Syllabus

BME 580.493 // 580.693
Imaging Instrumentation

MONDAYS, WEDNESDAYS, FRIDAYS 8:00 – 10:00 AM
Location: Design Studio, Clark 217

Course Director	J. Webster Stayman
Office	Traylor Research Building #605B
Phone	410-955-1314
E-mail	web.stayman@jhu.edu
Office Hours	In class time, additional may be scheduled
TA	Anthony Song
TA Email	asong18@jhu.edu

Introduction

This course provides students with hands on experience with imaging system design, performance evaluation, and data processing using an experimental test-bench using an optical system model. The course is experiment- and project-driven and will provide an intermediate-level understanding of the physics, engineering, and algorithms in a number of different optical imaging scenarios. It is intended for senior undergraduates (580.493) and/or graduate students (580.693) in Biomedical Engineering, Computer Science, Electrical and Computer Engineering, or related fields in science and engineering. Topics include measures of imaging performance, detector characterization, imaging with electromechanical elements, spectral imaging, optical tomography, and indirect imaging methods that rely on data processing.

Prerequisites

Prerequisite courses include one of the courses 580.222 (Systems and Controls) or 520.214, and intermediate programming skills. Students concurrently enrolled in one or the other of these courses must obtain written permission from the Course Director for an exception allowing enrollment. Students must be proficient with Python – basic signal processing methods should be familiar, additional Python modules will be provided.

Objectives

Upon completion of this course, students will have gained an intermediate-level knowledge of imaging system design, data processing, and performance evaluation approaches. While the class focuses on optical systems, these concepts are generally applicable to many imaging devices. Students will demonstrate their synthesis of concepts conveyed in lecture, reading materials, and experiments via laboratory write-ups and through the presentation and write-up of an imaging project of their own design.

Materials

Learning in this course will be predominantly through hands-on experiments; however, lectures introducing concepts and tools will be conducted at the beginning of many classes. An optical experimental kit will be provided to all students in the class (sharing in groups of up to 3 students).

Additional limited materials will be made available for the project portion of the class. While there is no textbook for the course, students may find it helpful to obtain a copy of a standard text that includes imaging processing and evaluation concepts. For example,

- Prince, J. and Links J., "Medical Imaging: Signals and Systems," (Pearson, Prentice Hall, New Jersey, 2006).
- Lim, J. “Two-dimensional Signal and Imaging Processing,” (Prentice Hall, New Jersey, 1990).
- Jain, A. “Fundamentals of Digital Imaging Processing,” (Prentice Hall, New Jersey, 1989).

The optical tomography portion of the class will require implementation of a reconstruction method and the following text will be helpful:

- A. C. Kak and M. Slaney, "Principles of Computed Tomography Imaging", (IEEE Press, New York, 1987). Free electronic version of the book: http://www.slaney.org/pct

Class Format

Classes are held twice per week according to the schedule above with the following general format:

- **READING MATERIALS** are often assigned including textbook chapters, journal articles, and course notes. Students should be prepared to discuss any assigned reading materials – this is considered as part of the class participation element of grading.
- Most of the class time will be dedicated to hands-on experimentation. This may start with a demonstration, but will mostly focus on group investigation of an imaging system – including hardware set up, algorithmic and control coding, and data analysis.
- In many weeks, a **LAB REPORT** assignment is due at the beginning of class. There is one report per group. The report receives a single grade based on successful completion of the experiments, analysis, and discussion of the experiment.
- To emphasize immediate feedback in learning, **LAB REPORTS** will be discussed after they are handed in. (For this reason, late assignments are not accepted.) Individuals in each group should be prepared to discuss experiments and interpret results. This may include demonstrations of portions of the experiment on the experimental setup. Individual grades will be assessed based on participation in these discussions.

There is one major **PROJECT** required during the semester:

- The last three weeks of the class is dedicated to this final project; however, there will be brainstorming and project proposals before this work period. The project is open-ended and students may propose a project of their own design. Some ideas, optical elements, etc. will be presented; however, it will be up to the student groups to propose a project that includes a specific hardware design, acquisition approach, data processing methods, and performance evaluations. The proposal will need to be approved by the instructor.
- The **PROJECT** will be assessed through the following methods:
    - A write-up of the project in a **FINAL REPORT**, which will be graded as a group.
    - A presentation of the proposed imaging device. This can include a live demonstration of the device in action, an analysis of operation and performance, etc.
    - Individuals within a group will be graded based on participation in the presentation and a class-led question and answer period.

ATTENDANCE and **PARTICIPATION** are key to this format. Attendance of each class is required in order to receive full participation credit, which form the basis for active learning, problem solving, and examples discussed in each lecture. Written and oral work must demonstrate a depth of understanding beyond that covered directly in class and require students to have participated in class reading assignments, experiments, and discussions.

Unexcused absences will substantially reduce a student’s participation grade and can result in a reduced score for an individual on a LAB REPORT if the student was not around to conduct the experiment. (Other individuals in a group will not be penalized for another group member’s absence.) Medically related absences will require a written letter from a healthcare professional.

Grades and Policies

Grading is based on LAB REPORTS, the PROJECT, and CLASS PARTICIPATION. Oral and written projects must demonstrate a depth of understanding beyond that covered directly in class.

Assignment	Points	% of Final Grade
Lab Report #1 - #4 (15 points each)	60	30.0%
Lab Report #5	20	10.0%
Lab Report #6	25	12.5%
Project: Proposal	15	7.50%
Project: Presentation / Demonstration**	25	12.5%
Project: Final Report	25	12.5%
Class Participation**	30	15.0%

** Individually graded.

Grades are assigned as follows:

A+ 98 - 100%	B+ 87 - 89%	C+ 77 - 79%	D+ 67 - 69%
A 94 - 97%	B 83 - 86%	C 73 - 76%	D 63 - 66%
A- 90 - 93%	B- 80 - 82%	C- 70 - 72%	D- 60 - 62%

Students taking the class for (S/N Pass/Fail) must receive a C+ or better to receive a (S, Pass) grade. Graduate and undergraduate students are graded according to the same scale (above), but graduate students are expected to demonstrate a deeper understanding of concepts in assignments, projects, and discussions.

- **Assignment Due-Dates**
  Assignments must be delivered at the beginning of class, in class on the due date. Assignments delivered late will not be accepted and will be scored at 0% toward the final grade. Cases of medical emergency must be communicated to the Course Director in a timely manner.

Students with a disability that requires modification of seating, testing, or other considerations should contact the Course Director so that appropriate arrangements can be made.

ABET Outcomes ("a through k") as defined by the BME program

a1. Apply knowledge of advanced mathematics (calculus, differential equations, linear algebra, statistics) to problems at the interface of engineering, biology and medicine
a3. Apply knowledge of natural sciences (chemistry and physics) to problems at the interface of engineering, biology and medicine
a4. Apply principles of engineering to problems at the interface of engineering, biology and medicine
b1. Formulate hypothesis for experiments, including those on living systems
b2. Devise procedures for experiments, including those on living systems
b3. Collect and validate data using appropriate equipment
b4. Display, describe, summarize and interpret experimental results in a lab report
b5. Relate the experimental results to previous work, including the interaction between living and non-living materials and systems
b6. Practice lab safety
c1. Identify a desired need and define the biomedical engineering problem to be solved

c2. Determine the constraints to the problem and assess the successful likelihood for different approaches
c3. Undergo the design process of creation, synthesis and integration
c4. Evaluate success of design to meet the desired need
d1. Communicate opinions, viewpoints and expertise with other team members
d2. Understand team goals and assume and fulfill individual responsibilities within the team
e1. Conceptualize the engineering problem
e2. Formulate a solution to the problem
e3. Solve problem using experimental, mathematical and/or computational tools
g1. Synthesize, summarize and explain technical content in a written report
g2. Synthesize, summarize and explain technical content in an oral presentation
k4. Utilize data acquisition systems
