**1. COURSE DESCRIPTION**

All imaging systems (cameras, microscopes, ultrasound detectors) have limitations. These typically break down into two categories, those due to hardware and those due to fundamental physical principles. This course will focus on way to surpass these limits through experimental design, new physical principles, and deep learning/computational processing. Toward this end, we will cover the fundamental mechanisms of image formation in the most common biomedical imaging modalities and describe recent approaches to extend resolution beyond conventional limits. Students will gain a critical understanding of how to quantify resolution in an image, how to interpret what’s real vs. artifact in biomedical images, and will review recent literature that highlights what new information can be revealed with cutting edge approaches. This course is designed for students who intend to develop or use biomedical imaging systems or work with biomedical images.

**2. INSTRUCTOR INFORMATION**

Wesley Legant, Ph.D.

Assistant Professor of Biomedical Engineering and Pharmacology

UNC/NCSU Joint Department of Biomedical Engineering, UNC School of Medicine

Contact: **legantw@email.unc.edu**

Office: Genetic Medicine Bldg room 4047

Office hours: Thursday 2:00-4:00 or by appointment

\*I’m happy to answer short questions before or after class. For more in-depth help, please let me know by email ahead if you plan to attend office hours and a short description of what you’d like to discuss. This will let me prepare and help you most efficiently.

**3. CLASS HOURS**

Tuesday/Thursday 12:30 pm - 1:45 pm

Location: Murphy 0221

Holidays this semester (no class): 10/26, 11/25

\*Students are expected to attend each class; let the instructor know if a class must be missed

**4. STUDENT LEARNING OBJECTIVES**

By the end of this course, students should be able to:

1. Describe how images are formed using common biomedical imaging systems.
2. Understand current approaches to surpass conventional resolution limits.
3. Know when and how to use different methods to quantify image resolution.
4. Understand and use computational approaches for image enhancement and critically evaluate real signals from restoration artifacts.
5. Critically evaluate and discuss primary literature
6. Effectively present scientific results to their peers

**5. REQUISITES**

BMME 365 and (COMP 116 or BMME 201) or by permission from instructor

**6. COURSE STRUCTURE**

The course will be comprised of three, equally weighted components:

**Introductory lectures:** Foundational material will be presented in both pre-class readings/videos and in-class lectures. These lectures will provide a quantitative springboard for literature discussions and student projects.

**Primary literature discussion:** A substantial portion of class material will be taken from primary research articles. Evaluation will be based on reading comprehension assignments due prior to class discussion and on group discussion and debate. Participation in group discussion is expected and included as part of the grade.

**Projects:** Students will gain hands-on experience with image restoration, super-resolution reconstruction and analysis routines through several projects throughout the semester.

**7. COMMUNICATION**

While open to upper-level undergraduates, this class is structured as a graduate-level course. This means that discussion is paramount. We will cover a broad range of topics out of the primary literature, and this means that it is impossible for any one student (or instructor!) to be an expert in all of the topics covered. This is part of the fun of the class: to ask questions, to interpret, to debate. We will devote much of class time to discussion, but in addition, we will have a class Slack workspace for communication throughout the semester.

**8. TEXTBOOKS AND COURSE MATERIALS**

There is no required textbook for this class. Lecture outlines and pre-class reading will be uploaded to Sakai prior to each lecture. Students will be responsible for reviewing primary literature and online videos prior to discussing during class. Short assessments on the pre-class materials will be given at the beginning of class. Primary research papers will be provided through the course website.

**9. COURSE WEBSITE (Sakai):**

**https://sakai.unc.edu/portal/site/81456222-571e-4c16-ad48-592c5aea64b1**

**10. STUDENT ASSESSMENT AND GRADING**

The grading rubric is as follows:

**Reading Comprehension (10%):** Each week reading/video comprehension questions will be at the beginning of the class. These will be a mix of multiple choice/short answer questions that require some interpretation in addition to details from the assigned materials. The purpose of these reading comprehension questions is to stimulate discussion during the following lecture.

**Discussion Participation (10%):** The class is discussion based, and participation is a significant component of the final grade. While open to upper-level undergraduates, this class is structured as a graduate-level course. We will cover a broad range of topics out of the primary literature, and this means that it is impossible for any one student (or instructor!) to be an expert in all of the topics covered. This is part of the fun of the class: to ask questions, to interpret, to debate.

**Leading Paper Discussions (30%):** Each student (in pairs, depending on class size) will be required to lead several paper discussions during the semester. Details on timelines will be provided during lecture.

**Projects (50%):** Students will gain hands-on experience with image enhancement and multiple super-resolution reconstruction modalities by completing several projects throughout the semester. As part of these projects, students will use Matlab to code their own image processing algorithms and test the influence of different imaging variables (e.g. digitization, signal to noise, etc). Assessments for each project will take different forms designed to guide students through various mechanisms used in the scientific community to communicate results. Examples include a written lab report, a scientific poster, and a short a scientific talk. Rubrics will be given for each assignment to indicate how the project will be graded.

The following grades are guaranteed for the stated weighted averages:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 93-96: A  90-92: A- | 87-89: B+  83-86: B  80-82: B- | 77-79: C+  73-76: C  70-72: C- | 67-69: D+  63-66: D  60-62: D- | 59 or less: F |

If your final average falls within one point of the next grade fraction, I reserve the right to adjust it upwards based on factors such as participation in class, engagement with the instructor, and improvement throughout the semester.

**11. EXPECTATIONS OF THE INSTRUCTOR**

I will….

* always start and finish class on time.
* never hold you accountable for material I do not cover in lecture.
* reply to emails within a day, frequently within hours, sometimes within minutes.
* be as available as I can for individual help and keep my door open whenever possible, including extra office hours before the final exam.
* make every effort to make this an enjoyable, thorough, difficult, useful, and rewarding class.

**12. EXPECTATIONS OF THE STUDENTS**

I expect you to….

* show up on time (preferably early) to class ready to learn.
* never hesitate to ask me questions in class, in person, or via email when you are confused.
* take the time outside class to understand the material I present in lecture.
* work with me to develop a love (or at least an appreciation) of the science and engineering in this class.

**13. POLICIES**

* Attendance
  + Please see the Attendance Regulation: <http://policies.ncsu.edu/regulation/reg-02-20-03> and <https://catalog.unc.edu/policies-procedures/attendance-grading-examination/>
  + DO NOT BE LATE. I will always end on time or early because I respect your time; please respect my time and the rest of the class’s time.
  + I expect you to attend every lecture unless you have an academic excuse (conference or research trip), medical reason, or religious holiday. I will post my lecture notes online, so check those and see me if you have any lingering questions.
  + If you know ahead of time that you will not be in class for an exam, let me know ASAP.
* Honesty and integrity
  + Please see the Code of Student Conduct Policy: http://policies.ncsu.edu/policy/pol-11-35-01
  + Unless stated otherwise, assume that all homework and exams should reflect your individual work (or your group’s work with partner programming assignments). While you may work with other students to discuss the approach to solving a homework problem, it should not include a discussion of detailed solutions or outright copying of a solution. By submitting an assignment or exam, you are pledging to comply with the instructor’s directions.
* Disability and accommodations

Reasonable accommodations will be made for students with verifiable disabilities. In order to take advantage of available accommodations, students must register with the Disability Services Office at Suite 2221, Student Health Center, Campus Box 7509, 919-515-7653. For more information on NC State’s policy on working with students with disabilities, please see the Academic Accommodations for Students with Disabilities Regulation (REG02.20.01) (<https://policies.ncsu.edu/regulation/reg-02-20-01/>).

* Face masks
  + As noted in the Updated Community Standards (<https://carolinatogether.unc.edu/community-standards/>), face masks are still required in all University buildings. This semester, while we are in the midst of a global pandemic, all enrolled students are required to wear a mask covering your mouth and nose at all times in our classroom. This requirement is to protect our educational community — your classmates and me – as we learn together. If you choose not to wear a mask, or wear it improperly, I will ask you to leave immediately, and I will submit a report to the Office of Student Conduct. At that point you will be disenrolled from this course for the protection of our educational community. Students who have an authorized accommodation from Accessibility Resources and Service have an exception. For additional information, see (https://carolinatogether.unc.edu/).

**I reserve the right to make changes to the syllabus, including assignment due dates and test dates, when unforeseen circumstances occur. These changes will be announced as early as possible so that you may adjust your schedule accordingly.**