Artificial Intelligence and Machine Learning in Environmental Engineering
ENV 6932 - Spec Prob in Env Engr
Credit hours: 3
Class Periods:
T | Period 7 (1:55 PM - 2:45 PM)
R | Period 7 - 8 (1:55 PM - 3:50 PM)
Location: Face-to-face and zoom both available, also lectures will be recorded and shared
BLK 0315
https://ufl.zoom.us/j/4711699763
Academic Term: Fall 2021

Instructor:
Sara Behdad
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(352) 294-7547
Office Hours: Thursday, 9th Period (4:05-4:55 pm) or by appointment [zoom link]
https://ufl.zoom.us/j/4711699763

Office Location: 412 BLK Hall

Teaching Assistant/Peer Mentor/Supervised Teaching Student: *N/A*
Please contact the instructor for any assistance.

Course Description
The objective is to educate graduate students with recent data science methods and available AI technologies for formulating, investigating, and analyzing real-world sustainability challenges. The course educates students with a wide range of machine learning and deep learning algorithms and further discusses their applications in environmental engineering. In addition, it discusses the mechanics of blockchain and cryptocurrencies, as well as the pros and cons of the distributed ledger technologies in a sustainability context. The course allows students to leverage their AI/ML skills through writing a term-paper project. The term paper is a group assignment that gives students the opportunity to work in a team and employ their data science skills in environmental engineering applications.

The AI course consists of three main parts (1) machine learning algorithms, (2) deep learning principles, and (3) elements of blockchain technology.

The *machine learning* part provides an introduction to supervised and unsupervised techniques. The focus will be on three groups of prediction, classification, and clustering techniques. It discusses methods such as linear regression, non-linear regression, K-nearest neighbors, decision trees, logistic regression, support vector machine, k-Means clustering, hierarchical clustering, and density-based clustering, among others.

The *deep learning* part covers principles of neural networks such as backpropagation algorithm, activation functions, dropout, gradient descent with momentum, batch normalization, and max polling. Further, it introduces different categories of neural network models such as convolutional neural networks, recurrent neural networks, and autoencoders. It also discusses different applications of deep learning models such as image classification, object detection, object tracking, semantic segmentation, and instance segmentation.

The *blockchain* part introduces distributed ledger technologies, the technology behind cryptocurrencies, and further discusses the building blocks of cryptocurrencies, specifically bitcoin. It covers topics such as cryptography, data structures, digital signatures, mechanics of bitcoin, bitcoin mining, how bitcoin achieves decentralization, and what are the environmental implications of blockchain technology.

Besides the above-mentioned topics, the course discusses different applications of machine learning and deep learning algorithms and why it is rewarding to learn how to leverage AI/ML skills in an engineering context, particularly in addressing sustainability problems.

Course Pre-Requisites / Co-Requisites: Background in Linear Algebra, Calculus, and Probability.

Course Objectives
After completion of this course, students will be able to:
- Understand different types of supervised and unsupervised machine learning algorithms.
- Apply the correct algorithms on different datasets, and show their understanding of ML/DP algorithms in a practical project.
- Learn the principles of deep learning and their applications in environmental engineering.
- Understand what blockchain technology is, how cryptocurrency networks operate and what are their sustainability implications.

Materials and Supply Fees
No materials and supply fees.

Required Textbooks and Software
No required textbooks.

Recommended Materials
- Bishop, Christopher M. Pattern recognition and machine learning. springer, 2006.
- Goodfellow, Ian, Yoshua Bengio, Aaron Courville, and Yoshua Bengio. Deep learning. Vol. 1, no. 2. Cambridge: MIT press, 2016.
- Narayanan, Arvind, Joseph Bonneau, Edward Felten, Andrew Miller, and Steven Goldfeder. Bitcoin and cryptocurrency technologies: a comprehensive introduction. Princeton University Press, 2016.

Course Schedule
Three types of AI topics will be covered: (1) machine learning algorithms, (2) deep learning models, and (2) blockchain technology and sustainability implications.
Notes: The schedule is tentative as the pace dictates. The HW and assignment dates may change with advance notice on Canvas.

Week 1-2:	Probability Theory Review and Intro to Machine Learning;	(Reading Assignment 1)
Week 3:	Prediction methods (Linear regression);	(HW1 term paper)
Week 4:	Prediction methods (Non-linear regression);	(HW2 Individual)
Week 5:	Classification methods (K-nearest neighbors);	(Reading Assignment 2)
Week 6-7:	Classification methods (decision tree, support vector machine);	(HW3 term paper)
Week 8:	Clustering algorithms (K-means);	(HW4 Individual)
Week 9:	Clustering algorithms (hierarchical and density-based clustering);	(HW5 term paper)
Week 10:	Graphical models (Bayesian Networks, Markov Processes);	(Reading Assignment 3)

Week 11:   Deep Learning_Part 1; (HW6 Individual)
Week 12:   Deep Learning_Part 2; Exam Review, Exam
Week 13:   Deep Learning_Part 3; (HW7 term paper)
Week 14:   Blockchain and distributed ledger technology; (Reading Assignment 4)
Week 14:   Building blocks of cryptocurrency (hash functions, digital signatures, data structure);
Week 15:   Blockchain_Sustainability implications; Term paper presentations (HW8 term paper)

Evaluation of Grades

Assignment	Total Points	Percentage of Final Grade
Individual Homework Assignments (3)	100 each	20%
Reading Assignments (4-5)	100 each	15%
Exam	100	10%
Term Paper Assignments for a team of 2-3 students (5)	100 each	50%
Term Paper Presentation	100	5%
		100%

Grading Policy

Percent	Grade	Grade Points
95.0 - 100	A	4.00
90.0 – 94.9	A-	3.67
85.0 - 89.9	B+	3.33
80.0 - 84.9	B	3.00
75.0 - 79.9	B-	2.67
70.0 - 74.9	C+	2.33
65.0 - 69.9	C	2.00
60.0 - 64.9	C-	1.67
55.0 - 59.9	D+	1.33
50.0 - 54.9	D	1.00
45.0 – 49.9	D-	0.67
0 - 44.9	E	0.00

More information on UF grading policy may be found at:
http://gradcatalog.ufl.edu/content.php?catoid=10&navoid=2020#grades

Term Paper Specifications/policies
A team of 2-3 students will work on each term paper.
Each team paper should have an original contribution.
The term paper should include the following sections: (1) problem definition (2) literature review (3) Method (4) Method Evaluation/Application (5) Results and Conclusion
Each paper should include a literature review of at least 20 prior studies.
Each paper should include a section describing the problem definition and a section describing the method suggested for solving that problem.
An ideal paper should be an integration of both method development and application.
Term paper page limit: 8-12 pages
Team members will evaluate themselves during the semester, and your grade is a function of your team members' evaluation
The followings are some suggested areas that your paper can belong to:

- *Air quality modeling and prediction*
- *Hazard assessment and prediction (e.g. environmental modeling and flood protection)*
- *Energy consumption modeling and prediction*
- *Land use mapping of coastal wetlands*
- *Water quality classification*
- *Wildfire science and management*
- *Product lifecycle prediction*
- *Forecasting environmental consumption*
- *Urban analytics: smart cities, urban informatics, and urban science*
- *Energy consumption and e-waste generation of crypto mining*

Term Paper Deadline (tentative)
The first draft of the papers (including literature review and the model development) is due on Thursday, October 28th (tentative).
Final papers (including results and design application) are due on Thursday, December 2nd.
Term-paper Presentations: The last week of classes.

Individual Homework Assignment Policies
- One individual homework assignment every three or four weeks, total 3 assignments in the semester. They are typically assigned on Thursday and due the following Thursday.
- The homework assignments will be posted on CANVAS, and they are due before the next lecture starts the following week.
- Individual work
- Late assignments are not accepted—one letter grade per day late.
- Requests for correcting possible grading errors must be submitted to the instructor within one week after the work is returned with a written explanation of the correction request; no corrections are possible afterward.
- The tentative schedule for the exam is Thursday, Nov 18, 2021.
- Acknowledge all resources used. Plagiarism is not acceptable. Identical homework submission (applied to individual homework assignments, not paper) receive zero. You should protect your own work, including individual assignments, term papers, and exam all the time.

Attendance Policy, Class Expectations, and Make-Up Policy
Attendance is not required. The lectures will be offered face-to-face as well as synchronously on zoom and will be recorded. To schedule a make-up for an excused, missed assignments, please contact the instructor through email. Requirements for make-up assignments are consistent with the university policies. Excused absences must be in compliance with university policies in the Graduate Catalog (*https://catalog.ufl.edu/ugrad/current/regulations/info/attendance.aspx*) and require appropriate documentation and advance notice to the instructor.

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 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/.

Online Course Recording

Our class sessions may be audio visually recorded for students in the class to refer back and for enrolled students who are unable to attend live. Students who participate with their camera engaged or utilize a profile image are agreeing to have their video or image recorded. If you are unwilling to consent to have your profile or video image recorded, be sure to keep your camera off and do not use a profile image. Likewise, students who un-mute during class and participate orally are agreeing to have their voices recorded. If you are not willing to consent to have your voice recorded during class, you will need to keep your mute button activated and communicate exclusively using the "chat" feature, which allows students to type questions and comments live. The chat will not be recorded or shared. As in all courses, unauthorized recording and unauthorized sharing of recorded materials is prohibited.

In-Class Recording

Students are allowed to record video or audio of class lectures. However, the purposes for which these recordings may be used are strictly controlled. The only allowable purposes are (1) for personal educational use, (2) in connection with a complaint to the university, or (3) as evidence in, or in preparation for, a criminal or civil proceeding. All other purposes are prohibited. Specifically, students may not publish recorded lectures without the written consent of the instructor.

A "class lecture" is an educational presentation intended to inform or teach enrolled students about a particular subject, including any instructor-led discussions that form part of the presentation, and delivered by any instructor hired or appointed by the University, or by a guest instructor, as part of a University of Florida course. A class lecture does not include lab sessions, student presentations, clinical presentations such as patient history, academic exercises involving solely student participation, assessments (quizzes, tests, exams), field trips, private conversations between students in the class or between a student and the faculty or lecturer during a class session. Publication without permission of the instructor is prohibited. To "publish" means to share, transmit, circulate, distribute, or provide access to a recording, regardless of format or medium, to another person (or persons), including but not limited to another student within the same class section. Additionally, a recording, or transcript of a recording, is considered published if it is posted on or uploaded to, in whole or in part, any media platform, including but not limited to social media, book, magazine, newspaper, leaflet, or third party note/tutoring services. A student who publishes a recording without written consent may be subject to a civil cause of action instituted by a person injured by the publication and/or discipline under UF Regulation 4.040 Student Honor Code and Student Conduct Code.

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 Conduct Code

(https://sccr.dso.ufl.edu/process/student-conduct-code/) specifies a number of behaviors that are in violation of this code and the possible sanctions. If you have any questions or concerns, please consult with the instructor or TAs in this class.

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
• Jennifer Nappo, Director of Human Resources, 352-392-0904, jpennacc@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
- You are expected to wear approved face coverings at all times during class and within buildings even if you are vaccinated.
- If you are sick, stay home and self-quarantine. Please visit the UF Health Screen, Test & Protect website about next steps, retake the questionnaire and schedule your test for no sooner than 24 hours after your symptoms began. Please call your primary care provider if you are ill and need immediate care or the UF Student Health Care Center at 352-392-1161 (or email covid@shcc.ufl.edu) to be evaluated for testing and to receive further instructions about returning to campus.
- If you are withheld from campus by the Department of Health through Screen, Test & Protect, you are not permitted to use any on campus facilities. Students attempting to attend campus activities when withheld from campus will be referred to the Dean of Students Office.
- UF Health Screen, Test & Protect offers guidance when you are sick, have been exposed to someone who has tested positive or have tested positive yourself. Visit the UF Health Screen, Test & Protect website for more information.
- Please continue to follow healthy habits, including best practices like frequent hand washing. Following these practices is our responsibility as Gators.

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: https://counseling.ufl.edu, 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://career.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://sccr.dso.ufl.edu/policies/student-honor-code-student-conduct-code/;https://care.dso.ufl.edu.

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