Theoretical Foundations of Computer Vision

CAP 6417, Spring 2006
Department of Computer Science, Florida State University

Class time and location

Tuesday and Thursday, 2:00-3:15PM, HTL (Hoffman Teaching Laboratory) 0217.

Instructor

- Instructor: Xiuwen Liu
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Course Home Page

http://www.cs.fsu.edu/~liux/courses/cap6417/index.html
This web page contains the up-to-date information related to this course such as news, announcements, assignments, lecture notes, useful links to resources that are helpful to this class. You are required to visit this web site on a regular basis. Besides the course home page, an email mailing list and news group will also be established and used to post news and updates.

Course Rationale

Computer vision has evolved into an important field to understand human visual information processing and to design machine vision systems that can interact with their environment flexibly with tremendous civil and military applications. In addition, with recent advances in medical imaging techniques and biological sensor techniques, computer vision techniques become important tools for medical image analysis and bio-informatics. During the last two decades, computer vision has matured with commonly accepted theoretical frameworks to formulate and approach vision problems. This course, instead of following a textbook, will focus on understanding the state of the art and recent developments in computer vision and related areas through understanding papers in the literature. Whenever needed, necessary background knowledge will be covered and reviewed. It is an important advanced course for students who are interested in research in computer vision.

Course Description

This course covers important aspects and recent advances of computer vision through papers in the literature. By formulating computer vision as a statistical inference process, computational approaches to vision and their elements are presented and analyzed. Topics include Marr's computational vision paradigm, feature extraction principles, classification algorithms, Bayesian inference framework for vision, pattern theory, and visual learning theories.

Prerequisites

CAP 5415 – Principles and Algorithms for Computer Vision, or permission of the instructor.

Course Objectives

Upon successful completion of this course of study a student:

- Knows how to formulate vision problems and understands different approaches to vision within this formulation.
- Understands the Marr's paradigm.
- Understands the elements of pattern theory and knows how to formulate and solve typical vision problems in pattern theory.
- Understands the Bayesian inference framework and knows to formulate and solve typical vision problems through Bayesian inference.
- Understands issues in a generic vision system and knows potential computational approaches.
- Knows the research issues in computer vision.
- Has some experience with creative research in computer vision.
- Is well prepared to carry out research in computer vision.

Textbook and Class Materials

This class will mainly use notes and papers from the literature that will be distributed along the lectures. As reference books, you may find the following books useful.

- "***Computer Vision -- A Modern Approach"***, Prentice Hall, 2003, by David Forsyth and Jean Ponce.
- "***2D Object Detection and Recognition: Models, Algorithms, and Networks***" (Yali Amit, MIT Press, 2002.
- "***Elements of Pattern Theory***," (Ulf Grenander, Johns Hopkins University Press, 1996.
- "***Vision: A Computational Investigation into the Human Representation and Processing of Visual Information***" (David Marr, W. H, Freeman and Company, 1982).
- "***Perception as Bayesian Inference***" (David C. Knill and Whitman Richards, Cambridge University Press, 1996.

The following are the most relevant journals and conference proceedings to this class:

- *IEEE Transactions on Pattern Analysis and Machine Intelligence*.
- *Internal Journal on Computer Vision*
- *Computer Vision and Image Understanding*
- *Proceedings of the International Conference on Computer Vision and Pattern Recognition*.
- *Proceedings of the International Conference on Computer Vision*.
- *Proceedings of the International Conference on Image Processing*.
- *Proceedings of the European Conference on Computer Vision*
- *Proceedings of the International Conference on Pattern Recognition*.

Student Responsibilities

Attendance is required for this class. Unless you obtain prior consent of the instructor, missing classes will be used as bases for attendance grading. In case that it is necessary to skip a class, students are responsible to make up missing covered materials. Participation of in-class discussions and activities is also required. All submitted assignments and projects must be done by the author. It is a violation of Academic Honor Code to submit other's work and the instructor and TA of this course take the violations very seriously.

Assignments and Projects

There will about five-seven homework assignments related to the papers and notes. There will be a term project based on the student's interest and background. A research paper, which can be a literature review or a survey on a particular topic, will be also assigned.

Grading Policy

Grades will be determined as follows:

Assignment	Points	Assignment	Points
Attendance	10 %	Presentations	10 %
Class participation	10 %	Research Paper	15 %
Homework assignments	30 %	Term project	25 %

Grading will be based on the weighted average as specified above and the following scale will be used (suppose the weighted average is S in 100 scale)

Score	Grade	Score	Grade	Score	Grade
$93 \leq S$	A	$80 \leq S < 83$	B-	$67 \leq S < 70$	D+
$90 \leq S < 93$	A-	$77 \leq S < 80$	C+	$63 \leq S < 67$	D
$87 \leq S < 90$	B+	$73 \leq S < 77$	C	$60 \leq S < 63$	D-
$83 \leq S < 87$	B	$70 \leq S < 73$	C-	$S < 60$	F

Late Penalties

Assignments are due at the beginning of the class on the due date. Assignments turned in late, but before the beginning of the next scheduled class will be penalized by 10 %. Assignments that are more than one class period late will **NOT** be accepted.

Submission and Return Policy

All tests/assignments/projects/homework will be returned as soon as possible after grading but no later than two weeks from the due date.

Tentative Schedule

- Week 1: Introduction
    - Computational characteristics of human visual information processing.
    - Generic constraints for an effective vision system.
    - General introduction to the mathematical frameworks for computer vision.
    - Problems and goals of computer vision.
- Week 2: Mathematical formulations of computer vision problems.
    - Typical structures in images.
    - Models and representations for typical structures.
    - Vision as a computational process.
    - Marr's computational vision paradigm.

- Weeks 3-4: Representations and features in computer vision.
  - Liner models
    - Principle component analysis.
    - Independent component analysis.
    - Fisher discriminant analysis.
  - Feature extraction
    - Minimum description length criterion.
    - Maximum entropy criterion.
    - Redundancy reduction criterion.
    - Descriptive models in computer vision.
- Week 5 Classification algorithms.
- Weeks 6-7: Computational approaches to vision.
  - Seeing as an approximate inference process.
  - Bayesian inference framework for vision.
  - Efficient approximations to Bayesian inference
- Week 8: Grenander's Pattern Theory.
  - Mathematical framework to represent visual patterns.
  - Deformation structures of visual patterns.
  - "Analysis as synthesis" paradigm.
  - Generative models for computer vision
- Week 9: Spring break.
- Weeks 10-11: 3D vision
- Weeks 12-13: Approaches to invariant object recognition.
- Week 14: Implementation issues in computer vision.
  - Computational complexity of vision algorithms.
  - Optimization techniques for computer vision systems.
  - Monte-Carlo Markov chain techniques for high dimensional problems.
  - Hardware implementation issues.
- Week 15: Current and future research directions in computer vision
  - Open issues in computer vision.
  - Challenges of developing generic computer vision systems.

Academic Honor Code

Programming assignments/written assignments/quizzes/exams are to be done individually, unless specified otherwise. It is a violation of the Academic Honor Code to take credit for the work done by other people. It is also a violation to assist another person in violating the Code (See the FSU Student Handbook for penalties for violations of the Honor Code.). The judgment for the violation of the Academic Honor Code will be done by the TA, the instructor and a third part member (another faculty member in the Computer Science Department not involved in this course). Once the judgment is made, the case is closed and no arguments from the involved parties will be heard. Examples of cheating behaviors include:

- Discuss the solution for a homework question.
- Copy programs for programming assignments.
- Use and submit existing programs/reports on the world wide web as written assignments.
- Submit programs/reports/assignments done by a third party, including hired and contracted.

Penalty for violating the Academic Honor Code: A 0 grade for the particular homework/project/exam and a reduction of one letter grade in the final grade for all parties involved. A report will be sent to the

department head for further administrative actions.

Accommodation for Disabilities

Students with disabilities needing academic accommodations should: 1. Register with and provide documentation to the Student Disability Resource Center (SDRC); 2. Bring a letter to the instructor from the SDRC indicating you need academic accommodations. This should be done within the first week of class. *This syllabus and other class materials are available in alternative format upon request.*