MPHY 6120: Artificial Intelligence for Medicine

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Web: **https://pennmed-ai-for-medicine.github.io/**
Github: **https://github.com/PennMed-AI-for-Medicine**
Office Hours: Virtual TBD
Office: PCAM 2-302 CMS
Credit Hours: 3

Class Hours: Thurs 1:45-4:45pm
Class Room: SCRT 12-146 AB

Course Description

This course offers an in-depth introduction to AI with a focus on medical applications through the lens of a medical physicist. It discusses fundamental principles of medical informatics, data science, and artificial intelligence, and emphasizes their applications to medical scenarios. The course explores image segmentation, registration, data analysis and natural language processing through hands-on learning using the Python programming language. AI assistants like GitHub copilot and ChatGPT are used to augment learning and facilitate coding exercises. The course is intended for a broad audience interested in medical AI, but a strong foundation in math and programming is recommended.

Course Materials

Required

No textbook required. Course materials will be provided online and will include videos, slides, Jupyter notebooks and a GitHub repository for skeleton code and examples.

- Course GitHub repository: https://github.com/PennMed-AI-for-Medicine
- Course website: https://pennmed-ai-for-medicine.github.io/
- Lecture presentations
- Coding exercises (github)
- Textbook: *The Little Book of Medical AI*, β Edition, by Rafe McBeth, PhD

Optional

- Machine and Deep Learning in Oncology, Medical Physics and Radiology by Issam El Naqa et al, second edition, 2022 ISBN 978-3-030-83046-5
- How to Think Like a Computer Scientist: Learning with Python 2ed by Jeffrey Elkner, Allen B. Downey and Chris Meyers (Open Book Project) [https://greenteapress.com/wp/think-python-2e/]
- Python for Data Analysis: Data Wrangling with Pandas, NumPy, and Jupyter 3rd Edition by Wes McKinney (Author) [ISBN-10: 109810403X]
- Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems 3rd Edition by Aurelien Geron [ISBN-10: 1098125975]

Popular Science:

- The AI Revolution in Medicine: GPT-4 and Beyond by Peter Lee , Carey Goldberg, Isaac Kohane [ISBN-10: 0138200130]

Prerequisites

Prerequisites: Linear algebra, Python programming

Course Objectives

Successful students will:

1. know the history of AI and its application to medicine
2. understand the fundamentals of data science
3. use python to perform data analysis on medically related datasets
4. understand the fundamentals of AI/ML (computer vision, language, ..)
5. use python to train and test AI/ML models on medically related datasets (computer vision, language, ..)

Course Structure

Class Structure

Each class will be broken down into 3 sections: Lecture, coding examples and lab (coding exercise, homework). The lecture section will typically be around 1 hour and the rest of the class will be dedicated to in-class exercises and time to work on assignments.

Lab

Class Projects

There will be two class projects required for this course. For each project it is recommended that work together in groups to ensure that we have appropriate access to compute/GPU resources. General project description:

- Project utilizing ML techniques on structured medical data
- Deep learning-based project on language or computer vision task on medical data

Grading Policy

The grade in the course will be based on the following proportions:

- **50%** Assignments
- **40%** Projects (20% each).
- **10%** Attendance

Course Policies

Attendance Policy

Attendance is expected in all lecture and lab sections. Valid excuses for absence will be accepted before class. In extenuating circumstances, valid excuses with proof will be accepted after class. For every class missed the participation grade will be dropped 2 point.

AI assistant policy

You will be expected to and will be taught to integrate tools like ChatGPT and GitHub co-pilot into your workflow. Recognize that these are new tools and they can often be incorrect. These tools alone will not solve any of our major homework problems by themselves. The models are not yet specific enough to our field and needs. We will learn how to assess them and how we may build on this technology for our specific goals.

Schedule and general topics

The schedule is tentative and subject to change.

Week 01, 01/15 - 01/19: Foundations 1

- Course Introduction
- History of AI in Medicine

Week 02, 01/22 - 01/26: Foundations 2

- Basics of python programming
- Infrastructure
- Data Science

Week 03, 01/29 - 02/02: Foundations 3

- Statistics
- Linear Algebra

Week 04, 02/05 - 02/09: Module 1

- Applied data science - Python for medical applications 1
  - Data analysis, machine QA, DICOM, EDA..

Week 05, 02/12 - 02/16: Module 1

- Applied data science - Python for medical applications 2
  - More EDA, Image registration, clinical automation,..

Week 06, 02/19 - 02/23: Module 2

- Introduction to machine learning

Week 07, 02/26 - 03/01: Module 2

- Machine learning: classification, regression, decision trees

Week 08, 03/04 - 03/08: Spring Break

Week 09, 03/11 - 03/15: **Midterm Project Due** - Module 2

- Machine learning: Dimensionality reduction, model selection, clustering...

Week 10, 03/18 - 03/22: Module 3

- Introduction to Deep Learning 1: Convolutional neural nets, UNet, encoder-decoder, transformers..

Week 11, 03/25 - 03/29: Module 3

- Practical Deep Learning 1: PyTorch

Week 12, 04/01 - 04/05: Module 3

- Practical Deep Learning 2: Image classification and segmentation with UNets

Week 13, 04/08 - 04/12: Module 3

- Practical Deep Learning 3: Other network models (GAN, reinforcement learning, NLP, diffusion...)

Week 14, 04/15 - 04/19: Module 3

- Practical Deep Learning 4: Other network models (GAN, reinforcement learning, NLP, diffusion...)
- Final project work

Week 15, 04/22 - 04/26: Module 3

- Practical Deep Learning 5: Other network models (GAN, reinforcement learning, NLP, diffusion...)
- Final project work

Week 16, 04/29 - 05/03: Final

- Final projects due - Presentations