HCI / CprE / ComS 575 - Computational Perception

Spring 2015
Tuesday and Thursday 2:10 - 3:30 p.m.
Howe Hall, Room 1242
Iowa State University
Ames, Iowa 50011

Instructor: Alexander Stoytchev

Office: Howe Hall, Room 1620F
Phone: 515-294-5904 (email preferred)
Email: alexs@iastate.edu
Web Page: http://www.ece.iastate.edu/~alexs
Office Hours: Tuesday and Thursday 3:30-4:00pm (after class), or by appointment

Teaching Assistant: Nate Kent (nkent@iastate.edu)
TA Office: TBD
TA Office Hours: TBD, or by appointment

Course Description: This class covers statistical and algorithmic methods for sensing, recognizing, and interpreting the activities of people by a computer. This semester we will focus on machine perception techniques that facilitate and augment human-computer interaction. The main goal of the class is to introduce computational perception on both theoretical and practical levels. You will work in small groups to design, implement, and evaluate a prototype of a human-computer interaction system that uses one or more of the techniques covered in the lectures.

At the end of this class you will have an understanding of the current state of the art in computational perception and will be able to conduct original research. In addition to that, you will have the skills to design novel human-machine interfaces that push the limits of current interfaces, which, in general, are deaf and blind to the human user.

Topics to be Covered: The class will cover the following topics: Overview of computational perception. Tutorials on Matlab, open computer vision (openCV), and speech recognition packages. Basic image processing. Color and movement detection. Audio processing and speech segmentation. The sense of self. 3D Vision processing. Sensory substitution. Sound classification and recognition. Tracking techniques including Kalman filters and particle filters. Face detection and face recognition: eigenfaces, cascades, and neural network-based approaches. Hidden Markov models for activity recognition and speech recognition. Gesture recognition. Theories of vision and intelligence. Affective computing, i.e., computing that relates to, arises from, or deliberately influences human emotions.
Readings: There are three required books for this class: 1) “Learning OpenCV: Computer Vision with the OpenCV Library” by Gary Bradski and Adrian Kaehler; 2) “Getting Started with MATLAB 7: A Quick Introduction for Scientists and Engineers” by Rudra Pratap; and 3) “On Intelligence” by Jeff Hawkins and Sandra Blakeslee. The lectures will be based on a number of sources most of which are available for download from the Internet. Reading material that is not available on-line will be placed on reserve in the library. The reading list is provided at the end of this document.

Organization*: This class will be taught as a seminar. The students will be expected to read the assigned papers for each lecture in advance and to actively participate in class discussions.

* The instructor reserves the right to change any and all aspects of this class for whatever reason or no reason at all (a.k.a., academic freedom).

Prerequisites: This is a joint graduate and advanced undergraduate class. Previous exposure to at least 2-3 of the following fields is highly recommended: statistics, linear algebra, computer vision, artificial intelligence, human-computer interaction. Programming skills will be required for the homework assignments and for the final project. The most important prerequisite of all, however, is your interest in the course, motivation, and commitment to learning.

For best results take two lectures weekly. Common side effects may include sweatiness, nervousness, lack of sleep, and diarrhea. Talk to your instructor if this class is right for you.

Students with Disabilities: Iowa State University is committed to assuring that all educational activities are free from discrimination and harassment based on disability status. All students requesting accommodations are required to meet with staff in Student Disability Resources (SDR) to establish eligibility. A Student Academic Accommodation Request (SAAR) form will be provided to eligible students. The provision of reasonable accommodations in this course will be arranged after timely delivery of the SAAR form to the instructor. Students are encouraged to deliver completed SAAR forms as early in the semester as possible. SDR, a unit in the Dean of Students Office, is located in room 1076, Student Services Building or online at www.dso.iastate.edu/dr/. Contact SDR by e-mail at disabilityresources@iastate.edu or by phone at 515-294-7220 for additional information.

Harassment and Discrimination: Iowa State University strives to maintain our campus as a place of work and study for faculty, staff, and students that is free of all forms of prohibited discrimination and harassment based upon race, ethnicity, sex (including sexual assault), pregnancy, color, religion, national origin, physical or mental disability, age, marital status, sexual orientation, gender identity, genetic information, or status as a U.S. veteran. Any student who has concerns about such behavior should contact his/her instructor, Student Assistance (http://www.dso.iastate.edu/sa/) at 515-294-1020 or email dso-sas@iastate.edu, or the Office of Equal Opportunity and Compliance (http://www.eoc.iastate.edu/) at 515-294-7612.

Religious Accommodation: If an academic or work requirement conflicts with your religious practices and/or observances, you may request reasonable accommodations. Your request must be in writing, and your instructor or supervisor will review the request. You or your instructor may also seek assistance from the Dean of Students Office (http://www.dso.iastate.edu/) or the Office of Equal Opportunity and Compliance (http://www.eoc.iastate.edu/).

Homework Assignments: There will be five homework assignments. You will have two weeks to complete each one of them. These assignments will be used to emphasize and clarify important concepts.
Final Project: The final project must be a research or design project that is related to the topics covered in class. You may choose to work individually or in small groups (2-3 members each). Working in groups, however, is highly recommended. You are encouraged to select a topic for your final project as soon as possible. A written project proposal (10-15 pages) will be due on March 14. The final project report (25-30 pages) will be due on April 25. Each team will be required to present the results of their final project during the last week of the semester.

Policy on Collaboration: You are encouraged to form study groups and discuss the reading materials assigned for this class. You are allowed to discuss the homework assignments with your colleagues. However, each student will be expected to write his own solutions/code. Sharing of code is not allowed.

IMPORTANT: Cheating, plagiarism, and other academic misconducts will not be tolerated and will be handled according to the ISU’s academic dishonesty procedures, which are posted here: http://catalog.iastate.edu/academiclife/regulations/#academicdishonestytext

Attendance: You are expected to attend every class and participate in the class discussions. If you miss a class, it is your responsibility to find out what we talked about, including any announcements.

Grading: Your grade will be determined as follows:

- Class Participation: 10%
- Homework Assignments: 50% ($5 \times 10\%$ each)
- Final Project Proposal: 10%
- Final Project: 30%
INTRO

Overview of the class

Intro to Computational Perception
- “2001: HAL's Legacy”, PBS Show. The documentary was produced by David Kennard and Michael O'Connell (InCA Productions) and funded by the Alfred P. Sloan Foundation.

Matlab Tutorial

OpenCV Tutorial

Review of Probability and Linear Algebra

BASIC IMAGE PROCESSING

Mathematical Morphology

IMAGE FILTERING

PROJECT UPDATES/FORM GROUPS

COLOR AND MOVEMENT DETECTION

Color and Skin detection

Motion Energy and Motion History
Applications


FACE DETECTION AND RECOGNITION

Eigenfaces


Neural Network-Based Approaches


Cascades


THE SENSE OF SELF

Phantoms in the Brain


Sensory Substitution

- Andy Clark, (2003). ”Who are we?”, Ch. 5 in Natural-Born Cyborgs: Minds, Technologies, and the Future of Human Intelligence, Oxford University Press.

PRELIMINARY PROJECT PRESENTATIONS
TRACKING TECHNIQUES

Kalman Filter


Particle Filters


HIDDEN MARKOV MODELS

Theory


Applications


WHAT IS INTELLIGENCE?

Theories of Vision


What is Intelligence?


AFFECTIVE COMPUTING

Affective Computing


FINAL PROJECT PRESENTATIONS
<table>
<thead>
<tr>
<th>Week</th>
<th>Day/Date</th>
<th>Topic</th>
<th>Assignment</th>
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<td>Tuesday</td>
<td>Introduction</td>
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<td></td>
<td>Thursday</td>
<td>Motivation and Inspiration</td>
<td>Homework 1 out</td>
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<td>2</td>
<td>Tuesday</td>
<td>Matlab Tutorial</td>
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<td>Thursday</td>
<td>Binary Image Processing</td>
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<td>3</td>
<td>Tuesday</td>
<td>Mathematical Morphology</td>
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<td>Thursday</td>
<td>OpenCV Tutorial</td>
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<td>4</td>
<td>Tuesday</td>
<td>Image Filtering</td>
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<td>Thursday</td>
<td>Project Ideas/Updates</td>
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<td>5</td>
<td>Tuesday</td>
<td>Color and Movement Detection</td>
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<td>6</td>
<td>Tuesday</td>
<td>Tracking Techniques</td>
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<td>7</td>
<td>Tuesday</td>
<td>Preliminary Project Presentations</td>
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<td>Audio Processing</td>
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<td>9</td>
<td>Tuesday</td>
<td>Face Recognition</td>
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<td>Thursday</td>
<td>Face Detection</td>
<td>Project Proposals due.</td>
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<td>Tuesday</td>
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<td>Hidden Markov Models</td>
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<td>The Sense of Self</td>
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<td>Thursday</td>
<td>What is Intelligence?</td>
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<td>13</td>
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<td>Theories of Vision</td>
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<td>15</td>
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