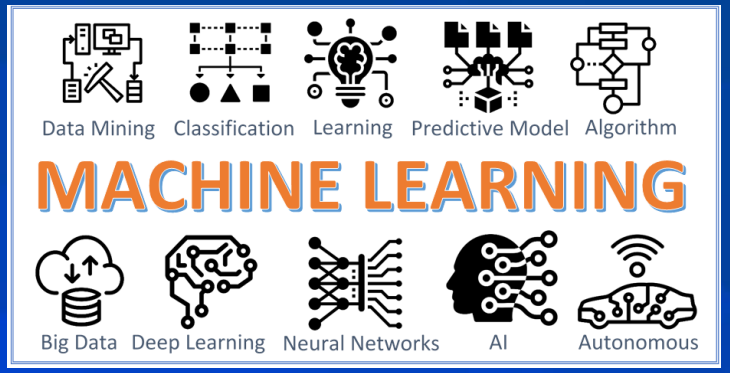
UF Herbert Wertheim College of Engineering
UNIVERSITY of FLORIDA

Department of Electrical and Computer Engineering

EEL5840/EEE4773 Fall 2024 Fundamentals of Machine Learning



Slack: uf-ece-fml-fall24.slack.com

GitHub Organization: https://github.com/UF-EEL5840-EEE4773-Fall-2024

POWERING THE NEW ENGINEER TO TRANSFORM THE FUTURE

EEL 5840 & EEE4773 – Fundamentals of Machine Learning

Course Description: Understand and utilize the concepts of machine learning for data science and electrical engineering. Focus on tools for multivariate data analysis and how to handle uncertain data with probability models.

This course relies mostly on foundational machine learning math!

- This course covers foundations of machine learning from bottom-up approach.
- A solid foundation of prerequisite math is necessary to appreciate the content and do well in the course!
  - Probability theory, statistics, and linear algebra.

This course relies in some programming experience (Python preferred).

- We will use Python and Jupyter Notebook during lecture and course assignments.

Teaching Team

Catia Silva
Professor
catiaspsilva@ece.ufl.edu
MALA 3122
Wednesdays 1pm-4pm, or by appointment

Dhruv Kushwaha
Supervised Teacher (ST)
dhruv.kushwaha@ufl.edu
Tuesdays 3:00pm-5:00pm

Spencer Chang
TA
chang.spencer@ufl.edu
Thursdays 7:30am-8:30am and 5:00pm-6:00pm

Joseph Conroy
TA
jconroy@ufl.edu
Tuesdays & Fridays 8:00am-9:00am

Peter Forcha
TA
peter.forcha@ufl.edu
Fridays 1pm-3pm

Erik Bloomquist
UPI
erikbloomquist@ufl.edu
Wednesdays 10:40am-12:35pm

Raul Valle
UPI
rvalle1@ufl.edu
Mondays 9:30-11:30am

Porto, Portugal, Dec. 2023

Bom Jesus, Braga, Portugal, Dec. 2023

Maggie (9yo)

Cátia S. Silva (KA-tee-uh SIL-vuh)

Instructional Assistant Professor @ ECE, UF

Research: multi-disciplinary machine learning, learning theory, computer vision, pattern recognition, computational neuroscience

Industry experience: ML scientist working on cardiac diagnostics @ Aventusoft, Boca Raton; wind and solar power forecast @ INESC TEC, Portugal

Hobbies: running, hiking, listening to podcasts, brain teasers

Contact: catiaspsilva@ece.ufl.edu or slack
Office: MALA 3122
Office Hours: Wednesdays 1-4pm

Dr. Silva will be on maternity leave ☺ in late November (expected).

Dhruv Kushwaha will be your instructor of record once her leave starts.

Dhruv Kushwaha (Duh-roov Kush-wah-ha)

- Office hours: Thursdays 3:00 pm – 5:00 pm
- Location: MALA 5200
- Contact: Slack, Canvas, Email (dhruv.kushwaha@ufl.edu)
- Research areas:
  - Safe Reinforcement Learning
  - Adaptive Control
  - Nonlinear Programming
- Hobbies: Soccer, Reading and 8/9-ball pool

Spencer J. Chang (Spen - sir)

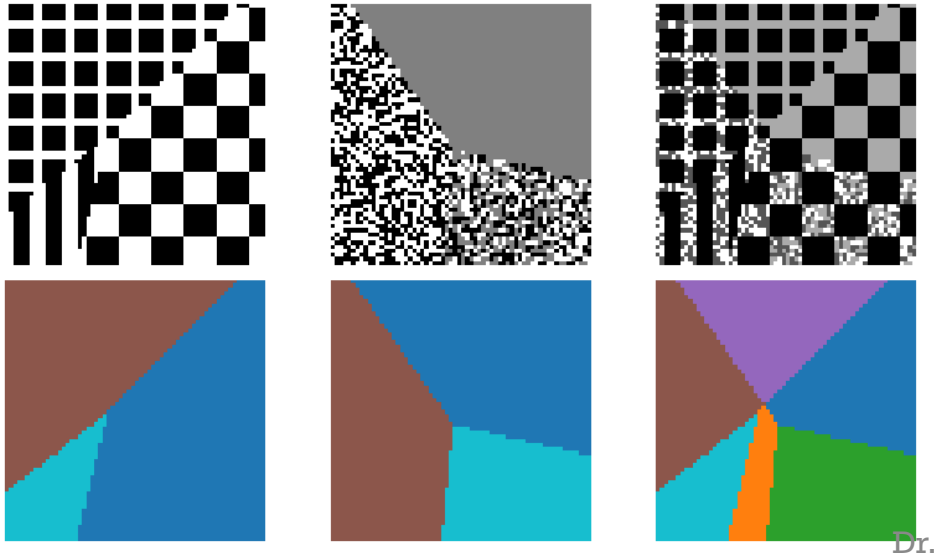
6th year PhD student in GatorSense Lab under Dr. Zare

- **Office Hours:** Thursday, 7:30-8:30a & 5-6p
- **Email**: chang.spencer@ufl.edu
- **Best Ways to Contact:** Slack, Email, Canvas

THE MACHINE LEARNING AND SENSING LABORATORY

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
UNIVERSITY OF FLORIDA

- **Academic Interests:**
  - Texture and histogram features
  - Applied (ie. agriculture, biomed, etc)



Dec 2022: Riverside, California

Hobbies

RIVERSIDE AQUATICS RAA SWIM TEAM

Joseph Arthur Conroy

Office Hours: Tuesday & Fridays 8:00 to 9:00 (MALA 5200, Hybrid)
Email: jconroy@ufl.edu but I prefer Slack.

Hobbies

Blues Piano

Powerlifting

Volunteer Teaching

Education & Research

- Undergraduate: Aerospace Engineering at Georgia Tech
  - Electrified flight research
  - Electric propulsion
- Graduate: Aerospace Engineering PhD, year 4
  - Improving laser communications on satellites
- AFRL Directed Energy Research
  - Machine learning for adaptive optics

GEORGIA INSTITUTE OF TECHNOLOGY 1885 PROGRESS AND SERVICE

ASDL Aerospace Systems Design Laboratory

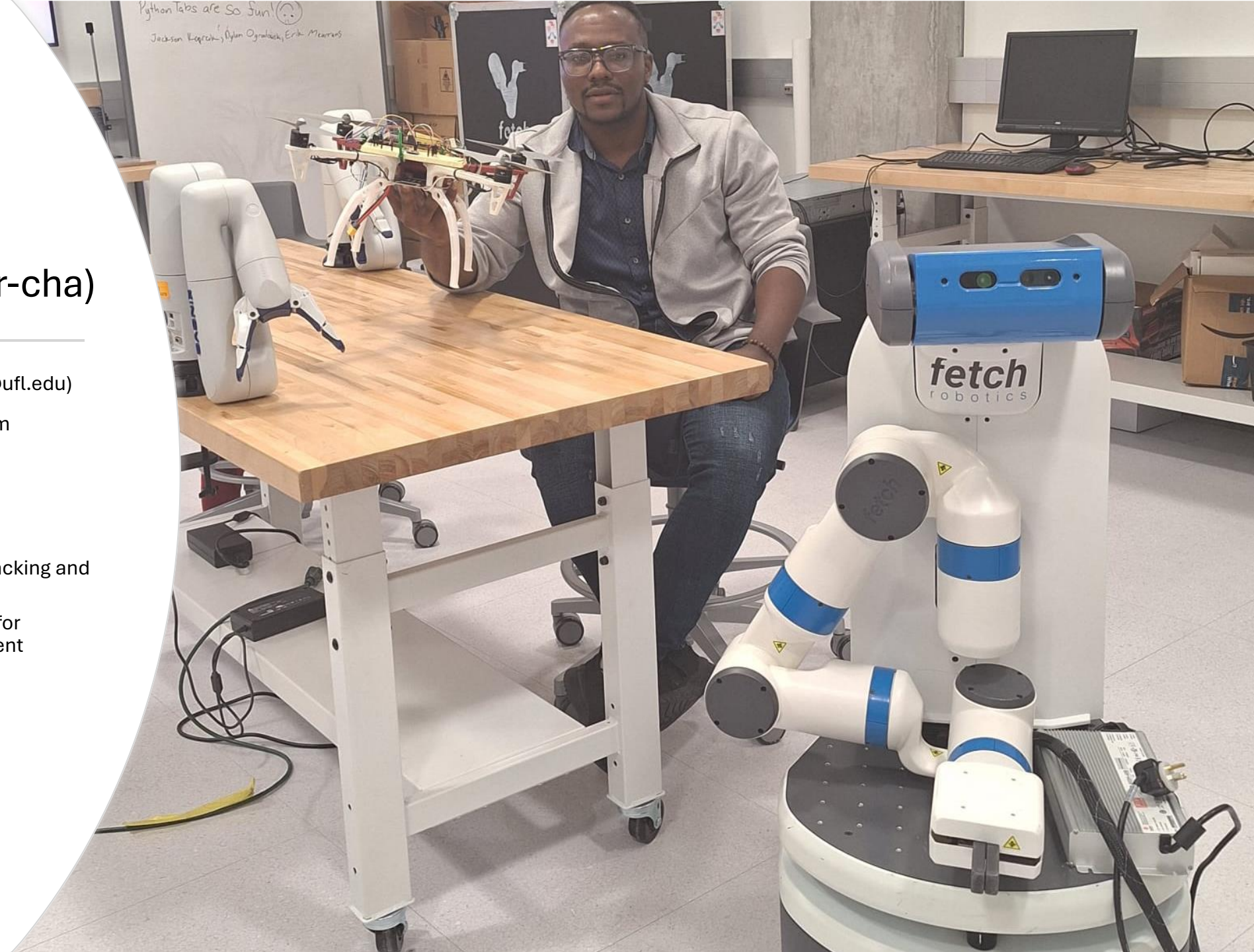
PSSL

Georgia Tech High-Power Electric Propulsion Lab
Daniel Guggenheim School of Aerospace Engineering

UF UNIVERSITY of FLORIDA

Peter Forcha (Pee-ter For-cha)

- **Contact**: Slack, email(peter.forcha@ufl.edu)
- **Office Hours**: Friday 1:00pm -3:00pm
- **Location** : MALA 5200
- **Research Area:**
  - Robotics
  - Computer Vision (Real time tracking and pose estimation)
  - Machine learning application for Parkinson's Disease Assessment
- **Hobbies**
  - Chess
  - Soccer
  - Music



Erik Bloomquist

(Air-ick Bloom-kwist)

Office Hours: Wednesday 10:40am-12:35pm
Location: MALA 5200 or Zoom
Contact: Slack, email (erikbloomquist@ufl.edu)

Research: Explainable Reinforcement Learning Algorithms (Dr. Woodard, FINS)
Hobbies: Guitar, Piano, Saxophone, Basketball

UF Herbert Wertheim College of Engineering
Florida Institute for National Security (FINS)
UNIVERSITY of FLORIDA

Name: Raul Valle (RA-ool Va-yleh)

Major: Computer Engineering

Office Hours: Mondays, 9:30-11:30 am

Preferred Contact: Slack, Discord

Research:

-Computational NeuroEngineering

-Wireless Communications

Hobbies:

-DJ & Producing

-Signal Processing Society & Audio Engineering Society

Office Hours

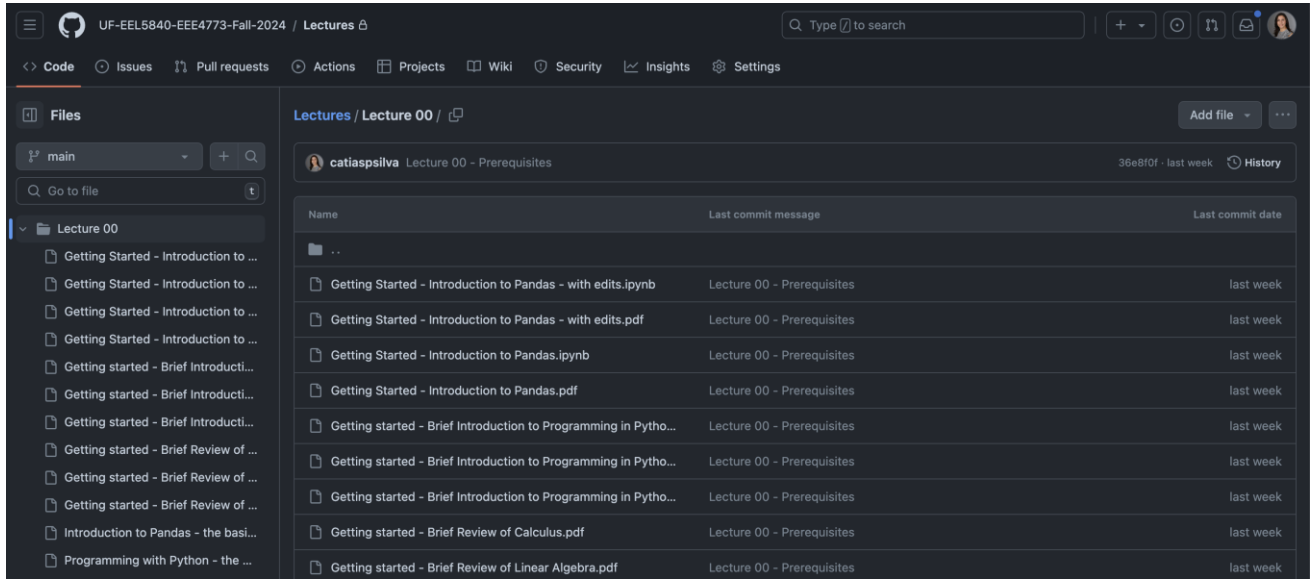
- (Almost) all office hours are hybrid (in-person and Zoom), and in Eastern Time (EST) zone.

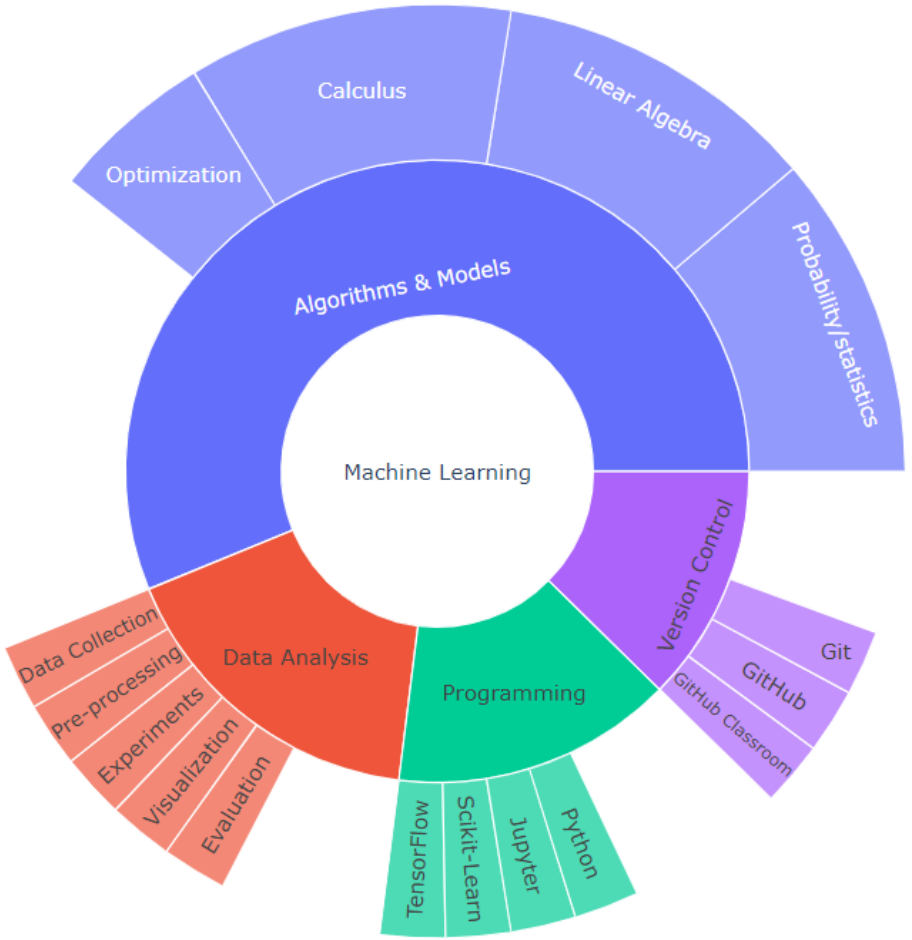
	Mornings	Afternoons	Evenings
Monday	Raul Valle 9:30am-11:30am (MALA 5200 or Zoom)		
Tuesday	Joseph Conroy 8:00am-9:00am (MALA 5200 or Zoom)		
Wednesday	Erik Bloomquist 10:40am-12:35pm (MALA 5200 or Zoom)	Dr. Silva 1:00pm-4:00pm (MALA 3122 or Zoom)	
Thursday	Spencer Chang 7:30am-8:30am (MALA 5200 or Zoom)	Dhruv Kushwaha 3:00pm-5:00pm (MALA 5200 or Zoom)	Spencer Chang 5:00pm-6:00pm (Zoom)
Friday	Joseph Conroy 8:00am-9:00am (MALA 5200 or Zoom)	Peter Forcha 1:00pm-3:00pm (MALA 5200 or Zoom)	

What tools will we use to teach Machine Learning?

Expected prerequisites:

- Probability theory
- Statistics
- Linear algebra
- Programming (Python preferred but not required)

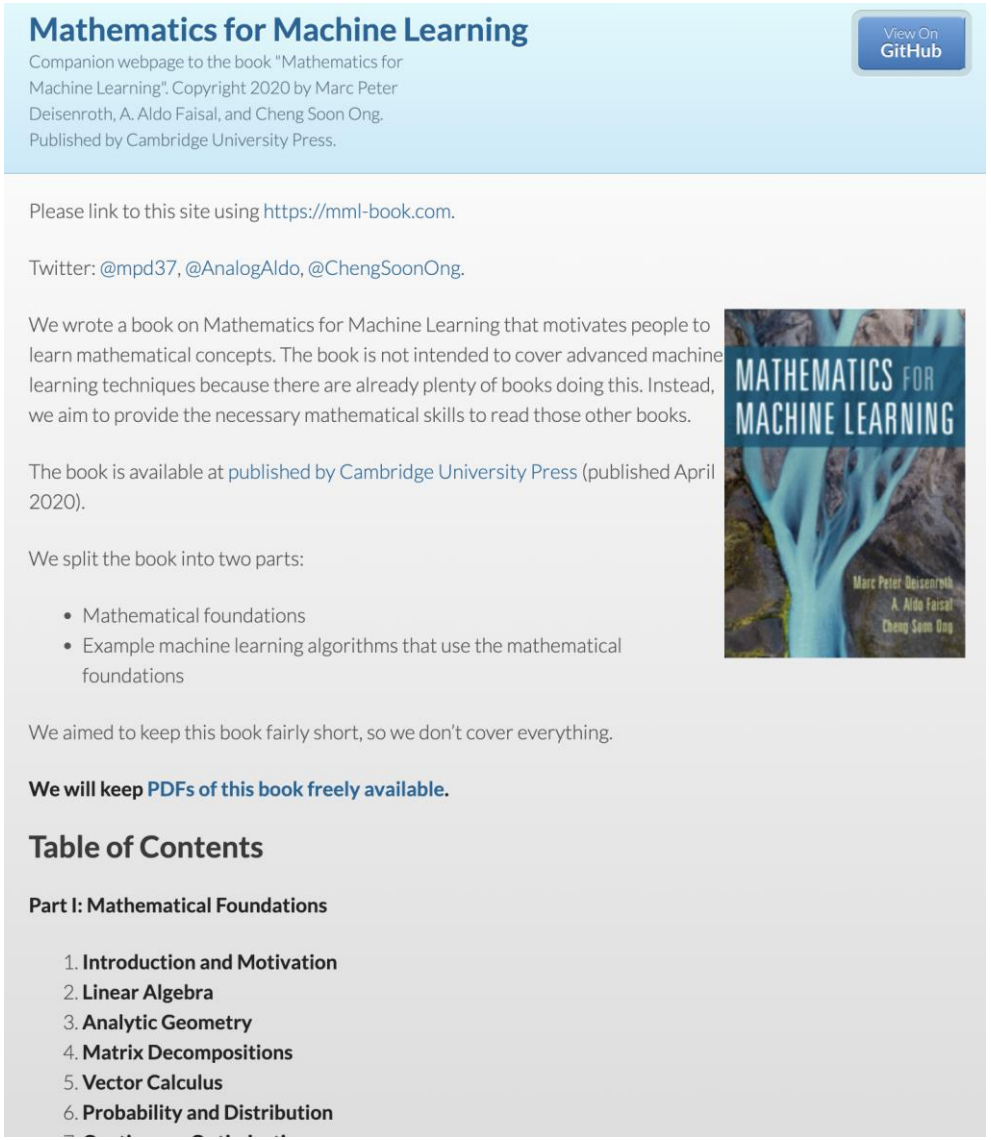




Prerequisites Self-Review

- Deisenroth, A., et al., “Mathematics for Machine Learning”. Cambridge University Press, 2000.
  - https://mml-book.github.io/

- Review chapters 1-6 as needed.



Mathematics for Machine Learning

View On GitHub

Companion webpage to the book "Mathematics for Machine Learning". Copyright 2020 by Marc Peter Deisenroth, A. Aldo Faisal, and Cheng Soon Ong. Published by Cambridge University Press.

Please link to this site using https://mml-book.com.

Twitter: @mpd37, @AnalogAldo, @ChengSoonOng.

We wrote a book on Mathematics for Machine Learning that motivates people to learn mathematical concepts. The book is not intended to cover advanced machine learning techniques because there are already plenty of books doing this. Instead, we aim to provide the necessary mathematical skills to read those other books.

The book is available at published by Cambridge University Press (published April 2020).

We split the book into two parts:

- Mathematical foundations
- Example machine learning algorithms that use the mathematical foundations

We aimed to keep this book fairly short, so we don't cover everything.

We will keep PDFs of this book freely available.

Table of Contents

Part I: Mathematical Foundations

1. **Introduction and Motivation**
2. **Linear Algebra**
3. **Analytic Geometry**
4. **Matrix Decompositions**
5. **Vector Calculus**
6. **Probability and Distribution**

Canvas

In Canvas, we will post:

- Announcements
- Send/receive emails

Discussion 0 - Meet & Greet

Please introduce yourself by sharing:

- Your preferred name
- Your major
- What course(s) are you taking this semester?
- What do you plan to do when you graduate? Or in what field do you currently work on?
- What skills do employers value in your field?
- What are your hobbies or what do you like to do outside of school?
- Tell us something surprising about you
- Where are you from?

Read about your classmates' posts. You are encouraged to reply to at least one post but it is not required.

Reply

Fall 2024

- Home
- Syllabus
- Announcements
- Zoom Conferences
- Honorlock
- Course Reserves
- Assignments
- Quizzes
- Discussions
- Grades
- People
- Pages
- Files
- Modules
- New Analytics
- GatorEvals
- Instructor Tools
- Outcomes
- Rubrics
- Collaborations
- Mediasite Course Lecture Videos

HiPerGator

Final Project (to appear)

0 - Getting Started - Welcome!

1 - Introduction to Machine Learning

2 - Experimental Design

3 - Bayesian Learning

4 - Generative Models

5 - Non-parametric Learning

Midterm Exam

6 - Discriminative Classification

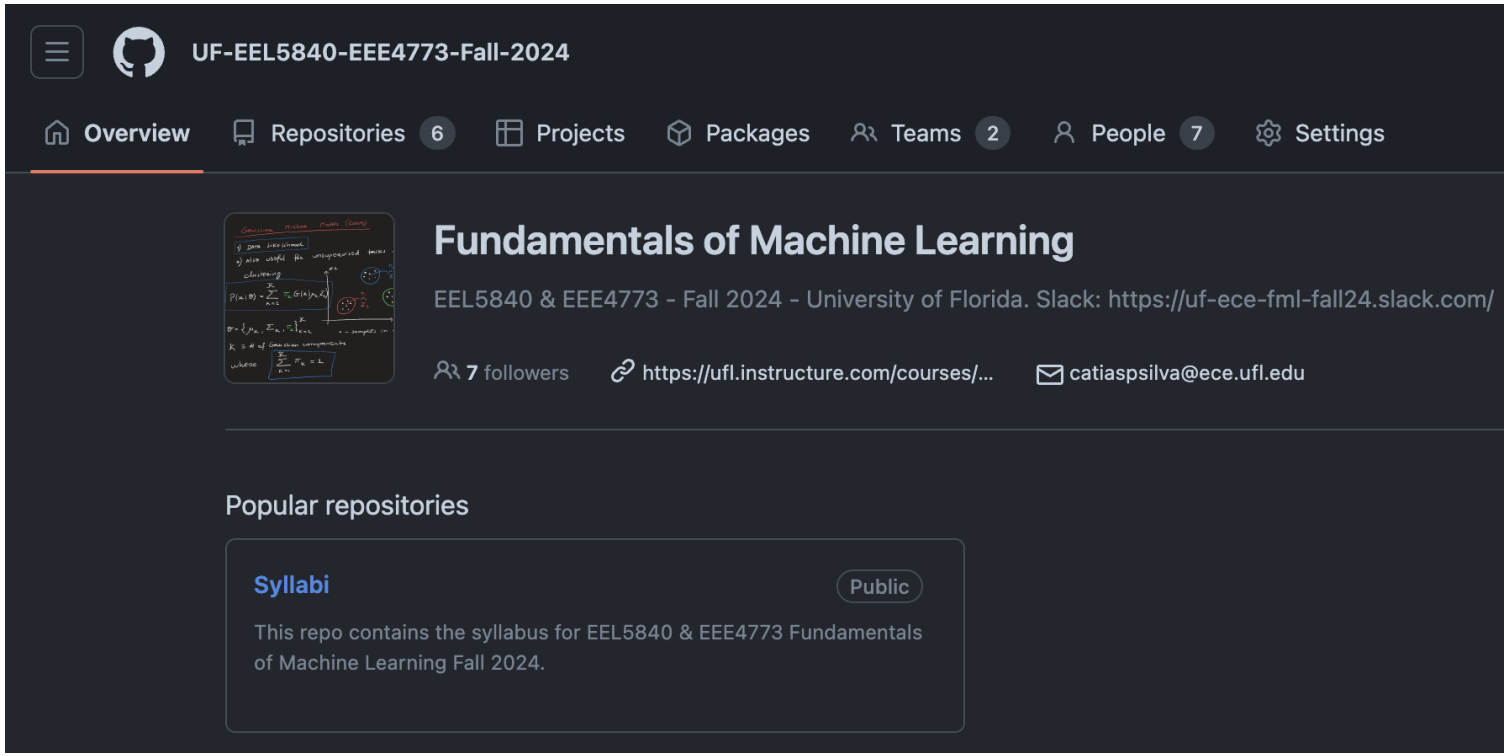
7 - Kernel Machine

GitHub

In GitHub, we will post:

- Lecture notes
- Assignment solutions
- Individual assignment repositories
- Final project group repositories

https://github.com/UF-EEL5840-EEE4773-Fall-2024



Slack

https://uf-ece-fml-fall24.slack.com

- This an optional resource for students to discuss the course amongst each other and with the teaching team.
- This resource is intended to supplement office hours and student interactions.
- No official communication/submission happens over Slack.
- No assignment submissions will be accepted over Slack.

Time Commitment

Work	Hours/Week
Attend lectures, ask questions	2.5
Study/Read ~20 pages of lecture notes and code	3
Reading assignments	1
Homework exercises	3
Total	**9.5**

How does a typical lecture look like?

A typical lecture will be presented in Jupyter Notebook accompanied by digital board illustrations. Some lectures will include either live coding or running code examples from lecture notes.

- We will publish the class notes (Jupyter notebooks) *before* every lecture
- We will share the notebook with edits after class
- We will share the handwritten board pages after class as well

Software

Anaconda Distribution

- Includes Python 3.12
- It includes all libraries, modules and tools we will use: Jupyter Notebooks, NumPy, Matplotlib, SciPy, Pandas, Scikit-Learn, TensorFlow
- **Install it (or update it) before next lecture**

Package Managers: conda & pip

- You have 2 options to manage your packages and virtual environment/s:

  1. using **pip**. System that manages Python packages.
  2. using **conda**. System that manages packages that may be written in any programming language.

- Since we will use Python packages, you can use either one of these systems to manage your virtual environment. Which one to use typically comes with your specific needs.

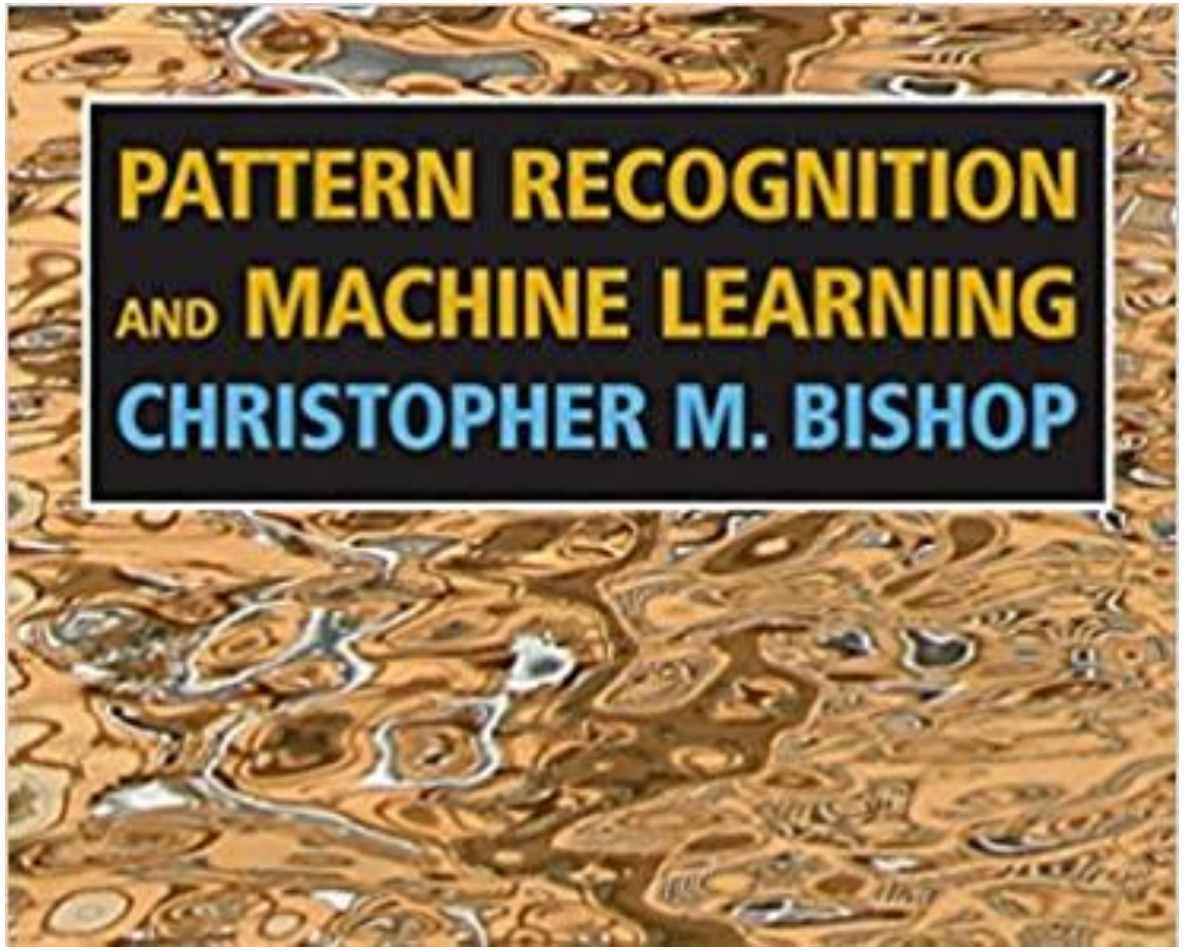
- Finding help for creating and managing your **conda environments**:
  - using **conda** to manage your conda environment.
  - using **pip** to manage conda environments.

Textbooks

Pattern Recognition and Machine Learning

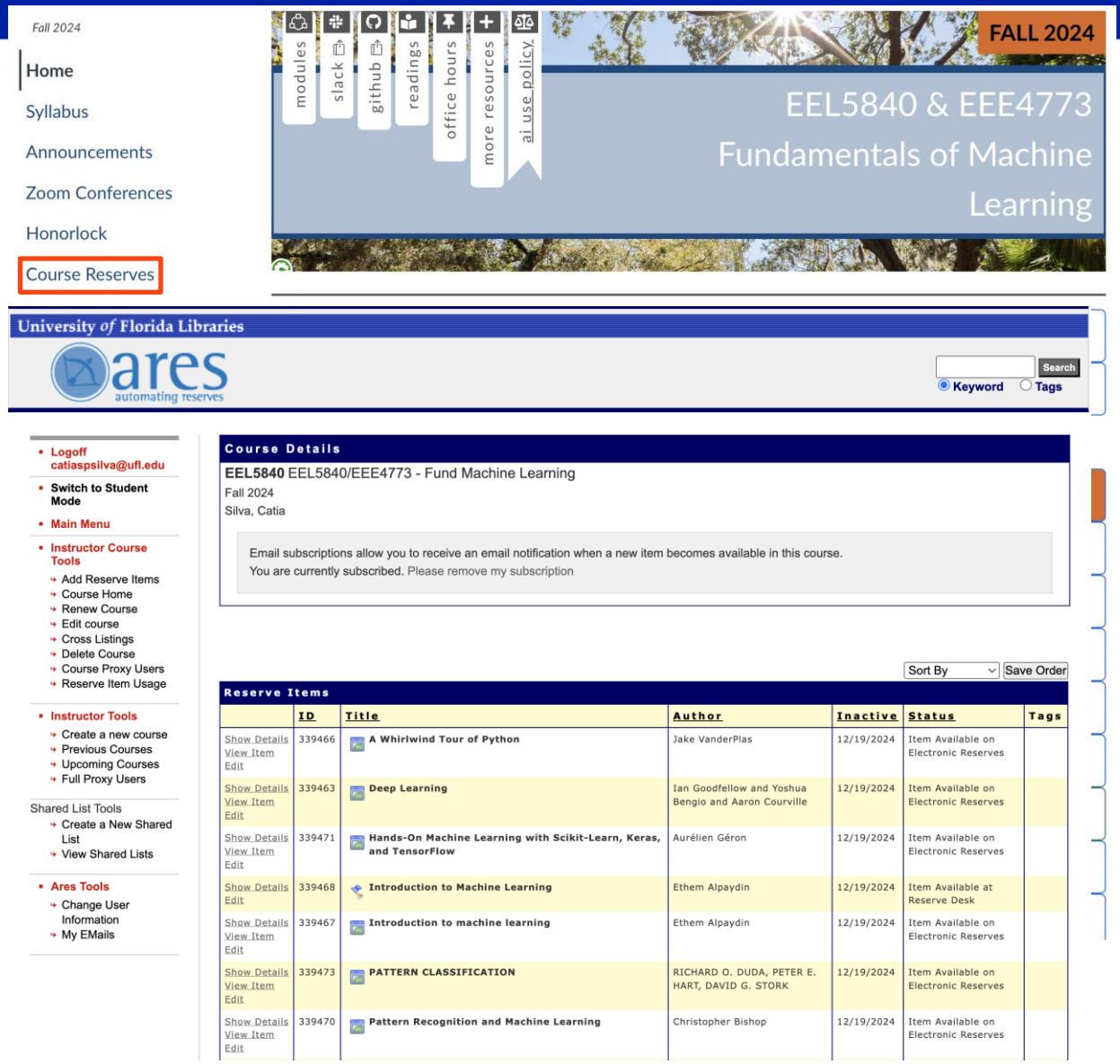
- Author: Christopher Bishop
- Publisher: Springer
- Year: 2006
- ISBN: 978-0-38731-073-2

- A **digital version** (PDF print) is freely available and is perfectly fine for this course: you can download it here.



Course Reserves

- Additional readings will be listed in Canvas under each module.
- All reading materials are available in Course Reserves as electronic texts and hard copy (at the Marston's library).
- Access Course Reserves directly in Canvas.



Course Schedule

Weekday, Month/Day	Module	Lecture	Topic/s
R, 08/22	Introduction to Machine Learning	1	Introduction to the course, expectations. Introduction to types of learning in machine learning and general terminology.
T, 08/27		2	Introduction to supervised learning with regression. Linear regression with non-linear features. Code implementation.
R, 08/29	Experimental Design and Analysis	3	Regularization and cross-validation.
T, 09/03		4	Hyperparameter tuning. The Curse of Dimensionality.
R, 09/05	Bayesian Learning	5	Maximum Likelihood Estimation (MLE).
T, 09/10		6	Maximum A Posteriori (MAP). Conjugate Prior.
R, 09/12		7	Introduction to supervised learning with classification. Naïve Bayes Classifier.
T, 09/17		8	**HiPerGator** info session.
R, 09/19	Generative Models	9	Introduction to unsupervised learning with clustering. (Gaussian) Mixture Models.
T, 09/24		10	Expectation-Maximization (EM) algorithm.
R, 09/26		11	Cluster validity metrics.
T, 10/01	Non-Parametric Learning	12	k-Means Clustering.
R, 10/03		13	K-Nearest Neighbors (KNN).
T, 10/08		14	Midterm Exam Review.
R, 10/10	Discriminative Classification	15	The Perceptron Algorithm. Stochastic Gradient Descent.
T, 10/15		16	Linear Discriminant Functions. Fisher's Linear Discriminant Analysis (FLDA).
R, 10/17		17	Logistic Regression.
Midterm Exam: 10/21/2024 @ 7:20 PM – 9:20 PM			
T, 10/22	Kernel Machine	18	Kernel Machines. Constrained Optimization with Lagrange Multipliers.
R, 10/24		19	Hard-margin Support Vector Machine (SVM).
T, 10/29		20	Slack variables. Soft-margin SVM.
R, 10/31	Dimensionality Reduction & Manifold Learning	21	Principal Component Analysis (PCA).
T, 11/05		22	Multi-Dimensional Scaling (MDS). Isometric Feature Mapping (ISOMAP).
R, 11/07		23	Locally Linear Embedding (LLE)
T, 11/12	Artificial Neural Networks	24	Multi-Layer Perceptron (MLP). Backpropagation.
R, 11/14		25	Best practices for training artificial neural networks (ANNs).
T, 11/19		26	Best practices continued. Code implementation.
R, 11/21	Deep Learning	27	Convolutional Neural Networks (CNNs). Transfer Learning
T, 12/03		28	Final project discussions. Final Exam Review.
Final Exam: 12/10/2024 @ 3:00 PM – 5:00 PM			

Course Policies

Read the syllabus

1. **How to get help:** office hours, email, telephone, or Slack.
2. **Attendance:** attendance is not required but I will prepare course materials with the expectation that students will attend class synchronously.
3. **Grading:** make sure your submissions are carefully completed with clean and well documented code. Make full use of Jupyter features, such as markdown text. Individual assignments will **not** be curved. Final grades **will** be curved.
4. **Late Work:** we will accept all assignment submissions if solutions have not yet been released, but you will lose the **on-time points** listed in the rubric. Solutions will typically be released 1 week after the assignment is due.
5. **Make-Up Policy:** If you feel that any assignment needs to be re-graded, you must discuss this with me within 1 week of grades being posted. If approved, the entire assignment will be subject to complete evaluation.
6. **Collaboration:** healthy collaboration is encouraged. If another student contributes substantially to your understanding of a problem, you should cite this student. You will not be negatively judged for citing another student.
7. **Cheating and Plagiarism:** you are expected to submit your own work. If you are suspected of dishonest academic activity, I will invite you to discuss it further in private. Academic dishonesty will likely result in grade reduction, with severity depending on the nature of the dishonest activity. I am obligated to report on academic misconduct with a letter to the department, college and/or university leadership. Repeat offenses will be treated with significantly greater severity.

Grading

Assignment Type	Total	Percentage Final Grade
Exams	2	20% each
Homework	4	20%
Practicals	7	20%
Final Project	1 (group project)	20%

Grading will be based on:

- **Homework** will have 2 parts: (1) quiz with analytical exercises, typically solved on paper. (2) practical problems to be implemented in Python.
- **Exams** will be drawn from lectures and readings. Practice exams will be provided.
- **Practicals** will typically consist of short problems (with shorter turnaround time) to help consolidate and retain the information learned in class.
- **Final Project** is a group assignment. The objective of this project is to implement an end-to-end Machine Learning/Deep Learning model using a data set collected from students in the class. The outcomes of the final project include working code and a report.

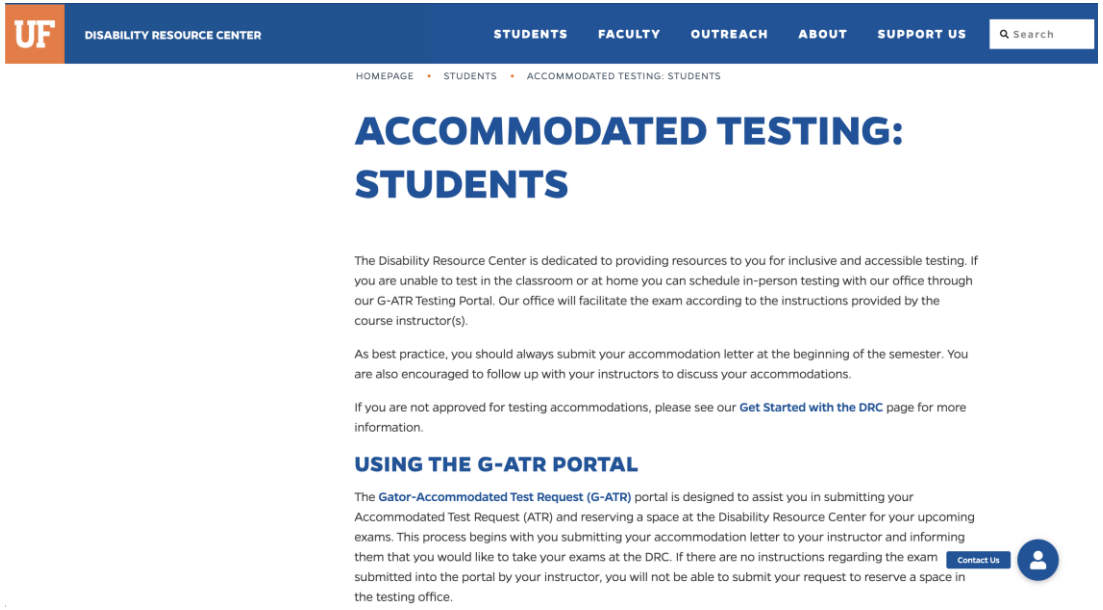
Mark your calendars!

- Midterm Exam
  - On-campus: Monday, October 21 at 7:20 PM – 9:20 PM, TUR L007
  - EDGE/Online: Monday, October 21, within 24 hours, Honorlock
- Final Project
  - Wednesday, December 4 at 11:59 PM
- Final Exam
  - On-campus: Tuesday, December 10 at 3:00 PM – 5:00 PM, TBD
  - EDGE/Online: Tuesday, December 10, within 24 hours, Honorlock

Students requiring accommodations

- Students with disabilities who experience learning barriers and would like to request academic accommodations should connect with the DRC (Disability Resource Center) by visiting https://disability.ufl.edu/students/get-started/.

- Please make sure you share your accommodation letter with me as soon as you have it, so we can discuss your access needs.



Any questions?

What is Machine Learning?

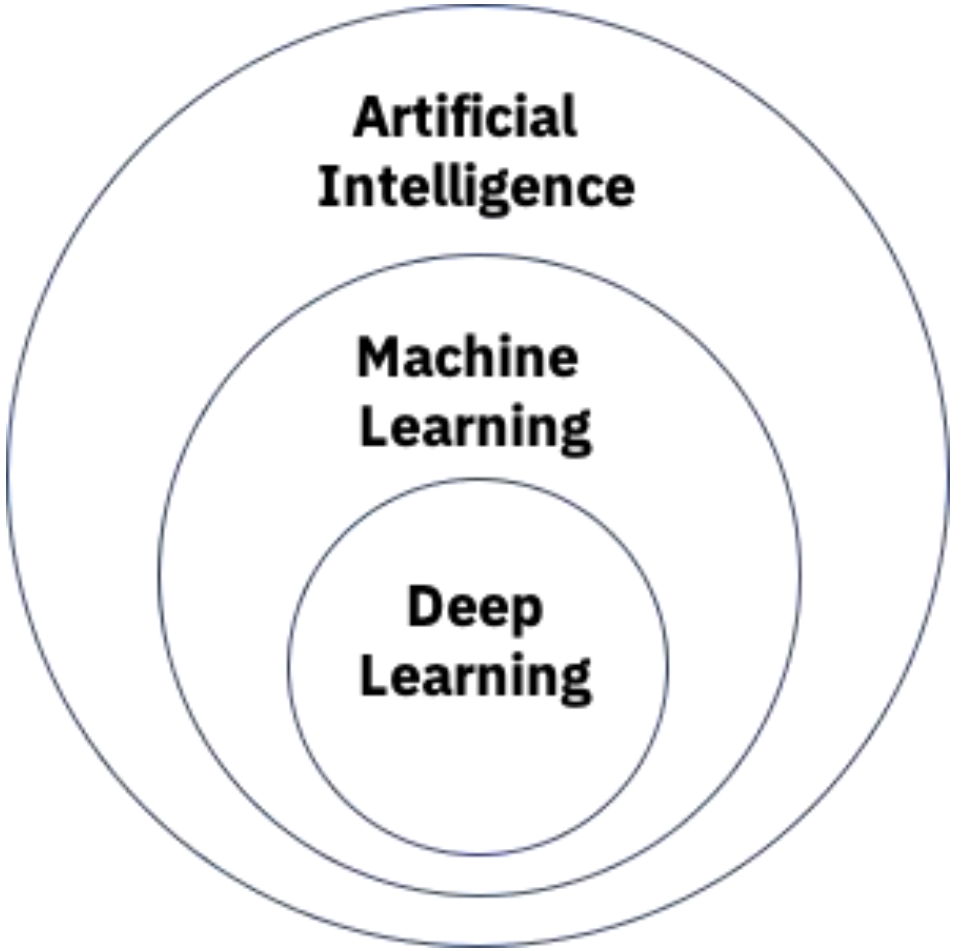
Think-Pair-Share activity

https://app.wooclap.com/NRQJRH

What is Machine Learning?

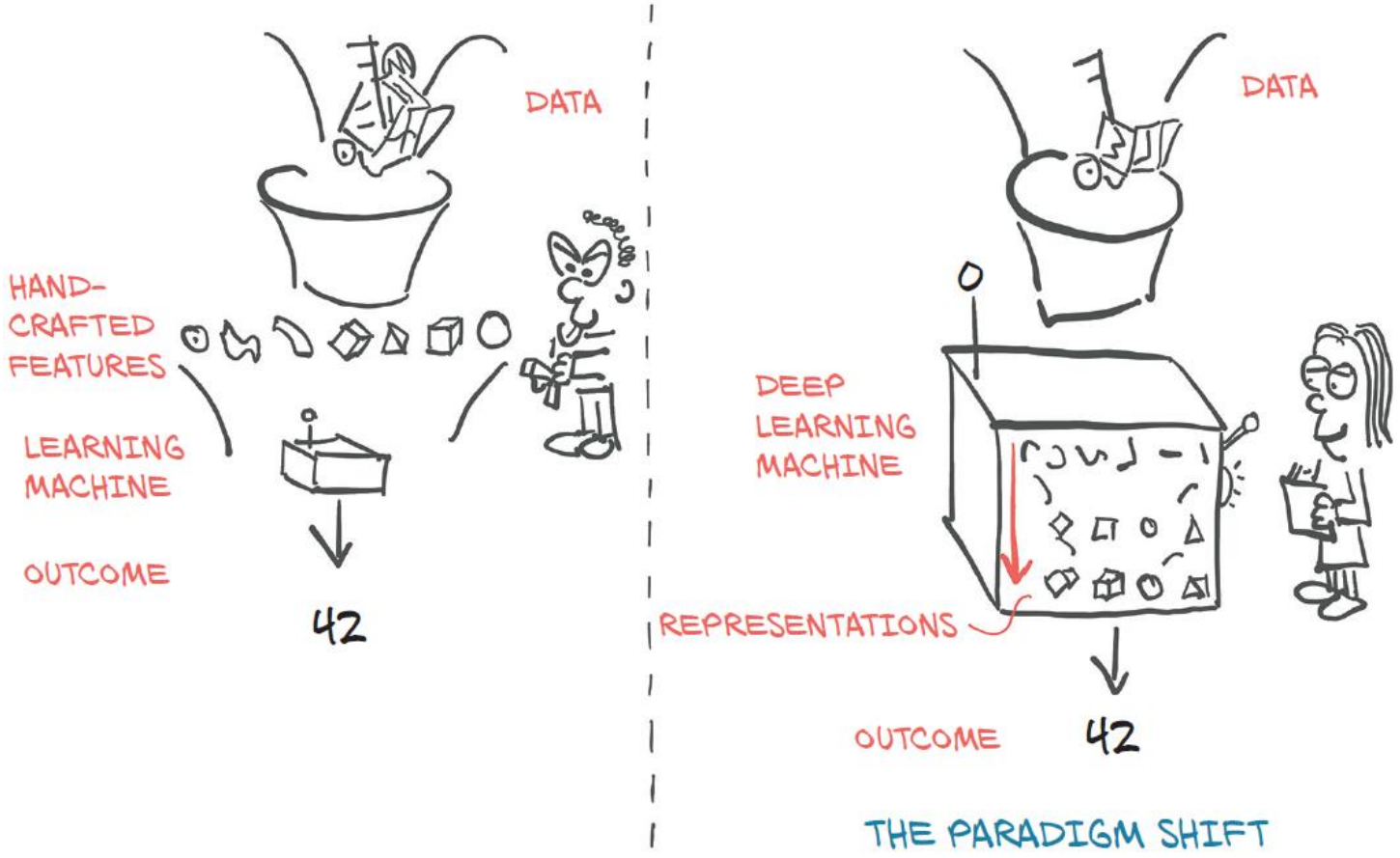
- **Machine Learning** is a subset of Artificial Intelligence.

Machine Learning can be defined as the machine general ability to solve intelligent tasks by learning from experience/data without being explicitly programmed.



What is Deep Learning?

- Deep learning distinguishes itself from classical machine learning by the type of data that it works with and the methods in which it learns.
- Deep learning is comprised of neural networks. "Deep" in deep learning refers to a neural network comprised of more than three layers.
- **Feature engineering** consists of producing the right transformations so that the downstream algorithm can solve a task.
- Deep learning deals with finding such **representations** automatically, from raw data, in order to successfully perform a task.



Git and GitHub

- In collaboration with Dr. Matt Gitzendanner (from UFIT Research Computing), we have developed an online Git and GitHub training.

- This course introduces users to Git and GitHub.com. The course features hands-on activities and does not assume any coding background.
  - Module 1: Version Control with Git
  - Module 2: GitHub, GitHub Classroom, GitHub Pages, and GitHub Issues and Actions
  - Module 3: Git and GitHub on HiPerGator

- **This course is freely available in Canvas as a self-registration course: https://ufl.instructure.com/enroll/TWR9LR**

Demonstrations – Git Basics

- Install Git. Alternatively, you can install GitHub Desktop.
- Create a GitHub account.

How to ***clone*** a repository?

- You can use **Git Bash** to clone a repo (alternative GUI Client: GitHub Desktop).
- For example, let's create the ”Practical 0” repository and clone it.

Getting the latest edits from a repository with **git pull.**

- To **pull** from a repository, simply call **git pull** using Git Bash.

How to manage files within a repo?

- The 3 most used Git commands are: **git pull**, **git add**, **git commit** and **git push**. You can call these commands directly with the **Git Bash** console or using the GitHub Desktop interface.

Demonstrations – Conda Environment

1. Install the Anaconda Package (it includes Python 3.12).
   - If you are installing Anaconda for the first time, this will create a ***base*** environment with all the Anaconda libraries installed and ready to run.

2. Create a new environment and install all packages/libraries.
   - ***conda create --name eel5840***
   - ***conda activate eel5840***
   - ***conda install anaconda***

3. Launching Jupyter Notebooks
   - ***conda activate eel5840***
   - ***jupyter notebook***

Any questions?

Let’s take a break before starting the next period