

BME4931/6938: Medical Artificial Intelligence (MAI)

Section 36EG

Class Periods: M/W/F, Period 3, 9:35 am – 10:25 am

Location: 315 Black Hall

Academic Term: Fall 2023

Instructor:

Professor Ruogu Fang, Ph.D.

Associate Professor, Pruitt Family Endowed Faculty Fellow

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Office Location: BMS J287

Telephone: 352-294-1375

Website: Canvas Page

Office Hours: Friday 4:00 PM – 5:00 PM (Zoom. Please message Dr. Fang to schedule in-person meetings)

Course Description (3 credit hours)

This course introduces advanced undergraduate and graduate students to artificial intelligence, machine learning, deep learning with a focus on biomedical applications. Students will learn the fundamentals, implementation, and applications of machine learning and deep learning methods and algorithms to biomedical data.

Course Pre-Requisites / Co-Requisites

Computer programming (COP 2271 and COP 2271L or equivalent and MAC 2312), computer applications (BME3503C), with minimum grades of C.

Foundational knowledge in python and computer programming is recommended to be successful in this course. Be prepared to learn Python from scratch in this course if you are not familiar with Python.

Course Objectives

At the completion of this course, students will be able to do the following:

Course Level:

1. Understand the basic concepts and techniques of machine learning.
2. Formulate machine learning problems corresponding to different applications.
3. Understand a range of machine learning algorithms along with their strengths and weaknesses.
4. Acquire skills of using recent machine learning software for solving practical problems.
5. Apply machine learning algorithms to solve problems of moderate complexity.
6. Apply machine learning algorithms to a real-world problem, optimize the model learned and report the expected performance that can be achieved by applying the models.

Knowledge and Skill Level:

1. Implement and analyze existing learning algorithms, including well-studied methods for classification, regression, structured prediction, clustering, and representation learning.
2. Integrate multiple facets of practical machine learning in a single system: data preprocessing, learning, regularization, and model selection.
3. Describe the formal properties of models and algorithms for learning and explain the practical implications of those results.
4. Compare and contrast different paradigms for learning (supervised, unsupervised, etc.)
5. Design experiments to evaluate and compare different machine learning techniques in real-world problems.

Professional Component (ABET)

This course provides 3 credits of engineering topics.

Relationship of course to program outcomes (ABET)

Outcome	Coverage*
1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics	High
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors	Medium
3. an ability to communicate effectively with a range of audiences	Low
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts	
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives	Medium
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions	
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies	

* Coverage is given as high, medium, or low. An empty box indicates that this outcome is not part of the course.

Textbooks and Software Required

Required Textbooks

Course notes and assigned readings are derived from various published sources and professional records of the course instructor. These materials will be distributed through the course website on Canvas.

The code in this book can be very useful.

- **[MLP]** Machine Learning with PyTorch and Scikit-Learn, Sebastian Raschka, Yuxi (Hayden) Liu, Vahid Mirjalili, Packet Publisher. [\[Code\]](#)

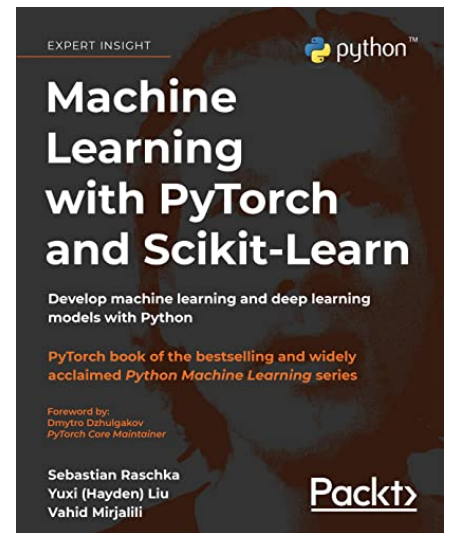
Required Software

Python, PyTorch, Scikit-Learn. Students can use Google Colab, HiperGator, Anaconda, or other Python platforms.

Recommended Materials

The following are useful reference texts and websites:

- **[ML]** Machine Learning, Tom Mitchell. McGraw Hill, 1997 [\[Link\]](#)
- **[DL]** Deep Learning, MIT Press, Ian Goodfellow, Yoshua Bengio, Aaron Courville. [\[Link\]](#)
- Standard cs231n. <http://cs231n.stanford.edu/>.
- Stanford cs244d. <http://cs224d.stanford.edu/>



Course Outline: tentative schedule (subject to change)

Notation: L: Lecture; C: Coding Practice; **Bold:** In-Person Session. **Blue:** Holiday

Week	Day	Date	Sec	Topic	Quiz	HW	Project
Section 1: Introduction & Primer							
1	W	8/23	L1-1	Introduction & Course Logistics			
	F	8/25	L1-2	Welcome! What is Medical AI?	Quiz 1		Release
2	M	8/29	L2-1C	Python: Introduction			
	W	8/30	L2-2C	Numpy & Pandas			
	F	9/1	L2-3C	Colab, HiperGator, GitHub	Quiz 2		Group
Section 2: Biomedical Data							
3	M	9/4		Labor Day Holiday			
	W	9/6	L3-1	Medical Image Analysis		HW1 release	
	F	9/8	L3-2	Electronical Health Records (EHR)	Quiz 3		
4	M	9/11	L4-1	Exploratory Data Analysis			
	W	9/13	L4-2	Data Preprocessing			
	F	9/15	L4-3	Data Management	Quiz 4		
Section 3: Machine Learning Basics							
5	M	9/18	L5-1	Machine Learning & History			
	W	9/20	L5-2	Feature Engineering			
	F	9/22	L5-3	K-Nearest-Neighbors	Quiz 5		
6	M	9/25	L6-1C	Naïve Bayes			
	W	9/27	L6-2C	Support Vector Machines			
	F	9/29	L6-3C	Decision Tree / Random Forests	Quiz 6		
7	M	10/2	L7-1C	Model Evaluation & Imbalanced Data			
	W	10/4	L7-2C	Evaluation Metrics		HW1 due	
	F	10/6	L7-3	Machine Learning Pitfalls	Quiz 7		
Section 4: Deep Learning							
8	M	10/9	L8-1	Perceptron		HW2 release	
	W	10/11	L8-2	Neural Networks			
	F	10/13		Homecoming	Quiz 8		
9	M	10/16	L9-1	Deep Learning Overview			
	W	10/18	L9-2C	Convolutional Neural Networks (CNN)			
	F	10/20	L9-3C	CNN 2	Quiz 9		
10	M	10/23	L10-1	Recurrent Neural Networks (RNN)			
	W	10/25	L10-2	Long-Short Term Memory (LSTM)			
	F	10/27	L10-3C	RNN Programming Tutorial	Quiz 10		
11	M	10/30	L11-1	Generative Adversarial Networks		HW2 due	
	W	11/1	L11-2	GAN Programming Tutorial			
	F	11/3	L11-3	Transformer	Quiz 11		
Section 5: Unsupervised Learning							
12	M	11/6	L12-1	K-means & Mean-shift		HW3 release	
	W	11/8	L12-2	Hierarchical clustering			
	F	11/10		Veteran Day Holiday	Quiz 12		
13	M	11/13	L13-1	Dimensionality Reduction			
	W	11/15	L13-2	Principal Component Analysis			
	F	11/17	L13-3	Linear Discriminant Analysis	Quiz 13		
14	M	11/20		Project Teamwork		HW3 due	
	W	11/22		Thanksgiving Break			
	F	11/24					
Section 6: Conclusion							
15	M	11/27	L14-1	AI Ethics & Fairness			
	W	11/29	L14-2	Visualization & Explainability (Dr. Jessica Ray)			
	F	12/1	L14-3	Trustworthy AI (Skylar Stolte)			
16	M	12/4		Project Presentation			
	W	12/6	L15	Project Presentation & Conclusion			Report

Course Policies

Attendance Policy, Class Expectations, and Make-Up Policy

Attendance:

- View the recorded lecture videos (recommended twice) on time.
- Attend on-time attendance to in-person sessions.
- Attend office hours if having questions.

Expectations:

- Schedule video lecture “class times” for yourself.
- Complete the course activities (lecture videos, quizzes, homework) on time.
- Every week’s module will be available by every **Sunday at 10 AM** via Canvas.
- Quizzes and programming assignments are due **Saturday at 11.59 PM**.
- Write your code. Do not copy code from others (Code plagiarism will be checked)
- Practice implementing newly learned concepts will make you learn better
- Think creatively for final projects
- Better late than never
- Ask for help if you need it (the instructor holds office hour every Friday)

Evaluation of Grades:

Assignments	Percentage of Final Grade
Quiz	20%
Programming Assignments	30%
Admin + Attendance	10%
Final Project	40%
Total	100%

a. Quiz

Quizzes contribute 10 points to your grade. Quiz questions will be asked at the end of each module to help students consolidate their knowledge.

b. Programming Assignments

Programming assignments will contribute 30 points to your final grade. It will be Jupiter Notebook or python programming assignments.

c. Admin & Attendance

Administrative assignments (e.g., Introduce yourself discussion, Microsoft Teams), attendance to in-person class sessions, and evaluations at the end of each module will contribute 5 points to your final grade.

d. Final Project

The Final Project will contribute 40 points to your grade. This project report will be a [MICCAI](#) format paper ready for submission. Papers must be submitted electronically in searchable pdf format following the guidelines for authors and LaTeX and MS Word templates available at [Lecture Notes in Computer Science](#). Manuscripts should be up to 8 pages (text, figures, and tables) plus up to 2 pages of references. No modifications to the templates are permitted.

This proposal/manuscript can focus on the student’s specific area of graduate research and will be expected to integrate two or more methods as a central feature of the research proposal and demonstrate the integration of core knowledge of multiple modalities and machine learning/deep learning in biomedical engineering. This is intended to demonstrate the student’s mastery of the conceptual and practical application of methods and theoretical content covered during the course in their research program.

Category	Requirements	Percentage	Points	
Report (50%)	Abstract: 1 paragraph abstract of the MICCAI paper	Paper: ~0.5 pg	10%	4
	Manuscript introduction and methodology	Paper: 8 pages	15%	6
	Results & Analysis		15%	6
	Bibliography	5%	2	
	Language & Format	5%	2	
Code (10%)	The program runs well and produces the expected results	10%	4	
Present (30%)	Final Project Presentation	20%	8	
	Demo: Live demo of applying your system/method	10%	4	
Milestone (10%)	Milestone 1: Topic	2.5%	1	
	Milestone 2: Specific Aims	7.5%	3	
	Milestone 3: Research Strategy	optional	0	
	Milestone 4: Preliminary Results	optional	0	
Award	(Extra Credit) Best and runner-up in Oral Presentation	+2.5%	+1	
Score	Total Points	(100+2.5)%	40+1	

Grading Scale

Grade	A	A-	B+	B	B-	C+	C	C-	D+	D	D-	E
Points	93.4 - 100	90.0 - 93.3	86.7 - 89.9	83.4 - 86.6	80.0 - 83.3	76.7 - 79.9	73.4 - 76.6	70.0 - 73.3	66.7 - 69.9	63.4 - 66.6	60.0 - 63.3	0 - 59.9
Grade Points	4.00	3.67	3.33	3	2.67	2.33	2	1.67	1.33	1	0.67	0

More information on UF grading policy may be found at:

<http://gradcatalog.ufl.edu/content.php?catoid=10&navoid=2020#grades>

Late Policy

- This applies to quizzes, programming assignments, and project milestone reports.
- Does not apply to project final presentations, final project reports, and final project code.
- The first-time late submission will be given a warning only. From the second time on, (number of late minutes * 0.1 points) will be deducted from the points of the late assignment, e.g., 30 min late = 30*0.1=3 points if you did not make any mistakes.

Relevant University Policies

Students Requiring Accommodations

Students with disabilities who experience learning barriers and would like to request academic accommodations should connect with the Disability Resource Center by visiting <https://disability.ufl.edu/students/get-started/>. It is important for students to share their accommodation letter with their instructor and discuss their access needs, as early as possible in the semester.

Course Evaluation

Students are expected to provide professional and respectful feedback on the quality of instruction in this course by completing course evaluations online via GatorEvals. Guidance on how to give feedback professionally and respectfully is available at <https://gatorevals.aa.ufl.edu/students/>. Students will be notified when the evaluation period opens and can complete evaluations through the email they receive from GatorEvals, in their Canvas

course menu under GatorEvals, or via <https://ufl.bluera.com/ufl/>. Summaries of course evaluation results are available to students at <https://gatorevals.aa.ufl.edu/public-results/>.

University Honesty Policy

UF students are bound by The Honor Pledge which states, “We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honor and integrity by abiding by the Honor Code. On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied: “On my honor, I have neither given nor received unauthorized aid in doing this assignment.” The Honor Code (<https://sccr.dso.ufl.edu/policies/student-honor-code-student-conduct-code/>) specifies a number of behaviors that are in violation of this code and the possible sanctions. Furthermore, you are obligated to report any condition that facilitates academic misconduct to appropriate personnel. If you have any questions or concerns, please consult with the instructor or TAs in this class.

Honor Code

- If you turn in someone else’s work as if it were your own, you are guilty of cheating. This includes homework, codes, projects, quizzes, paper critiques, presentation slides (without citation or proper credit giving), and any required course turn-in material.
- You are also guilty if you knowingly aid in cheating.
- Software will be used to compare your submitted work to others.
- However, it is okay to discuss with other classmates about homework, paper critiques, and group projects (obviously, okay to work with a project partner). But everyone must turn in their original work.
- Do not post your work on public repositories like GitHub (private repositories are fine)
- If we catch you cheating, you will get negative points on the assignment: It is better to not do the work than to cheat! If it is a midterm exam, final exam, or final project, you get an E (fail) in the class. All cases of cheating will be reported to the office of student conduct.

Commitment to a Safe and Inclusive Learning Environment

The Herbert Wertheim College of Engineering values broad diversity within our community and is committed to individual and group empowerment, inclusion, and the elimination of discrimination. It is expected that every person in this class will treat one another with dignity and respect regardless of gender, sexuality, disability, age, socioeconomic status, ethnicity, race, and culture.

If you feel like your performance in class is being impacted by discrimination or harassment of any kind, please contact your instructor or any of the following:

- Your academic advisor or Graduate Program Coordinator
- Robin Bielling, Director of Human Resources, 352-392-0903, rbielling@eng.ufl.edu
- Curtis Taylor, Associate Dean of Student Affairs, 352-392-2177, taylor@eng.ufl.edu
- Toshikazu Nishida, Associate Dean of Academic Affairs, 352-392-0943, nishida@eng.ufl.edu

Software Use

All faculty, staff, and students of the University are required and expected to obey the laws and legal agreements governing software use. Failure to do so can lead to monetary damages and/or criminal penalties for the individual violator. Because such violations are also against University policies and rules, disciplinary action will be taken as appropriate. We, the members of the University of Florida community, pledge to uphold ourselves and our peers to the highest standards of honesty and integrity.

Student Privacy

There are federal laws protecting your privacy with regard to grades earned in courses and on individual assignments. For more information, please see: <https://registrar.ufl.edu/ferpa.html>

Campus Resources

Health and Wellness

U Matter, We Care:

Your well-being is important to the University of Florida. The U Matter, We Care initiative is committed to creating a culture of care on our campus by encouraging members of our community to look out for one another and to reach out for help if a member of our community is in need. If you or a friend is in distress, please contact umatter@ufl.edu so that the U Matter, We Care Team can reach out to the student in distress. A nighttime and weekend crisis counselor is available by phone at 352-392-1575. The U Matter, We Care Team can help connect students to the many other helping resources available including, but not limited to, Victim Advocates, Housing staff, and the Counseling and Wellness Center. Please remember that asking for help is a sign of strength. In case of emergency, call 9-1-1.

Counseling and Wellness Center: <http://www.counseling.ufl.edu/cwc>, and 392-1575; and the University Police Department: 392-1111 or 9-1-1 for emergencies.

Sexual Discrimination, Harassment, Assault, or Violence

If you or a friend has been subjected to sexual discrimination, sexual harassment, sexual assault, or violence contact the [Office of Title IX Compliance](#), located at Yon Hall Room 427, 1908 Stadium Road, (352) 273-1094, title-ix@ufl.edu

Sexual Assault Recovery Services (SARS)

Student Health Care Center, 392-1161.

University Police Department at 392-1111 (or 9-1-1 for emergencies), or <http://www.police.ufl.edu/>.

Academic Resources

E-learning technical support, 352-392-4357 (select option 2) or e-mail to Learning-support@ufl.edu.
<https://lss.at.ufl.edu/help.shtml>.

Career Resource Center, Reitz Union, 392-1601. Career assistance and counseling.
<https://www.crc.ufl.edu/>.

Library Support, <http://cms.uflib.ufl.edu/ask>. Various ways to receive assistance with respect to using the libraries or finding resources.

Teaching Center, Broward Hall, 392-2010 or 392-6420. General study skills and tutoring.
<https://teachingcenter.ufl.edu/>.

Writing Studio, 302 Tigert Hall, 846-1138. Help brainstorming, formatting, and writing papers.
<https://writing.ufl.edu/writing-studio/>.

Student Complaints Campus: <https://care.dso.ufl.edu>.

On-Line Students Complaints: <http://www.distance.ufl.edu/student-complaint-process>.