EE610: Image Processing

http://www.ee.iitb.ac.in/∼sumantra/courses/ip/ip.html

General Information

No one shall be permitted to audit the course. People are welcome to sit through it, however. The course is open to all suitably inclined B. Tech., Dual Degree, M. Tech. and Ph. D. students of all disciplines: EE, CSE, Mathematics, Physics, ME, etc. No pre-requisite course is required, nor is any background assumed, except for a knowledge of basic First Year B.Tech Mathematics or its equivalent, and a basic knowledge of programming.

Schedule for classes: **Credits:** 6

Mon: 10:30 - 11:30, Wed: 09:30 - 10:30, Thu: 09:30 - 10:30 EEG-101

Textbooks:

- R. C. Gonzalez, R. E. Woods. *Digital Image Processing.* Addison Wesley Longman, Inc., 1992.

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

Reference Books:

- R. M. Haralick, L. G. Shapiro. *Computer and Robot Vision.* Addison-Wesley, 1993.

- A. Rosenfeld, A. C. Kak. *Digital Picture Processing.* Addison-Wesley,1983

- D. A. Forsyth, J. Ponce. *Computer Vision: A Modern Approach.* Prentice-Hall, 2003.

- C. R. Giardina, E. R. Dougherty. *Morphological Methods in Image and Signal Processing.* Prentice-Hall, Englewood Cliffs, New Jersey, 1988.

- R. J. Schalkoff. *Digital Image Processing and Computer Vision.* John Wiley & Sons, Singapore, 1989.

- V. S. Nalwa. *A Guided Tour of Computer Vision.* Addision-Wesley, 1993.

- W. K. Pratt. *Digital Image Processing (Second Edition).* John Wiley & Sons, New York, 1991.

- B. K. P. Horn. *Robot Vision.* MIT Press, Cambridge, 1987.

- D. H. Ballard, C. M. Brown. *Computer Vision.* Prentice-Hall, Englewood Cliffs, 1982.

- G. C. Stockman, L. G. Shapiro. *Computer Vision.* Prentice-Hall, 2001.

- R. I. Hartley, A. Zisserman. *Multiple View Geometry in Computer Vision.* Cambridge University Press, ISBN: 0521623049, 2000.

- O. Faugeras. *Three-Dimensional Computer Vision: A Geometric Viewpoint.* MIT Press, 1993.

- R. Kasturi, R. C. Jain. *Computer Vision: Principles.* IEEE Computer Society Press Tutorial, 1991.

- W. H. Press, S. A. Teukolsky, W. T. Vetterling, B. P. Flannery. *Numerical Recipes in C (Second Edition).* Cambridge University Press, 1992.

- A. K. Jain, R. C. Dubes. *Algorithms For Clustering Data.* Prentice-Hall, 1988.

- R. Gose, R. Johnsonbaugh, S. Jost. *Pattern Recognition and Image Analysis.* Prentice-Hall, 1996.

- A. Tucker, D. Small. *A Unified Introduction to Linear Algebra: Models, Methods, and Theory.* Macmillan Publishing Company, 1989.

Papers:

- R. Y. Tsai. A Versatile Camera Calibration Technique for High-Accuracy 3-D Machine Vision Metrology Using Off-the-Shelf TV Cameras and Lenses. *IEEE Journal of Robotics and Automation*, RA-3, 4, 323 – 344, August 1987.

- A. Krishnan, N. Ahuja. Range Estimation From Focus Using a Non-frontal Imaging Camera. In *Proc. National Conference on Artificial Intelligence (AAAI)*, pp. 830 – 835, 1993.

- A. Krishnan, N. Ahuja. Stereo Display of Large Scenes from Monocular Images Using a Novel Non-Frontal Camera. In *Proc. Asian Conference on Computer Vision (ACCV)*, 1993.

- A. Krishnan, N. Ahuja. Panoramic Image Acquisition. In *Proc. IEEE International Conference on Computer Vision and Pattern Recognition (CVPR)*, pp. 379 – 384, 1996.

- A. Krishnan, N. Ahuja. Range Estimation From Focus Using a Non-Frontal Imaging Camera. *International Journal of Computer Vision*, Vol. 20, No. 3, 169 – 185, 1996.

- A. Castano, N. Ahuja. Omnifocussed 3D Display Using the Nonfrontal Imaging Camera. In *Proc. IEEE and ATR Workshop on Computer Vision for Virtual Reality Based Human Communications (CVVRHC)*, pp. 28 – 34, 1998.

- S. K. Nayar. Catadioptric Omnidirectional Camera. *In Proc. IEEE International Conference on Computer Vision and Pattern Recognition (CVPR)*, pp. 482 – 488, 1997.

- S. Baker and S. K. Nayar. A Theory of Single-Viewpoint Catadioptric Image Formation. *International Journal of Computer Vision*, Vol. 35, No. 2, 175 – 196, 1999.

- M. Irani, B. Rousso, S. Peleg. Computing Occluding and Transparent Motions. *International Journal of Computer Vision*, Vol. 12, No. 1, 5 – 16, 1994.

- M. Irani, B. Rousso, S. Peleg. Recovery of Ego-Motion Using Image Stabilization. In *Proc. IEEE International Conference on Computer Vision and Pattern Recognition (CVPR)*, pp. 454 – 460, 1994.

- B. Rousso, S. Avidan, A. Shashua, S. Peleg. Robust Recovery of Camera Rotation from Three Frames. In *Proc. DARPA Image Understanding Workshop*, pp. 851 – 856, 1996.

- R. Szeliski. Image Mosaicing for Tele-Reality Applications. *CRL 94/2, Cambridge Research Laboratory Technical Report Series*, May 1994.

- M. Kass, A. P. Witkin, D. Terzopoulos. Snakes: Active Contour Models. In *Proc. IEEE International Conference on Computer Vision*, pp. 259 – 268, 1987.

- M. Kass, A. P. Witkin, D. Terzopoulos. Snakes: Active Contour Models. *International Journal of Computer Vision*, Vol. 4, 321 – 331, January 1988.

- D. Marr, E. Hildreth. Theory of Edge Detection. *Proceedings of Royal Society of London*, Vol. 207, pp. 187 – 217, 1980.

- H. Murase and S. K. Nayar. Visual Learning and Recognition of 3D Objects from Appearance. *International Journal of Computer Vision*, Vol. 14, No. 1, pp. 5 – 24, 1995.

- S. K. Nayar and R. M. Bolle. Reflectance Based Object Recognition. *International Journal of Computer Vision*, Volume 17, No. 3, pp. 219 – 240, 1996.

- J. F. Canny. A Computational Approach to Edge Detection. *IEEE Transactions on Pattern Analysis and Machine Intelligence*, Vol. 8, No. 6, pp. 679 – 698, November 1986.

- Z. Zhang, H. Wang, E. K. Teoh. Analysis of Gray Level Corner Detection. *Pattern Recognition Letters*,

- G. K. Wallace. The JPEG Still Picture Compression Standard. *Communications of the ACM*, Vol. 34, No. 4, pp. 30 – 44, April 1991.

- A. N. Skodras, C. A. Christopoulos, T. Ebrahimi. JPEG2000: The Upcoming Still Image Compression Standard. *Pattern Recognition Letters*, Vol. 22, pp. 1137 – 1345, 2001.

- S. Geman and D. Geman. Stochastic Relaxation, Gibbs Distributions, and the Bayesian Restoration of Images. *IEEE Transactions on Pattern Analysis and Machine Intelligence*, Vol. 6, No. 6, pp. 721 – 741, November 1984.
- M. A. Isard. *Visual Motion Analysis by Probabilistic Propagation of Conditional Density*. PhD Thesis, Department of Engineering Science, University of Oxford, September 1998.
- M. S. Arulampalam, S. Maskell, N. Gordon and T. Clapp. A Tutorial on Particle Filters for Online Nonlinear/Non-Gaussian Bayesian Tracking. *IEEE Transactions on Signal Processing*, vol. 50, no. 2, pp. 174 - 188, February 2002.
- I. M. Rekleitis. A Particle Filter Tutorial for Mobile Robot Localization. TR-CIM-04-02, Centre for Intelligent Machines, McGill University.

Online Tutorial Material:

- Prof. U. B. Desai's Image Processing Course Page
- Prof. S. Chaudhuri's Image Processing Course Page
- CVonline
- The Computer Vision Homepage at CMU
- C. Tomasi. Mathematical Methods for Robotics and Vision
- T. Vieville. A Few Steps Towards 3D Active Vision
- S. Birchfield. An Introduction to Projective Geometry
- (Author not known). A Tutorial on 3D Projection and Viewing
- S. Carlsson. Geometry and Algebra of Projective Views: Chapter 1; Chapter 2; Chapter 3; Chapter 4; Chapter 6; Appendix
- S. Banerjee. Tutorial on Geometrical Models; Camera Models and Affine Multiple Views Geometry; Projective Geometry for Computer Vision; How to compute a homography
- D. P. Huttenlocher. Fast Detection Algorithms; Distance Transforms - Hausdorff and Chamfer Matching; Hausdorff and Chamfer Matching (contd.); Edge and Corner Detection, Gaussian Filtering; Visual Motion; Regularization and MRF's; Multi-Camera Geometry; Structure from Motion; Image Segmentation
- A. Zisserman. 2 Views - Epipolar Geometry and the Fundamental Matrix; 2 Views - Uncalibrated 3D Reconstruction; 2 Views - Planes; 3+ Views - Points, Lines, Curves; General notes on Projective Geometry,
- R. Mohr, B. Triggs. Projective Geometry for Image Analysis. Tutorial on projective geometry given at the *International Symposium of Photogrammetry and Remote Sensing*, Vienna, July 1996.
- M. Pollefeys. Tutorial on 3D Modeling from Images. In conjuction with the *European Conference on Computer Vision (ECCV)* 2000, Dublin, 2000.
- James D. Murray. FAQ on File Formats

The above list is (obviously!) not exhaustive. Other reference material will be announced in the class. The Web has a vast storehouse of tutorial material on Image Processing, and other related areas.

Assignments ... A combination of theoretical work as well as programming work. Both will be scrutinized in detail for original work and thoroughness. For programming assignments, there will be credit for good coding. Sphagetti coding will be penalized. Program correctness or good programming alone will not fetch you full credit ...also required are results of extensive experimentation with varying various program parameters, and explaining the results thus obtained. Assignments will have to be submitted on or before the due date and time. Late submissions will not be considered at all. Unfair means will be result in assigning as marks, the number said to have been discovered by the ancient Indians, *to both parties (un)concerned.*

Examinations and Grading Information:

Mid-Sem: 33   Assignments: 34   End-Sem: 33

Attendance Requirements: As per Institute rules for M. Tech, Dual Degree and B. Tech students. Illness policy: illness to be certified by the IITB Hospital.
Attendance in Examinations is Compulsory.

Proposed Course Outline

1. Introduction

Relation between Image Processing, Computer Vision and Computer Graphics
What is Image Processing
Overview

2. The Camera: The Basic Apparatus

Radiosity: *The 'Physics' of Image Formation*
Projective Model: *The 'Maths' of Image Formation*
New Sensors: *Getting more from the Good 'ol Camera*
The NICAM: *Keeping everything in focus*
The Omnicam: *Looking all around*
Mosaics: *Stitching images together*

3. Image Representation, Modeling, Operations

Signal Processing Hangover . . .
Introduction to the Frequency Domain: The Fourier Transform
Image Transforms: *Viewing it differently*

4. Image Enhancement: *Getting a better picture*

5. Image Restoration: Removing the subjectivity

6. Image Analysis

Edge Detection
Corner Detection
Shape
Texture
Segmentation

7. Image Reconstruction from Projections: *Piecing it together*

8. Image Compression: *Packing it all in*

9. Motion Analysis: *Examining things . . . on the move*

10. Miscellaneous Topics: A Pot-pourri assortment

(N)one or more, as time permits
Mathematical Morphology
Active Contours: Snakes
A brief introduction to wavelets
Multispectral Image Analysis: Colour
Visual Tracking