ECE5780 Computer Analysis of Biomedical Images

Spring 2017

Anthony P. Reeves

Introduction

A variety of powerful imaging modalities with attending computer image processing methods are available for the evaluation of health and the detection of disease. This course will focus on the quantitative analysis of these images and Computer Aided Diagnosis (CAD); that is, the automatic identification and classification of abnormalities by the computer from image data. The confluence of new technology providing more and higher resolution images together with policies for providing low cost non-invasive diagnostic methods is producing an imperative for the development of CAD. Commercial CAD systems for cell analysis and mammography diagnosis are currently available and many more applications are in development. This methodology may also be applied to research in the life sciences where evaluation of biological processes and events may be achieved through observations and analysis of image data. In this context, microscopy is the most frequently used imaging modality.

Biomedical image analysis extends conventional computer vision methods in novel directions. Traditional computer vision methods have their foundation in industrial vision applications where the primary modality is the lens based video camera that provides two-dimensional projection images of a three-dimensional scene. However, many biomedical image modalities such as MR, CT, ultrasound, and light microscopy, have the ability to directly acquire true three-dimensional images. Consequently, three-dimensional (and four-dimensional with time) computer vision algorithms will be studied in detail.

Contact Information

The primary information source for ECE5780 is the on-line web site at the following URL:

http://www.via.cornell.edu/ece5780

This will provide up-to-date information on announcements, course materials and schedules etc. All course grades will be managed on the Cornell blackboard system. for which there is a link from the course home page. Piazza will be used to address student questions in an accessible forum.

Lectures will be in Phillips Rm. 403 on Tuesday and Thursday at 10:10 to 11:25 am.

The course instructor is Anthony P. Reeves. Contact information: Office, Rhodes Hall Rm 392; Phone 255 2342; email, reeves@ece.cornell.edu. To meet individually with Professor Reeves you should schedule an appointment. The best way to do this is either to arrange a time with him at the end of a class, or to call him to arrange a time on his office phone listed above.

Organization and Content

This course has been offered a number of times and each time there has been a significant difference in the organization. The newness of the topic precludes a set formal outline and each semester new topics are explored through the means of course projects. The following is based on the last offering of this course in the Spring of 2016; some changes may be made this semester depending upon the makeup of the class. A continuing theme for the course is to allow entrance from two groups of students with different backgrounds: (a) engineers and computer scientists with experience in image analysis and (b) biologists, engineers, etc. with experience in the life sciences with or without any image analysis experience.

Prerequisites

This course is open to students with either a biology, computer science, or engineering background. There are no explicit prerequisites for the course; the appropriate background will be discussed at the first class meeting. The course will provide the necessary background on the imaging modalities, the medical issues, and the computer algorithms for image analysis. Having taken either ECE 5470 or the three credit version of BME 6180 would be a very good preparation for this course.

This course is intended to meet the needs of both engineers interested in the life sciences and life scientists that are interested in gaining experience in quantitative image analysis methods. Class participation and project research is important. This is a graduate level course and, although it does not have demanding prerequisites, an active interest in biomedical imaging, the maturity to identify and the address any specific knowledge shortcomings, and active class participation are expected.

Course Text

M. Sonka, V. Hlavac, and R. Boyle *"Image Processing, Analysis, and Machine Vision 4th Edition,"* Cengage Learning, 2015. The 3rd edition released in 2008 is a suitable alternative. The text is an important common reference for the course; however, the class lectures do not in general follow the same sequence as the text.

Lectures

Courses lectures fall into three different categories: biomedical image analysis methods, fundamentals of image analysis, and class presentations.

1. Biomedical Image analysis methods are the key foundation material for the course and covers image analysis methods, medical image modalities, and statistical methods for evaluating image measurements and CAD tools.
2. Image processing fundamentals covers basic image analysis methods and repeats some of the material in ECE 5470. Students who have taken ECE 5470 or an equivalent course are generally excused from these classes.
3. Selected application class presentations that are made mainly by the class project groups; some are given by guest lecturers. Each project group will make at least one presentation to the class.

The Class Project

The class project is done in groups of at least three. The project typically consists of background research, and the implementation and evaluation of a specific image analysis method on appropriate image data. Short class presentations of the project proposal and the final project outcome may be required. Each group explores a different problem to provide the broadest experience to the class.

Course Requirements

The grade for this course will be determined from thee components that have similar weight: (a) lab exercises and homework (35%), (b) review exercises (prelims) (30%), and (c) the project (35%). The project will require the submission of a proposal, a final report, and a class presentation may be required. Class presentations are timed and lead to in depth class discussions. There are no absolute thresholds for grades. All work for this course is expected to be original.

Course Objectives

Students having either an engineering or life science background will gain an understanding of the state of the art in the computer analysis of biomedical images. They will have a good knowledge of the image processing algorithms, the essential characteristics of the main image modalities, and the statistical methods to analyze and validate CAD systems. Through the course project students will gain experience in designing and validating computer algorithms for image analysis and in presenting this work to the class audience in a succinct and professional manner.

Academic Integrity

Each student in this course is expected to abide by the Cornell University Code of Academic Integrity. Any work submitted by a student in this course for academic credit will be the student's own work. For this course collaboration is allowed in the following instance: the class project.

See also ECE5470 - Computer Vision offered in the fall.