Statistical Image Processing
ECE697SP

The class meets every Tuesdays and Thursdays from 11:15 am to 12:30 am in ELAB 327. Class website: offered in the Umass Moodle system

Instructor

Prof. Mario Parente, Knowles 113D, mparente@ecs.umass.edu
Office hours: Tuesdays 3:00 - 4:30 pm

Textbook

Weekly assigned readings, no required textbook.

Optional References

- Trevor Hastie, Robert Tibshirani, and Jerome Friedman. *The Elements of Statistical Learning*. Springer Series in Statistics Springer New York Inc., New York, NY, USA, (2001).
- Christopher M. Bishop. *Pattern recognition and machine learning*. Springer, New York, (2006).
- by Rafael C. Gonzalez, Richard E. Woods. *Digital Image Processing (3rd Edition)*. Prentice-Hall, Upper Saddle River, NJ, (2007)

Learning purposes

Digital image processing and analysis of information in images are methods that become increasingly important in many technical and scientific fields. The aim of the course is to provide a basic knowledge of how to use probabilistic and statistical methods for image analysis. Methods for representing, segmenting and detecting information in images are covered in the course, including methods for performing quantitative scientific measurements.

Core subjects in the course is pattern recognition and feature extraction applied to images. In pattern recognition we study methods for discrimination between classes of objects characterized by suitably chosen features.

Examples are taken from remote sensing, microscopy, photography and medical imaging. In the course special interest will be devoted to applications in remote sensing, including analysis of images of planetary surfaces. Examples of research topics that will be covered include image texture recognition, image classification and regression.

Practical computer work is included, typically using Matlab. An important part of the course is to carry through a project in a small group, presenting the results at a seminar and writing a project report.

Prerequisites

Vector and matrix algebra, multidimensional probability. Students possessing some familiarity with concepts of signal theory equivalent to those obtained in ECE 608 are encouraged to apply. Although attendance of ECE 608 is not a requirement and the necessary concepts for this class could be learned along the way, student unfamiliar with signal theory should consult with instructor.

1 Course Requirements

1. Homework: bi-weekly, with numerical exercises based on theory and coding to illustrate the concepts.

2. Midterm Exam: TBD but later than other classes

3. Final Project: All students are required to complete a project on an application of image analysis. The research topics will be provided by the instructor. You are encouraged to define the objective of your project, collect all necessary data, review all the previous research, and perform image processing. Your final project will be graded based on the soundness of your method and approach adopted and how well you paper is organized and wrote in your research purpose, methods, and results of your final project. A final report is due on the last day of finals week. Late hand in will also get 10% reduction in points each working day. The format of proposal and final report follow the formats from the journal of Remote Sensing of Environment. The final report should be 8-10 pages (not including bibliography, tables, and pictures), double spaced, 12-point font size and include title and abstract, introduction, literature review/background, data and methodology, result, discussion, conclusion, and reference.

4. Attendance: Attendance is required. Attendance will undoubtedly improve your understanding of principles and your ability to perform well in the class as a whole. When a student can not attend class due to certain reasons, it is the studentÕs responsibility to obtain class materials that were presented in class.

Grading and Evaluation Policies

Your final grades will be based on 1 midterm, the final project, and homework. All due dates are shown on the Moodle course schedule or they will be specified in lecture.

Academic Honesty Policy Statement

Since the integrity of the academic enterprise of any institution of higher education requires honesty in scholarship and research, academic honesty is required of all students at the University of Massachusetts Amherst.

Academic dishonesty is prohibited in all programs of the University. Academic dishonesty includes but is not limited to: cheating, fabrication, plagiarism, and facilitating dishonesty. Appropriate sanctions may be imposed on any student who has committed an act of academic dishonesty. Instructors should take reasonable steps to address academic misconduct. Any person who has reason to believe that a student has committed academic dishonesty should bring such information to the attention of the appropriate course instructor as soon as possible. Instances of academic dishonesty not related to a specific course should be brought to the attention of the appropriate department Head or Chair. The procedures outlined below are intended to provide an efficient and orderly process by which action may be taken if it appears that academic dishonesty has occurred and by which students may appeal such actions.

Since students are expected to be familiar with this policy and the commonly accepted standards of academic integrity, ignorance of such standards is not normally sufficient evidence of lack of intent. For more information about what constitutes academic dishonesty, please see the Sean of Students' website: `http://umass.edu/dean_students/codeofconduct/acadhonesty/`.

Disability Statement

The University of Massachusetts Amherst is committed to providing an equal educational opportunity for all students. If you have a documented physical, psychological, or learning disability on file with Disability Services (DS), Learning Disabilities Support Services (LDSS), or Psychological Disabilities Services (PDS), you may be eligible for reasonable academic accommodations to help you succeed in this course. If you have a documented disability that requires an accommodation, please notify me within the first two weeks of the semester so that we may make appropriate arrangements.

Tentative schedule

All scheduled content and topics are tentatively scheduled and may change during the semester at the instructors discretion. Students will be made aware of any changes.

Week	**Lecture**	**Topics/Sections**

1	Introduction and review	Course introduction, math review, image analysis and machine learning concepts
2	Overview of supervised learning	Classification and regression, Bayes decision theory, bias-variance trade-off curse of dimensionality.
3	Face detection with Eigenfaces	PCA, SVD, eigenfaces
4	Boosting and the Viola-Jones algorithm	boosting, integral image, local features, Viola-Jones algorithm
5	Image features	Detecting edges, lines and other local features in images, hyperspectral features
6	Supervised image classification	kernel methods, SVM, hyperspectral image classification techniques
7	Unsupervised image classification	Clustering and image segmentation of color images and hyperspectral data, agglomerative algorithms, graph-theory based algorithms
8	Manifold Learning	Classical manifold learning techniques applied to natural and hyperspectral images
9	Contextual and texture measures	Texture statistics, texture recognition and synthesis, random fields

Project Ideas

The details and publications related to these projects are on the Moodle site. Feel free to propose your own contribution

1. Stroke analysis of master paintings using high resolution color imaging
2. Crater detection on the Moon based on active contours based on high resolution imaging.
3. N-dimensional data visualization tool.
4. Texture synthesis or recognition.
5. Optimal RGB visualization of hyperspectral images.

6. Super-resolution of CRISM images.
7. Manifold learning applied to the understanding of hyperspectral data clouds
8. Evaluate algorithms for superpixel segmentation of 2d and 3d images
9. Matlab Hyperspectral Image Toolbox with efficient memory management
10. Nonlinear hyperspectral image unmixing
11. improving on the Viola-Jones face detection algorithm