



BME 465

Principles of Biomedical Imaging

Spring 2025

Instructor: Shang Wang, Ph.D.

Course Schedule: Tuesday, 6:30-9:00 pm, in McLean 211

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Office Hour: Friday, 2-3 pm, over Zoom (Meeting ID: 914 6743 9233)

Prerequisite(s): BME 306 and BME 460

COURSE DESCRIPTION

Imaging is essential for biology and medicine. This biomedical imaging course emphasizes the understanding of basic principles of major imaging modalities and how these modalities can be applied to address the great imaging needs faced by today's biomedicine. Learning of the imaging principles focuses on the contrast mechanisms and the image formation process, with a highlight of the imaging physics. Applications of imaging will be discussed in the context of the current needs in biological studies and clinical screening, diagnosis and treatment, featuring the suitability of particular imaging parameters in addressing specific problems in biomedicine. The course covers X-ray computed tomography, Magnetic resonance imaging, ultrasound imaging, and optical coherence tomography, as the representative major imaging modalities, all of which are widely used in both research and clinics. MATLAB-based projects are developed to enhance the students' understanding of important topics and to help students gain programming skills for engineering.

STUDENT LEARNING OUTCOMES

This course has the following four objectives:

To have the students

- 1) Discuss how major biomedical imaging modalities work and their primary imaging characteristics.
- 2) Differentiate why particular imaging modalities are utilized for specific applications.
- 3) Apply engineering-related programming skills.
- 4) Acquire the motivation and approach to continue learning biomedical imaging modalities and their applications as needed in the future.

Student Outcome 1: (Complex Problem Solving) An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.

- Course Outcome 1.1: Students can apply Radon transform to generate sinogram and can reconstruct CT image based on the sinogram using backprojection.

Student Outcome 2: (Design) An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors

- Course Outcome 2.1: With X-ray CT, MRI, ultrasound, and OCT, I can come up with the suitable imaging solution for an imaging task by taking the imaging scale, speed, contrast, cost and safety into consideration.

Student Outcome 4: (Bioethics) An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts

- Course Outcome 4.1: Student can recognize ethical responsibilities in relation to biomedical imaging.

Student Outcome 6: (Experimentation) An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions

- Course Outcome 6.1: Students can develop a MATLAB program to quantify the size of a brain tumor in an MRI image.

Student Outcome 7: (Ability to Learn) Ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

- Course Outcome 7.1: Students can use MATLAB to understand how to form an OCT image.

TENTATIVE COURSE SCHEDULE

Week	Lecture Topic	Homework & Project
1	Introduction of course & basic imaging concepts Course policy Basic concepts of biomedical imaging	Homework 1 release
2	X-ray computed tomography Principle of image formation (focus on contrast) Introduction of Project 1	Homework 1 due Project 1 release
3	X-ray computed tomography Principle of image formation (focus on engineering)	
4	X-ray computed tomography Techniques and Applications Discussion of Project 1	Project 1 due Homework 2 release
5	Magnetic resonance imaging Principle of image formation (focus on contrast) Introduction of Project 2	Homework 2 due Project 2 release

6	Magnetic resonance imaging Principle of image formation (focus on engineering)	
7	Magnetic resonance imaging Techniques and Applications Discussion of Project 2	Project 2 due Homework 3 release
8	Ultrasound imaging Principle of image formation (focus on contrast) Introduction of Project 3	Homework 3 due Project 3 release
9	Ultrasound imaging Principle of image formation (focus on engineering)	
10	Ultrasound imaging Techniques and Applications Discussion of Project 3	Project 3 due Homework 4 release
11	Optical coherence tomography Principle of image formation (focus on contrast) Introduction of Project 4	Homework 4 due Project 4 release
12	Optical coherence tomography Principle of image formation (focus on engineering)	
13	Optical coherence tomography Techniques and Applications Discussion of Project 4	Project 4 due Homework 5 release
14	Semester review	Homework 5 due
	Final exam period	

COURSE MATERIALS

Suggested Readings

- The Essential Physics of Medical Imaging, 4th Edition, by Jerrold T. Bushberg, J. Anthony Seibert, Edwin M. Leidholdt, Jr., and John Boone, Wolters Kluwer, 2022.
- Fundamentals of Biomedical Optics, 1st Edition, by Caroline Boudoux, Blurb, 2017.

Materials

- Lecture slides will be posted
- Your in-class notes are important

COURSE REQUIREMENTS

Grading

Participation – 10%

Homework – 25%

Project – 48%

Final exam – 17%

Attendance and Participation

Attendance is required, and you are expected to participate in discussions. Your attendance in every class (except for the first one) will be recorded. Missing one class will cost 1%.

Homework

Homework should be submitted through Canvas. Each homework is worth 5%. A late submission within 24 hours will reduce the full score to 2.5%. A late submission over 24 hours will not be accepted.

Project(s)

Projects should be submitted through Canvas. Each project is worth 12%. A late submission within 24 hours will reduce the full score to 6%. A late submission over 24 hours will not be accepted.

Final Exam

The final exam will be for everything we discuss in the semester. It will be in person, with the date during the final exam period. There will be a review class prior to exam.

TECHNOLOGY REQUIREMENTS

You will need to use Microsoft Office and MATLAB (2020a or above).

ACADEMIC INTEGRITY

Undergraduate Honor System

Enrollment into the undergraduate class of Stevens Institute of Technology signifies a student's commitment to the Honor System. Accordingly, the provisions of the Stevens Honor System apply to all undergraduate students in coursework and Honor Board proceedings. It is the responsibility of each student to become acquainted with and to uphold the ideals set forth in the Honor System Constitution. More information about the Honor System including the constitution, bylaws, investigative procedures, and the penalty matrix can be found online at <http://web.stevens.edu/honor/>.

The following pledge shall be written in full and signed by every student on all submitted work (including, but not limited to, homework, projects, lab reports, code, quizzes and exams) that is assigned by the course instructor. No work shall be graded unless the pledge is written in full and signed.

"I pledge my honor that I have abided by the Stevens Honor System."

Students who believe a violation of the Honor System has been committed should report it within ten business days of the suspected violation. Students have the option to remain anonymous and can report violations online at www.stevens.edu/honor.

ACCOMMODATIONS

Stevens Institute of Technology is dedicated to providing appropriate accommodations to students with documented disabilities. The Office of Disability Services (ODS) works with

undergraduate and graduate students with learning disabilities, attention deficit-hyperactivity disorders, physical disabilities, sensory impairments, psychiatric disorders, and other disabilities to help students achieve their academic and personal potential. They facilitate equitable access to the educational programs and opportunities offered at Stevens and coordinate reasonable accommodations for eligible students. These services are designed to encourage independence and self-advocacy with support from the ODS staff. The ODS staff will facilitate the provision of accommodations on a case-by-case basis.

For more information about Disability Services and the process to receive accommodations, visit <https://www.stevens.edu/student-diversity-and-inclusion/disability-services>. If you have any questions please contact the Office of Disability Services at disabilityservices@stevens.edu or by phone: 201.216.3748.

Disability Services Confidentiality Policy

Student Disability Files are kept separate from academic files and are stored in a secure location within the Office of Disability Services. The Family Educational Rights Privacy Act (FERPA, 20 U.S.C. 1232g; 34CFR, Part 99) regulates disclosure of disability documentation and records maintained by Stevens Disability Services. According to this act, prior written consent by the student is required before our Disability Services office may release disability documentation or records to anyone. An exception is made in unusual circumstances, such as the case of health and safety emergencies.

INCLUSIVITY

Stevens Institute of Technology believes that diversity and inclusiveness are essential to excellence in academic discourse and innovation. In this class, the perspective of people of all races, ethnicities, gender expressions and gender identities, religions, sexual orientations, disabilities, socioeconomic backgrounds, and nationalities will be respected and viewed as a resource and benefit throughout the semester. Suggestions to further diversify class materials and assignments are encouraged. If any course meetings conflict with your religious events, please do not hesitate to reach out to your instructor to make alternative arrangements.

You are expected to treat your instructor and all other participants in the course with courtesy and respect. Disrespectful conduct and harassing statements will not be tolerated and may result in disciplinary actions.

Name and Pronoun Usage

As this course includes group work and class discussion, it is vitally important for us to create an educational environment of inclusion and mutual respect. This includes the ability for all students to have their chosen gender pronoun(s) and chosen name affirmed. If the class roster does not align with your pronouns and/or name, please inform the instructor of the necessary changes.

Religious Holidays

Stevens is a diverse community that is committed to providing equitable educational opportunities and supporting students of all ethnicities and belief systems. Religious observance is an essential reflection of that rich diversity. Students will not be subject to any grade penalties for missing a class, examination, or any other course requirement due to religious observance. In addition, students will not be asked to choose between religious observance and academic work. Therefore, students should inform the instructor at the beginning of the semester if a requirement for this course conflicts with religious observance.

so that accommodations can be made for students to observe religious practices and complete the requirements for the course.

MENTAL HEALTH RESOURCES

Part of being successful in the classroom involves a focus on your whole self, including your mental health. While you are at Stevens, there are many resources to promote and support mental health. The Office of Counseling and Psychological Services (CAPS) offers free and confidential services to all enrolled students who are struggling to cope with personal issues (e.g., difficulty adjusting to college or trouble managing stress) or psychological difficulties (e.g., anxiety and depression). Appointments can be made by phone (201-216-5177), online at <https://stevensportal.pointnclick.com/confirm.aspx>, or in person on the 2nd Floor of the Student Wellness Center.

EMERGENCY INFORMATION

In the event of an urgent or emergent concern about your own safety or the safety of someone else in the Stevens community, please immediately call the Stevens Campus Police at 201-216-5105 or on their emergency line at 201-216-3911. These phone lines are staffed 24/7, year-round. For students who do not reside near the campus and require emergency support, please contact your local emergency response providers at 911 or via your local police precinct. Other 24/7 national resources for students dealing with mental health crises include the National Suicide Prevention Lifeline (1-800-273-8255) and the Crisis Text Line (text “Home” to 741-741). If you are concerned about the wellbeing of another Stevens student, and the matter is *not* urgent or time sensitive, please email the CARE Team at care@stevens.edu. A member of the CARE Team will respond to your concern as soon as possible.