Course number: EEE598
Title: Computational Image Understanding and Pattern Analysis
Instructor: Pavan Turaga, (pturaga (at) asu.edu)

Course Objectives and Expected Learning Outcomes

This graduate course introduces students to the field of computer vision, whose broad goal is to create algorithms and systems for processing of visual signals (images, videos etc.) for low-level, mid-level, and high-level perceptual tasks. This course presents the broad principles and techniques for devising computer vision algorithms starting from understanding the imaging process for a pin-hole camera, understanding lenses, image-statistics such as gradients and edges, 3D structure estimation, motion estimation, illumination modeling to perceptual tasks such as shape recognition, texture modeling, face recognition, activity recognition, and scene recognition. The class will be a mixture of in-class lectures and discussions, and individual and group projects.

Textbook:
Computer Vision: Algorithms and Applications by Richard Szeliski available for free at http://szeliski.org/Book/.

Reference Textbooks:

- Computer Vision: A Modern Approach by David Forsyth and Jean Ponce.
- Multiple View Geometry in Computer Vision by Richard Hartley and Andrew Zisserman.
- Pattern Classification by Richard O. Duda, Peter E. Hart and David G. Stork.

Pre-requisites

Undergraduate level linear algebra, signal processing, and probability theory are a plus. However, we plan to keep the course accessible to students from other backgrounds, and will be mostly self-contained.

Grade Policies

The class will consist of individual and group projects.

Assignements (approx. 5)	Project 1	Project 2	Class Participation
20%	30%	40%	10%

The projects are planned to be group projects, where you will be encouraged to clearly define a problem statement, propose a novel solution, and design an implementation.

Attendance Policy

Students are expected to attend all classes. Unexcused absences beyond three will result in a reduction in the student's final grade by one letter grade for every two absences. Tardiness over 10 minutes will be considered an unexcused absence. Attendance will be taken every class, starting the second week of class to allow for new students. If you anticipate having a problem attending class for whatever reason, you are urged to contact the instructor in advance of your expected absence. Absences beyond 6 classes without informing the instructor would result in you being dropped from the course according to ASU rules.

<u>Office Hours</u>
Pavan Turaga – TBA and by appointment, please contact us via email to set up appointments in advance.

<u>Academic Dishonesty</u>
All necessary and appropriate sanctions will be issued to all parties involved with plagiarizing any and all course work. Plagiarism and any other form of academic dishonesty that is in violation with the Student Code of Conduct will not be tolerated. For more information, please see the ASU Student Academic Integrity Policy.

<u>Special Accommodations</u>
To request academic accommodations due to a disability; please contact the ASU Disability Resource Center (http://www.asu.edu/studentaffairs/ed/drc/# ; Phone: (480) 965-1234; TDD: (480) 965-9000). This is a very important step as accommodations may be difficult to make retroactively. If you have a letter from their office indicating that you have a disability which requires academic accommodations, in order to assure that you receive your accommodations in a timely manner, please present this documentation to me no later than the end of the first week of the semester so that your needs can be addressed effectively.

<u>Tentative list of Topics:</u>

Date	Topic
1/11/16	Intro; Pinhole model
1/13/16	Derivation of pinhole projection models, properties etc.
1/18/16	MLK Day; holiday
1/20/16	Camera projection matrix derivation, properties, degrees of freedom.
1/25/16	Linear, non-linear least squares, application to calibration, Triangulation
1/27/16	Epipolar geometry, fundamental matrix, 8 point algorithm etc.
2/1/16	Rectified stereo systems, depth-from-disparity, edges, gradients, Max demo
2/3/16	Canny edges, image hessian, associated eigenvalue problem.
2/8/16	Discussion of Harris corners, scale-selection, SIFT
2/10/16	SIFT examples, Dense depth, window search, dynamic programming stered
2/15/15	Introduction to recognition, Bayesian decision theory

2/17/16	Nearest Neighbors, Voronoi cell, Asymptotic Error Rate, Example from Efros and
2/22/16	NN improvements with condensing, tree-search, hashing. Dim reduction PCA
2/24/16	PCA (contd.) + Manifold Learning (Isomaps, LLE)
2/29/16	Linear Discriminants. LDA, Perceptron Rule, MSE, SVMs
3/2/16	Intro to Deep Learning
3/7/16	Spring Break
3/9/16	Spring Break
3/14/16	Project 1 Proposals
3/16/16	Project 1 Proposals
3/21/16	Motion: Background Subtraction, Optical Flow Brightness constancy constrai
3/23/16	Lucas-Kanade Flow, Hierarchical Flow, Point tracking with flow
3/28/16	Structrure from Motion under Orthography
3/30/16	Tracking, particle filters, sampling?
4/4/16	Project 1 Presentations
4/6/16	Project 1 Presentations
4/11/16	Clustering, spectral clustrering, Normalized cuts
4/13/16	Shape/Texture
4/18/16	Light, Shading, shape from shading, photometric stereo
4/20/16	Activity Analysis
4/25/16	Final presentations
4/27/16	Final presentations

Readings

A. Primary readings

Computer Vision: A Modern Approach, Forsyth and Ponce.

- Chapter 1: Cameras
- Chapter 2: Geometric Camera Models
- Chapter 3: Geometric Camera Calibration
- Chapter 4: Radiometry: Measuring Light
- Chapter 8: Edge Detection
- Chapter 10: The geometry of multiple views
- Chapter 11: Stereopsis

B. Reference Readings

H. Christopher Longuet-Higgins (September 1981). "A computer algorithm for reconstructing a scene from two projections". Nature 293 (5828): 133–135.

Richard I. Hartley (June 1997). "In Defense of the Eight-Point Algorithm". IEEE Transaction on Pattern Recognition and Machine Intelligence 19 (6): 580–593.

B.K.P. Horn and B.G. Schunck, "Determining optical flow." Artificial Intelligence, vol 17, pp 185–203, 1981.

B. D. Lucas and T. Kanade (1981), An iterative image registration technique with an application to stereo vision. Proceedings of Imaging Understanding Workshop, pages 121—130

Carlo Tomasi and Takeo Kanade. 1992. Shape and motion from image streams under orthography: a factorization method. Int. J. Comput. Vision 9, 2 (November 1992), 137-154.

David G. Lowe, "Distinctive image features from scale-invariant keypoints," International Journal of Computer Vision, 60, 2 (2004), pp. 91-110.Chris Stauffer,

W. Eric L. Grimson: Adaptive Background Mixture Models for Real-Time Tracking. CVPR 1999: 2246-2252A. Elgammal, R. Duraiswami, D. Harwood and

L. S. Davis "Background and Foreground Modeling using Non-parametric Kernel Density Estimation for Visual Surveillance", Proceedings of the IEEE, July 2002

Christopher J. C. Burges. 1998. A Tutorial on Support Vector Machines for Pattern Recognition. Data Min. Knowl. Discov. 2, 2 (June 1998), 121-167.M.

Turk and A. Pentland (1991). "Eigenfaces for recognition" (PDF). Journal of Cognitive Neuroscience 3 (1): 71–86.

J. B. Tenenbaum, V. de Silva, J. C. Langford, A Global Geometric Framework for Nonlinear Dimensionality Reduction, Science 290, (2000), 2319–2323

S. T. Roweis and L. K. Saul, Nonlinear Dimensionality Reduction by Locally Linear Embedding, Science Vol 290, 22 December 2000, 2323–2326.

P. Turaga, A. Veeraraghavan, A. Srivastava, and R. Chellappa, "Statistical Computations on Grassmann and Stiefel Manifolds for Image and Video based Recognition", IEEE Transactions on Pattern Analysis and Machine Intelligence, Nov 2011.

Assorted tutorials on Deep Learning.