series and Fourier transform and properties.
Signals & Systems: Linear, discrete-time systems. Time-domain analysis and convolution.
Sampling in time, aliasing, interpolation and quantization.
Discrete-time Fourier series and Fourier transform, Discrete Fourier transform, z-Transform and properties.
FIR, IIR filters and Windows.
Spectral analysis with the DFT.

**2. Basic Digital Image Processing** *(6 Lectures - Mirchandani)*
Image acquisition, Sampling in 2D, Aliasing, Quantization. Two-Dimensional Signals & Systems. 2-D Convolution and Correlation. 2-D Filters. Random signals. Stationary Processes, Covariance.

**3. Inverse Optics & Reconstruction Techniques** *(12 Lectures - Oughstun)*
Diffraction theory of Image Formation. Back Projection (Projection Slice Theorem, Filtered Back Projection, Radon Transform), Diffraction Tomography.

**4. Image Transforms** *(8 Lectures - Mirchandani)*
1-D and 2-D Orthogonal Transforms. Energy Compaction and Decorrelation. 1-D, 2-D DFT and DCT. KL Transform and Singular Value Decomposition.

**5. Introduction to Statistical Models in Image Processing** *(8 Lectures - Snapp)*
Feature Space. Reduction of Feature Space by Principal Component Methods. Statistical Pattern Recognition. Relation to Neural Network methods. Markov Random Fields and the Bayesian Framework.

**6. Image Filtering & Restoration** *(4 Lectures - Mirchandani)*
Inverse and Wiener Filtering. Splines and Interpolation. Least-Squares Filtering.

**Homeworks & Lab Assignements**
Homeworks will be assigned each week and graded.
Homeworks will often require use of MATLAB, ImageJ or IMOD software.
The IMOD software will be used to illustrate Tomographic and 3D reconstruction of Electron Microscope serial sections.
Previously assigned Labs in EE 276 (2006) can be seen at:
http://www.emba.uvm.edu/mirchand/˜ee276/coursemat.html

**Class Projects**
Students must find and have approved, a project consistent with the subject matter in the course. Projects may be entirely theoretical, selected from a list of suggested ones that use real data or they may propose one of their own.

**Assessment Methods**
Homeworks 60%
2 Exams, 10%
1 Project, 20%

**Texts** (all three optional)
( *Lecture Notes from most lectures will be distributed)*
A.K.Jain, *Fundamentals of Digital Image Processing*, Prentice-Hall, 1989.
Chs:1,2,4,5,6,7,11
K.R.Castleman, *Digital Image Processing* Prentice-Hall, 1996. Chs:11
O.Faugeras, *Three-Dimensional Computer Vision*, MIT Press, 1999. Ch:4

**Recommended Further Reading**
R.J.Clarke, *Transform Coding of Images*, Academic Press, 1985
Sonka, Hlavac and Boyle, *Image Processing, Analysis and Machine Vision*, 2nd edition. Chapman and Hall. 1993
Trucco and Verri, *Introductory Techniques for 3-D Computer Vision*, Prentice-Hall. 1998