BME42-731/ECE18-795/CB02-740 Bioimage Informatics (12 Units)

Spring 2012

Instructor

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Instructor Contact Information

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- Preferred communication approach is by email. Please include BME42-731 in the subject.

Instructor Office Hour & Location

1:00PM – 2:00PM Friday or by appointment
Mellon Institute 403

Pre-requisite or Co-requisite

- Image processing; Background in computer vision and/or medical image analysis is very helpful but not essential.
- Proficiency in programming; Familiarity with MATLAB is very helpful but not essential.

Class Times & Locations

- Monday & Wednesday, 11:30AM - 12:50PM, Doherty Hall 1209

Class Website

- http://www.andrew.cmu.edu/course/42-731/

Teaching Assistant(s) and Contact Information:

Anuparma Kuruvilla
Email: anupamak@andrew.cmu.edu
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Directions: http://www.cbi.cmu.edu/contact/directions/index.html
Office hour: Not assigned; By appointment.

Course description & objectives

Development of biology over the past half a century has made it possible to identify the complete set of genes and proteins of a live organism. The complex interactions between these molecules in space and time define life. These interactions can now be visualized using fluorescence microscopy techniques, whose development represents one of the most fundamental and exciting advances in biomedical science and engineering over the past two decades. However, without quantitative measurement, fluorescence microscopy is restricted to a tool of visualization. The field of bioimage informatics is created over the past few years with the goal of applying computation, statistical analysis, and engineering techniques to effectively manage, visualize, analyze, and eventually understand the tremendous amount of image data generated routinely using fluorescence microscopy in contemporary biomedical research. Highly interdisciplinary in nature, bioimage informatics provides exciting opportunities for

students with solid analytical and/or engineering skills to make fundamental contributions in research and development. The main purpose of this class is to prepare students for such opportunities through course training. Specifically, by completing the training of this course, the students should be able to

- Understand basic concepts and principles of bioimage informatics.
- Understand fundamentals of fluorescent microscopy.
- Apply basic image processing and computer vision techniques in fluorescence image data analysis.
- Apply basic statistical analysis and information extraction techniques in fluorescence image data understanding.

Required Textbook(s)

None.

Recommended References

Image processing & computer vision

- Szeliski, *Computer vision: algorithms and applications*, Springer, 2010.
- Gonzalez & Woods, *Digital image processing*, 3rd ed., Prentice Hall, 2007.

- Snyder & Qi, *Machine vision*, Cambridge University Press, 2004.
- Sonka, Hlavac, & Boyle, *Image processing, analysis, and machine vision*, CL-Engineering, 2007.

Optics

- Hecht, *Optics*, 4th ed. (or 3rd ed), Addison Wesley, 2001.
- Born & Wolf, *Principles of optics*, 7th ed., Cambridge University Press, 1999.

Light & fluorescence microscopy

- Herman, *Fluorescence microscopy*, 2nd ed., Taylor & Francis, 1998.
- Inoue & Spring, *Video microscopy*, 2nd ed., Plenum Press, 1997.

This list is not exhaustive as there are other excellent references. A substantial collection of additional reference materials, including research papers and online information, will be distributed in class or posted on the course web page.

Classroom Policy

- Lectures will start and end on time. If you are late, you should enter the class without causing disruptions.

- Use of cell phones during class is prohibited.

- Class participation will be considered in grading, especially when a student's grade is borderline between two tiers (e.g. A- versus B+).

Academic Integrity

- University regulations will be followed. See http://www.studentaffairs.cmu.edu/acad_integ/acad_integ_text.html

Reading and Project Assignments:

- Instructions for reading and project assignments will be handed out in class.

- Completed reading and project assignments must be submitted before deadline. Late assignments will not be accepted. Exception will only be considered on a case-by-case basis by the instructor.

Grading*

Reading assignment	(5 in total)	40%
Project assignment	(4-5 in total)	50%
Class participation*		10%
Total		**100%**

* - The instructor reserves the rights to make small adjustments to the percentage scores.
* - Students are expected to attend lectures. Repetitive (>3) absences from lectures without instructor approval will result in up to 10% deduction of final grade.
* - Policy regarding absence from your group presentations without approval by the instructor before the class.
  - First time: warning; 10% deduction of final percentage grade
  - Second time: warning; final grade lowered by one tier (i.e. A→B; B→C)
  - Third time: automatic failure

List of topics

Note: For reference only. Adjustments are likely as the class proceeds.

Lecture	Topics
Lecture 1	Introduction
Lecture 2	Fundamentals of light microscopy
Lecture 3	Practical issues in bioimage informatics
Lecture 4	Fundamentals of fluorescence microscopy
Lecture 5	Applications of fluorescence microscopy
Lecture 6	Literature review
Lecture 7	Lab visit: fluorescence microscopy
Lecture 8	Bioimaging data analysis: point feature detection
Lecture 9	Bioimaging data analysis: line/curve detection
Lecture 10	Project presentation & review
Lecture 11	Bioimaging data analysis: registration
Lecture 12	Bioimaging data analysis: segmentation

Lecture 13	Literature review
Lecture 14	Bioimaging data analysis: tracking
Lecture 15	Project presentation & review
Lecture 16	Bioimaging data analysis: image database
Lecture 17	Bioimage analysis: information extraction
Lecture 18	Bioimage analysis: data mining
Lecture 19	Special focus I: Statistical methods for bioimaging informatics
Lecture 20	Special focus II: High-throughput screening
Lecture 21	Literature review
Lecture 22	Project presentation & review
Lecture 23	Special focus III: analysis of protein dynamics
Lecture 24	Electron microscopy
Lecture 25	Other molecular imaging modalities
Lecture 26	Literature review; Outlook; Course evaluation
Lecture 27	Project presentation & review
Final exam week	TBD