BME i9400

Special Topics in Machine Learning

Fall 2025 Course Syllabus

Graduate Program
Biomedical Engineering
City College of New York

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Office: Steinman Hall, Room 460

Schedule: Mon & Wed, 11:00 AM - 12:15 PM

Location: Steinman Hall C-51

Course Description

This graduate-level course provides hands-on experience with machine learning techniques applied to biomedical engineering problems. Students will master fundamental ML concepts, implement neural networks and transformers, work with multimodal biomedical data, and critically evaluate AI systems for healthcare applications. The course emphasizes practical implementation through interactive coding sessions using Python and modern ML frameworks.

Learning Outcomes

- **Formulate** biomedical problems as regression/classification tasks
- **Train** models via gradient-based optimization
- **Implement** CNNs, sequence models, and transformer-based workflows
- **Integrate** text, images, and time-series in multimodal pipelines
- **Critically evaluate** fairness, explainability, and privacy in biomedicine
- **Deliver** reproducible projects with appropriate metrics and visualizations

Assessment & Grading

Component	Weight	Description
Micro-deliverables	20%	Weekly in-class artifacts
Homework	10%	Take-home exercises
Midterm Exam	30%	Practical exam (Week 7)
Final Project	40%	Capstone with presentation

Course Schedule

Weeks 1-3: Foundations

Lec	Week	Topic	Key Concepts
1	1	Python Crash Course	NumPy, Pandas, Matplotlib
2	1	Probability & Distributions	Bayes' rule, sensitivity/specificity
3	2	Linear Algebra for ML	PCA on gene expression
4	2	Least Squares Regression	Normal equations, geometric view
5	3	Optimization Basics	GD/SGD, learning rates
6	3	Classification & Evaluation	ROC/PRC, AUC

Weeks 4-5: Core ML in Biomedical Context

Lec	Week	Topic	Key Concepts
7	4	Logistic Regression	L1/L2 regularization
8	4	Convolutional Neural Networks	Medical image analysis
9	5	Neural Networks	MLP, nonlinearity
10	5	Sequence Models	RNN/LSTM for ECG/EEG

Weeks 6-8: Generative AI Fundamentals

Lec	Week	Topic	Key Concepts
11	6	From RNNs to Transformers	Attention mechanism
12	6	Transformer Internals I	Embeddings, positional encoding
13	7	Transformer Internals II	Self-attention, multi-head
14	7	MIDTERM EXAM	Covers lectures 1-13
15	8	Training an LLM	Tokenization, fine-tuning
16	8	Inference & Prompting	PubMed summarization

Weeks 9-10: Multimodal Biomedical AI

Lec	Week	Topic	Key Concepts
17	9	Text + Images	CLIP-style pairing, zero-shot

Lec	Week	Topic	Key Concepts
18	9	Text + Time Series	Simple fusion strategies
19	10	Self-Supervised Multimodal	Masked reconstruction

Weeks 10-11: Translation, Ethics, and Safety

Lec	Week	Topic	Key Concepts
20	10	Bias & Fairness	Audit & mitigation strategies
21	11	Explainability	SHAP/Grad-CAM, trust boundaries
22	11	Privacy & Federated Learning	Toy federation simulation

Weeks 12-14: Capstone Sprint

Lec	Week	Topic	Deliverable
23	12	Ideation & Dataset	1-page proposal
24	12	Prototype I	Working baseline
25	13	Prototype II	LLM/multimodal integration
26	13	Peer Review & Critique	Peer review forms
27	14	Presentations I	Final presentation
28	14	Presentations II	Final presentation

Course Policies

Attendance

Workshop format requires active participation. One unexcused absence permitted. Do not email explanations after missing class.

Academic Integrity & AI Usage

Individual work must be your own. Pair programming allowed with attribution. AI tools (ChatGPT, Copilot) permitted as educational aids with prompt citation. Validate all AI outputs manually.

Technical Requirements

- JupyterHub access via web browser (http://52.202.195.38)
- All computation on cloud (no local installation needed)
- CPU-only instances (no GPU required)
- Python 3.11 with pre-installed ML libraries

Last updated: August 2025