Machine Learning

EEL 4930 Section 1954
Class Periods: MW, 4-5, 10:40 AM – 12:35 PM
Location: LAR 310
Academic Term: Spring 2020

Instructor: Dr. Catia S. Silva
- Office: New Engineering Building 467
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- Office Hours: Tuesdays 10:40 AM – 11:40 AM, or by appointment

Supervised Teaching Student:
Please contact through the Canvas website
- Matthew Cook
- Email: matthew.cook@ufl.edu
- Office Hours: TBD

Course Description:
(4 credits) This course will cover introductory topics in pattern recognition and machine learning and use of these methods towards a variety of real-world applications. The focus of this course is to introduce basic machine learning concepts and learn how to use associated state-of-the-art machine learning tools. Topics covered include deep learning, linear and non-linear classifiers.

Course Pre-Requisites / Co-Requisites:
Programming Experience. We will be programming in Python.

Course Objectives:
Understand and use the concepts of machine learning for data science. Focus on tools for application of deep learning and multivariate data analysis to real world data and problems.
These objectives will be accomplished through:
1. Semester-long group project that involves implementing a deep learning system
2. Discussion of pattern recognition and machine learning methods
3. Implementation of a variety of machine learning methods in code in assignments and lab activities

Professional Component (ABET):
This course consists of 1.5 credits of Engineering Design and 1.5 credits of Engineering Science

Relation to Program Outcomes (ABET):

Outcome	Coverage*
1. An ability to identify, formulate, and solve engineering problems by applying principles of engineering, science, and mathematics.	High
2. An ability to apply both analysis and synthesis in the engineering design process, resulting in designs that meet desired needs.	High

3. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.	High
4. An ability to communicate effectively with a range of audiences	
5. 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.	
6. An ability to recognize the ongoing need for additional knowledge and locate, evaluate, integrate, and apply this knowledge appropriately.	
7. An ability to function effectively on teams that establish goals, plan tasks, meet deadlines, and analyze risk and uncertainty	

Required Textbooks and Software:

- Python Machine Learning
  - 2nd edition
  - Sebastian Raschka and Vahid Mirjalili
  - Packt Publishing, 2017
  - ISBN: 978-1-78712-593-3
  - Publisher website

- Deep Learning with Pytorch
  - Eli Stevens and Luca Antiga
  - Manning Publications, 2020
  - ISBN number: 978-1-61729-526-3
  - Manning Publications MEAP Live Book

- Software:
  - Python 3+
  - Git
  - Pytorch

Recommended Textbooks:

- Pattern Recognition and Machine Learning
  - Christopher Bishop
  - Springer, 2006
  - ISBN: 978-0-38731-073-2
  - Christopher Bishop Webpage

- Python Data Science Handbook – Essential Tools for Working with Data
  - Jake VanderPlas
  - O'Reilly Media, 2017
  - ISBN: 978-1-491912-05-8
  - https://jakevdp.github.io/PythonDataScienceHandbook/

- Deep Learning (Adaptive Computation and Machine Learning Series)
  - Ian Goodfellow, Yoshua Bengio and Aaron Courville
  - MIT Press, 2016
  - ISBN: 978-0-262035-61-3
  - http://www.deeplearningbook.org

Course Schedule:

PART I – Introduction to Machine Learning

(Homework 1-2, Lab assignment 1)

Week 1 – Introduction to Machine Learning

- What is Machine Learning?
- Introduction to Git
- Introduction to Python
- Machine Learning Terminology

Week 2 – Linear Regression, Generalization & Regularization

- Regression
- Overfitting & Underfitting
- Cross-validation

Week 3 – Evaluation of Methods

- Curse of Dimensionality
- Error and Accuracy Metrics
- ROC Curves

PART II – Introduction to Supervised Classification

(Homework 3-4, Lab Assignment 2)

Week 4

- Feature Extraction and Feature Selection
- K-Nearest Neighbors
- Linear Classifiers

Week 5

- Decision Trees
- Random Forests

Week 6

- Support Vector Machine
- Experimental Design and Hyperparameter Tuning Strategies

PART III – Introduction to Neural Networks

(Homework 5-6, Lab Assignment 3)

Week 7

- The Perceptron
- Brief history of Neural Networks

Week 8

- Multilayer Perceptron
- Backpropagation

Week 9

- Introduction to Pytorch
- **(Midterm Exam)**

PART IV – Introduction to Deep Learning
(Homework 7-8 due, Lab Assignment 4)

Week 10
- Difference between Machine Learning, Deep Learning and Artificial Intelligence
- Deep Learning Fundamentals and Applications

Week 11
- Introduction to Convolutional Neural Networks

Week 12
- Applications and Implementation in Pytorch

PART V – Project Discussion
(Project due)

Week 13
- Project Discussion
- Completion of Project: in class project focus

Week 14
- Completion of Project: in class project focus

Week 15
- Project Presentations
- (Final exam during final week)

Attendance Policy, Class Expectations, and Make-Up Policy:
- While attendance is not graded, lectures will include regular homework help and in-class discussions and in-class lab assignments.
- Students are expected to attend class.
- Students are expected to bring a portable computer to class.
- Excused absences are consistent with university policies in the undergraduate catalog (https://catalog.ufl.edu/ugrad/current/regulations/info/attendance.aspx) and require appropriate documentation.

Evaluation of Grades:

Assignment	Percentage of Final Grade
Homework (8)	30%
Lab Assignments (4)	20%
(Semester-long) Project	10%
Midterm Exam	20%
Final Exam	20%
TOTAL	100%

- Each homework and lab assignment will be weighted equally.
- **Late Assignments will not be accepted**.
- If you feel a graded assignment or exam needs to be re-graded, you must discuss this with the instructor within one week of grades being posted for that assignment/exam.
    - If approved, the entire assignment or exam will be subject to complete evaluation.
- After one week, items will not be considered for re-grading.
- For maximum credit in any assignment, students must submit correct and elaborated answers, submitted on time, follow submission instructions and, for assignments that require code, clean, easy to read, easy to run, and well commented Python 3.4.3+ code are required.

- Complete your assignments with care and ensure that your submission is complete and illustrates your understanding of the concepts being assessed.

Lab and Project Assignments:

- Lab 1 (5%): The objective of Lab 1 is to introduce students to the experimental design process for machine learning. Students will develop a project proposal that includes identification of a data set with discussion as to whether the data is easily available, the amount of data available, whether ground truth is available or can be generated. The proposal will also discuss a set of appropriate error metrics for the proposed project, methods for cross-validation and blind test set generation appropriate for the proposed problem, a set of experiments to be conducted and the proposed experimental design.

- Lab 2 (5%): The objective of Lab 2 is to introduce the students to the importance of pre-processing, normalization, feature extraction and feature selection. Students will develop, implement and compare several pre-processing pipelines on their approved project data sets. Students will also implement feature visualization scripts and cluster validity-type metrics to aid in their pre-processing evaluation and visualization.

- Lab 3 (5%): The objective in Lab 3 is to compile an initial end-to-end machine learning pipeline for provided data sets that include pre-processing, classification and evaluation on their approved project data sets. Students will compare classifiers implemented and provide discussion as to why some out-perform others given the properties of their data set and the classifiers used.

- Lab 4 (5%): The objective of Lab 4 is to finalize their choice of pre-processing pipeline and classifier selection, provide discussion and motivation for their chosen approach based on outcomes from Labs 1-3 and any additional experiments required

- Final Project (10%): In their final project, students will carry out their full experimental design, run and evaluate their performance on a hold-out blind test set, provide extensive comparisons and discussions to alternative approaches, and present their work to the class.

Grading Policy:

Percent	Grade	Grade Points
93.4 - 100	A	4.00
90.0 – 93.3	A-	3.67
86.7 – 89.9	B+	3.33
83.4 – 86.6	B	3.00
80.0 – 83.3	B-	2.67
76.7 – 79.9	C+	2.33
73.4 – 76.6	C	2.00
70.0 – 73.3	C-	1.67
66.7 – 69.9	D+	1.33
63.4 – 66.6	D	1.00
60.0 – 63.3	D-	0.67
0 – 59.9	E	0.00

A "C-" will not be a qualifying grade for critical tracking courses. In order to graduate, students must have an overall GPA and an upper-division GPA of 2.0 or better (C or better). Note: A "C-" average is equivalent to a GPA of 1.67, and therefore, it does not satisfy this graduation requirement.

More information on UF grading policy may be found at:
https://catalog.ufl.edu/ugrad/current/regulations/info/grades.aspx

Students Requiring Accommodations:
Students with disabilities requesting accommodations should first register with the Disability Resource Center (352-392-8565, https://www.dso.ufl.edu/drc) by providing appropriate documentation. Once registered, students will receive an accommodation letter which must be presented to the instructor when requesting accommodation. Students with disabilities should follow this procedure 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 in a professional and respectful manner 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.
Any student found to have cheated or plagiarized on an exam or assignment will be given a grade of 0 for that exam or assignment and the evidence will be sent to the Provost's Office for the determination of any additional disciplinary action.

- Unless an assignment is specifically structured as a group project, duplicate assignments written in collaboration with others is not acceptable. Although it is permissible to discuss the homework with others, these discussions should be of a general nature. All work at a detailed level must be done on your own. Students submitting the same or similar solutions to the homework will be considered as having cheated. No statements or actions made by anyone can alter this policy. Please review what constitutes plagiarism: https://guides.uflib.ufl.edu/copyright/plagiarism

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 regards 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 suppor*t*, 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://www.dso.ufl.edu/documents/UF_Complaints_policy.pdf.

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