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)
- Github / git and Overleaf / LaTeX

FCK COVID AND THE P*X! This is an in-person course. To stay safe, we need to follow the university policies of wearing masks and social distancing.

Teaching Staff

Instructor: Daniel Haehn
Teaching Assistants/Graders: Mahsa Geshvadi, Kunal Jain, and Kiran Sandilya Balivada
Contact: `staff@cs666.org`

Lectures

Mondays, Wednesdays, Fridays
11:00-11:50am
Healey HLL-3507

Office Hours

Mondays, Wednesdays, Fridays
10:00-11:00am and by request
McCormack M-3-0201-20, 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/`.

Questions and Concerns

Please direct questions and concerns of any kind (now and during the semester) to the teaching staff in person or at `staff@cs666.org`.

Course Structure

40 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 (remote and as part of blackboard 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 at `staff@cs666.org`.

Assignments

Assignments include research questions and coding challenges. All assignments require a written report in LaTeX. You will use a standard git workflow to submit your work. Instructions and templates are available in the Blackboard system. **Assignments are due Mondays 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

Remote class attendance and participation, as well as posts in the online discussion forum, count towards your grade. Please skip at most 4 classes and contribute at least once to every official discussion topic, if you want a 100% participation score.

Collaboration Policy

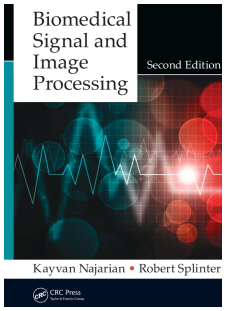
You are allowed and encouraged to collaborate with anybody. However, please make sure to give proper credit. For instance, if your friend helps you with your report or you copied code from another source, you must acknowledge their name in your code and the project documentation.

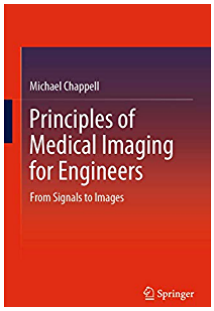
Open Source License and Proprietary Code

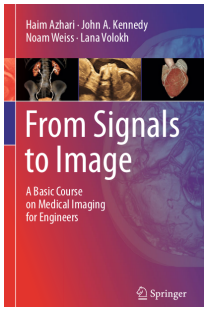
The course material is publicly available under the MIT license (`https://opensource.org/licenses/MIT`). This includes provided code. You are free to adopt a different license for the code you write in the course.

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	M	01	Introduction	
01/25/2023	W	02	Signals and Images I	
01/27/2023	F	03	Journal Club Prep: Intro to Research	
01/30/2023	M	04	Signals and Images II	
02/01/2023	W	05	Electrocardiography	
02/03/2023	F	06	Journal Club Prep: How to read a paper	Quiz 1
02/06/2023	M	07	Guest Lecture by Michal Depa (Stata Diagnostics)	
02/08/2023	W	08	Data Wrangling	
02/10/2023	F	09	TBA	
02/13/2023	M	10	EEG/MEG	Assignment 1
02/15/2023	W	11	2D Signals and Images	
02/17/2023	F	12	Journal Club Prep: How to write a paper	Quiz 2
02/20/2023	M		No Class (President's Day)	
02/22/2023	W	13	Segmentation and Registration	
02/24/2023	F	14	Journal Club 1	Quiz 3
02/27/2023	M	15	Visualization	Assignment 2
03/01/2023	W	16	Guest Lecture by Mike Halle (Harvard Medical School)	
03/04/2023	F	17	Journal Club 2	Quiz 4
03/06/2023	M	18	Processing Frameworks	
03/08/2023	W	19	Ultrasound	
03/10/2023	F	20	Journal Club 3	
03/13/2023	M		No Class (Spring Break)	
03/15/2023	W		No Class (Spring Break)	
03/17/2023	F		No Class (Spring Break)	
03/20/2023	M	21	Guest Lecture by Rudolph Pienaar (Boston Children's Hospital)	Assignment 3
03/22/2023	W	22	X-Ray	
03/24/2023	F	23	Journal Club 4	Quiz 5
03/27/2023	M	24	Microscopy	
03/29/2023	W	25	Guest Lecture by Kai Kang (Etiometry, Inc.)	
03/31/2023	F	26	Journal Club 5	Quiz 6
04/03/2023	M	27	CT	Assignment 4
04/05/2023	W	28	MRI/fMRI	
04/07/2023	F	29	Journal Club 6	Quiz 7
04/10/2023	M	30	TBA	Assignment 5
04/12/2023	W	31	Applied Deep Learning	
04/14/2023	F	32	Journal Club 7	Quiz 8
04/17/2023	M		No Class (Assignment 6)	
04/19/2023	W		No Class (Assignment 6)	
04/21/2023	F		No Class (Assignment 6)	
04/24/2023	M	33	Applied Deep Learning II	Assignment 6
04/26/2023	W	34	SPECT/PET	
04/28/2023	F	35	Journal Club 8	Quiz 9
05/01/2023	M	36	Biometrics	Assignment 7
05/03/2023	W	37	Future and Outlook	
05/05/2023	F	38	Journal Club 9	Quiz 10
05/08/2023	M	39	AMA	
05/10/2023	W	40	Final Recap	