Machine Learning Applications in Civil Engineering
EGN 5XXX
Class Periods: TBD
Location: TBD
Academic Term: TBD

Instructor:
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Office Hours: by appointment

Teaching Assistant/Peer Mentor/Supervised Teaching Student: TBD
Please contact through the Canvas website

Course Description:
EGN 5XXX Machine Learning Applications in Civil Engineering   3 Credits

Students will leverage state-of-the-art techniques and tools in machine learning to solve Civil Engineering problems. Fundamentals of data analytics and machine learning techniques will be applied to real-world tasks in Civil Engineering. Students will gain essential knowledge and programming skills (using R) in data preprocessing, feature selection, model comparison, hyperparameter tuning and machine-learning interpretation. Case studies and applications are included for hands-on experience.

Course Pre-Requisites / Co-Requisites:
Undergraduate level courses in probability and statistics.

Grading Scheme: Letter Grade

Course Objectives:
After taking this course, the students will be able to:
- Identify potential applications of machine learning in Civil Engineering
- Select appropriate machine-learning techniques for a Civil Engineering application
- Apply popular algorithms in supervised and unsupervised learning
- Analyze model performance using relevant error metrics for different applications
- Interpret machine-learning models to gain insights for decision making
- Implement these techniques and tools in R

Required Textbooks and Software:
- **An Introduction to Statistical Learning: with Applications in R (Springer Texts in Statistics)**
- Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirani
- 1st ed. 2013, Corr. 7th printing 2017 Edition
- ISBN-13: 978-1461471370
- Software: R (open-source software)
- Online available at: http://faculty.marshall.usc.edu/gareth-james/ISL/

Recommended Materials:

- **Interpretable Machine Learning**
  Christoph Molnar
  March 24, 2019, 1st edition
  ISBN 9780244768522
  Online available at: https://christophm.github.io/interpretable-ml-book/

- **The Elements of Statistical Learning: Data Mining, Inference, and Prediction, Second Edition (Springer Series in Statistics)**
  Trevor Hastie, Robert Tibshirani, Jerome Friedman
  ISBN-13: 978-0387848570
  Online available at: https://web.stanford.edu/~hastie/ElemStatLearn/printings/ESLII_print12.pdf

Course Schedule:

Week 1:   Overview of machine-learning applications in Civil Engineering; fundamentals of data science and machine learning

Week 2:   Data preprocessing techniques: Missing data imputation and multicollinearity (VIF and PCA)

Week 3:   Feature selection techniques: Ridge, Lasso, and best-subset selection

Week 4:   **Lab 1:** Apply data preprocessing and feature selection techniques to travel mode choice data (a classification problem) and disaster risk assessment data (a regression problem) using R/**Quiz**

Week 5:   Concept of bias-variance tradeoff; model comparison methods: AIC/BIC, adjusted R-squared, cross validation, and holdout test; model performance metrics: MSE, MAE, accuracy, and AUC

Week 6:   Fundamentals of machine-learning models – Part 1: linear regression, logistic regression, naïve Bayes

Week 7:   **Lab 2:** Implement abovementioned machine-learning algorithms for travel mode choice data and disaster risk assessment data using R/**Quiz**

Week 8:   Fundamentals of machine-learning models – Part 2: support vector machine and classification and regression trees, boosting trees, bagging trees, and random forest

Week 9:   Fundamentals of machine-learning models – Part 3: artificial neural networks

Week 10:   **Lab 3:** Compare multiple machine-learning algorithms and identify best-performing models for travel mode choice data and disaster risk assessment data using R

Week 11-12:   Interpretable machine learning – Part 1: variable importance, partial dependence plot, accumulated local effects plot, and individual conditional expectation plot/**Midterm exam**

Week 13:   Interpretable machine learning – Part 2: model distillation, global surrogate, and local surrogate

Week 14:   **Lab 4:** Apply interpretable machine learning tools to extract insights from black-box models for travel mode choice data and disaster risk assessment data using R

Week 15:   Term project preparation and discussion

Attendance Policy, Class Expectations, and Make-Up Policy:

Excused absences must be in compliance with university policies in the Graduate Catalog (http://gradcatalog.ufl.edu/content.php?catoid=10&navoid=2020#attendance) and require appropriate documentation.

Evaluation of Grades:

Assignment	Total Points	Percentage of Final Grade
Homework Sets (6)	100 each	25%
Quizzes (2)	100 each	15%
Midterm Exam	100	30%
Term Project	100	30%
		100%

Grading Policy:

Percent	Grade	Grade Points
90.0 - 100.0	A	4.00
87.0 - 89.9	A-	3.67
84.0 - 86.9	B+	3.33
81.0 – 83.9	B	3.00
78.0 - 80.9	B-	2.67
75.0 - 77.9	C+	2.33
72.0 – 74.9	C	2.00
69.0 - 71.9	C-	1.67
66.0 - 68.9	D+	1.33
63.0 - 65.9	D	1.00
60.0 - 62.9	D-	0.67
0 - 59.9	E	0.00

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

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/.

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.

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://care.dso.ufl.edu.

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