cs666
Biomedical Signal and
Image Processing

# Syllabus for CS666: Biomedical Signal and Image Processing

## Computer Science for Biomedical Diagnostics and Research!

This course introduces important signal and image processing methods for biomedical diagnostics and research. You will learn hands-on how to reconstruct, visualize, and analyze datasets from different modalities such as electrocardiography (ECG), electroencephalography and magnetoencephalography (EEG/MEG), ultrasound (US), X-ray, electron and light microscopy (EM/LM), computerized tomography (CT), structural and functional magnetic resonance imaging (MRI/fMRI), as well as single photon emission computed tomography and positron emission tomography (SPECT/PET). Course discussions and assignments include the fundamentals of digital signal processing, filtering and denoising, Fourier transformations, pattern recognition, and state-of-the-art registration and segmentation pipelines. After completion, you will have the $kills to work at hospitals, life science institutions, and biotech companies!

**We will examine, learn, and use:**

- Real-world Data acquired using ECG, EEG/MEG, US, X-ray, EM/LM, CT, MRI/fMRI, and SPECT/PET

- Popular Medical Applications such as 3D Slicer, The ChRIS Project, SliceDrop.com, and many others..

- Medical Signal and Image Analysis with Python (Pandas, OpenCV, SciKit-Image, Mahotas..)

- Applied Deep Learning for Medical Imaging with Keras/TensorFlow

- Recent Research from the International Conference on Medical Image Computing and Computer Assisted Intervention (MICCAI 2020—2023)

- Github / git and Overleaf / LaTeX

## Teaching Staff

Instructor: Daniel Haehn
Teaching Assistants/Graders: VidhyaSree Narayanappa, Edward Gaibor, and TBA
Contact: @staff on Discord

## Lectures

Tuesdays and Thursdays
11:00am-12:15pm
McCormack M02-0207

## Office Hours

Tuesdays and Thursdays
09:30-11:00am and by request
McCormack M03-2120, please use https://calendly.com/haehn/ to reserve a slot.

## Blackboard Access

Please use Blackboard to access lecture videos, slides, and all other materials.
Login at https://umb.umassonline.net/.

## Discord Access

The teaching staff is available via Discord. The invite link will be shared in class.

## Questions and Concerns

Please direct questions and concerns of any kind (now and during the semester) to the teaching staff in person or via Discord @staff or in the #help channel.

## Course Structure

39 Lectures
**7 Assignments** (30% of final grade, plus 10% bonus)
**10 Quizzes** (20% of final grade, take-home through blackboard)
**Journal Club** (30% of final grade)
**Participation** (in-class, in-office, and as part of Discord discussions, 20% of final grade)

We will have **multiple guest lectures** from experienced researchers.

## Final Grade

The weighted scores from above will result in a final grade as follows:

| | |
|---|---|
| $\geq$ 90 = A | 69-66 = C |
| 89-86 = A- | 65-62 = C- |
| 85-82 = B+ | 61-58 = D+ |
| 81-78 = B | 57-54 = D |
| 77-74 = B- | 53-50 = D- |
| 73-70 = C+ | below 50 = F |

## Interactive Lectures

Lectures will include interactive components. If you do not have a laptop or reliable internet, please contact the teaching staff via Discord.

## Assignments

Assignments include research questions and coding challenges. All assignments require a written report. You will use a standard git workflow to submit your work. Instructions and templates are available in the Blackboard system. **Assignments are due Tuesdays at 11:59pm. No late submissions.**

## Quizzes

Quizzes include multiple-choice and free-text questions. They are take-home quizzes and available in the Blackboard system. **Quizzes are due Fridays at 11:59pm. No late submissions.**

## Journal Club

We will read classic and recent papers during the weekly journal club sessions. You will present 1-2 papers per semester during these sessions followed by class discussions.

## Participation

In-class participation and Discord activity count towards your grade. If class attendance drops below 50%, surprise tests may happen during lectures.

## Collaboration Policy

You are allowed and encouraged to collaborate with anybody. However, please make sure to give proper credit. For instance, if your friend helps you with your report or you copied code from another source, you must acknowledge their name in your code and the project documentation. **ChatGPT or any other AI tool requires credit and the student is responsible to double-check the content!**

## Open Source License and Proprietary Code

The course material is publicly available under the MIT license (`https://opensource.org/licenses/MIT`). This includes provided code. You are free to adopt a different license for the code you write in the course.

## Readings

The course material is based on the following books:
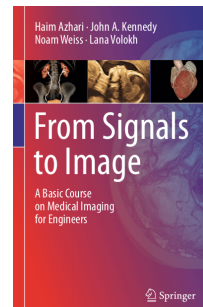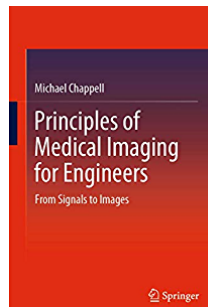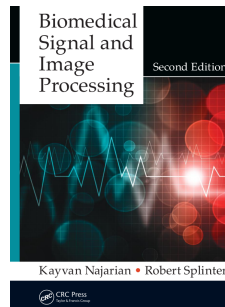


- Biomedical Signal and Image Processing by K. Najarian and R. Splinter

- Principles of Medical Imaging for Engineers by M. Chappell

- From Signals to Image by H. Azhari, J.A. Kennedy, N. Weiss, and L. Volokh

Limited copies of all books are available through the teaching staff. While the books are great, **you do not need to purchase them**—the most up-to-date information is available online.

## Disability Accommodations

If you have a disability and feel you will need accommodation to complete course requirements, please contact the Ross Center for Disability Services at 617.287.7430.

## Other Policies

We follow the Academic Policies of the Office of the Registrar.
See `https://www.umb.edu/registrar/academic_policies` or contact `staff@cs410.net` for questions.

## Timeline

| Date | | | Lecture | Due at 11:59pm |
|------|---|---|---------|----------------|
| 01/23/2023 | Tu | 01 | Introduction | |
| 01/25/2023 | Th | 02 | Signals and Images I | |
| | | | Journal Club Prep: Intro to Research | |
| 01/30/2023 | Tu | 04 | Signals and Images II | |
| 02/01/2023 | Th | 05 | Electrocardiography | |
| | | | Journal Club Prep: How to read a paper | Quiz 1 |
| 02/06/2023 | Tu | 07 | Data Wrangling | |
| 02/08/2023 | Th | 08 | Guest Lecture by Loraine Franke (UMass Boston) | |
| | | | Journal Club Prep: How to read a paper II | |
| 02/13/2023 | Tu | 10 | EEG/MEG | Assignment 1 |
| 02/15/2023 | Th | 11 | 2D Signals and Images | |
| | | | Journal Club Prep: How to write a paper | Quiz 2 |
| 02/20/2023 | Tu | | No Class (President's Day) | |
| 02/22/2023 | Th | 13 | Segmentation and Registration | |
| | | | Journal Club 1 | Quiz 3 |
| 02/27/2023 | Tu | 15 | Visualization | Assignment 2 |
| 02/29/2023 | Th | 16 | TBA | |
| | | | Journal Club 2 | Quiz 4 |
| 03/05/2023 | Tu | 18 | Processing Frameworks | |
| 03/07/2023 | Th | 19 | Ultrasound | |
| | | | Journal Club 3 | |
| 03/12/2023 | Tu | | No Class (Spring Break) | |
| 03/14/2023 | Th | | No Class (Spring Break) | |
| 03/19/2023 | Tu | 21 | Guest Lecture by Michal Depa (Stata Diagnostics) | Assignment 3 |
| 03/21/2023 | Th | 22 | X-Ray | |
| | | | Journal Club 4 | Quiz 5 |
| 03/26/2023 | Tu | 24 | Microscopy | |
| 03/28/2023 | Th | 25 | Guest Lecture by Kai Kang (Etiometry, Inc.) | |
| | | | Journal Club 5 | Quiz 6 |
| 04/02/2023 | Tu | 27 | CT | Assignment 4 |
| 04/04/2023 | Th | 28 | MRI/fMRI | |
| | | | Journal Club 6 | Quiz 7 |
| 04/09/2023 | Tu | 30 | TBA | Assignment 5 |
| 04/11/2023 | Th | 31 | Applied Deep Learning | |
| | | | Journal Club 7 | Quiz 8 |
| 04/16/2023 | Tu | | No Class (Assignment 6) | |
| 04/18/2023 | Th | | No Class (Assignment 6) | |
| 04/23/2023 | Tu | 33 | Applied Deep Learning II | Assignment 6 |
| 04/25/2023 | Th | 34 | SPECT/PET | |
| | | | Journal Club 8 | Quiz 9 |
| 04/30/2023 | Tu | 36 | Biometrics | Assignment 7 |
| 05/02/2023 | Th | 37 | Future and Outlook | |
| | | | Journal Club 9 | Quiz 10 |
| 05/07/2023 | Tu | 39 | Final Recap | |