Computational Perception and Scene Analysis
15-485/785, 85-485/785

1 Teaching Staff

- **Instructor**

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2 Meeting Times

Tuesdays and Thursdays 3:00 - 4:20 pm in DH 2122 .

3 Course Description and Goals

This course teaches advanced aspects of perception, scene analysis, and recognition in both the visual and auditory modalities, concentrating on those aspects that allow us and animals to behave in natural, complex environments. The course emphasizes both the experimental approaches of scientific disciplines and the computational approaches of engineering disciplines.

Each topic in the course begins by studying the ethology of natural behaviors, analyzing and decomposing these to identify the essential computational components that are required for the total behavior in a natural environment. This aspect of the course follows the lines of scientific reasoning and key experimental results that lead to our current understanding of the important computational problems in perception and scene analysis. The course then surveys the most important solutions to these problems, focusing on the idealizations and simplifications that are used to achieve practical computational algorithms. Specific topics include sensory coding, perceptual invariance, spatial vision and sound localization, visual and auditory scene segmentation, many aspects of attention, and the basics of recognition in natural visual and auditory scenes.

The goal of this course is to teach how to reason scientifically about problems and issues in perception and scene analysis, how to extract the essential computational properties of those abstract ideas, and finally how to convert these into explicit mathematical models and computational algorithms.

The class is fortunate to have a diverse and talented group of students, and we will make use of this expertise through in class discussions. An important goal of the class is to teach productive discussion, analysis, and critique of issues and topics related to perception and scene analysis.

4 Class Schedule

The schedule is shown on the table and is subject to change. Please check the web page for the latest schedule.

Lecture	Date	Notes	Topic
1	Tue Jan 15		Introduction and Overview
2	Thu Jan 17		Sound localization, linear systems theory
3	Tue Jan 22		
4	Thu Jan 24	assignment 1	
5	Tue Jan 29		Auditory sensory coding, information and probability theory, efficient coding
6	Thu Jan 31		
7	Tue Feb 5	assignment 1 due	Visual sensory coding, more information theory
8	Thu Feb 6		
9	Tue Feb 12	assignment 2	
10	Thu Feb 14		multi-resolution representations and wavelets
11	Tue Feb 19		visual orienting, motion perception and computation
12	Thu Feb 21	assignment 2 due	
13	Tue Feb 26		exploratory perception and eye movements
14	Thu Feb 28	take-home midterm	Bayesian modeling of perception
15	Tue Mar 5	midterm due	
-	Thu Mar 7	*mid-term break*	*no class*
16	Tue Mar 12		Visual structure: depth, shape and surface perception, shape from shading
17	Thu Mar 14		
18	Tue Mar 19	assignment 3	
19	Thu Mar 21		Perceptual invariance
20	Tue Mar 26		
21	Thu Mar 28	assignment 3 due	Auditory structure, auditory perceptual invariance
-	Apr 1-5	*spring break*	*no class*
22	Tue Apr 9	grad proposals due	auditory stream segmentation, auditory grouping, blind source separation
23	Thu Apr 11		
24	Tue Apr 17		figure ground organization, visual scene segmentation and organization, visual grouping
25	Thu Apr 18	assignment 4	
26	Tue Apr 23		
27	Thu Apr 25		focal attention, tracking
28	Tue Apr 30	assignment 4 due	object and sound recognition
29	Thu May 2	take-home final	
	Fri May 3	grad projects due	
	TBA	final due	

5 Textbooks and Reading Materials

There are at present no suitable textbooks for this course. Background material and papers will be handed out in class for subsequent lectures. You will be responsible for understanding the material and participating in class discussion.

6 Course Requirements

The course requirements consist of

- reading the assigned background material
- participation in class discussion
- completion of homework assignments
- taking the midterm and final exams
- completion of an independent research project (grad students)

7 Tutorials

Because the class consists of people from a diverse range of backgrouns, tutorials will be provided throughout the course to introduce important background material, and provide exercises to aid understanding of lectures and homework assignments. These will not be graded and are only for the benefit of those who want to get up to speed quickly in a topic or concepts. I will except as extra credit problems of your own design (with solutions) that you think is instructive for illustrating a particular concept. These problems can then be made available as an instructive aid for other members of the class.

8 Homework

There are a total of homework assignments, but, because this is only the second time this course is being offered, we may adjust that up or down depending on how the class is progressing. Homeworks will be the primary means by which the mathematical material presented in class. These will emphasize thinking more thoroughly about the theoretical problems presented in class, making decisions about how to model complex systems or processes, and design algorithms to solve a particular computational problem. Some of the advanced methods discussed in class are not practical to cover in a homework because of their sheer complexity. If you would like to study a paticular topic in greater detail, it would be well worth considering designing a class project around that topic.

9 Exams

There will be a midterm and a final exam. Both will be take-home. The exams will test

- knowledge and understanding of perceptual and computational issues
- ability to simplify and idealize complex processes
- ability to critically research and evaluate scientific findings and computational techniques

10 Final Grade

Final grades will be a composite score of course requirements in the following proportions:

	undergrad	grad
participation	10%	10%
homeworks	40%	30%
midterm	20%	15%
final	30%	20%
project	(10%)	25%

All students must take the final to pass. Graduate students must also complete a final project to pass. The final letter grade for the course will be determined by evaluating each student's performance relative to that of the other students in the class. Undergraduates who wish to do a class project will receive at most 10% extra credit. Extra credit, attendance, and any special circumstances will be used in determining borderline cases.

11 Collaboration

Collaborative discussion is encouraged, but any work submitted as a homework assignment must be entirely your own and may not be derived from the work of others, whether a published source, assignments from previous years, another student, or any other person. Doing otherwise is cheating. It is your responsibilty to take standard measures to protect your programs, homework assignments, and examinations from illicit inspection or copying. Violations will be handled in accordance with the University Policy on Cheating and Plagiarism.

12 Web Page

The course is listed in blackboard:

`https://blackboard.andrew.cmu.edu`

Be sure to check there for the latest announcements, homeworks, discussions, etc.