Imaging and Modeling (ANAT 6205)

Course Director

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Teaching Assistants

- Emily Swenson
- Jason Nadeau

Class Location and Hours

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<th>Day</th>
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<td>Tuesday</td>
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<td>Wednesday</td>
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Class Room: Can (and will) vary daily. Please check the course calendar for the class room du jour.

Course Description

Rapid advances in imaging techniques are providing an unprecedented window into internal anatomical structures previously poorly resolved or completely hidden from view. From the cellular to the organism level, these imaging techniques have led to untapped veins of anatomical research and novel medical diagnoses. However, these techniques can also result in gigabytes and even terabytes of imaging data as they typically employ new high-throughput technologies. Structures of anatomical interest may be buried deep in this collection of digital data and may require advanced computational techniques coupled with manual annotation to excavate the structures of interest and illuminate a living world that is so often hidden from us.

Successful Anatomical Scientists and Medical professionals wishing to capitalize on these cutting-
edge technologies must become proficient not only in the current state of imaging modalities and their future direction but in the language of the digital images themselves: the underlying ones and zeroes from which these image datasets arise.

In this course, we will cover the basic properties of digital images and learn basic image acquisition, processing, segmenting, modeling and rendering workflows using several industry standard software packages including MATLAB, Fiji, ScanIP, and 3D Slicer. We will also survey the current state, strengths and weaknesses of major imaging modalities from microscopy to magnetic resonance imaging by exploring sample image datasets from each of these modalities. Examples of these modalities will then be used for problem-based-learning tasks.

**Hardware and Software Requirements**

You are required to bring a laptop to class EVERY day. Most class exercises, labs, assignments and assessments will be performed on the laptop.

**IMPORTANT:** We will be using **MATLAB** from DAY ONE. Be sure to have it installed on your laptop before you come to the first day of class.

**Minimum Laptop Requirements:**

You will need a decently equipped laptop that can handle the large image datasets and software packages that we will use in class. Please refer to the following guidelines when considering whether your current laptop is up to muster.

**Critical**

- 64-bit dual core CPU (Intel Core i5 or equivalent)
- 8 GB RAM minimum (16 GB strongly recommended, especially for Mac computers)

**Highly Recommended**

- 64-bit quad core CPU (Intel Core i7 or equivalent)
- OpenGL-compatible graphics card (with at least 1 GB RAM)
- 256 GB (or larger) SSD drive (solid state drives are much faster than ordinary drives, but hold less data)

**PLEASE NOTE.** If your laptop does not meet the minimum requirements, you may have difficulty completing class exercises and course assignments, especially the **Final Course Project**.

**Upgrading suggestions:** RAM is one of the *easiest and cheapest* upgrades that you can make to a laptop. Say, for example, you already have a 64-bit dual core processor, but you only have 4 GB of RAM: it is often very inexpensive to upgrade to 8 GB and is something that you can usually do yourself… unless you have a recent Mac, in which case you may be stuck, as recent models of mac laptops cannot be upgraded. Click on this [link](#) to find out which Macs can be upgraded.
Buying Recommendations: Pay for additional CPUs before you pay for the RAM, but make sure that you have the minimum 8 GB RAM. An SSD drive is also very nice (because it’s much faster), but they’re expensive and typically don’t hold as much data as a normal hard drive.

Required Software

- **MATLAB** - Free, site license available. See here for installation instructions.
- **Fiji** - Free. Download from here.
- **3D Slicer** Free. Download from here.
- **ScanIP** - MSMHA provided. We will provide instructions for installing ScanIP during class.
- **Boot camp** or **Parallels** - *Macs only*.

A note about Bootcamp, Parallels Installation

Relevant only to Mac users

ScanIP is Windows only. To run ScanIP on your Mac, you need to run Microsoft Windows on your Mac, which is what Bootcamp and Parallels do.

**Bootcamp** is free and very fast (basically runs at the speed of a windows laptop), but requires you to restart your computer every time you would like to switch from Windows to Mac or vice versa, which can be burdensome. Instructions for installing boot camp on a Mac can be found here and here. This is the manufacturer’s (Simpleware) recommended solution for running ScanIP on Macs.

**Parallels** does not require you to restart your mac and is far more user friendly. However, it is not as fast as bootcamp and requires a lot of memory (RAM) to handle running both Windows and macOS at the same time. That being said, newer Macs that meet the minimum hardware requirements have been able to handle running Parallels at sufficient speeds to complete the final project. So, Parallels is the far simple solution for running ScanIP.

For either software, you will also need to obtain a copy of Windows. Please talk with Noah Leppek on acquiring Microsoft Windows and installing Bootcamp, and / or Parallels. Please talk with Jennifer Thurston for assistance in purchasing Parallels.

Suggested Software and add-ons

- Three button mouse - visualization software often employ that third mouse button for additional functions.
- External Hard drive and backup software (Back up your laptop regularly)

Course Outcomes and Learning Objectives

The course is divided into four major units, the first three of which will be assessed based on the
following learning objectives

1. **Unit 1:** Basic Programming, Digital images and Image processing. The major learning objectives for this unit are as follows:

   - Explain the base–2 (binary) numeral system and be able to count in binary. Describe how computers store information using bits and bytes.
   - Define variable, function, and syntax as they relate to computer programming. Assign values to variables in MATLAB and pass these variables into basic functions in MATLAB.
   - Be able to generate simple MATLAB scripts and use control elements to input and process data.
   - Perform basic measures of central tendency (mean, median and mode) and display measurements as bar plots (with error bars) or as box plots.
   - Perform basic statistic comparisons such as calculating the confidence interval, or perform parametric and non-parametric tests such as t-tests or correlations.
   - Open and properly display any image using MATLAB or Fiji.
   - Perform basic digital image processing using MATLAB or Fiji.

2. **Unit 2:** Visible Light. The major learning objectives for this unit are as follows:

   - Describe electromagnetic radiation and define the frequency range of visible light.
   - Describe the basic properties of a simple lens and explain how a lens forms an image.
   - Describe the anatomy of the human eye and explain how the eye forms and detects images. Explain the difference between photopic and scotopic vision and explain how the eye detects color.
   - Explain how a CCD forms an image in a digital camera.
   - Explain how a light microscope works and detail the differences between light, fluorescence, and confocal microscopy.
   - Open and properly display 3D image datasets using MATLAB or FIJI.

3. **Unit 3:** Medical Imaging Modalities

   - Describe how X-ray radiation is used to create images of the internal body.
   - Give a general overview on how magnetic resonance is used to create an internal image of the body.
   - Describe how ultrasound is used to create internal images of the body.
- Compare and contrast the strength and weaknesses of CT scans vs MRI vs Ultrasound
- Open and properly display DICOM images using software such as MATLAB, Fiji, 3D Slicer, and ScanIP
- Model 3D structures from DICOM datasets using software such as MATLAB, Fiji, 3D Slicer, and ScanIP

4. **Unit 4: Final Course Project**

see below

**Final Course Project**

The final project is your opportunity to show off your new imaging and modeling savvy. For this project, you will need to process and model a three-dimensional image dataset using the imaging and modeling workflow steps learned in this course. You can use any suitable anatomical dataset you can find that is available to use for educational purposes. A critical component of this project will be to develop, describe, and execute a methodology to measure something anatomical from a three-dimensional medical image dataset — for example, measuring the volume of a segmented object.

The measurement methodology that you develop can be based off of a publication. For example, in this [Anatomical Record article](#), discussed here on [CNN](#), the authors generate volumetric measurements to evaluate whether nasal architecture accommodates the need for effective conditioning of respired air. A feasible class project could be to generate similar measurements in the cadaveric datasets that you will received during the course, and compare and discuss your results to the results in the publication.

This project includes two main parts: a written component and a presentation component. The written component should contain the following sections: Introduction, Methods, Results, Discussion, Citations. You can also include Supplementary Documentation that includes any pertinent MATLAB scripts, source files, or image datasets used to generate your models.

The presentation component should be 10 minutes long and there will be three minutes for questions. The presentation should give an overview of your methodology and discuss the insights you gained about your tissue system by modeling it.

This project will be evaluated on its extent, scope, clarity, and thoroughness. A grading rubric will be made available so you can plan your project.

**Group Projects:** Imaging and Modeling projects are rarely a one-person effort. To reflect this, group projects will be allowed. However, it is expected that each individual in the group will contribute equally to the design and implementation of the project. Moreover, the scope of a group project should be commensurately larger than an individual project. That is to say, a 3-group project should be roughly 3X the size of an individual project.
Assessment

- **50% - Exams.** There will be three main Exams
- **30% - Final Course Project.** Due at the end of the semester
- **20% - Quizzes / Homework / Lab assignments.**

Grading Policy

At the end of the course, a final letter grade will be assigned according to the MHA program scale. As per program policy, a minimum grade of B- is required for successful completion of the course.

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<td>A-</td>
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Credits

This course is **Five Credit Hours:** In addition to attending all lectures and labs, you should plan to spend at least 10 hours a week outside of lecture working on the assignments for the course.

CANVAS

Check your email and the CANVAS website DAILY for important notices about this course.

MSMHA General Course Policies

Please refer to the student handbook for more information on these policies:

**Religious Accommodation Policy:** Students who anticipate the necessity of being absent from class due to the observation of major religious observance must provide advance notice to the Course Director in writing.

**Disability Accommodation Policy:** Students with documented learning and/or physical disabilities should inform the Course Director as soon as possible to discuss and arrange for reasonable
accommodations. All reasonable efforts will be made to accommodate students with regard to note taking, reading assignments, and test taking.

**Equal Opportunity Policy:** In line with the goals of the University, we will maintain a work and study environment free of discrimination on the basis of race, color, sex, gender, marital status, religion, national origin, veteran status, handicap or age and to maintain an environment of respect for all.

**Recording Policy:** You are permitted to use tablets or laptop computers to take notes. In addition, you are permitted to video or audio record any or all lectures for the purpose of self-study. However, you are not permitted to use notes, tapes or other recorded data for the purposes of sale or posting on the internet.

**Withdrawal Policy:** Students may withdraw from a course with an ANAT prefix no later than the completion of 70% of the course (by the end of Week 12). Please contact the Course Director to discuss possibility of a course withdrawal.

**Incomplete Policy:** Incomplete (I) grades are not granted for low academic performance. To be eligible for an “I” grade, you must:

1. Successfully complete a minimum of 75% of the course
2. Have a special circumstance(s) beyond your control that prevents you from attending class and/or completing coursework. Documentation is required.
3. Make arrangements to complete missing coursework with the original instructor
4. If the missing coursework is not completed within 1 year from the end of the semester in which the original course was scheduled, the “I” grade will convert to an “F” grade on your official transcript.

**Resolution of Conflicts Policy:** Good faith efforts will be made by students, faculty, and program and university administration to settle all appeals, complaints and grievances on an informal basis. Such efforts include conferences between the persons directly involved and others who may help solve the problems. Formal conflict resolution policies are detailed in the policies and procedures of the Graduate School, University of Colorado Denver.