CMB 427X: Life Sciences Applications of Artificial Intelligence

Course Code: CMB 427X - Section 0001
Credits: 3

Lecture Time: TBD
Location: TBD
Instructor: Pengyu (Peter) Liu
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Office Hours: TBD

Prerequisites: Junior standing or above. No prior programming experience is required. A background in Introductory Biology (BIO 101 or equivalent) is recommended.

Course Description

This course provides an introduction to artificial intelligence (AI) techniques and their applications in the life sciences and medicine. Students will explore foundational AI concepts, learn how to apply machine learning (ML) and data science tools to biological datasets, and examine case studies that demonstrate the applications of AI in fields such as genomics, molecular structures, and systems biology. No prior programming experience is required.

Required Materials

No textbook is required. Course materials, including lecture slides, reading lists, and tutorial links, will be provided weekly through Brightspace. Students will use Google Colab (https://colab.research.google.com/), a free, browser-based platform, for all hands-on sessions and coding assignments — no software installation is required. Students will need reliable internet access and a laptop.

Learning Outcomes

By the end of this course, students will be able to:

1. Demonstrate an understanding of the current applications of AI/ML models in the life sciences, including genomics, structural biology, and biomedical imaging.
2. Apply existing AI/ML models to analyze biological datasets, with a focus on sequence data, structural data, and image data.
3. Develop and implement simple neural network models for biological data analytics, gaining practical experience in model construction, training, and optimization.
4. Evaluate and validate neural network models, using appropriate techniques to assess accuracy, reliability, and generalizability in the context of biological data.

Homework and Projects

As AI/ML is a rapidly evolving field, students are expected to research current developments by reviewing scientific literature and online resources, either independently or in teams of up to three. Weekly homework assignments will require students to identify relevant materials related to the topic covered in class and present their findings during the following week's discussion session. Each student is required to prepare at least one presentation slide, ask at least one question, and share at least one item they found interesting. Homework will be assessed based on the clarity of the in-class presentation and the quality of the student's contribution to the discussion. Homework is due at the beginning of each week’s discussion session (see Course Schedule for dates).

Two major projects will provide opportunities to apply course knowledge to real-world problems. Students may work individually or in teams of up to three. For team projects, each team must submit a single report that clearly identifies each member's contributions, including a brief accountability statement describing each member's specific role and responsibilities. Projects will be assessed based on the following criteria: (1) clarity of the introduction and problem statement; (2) description of the model architecture; (3) description

of the data used for training and testing; (4) presentation of results; and (5) quality of discussion. Further details regarding the projects will be provided during the semester.

Evaluation

Final grades will be based on the following components:

- Homework, in-class presentations and discussions: 60pts (30%)
    - 12 weekly assignments, 5pts each
- Project 1 (with literature review): 70pts (35%)
    - 1 report, 70pts
- Project 2 (with literature review): 70pts (35%)
    - 1 report, 70pts

Grading scale: A: 90.0% – 100%, A-: 87.0% – 89.9%, B+: 85.0% – 86.9%, B: 83.0% – 84.9%, B-: 80.0% – 82.9%, C+: 77.0% – 79.9%, C: 73.0% – 76.9%, C-: 70.0% – 72.9%, D+: 67.0% – 69.9%, D: 60.0% – 66.9%, F: Below 60%

Workload Expectations

This is a 3-credit course. In accordance with federal credit hour guidelines, students should expect to spend approximately 2.5 hours per week in class and a minimum of 5–6 hours per week on out-of-class work, for a total of approximately 7.5–8.5 hours per week. The approximate weekly breakdown is as follows:

- In-class lectures and discussion: 2.5 hours
- Reading assigned articles and online resources: 1.5–2 hours
- Preparing homework presentation slides: 1–1.5 hours
- Working on projects (coding, data analysis, report writing): 2–2.5 hours (heavier during project periods)

Policies and Statements

University's AI Safety and Ethics Policy: The University of Rhode Island (URI) embraces artificial intelligence (AI) as a powerful tool for teaching, learning, research, and innovation. However, we recognize the importance of ensuring AI is used securely, ethically,

and responsibly to reflect our values of transparency, fairness, and accountability. Please visit https://its.uri.edu/ai-at-uri/ for understanding URI's standards and practices for responsible AI use.

Course-Specific AI Use Policy: Because this course focuses on artificial intelligence, students are encouraged to use AI tools (such as ChatGPT, Claude, GitHub Copilot, etc.) as learning aids for understanding concepts, debugging code, and exploring ideas. However, students must demonstrate their own understanding of the material. For all submitted work, students are required to (1) disclose any AI tools used and (2) include the key prompts or a brief description of how AI was used in an appendix to their report. Copying AI-generated content without understanding or attribution is considered a violation of the Academic Honesty Policy.

Academic Honesty Policy: Cheating is defined in the University Manual section 8.27.10 as the claiming of credit for work not done independently without giving credit for aid received, or any unauthorized communication during examinations. Students are expected to be honest in all academic work. The resolution of any charge of cheating or plagiarism will follow the guideline set forth in the University Manual sections 8.27.10-8.27.21. Furthermore, course content and outlines, exams, and assignments created by instructors shall be considered the instructors' intellectual property. Course materials shall not be distributed, shared in any public domain or third party website, or sold without prior written consent of the instructor. See the University Manual section 8.27.2

Academic Accommodations: Your access in this course is important. Please send your instructor your Disabilities, Access, and Inclusion (DAI) accommodation letter early in the semester so that we have adequate time to discuss and arrange your approved academic accommodations. If you have not yet established services through DAI, please contact them to engage in a confidential conversation about the process for requesting reasonable accommodations in the classroom. DAI can be reached by calling: 401-874-2098, visiting: https://www.uri.edu/disability, or emailing: dai@etal.uri.edu

Anti-bias Statement: We respect the rights and dignity of each individual and group. We reject prejudice and intolerance, and we work to understand differences. We believe that equity and inclusion are critical components for campus community members to thrive. If you are a target or a witness of a bias incident, you are encouraged to submit a report to the URI Bias Response Team at www.uri.edu/brt. There you will also find people and resources to help.

Health and Safety: The University is committed to delivering its educational mission while protecting the health and safety of our community. While the university has worked to create a healthy learning environment for all, it is up to all of us to ensure our campus stays that way. As members of the URI community, students are required to comply with standards of conduct and take precautions to keep themselves and others safe. If you are unable to attend class, please notify your instructor prior to the start of class through the medium they have established for the class.

Religious Holidays: It is the policy of the University of Rhode Island to accord students, on an individual basis, the opportunity to observe their traditional religious holidays. Students who plan to be absent from classes or examinations for religious holy days that traditionally preclude secular activity shall discuss this with the appropriate instructor(s) in advance of the holy day. See the University Manual section 8.51.11 for details.

Standards of Behavior: Students are expected to treat faculty and fellow classmates with dignity and respect. Students are responsible for being familiar with and adhering to the published "Community Standards of Behavior: University Policies and Regulations" which can be accessed in the University Student Handbook https://web.uri.edu/studentconduct/university-student-handbook.

University Statements: Please visit the following webpage or scan the QR code to read more detailed University Statements and Policies. https://web.uri.edu/atl/syllabus-statements/

Course Schedule (Tentative)

Week	Events	Topics
Week 1		Overview of AI and ML models, from their bionic background of biological neural networks (BNNs) to their broad applications in biology and medicine.
Week 2	Homework 1 due	Introduce three major types of data in life sciences (sequence data, structure data and image/video data) and their biological background.
Week 3	Homework 2 due	Introduce computational basics for AI, including graphs, networks, artificial neural networks (ANNs), Python and PyTorch. Build a first ANN model for biological applications to understand its mechanisms and biological inspiration.
Week 4	Homework 3 due	Introduce sequence data (nucleic acid sequences and amino acid sequences), publicly available databases, and apply a basic ANN model to classify sequence data (supervised learning).
Week 5	Homework 4 due **First Project Assignment**	Introduce biomolecular structural data (nucleic acid structures and protein structures), publicly available databases, and available online AI models such as AlphaFold 3.
Week 6	Homework 5 due	Introduce image/video data in biology and medicine, publicly available databases, and available online AI computer vision models for image/video

		data such as the Segment Anything Model.
Week 7	Homework 6 due	Introduce convolution and convolutional neural networks designed for biological applications.
Week 8	Homework 7 due	Apply CNN models to classify sequence data and image/video data (supervised learning).
Week 9	**First Project Due**	Spring Break
Week 10	Homework 8 due **Second Project Assignment**	Introduce data clustering (unsupervised learning) models such as autoencoder for analyzing biomolecular structures.
Week 11	Homework 9 due	Introduce biomolecular structure encoding techniques and data clustering (unsupervised learning) models such as autoencoder and graph neural networks (GNN).
Week 12	Homework 10 due	Apply autoencoder and GNN models to cluster biomolecular structures (unsupervised learning).
Week 13	Homework 11 due	Introduce grammar and language models such as recurrent neural networks (RNNs) and transformers (the ‘T’ in ‘GPT’) designed for biological applications.
Week 14	Homework 12 due	Apply grammar and language models to analyze sequence data.
Week 15	**Second Project Due**	Discussion session