18-496, 42-431: Introduction to Biomedical Imaging and Image Analysis
Fall Semester, 2012

Course Personnel:
Instructor:
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Course Description:
This course gives an overview of tools and tasks in various biological and biomedical imaging modalities, such as fluorescence microscopy, electron microscopy, magnetic resonance imaging, ultrasound and others. The major focus will be on automating and solving the fundamental tasks required for interpreting these images, including (but not restricted to) deconvolution, registration, segmentation, pattern recognition, and modeling, as well as tools needed to solve those tasks (such as Fourier and wavelet methods). The discussion of these topics will draw on approaches from many fields, including statistics, signal processing, and machine learning. As part of the course, students will be expected to complete an independent project.

Prerequisites: 18-290

Class Schedule:
• Lecture:
  Tuesday & Thursday, 1:30 p.m. – 2:50 p.m., GHC 4215

Textbook: None. Readings will be posted in blackboard and at the course web page: http://tango.andrew.cmu.edu/~gustavor/42431-intro-bioimaging/
**Course Blackboard:**
In order to access the course blackboard from an Andrew Machine, go to the login page at: [http://www.cmu.edu/blackboard](http://www.cmu.edu/blackboard). You should check the course blackboard daily for announcements and handouts.

**Grading Algorithm:**
- 75% problem sets (10% penalty for each day handed in late). Homeworks should be handed in at the beginning of the class in which it is due. Homeworks handed in after class will be counted as 1 day late.
- 15% final project
- 5% in class quizzes
- 5% in class participation

Grades will not be “curved.” The general scale will be used:

- > 90% A
- > 80% B
- > 70% C
- > 60% D

When available, modifiers (+/-) will be used. For example, low 80s would mean B-, mid 80s would receive a B, and high 80s would receive a B+.

**Tentative Course Calendar**

- Week 1: Course intro, least squares signal/image analysis
- Week 2: least squares signal analysis, linear algebra
- Week 3: Fourier analysis, filtering, sampling
- Week 4: Microscopy (optics, fluorescence)
- Week 5: Microscopy (optics, fluorescence), deconvolution
- Week 6: deconvolution, restoration, denoising, interpolation
- Week 7: Magnetic Resonance Imaging
- Week 8: Magnetic Resonance Imaging
- Week 9: Computed tomography
- Week 10: Computed tomography
- Week 11: Image segmentation
- Week 12: Image segmentation
- Week 13: Image alignment
- Week 14: Image alignment
- Week 15: Image-based morphometry
<table>
<thead>
<tr>
<th>Program Outcome</th>
<th>Relation to Program Outcome</th>
<th>Mechanism</th>
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</thead>
<tbody>
<tr>
<td>Ability to apply knowledge of mathematics, science, and engineering</td>
<td>Primary</td>
<td>Lectures, project, homework</td>
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<td>Ability to design and conduct experiments, as well as to analyze and interpret data</td>
<td>Primary</td>
<td>Project, homework</td>
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<td>Ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability</td>
<td>Primary</td>
<td>Project</td>
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<td>Ability to function on multidisciplinary teams</td>
<td>Secondary</td>
<td>Project</td>
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<tr>
<td>Ability to identify, formulate, and solve engineering problems</td>
<td>Primary</td>
<td>Project, homework</td>
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<tr>
<td>Understanding of professional and ethical responsibility</td>
<td>Tertiary</td>
<td>Lectures, project</td>
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<td>Ability to communicate effectively</td>
<td>Secondary</td>
<td>Class paper, project presentation</td>
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<td>Broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context</td>
<td>Tertiary</td>
<td>Lectures, project, homework</td>
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<td>Recognition of the need for, and an ability to engage in life-long learning</td>
<td>Primary</td>
<td>Lectures, project, homework</td>
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<td>Knowledge of contemporary issues</td>
<td>Tertiary</td>
<td>Lectures, project</td>
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<td>Ability to use the techniques, skills, and modern engineering tools necessary for engineering practice</td>
<td>Primary</td>
<td>Project, homework</td>
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<td>Understanding of biology and physiology</td>
<td>Secondary</td>
<td>Lectures, project</td>
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<tr>
<td>Capability to apply advanced mathematics (including differential equations and statistics), science, and engineering to solve the problems at the interface of engineering and biology</td>
<td>Primary</td>
<td>Lectures, project, homework</td>
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<tr>
<td>Ability to make measurements on and interpret data from living systems</td>
<td>Secondary</td>
<td>Project, homework</td>
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<tr>
<td>Ability to address problems associated with the interaction between living and non-living materials and systems</td>
<td>Tertiary</td>
<td>Lectures, project, homework</td>
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Academic Integrity Policy ([http://www.ece.cmu.edu/student/integrity.html](http://www.ece.cmu.edu/student/integrity.html)):

The Department of Electrical and Computer Engineering adheres to the academic integrity policies set forth by Carnegie Mellon University and by the College of Engineering. ECE students should review fully and carefully Carnegie Mellon University's policies regarding Cheating and Plagiarism; Undergraduate Academic Discipline; and Graduate Academic Discipline. ECE graduate student should further review the Penalties for Graduate Student Academic Integrity Violations in CIT outlined in the CIT Policy on Graduate Student Academic Integrity Violations. In addition to the above university and college-level policies, it is ECE's policy that an ECE graduate student may not drop a course in which a disciplinary action is assessed or pending without the course instructor's explicit approval. Further, an ECE course instructor may set his/her own course-specific academic integrity policies that do not conflict with university and college-level policies; course-specific policies should be made available to the students in writing in the first week of class.

This policy applies, in all respects, to 18-496 A and 42-431.

Carnegie Mellon University's Policy on Cheating and Plagiarism ([http://www.cmu.edu/policies/documents/Cheating.html](http://www.cmu.edu/policies/documents/Cheating.html)) states the following,

Students at Carnegie Mellon are engaged in preparation for professional activity of the highest standards. Each profession constrains its members with both ethical responsibilities and disciplinary limits. To assure the validity of the learning experience a university establishes clear standards for student work.

In any presentation, creative, artistic, or research, it is the ethical responsibility of each student to identify the conceptual sources of the work submitted. Failure to do so is dishonest and is the basis for a charge of cheating or plagiarism, which is subject to disciplinary action.

Cheating includes but is not necessarily limited to:

1. Plagiarism, explained below.
2. Submission of work that is not the student's own for papers, assignments or exams.
3. Submission or use of falsified data.
4. Theft of or unauthorized access to an exam.
5. Use of an alternate, stand-in or proxy during an examination.
6. Use of unauthorized material including textbooks, notes or computer programs in the preparation of an assignment or during an examination.
7. Supplying or communicating in any way unauthorized information to another student for the preparation of an assignment or during an examination.
8. Collaboration in the preparation of an assignment. Unless specifically permitted or required by the instructor, collaboration will usually be viewed by the university as cheating. Each student, therefore, is responsible for understanding the policies of the department offering any course as they refer to the amount of help and collaboration permitted in preparation of assignments.
9. Submission of the same work for credit in two courses without obtaining the permission of the instructors beforehand.

*Plagiarism* includes, but is not limited to, failure to indicate the source with quotation marks or footnotes where appropriate if any of the following are reproduced in the work submitted by a student:

1. A phrase, written or musical.
2. A graphic element.
3. A proof.
4. Specific language.
5. An idea derived from the work, published or unpublished, of another person.