# GEOL 701T Applications of Machine Learning in Hydrology (Listed in Registrar as Advanced Geology)

## Spring Semester, 2023

Tuesday/Thursday 4:30-5:45pm

CRVB Computer Lab, DRI

### Course Information

#### Instructor Information

**Instructor:** Marc Berghouse **Instructor:** Lazaro Perez  
**Office:** CRVB Computer Lab **Office:** CRVB Computer Lab (DRI Campus)  
**Phone:** 650-576-4226 **Phone:** 775-673-7696  
**Email:** [Marc.Berghouse@dri.edu](mailto:Marc.Berghouse@dri.edu) **Email:** [Lazaro.Perez@dri.edu](mailto:Lazaro.Perez@dri.edu)  
**Office Hours:** **Office Hours:**

**By Request** By Request

#### Course Description

Introduction to machine learning and its applications in hydrology. Students will learn the basics of machine learning theory and will use the Scikit learn framework in Python and the Regression Learner Toolbox in Matlab to solve a variety of hydrologic problems.

#### Course Pre/Co-requisites

There are no course prerequisites, but this class will be much easier if you have done any programming in Python and Matlab and/or if you have any prior experience with machine learning.

#### Required Texts/Course Materials

There are no textbooks on machine learning in hydrology, so we will be reading and recreating experiments from academic papers.

Most of the class materials will be iPython notebooks (.ipynb) and Matlab scripts. To view the iPython notebooks, you must install Anaconda and open JupyterLabs or Jupyter Notebook. All homework will be in the form of iPython notebooks.

#### Class Structure

Tuesday/Thursday from 4:30-5:45pm. The class will consist of lectures and programming walkthroughs. Generally, we will focus on theory and lectures for one day of the week and programming for the other day.

There will be 5 homework assignments, and a project due at the end of the semester.

Instructors will send necessary communications (class cancellations or schedule changes, for example) to the students’ unr.edu email address.

#### Student Learning Outcomes

Upon completion of this course, the student will be able to:

* SLO1. Apply knowledge of hydrology and hydrogeology to identify questions related to real-world water problems.
* SLO2. Apply knowledge of statistics and machine learning to solve a variety of problems in hydrology and hydrogeology
* SLO3. Describe the basics of machine learning and create machine learning models in the Scikit learn framework with Python
* SLO4. Document and present results from machine learning studies

#### Course Requirements

A final grade is based on discussions, presentations, and written reports count toward the final grade. They are weighted as follows:

|  |  |
| --- | --- |
| **Homework Assignments** | **60%** |
| **Project Approval** | **5%** |
| **Final Report** | **20%** |
| **Final Presentation** | **10%** |
| **Participation** | **5%** |
| **TOTAL** | **100%** |

#### Grading Criteria, Scale, and Standards

Letter grades will be assigned according to the following scale:

A: 93% - 100%

A-: 90% - 92.9%

B+: 87% - 89.9%

B: 84% - 86.9%

B-: 80% - 83.9%

C+: 77% - 79.9%

C: 74% - 76.9%

C-: 70% - 73.9%

D+: 67% - 69.9%

D: 64% - 66.9%

D-: 60% - 63.9%

F: <60%

#### **Course Calendar and Topics Outline**

|  |  |  |
| --- | --- | --- |
| Date | Topic | Assignment Due |
| 01/19 | **Introduction**  **What is Machine Learning?**  **Getting set up with MATLAB (Marc & Laz)** |  |
| 01/26 | **How to put together a ML model**   * **Gathering/cleaning data** * **Train/test split** * **Cross-validation and Holdout**   **Common applications of ML (Marc & Laz)** |  |
| 02/02 | **Getting setup with Python**  **Scikit Learn**  **More applications of ML (Marc)** | **Homework 1** |
| 02/09 | **Applications of Machine Learning in Hydrology (Marc & Laz)** |  |
| 02/16 | **Random Forest Models (Laz)** | **Homework 2** |
| 02/23 | **K-Nearest Neighbors (kNN) Models (Marc)** |  |
| 03/02 | **Support Vector Machines (SVM) (Laz)** | **Homework 3** |
| 03/09 | **Stochastic Gradient Descent (SGD) (Marc)** |  |
| 03/16 | **No class - spring break** |  |
| 03/23 | **Decision Trees (Laz)** | **Homework 4** |
| 03/30 | **Naïve Bayes (Marc)** | **Final Project Approval** |
| 04/06 | **Ensemble Methods (Marc & Laz)** | **Homework 5** |
| 04/13 | **Neural Networks (Marc & Laz)** |  |
| 04/20 | **Work on Project (If people want, we can do more deep learning here)** |  |
| 04/27 | **Work on Project** |  |
| 05/04 | **Project Presentations** | **Give 20-minute final presentation on your ML model and results** |
| 05/07 | **Project Presentations** | **Turn in final written report on your ML model and results** |
|  |  |  |

**Readings/Links**:

* **Anaconda (Easy Python Environment for Mac and Windows)**
  + - [**https://www.anaconda.com/products/distribution**](https://www.anaconda.com/products/distribution)
* **Regression Learner Toolbox**
  + - [**https://www.mathworks.com/help/stats/regression-learner-app.html**](https://www.mathworks.com/help/stats/regression-learner-app.html)
* **Scikit Learn**
  + - [**https://scikit-learn.org/stable/**](https://scikit-learn.org/stable/)
* **Various applications of Random Forest models**
  + - [**https://www.mdpi.com/2073-4441/11/5/910/htm**](https://www.mdpi.com/2073-4441/11/5/910/htm)
* **Streamflow prediction**
  + - **Random forest:** [**https://hess.copernicus.org/articles/25/2997/2021/**](https://hess.copernicus.org/articles/25/2997/2021/)
    - **ELM and Random forest: ​​**[**https://www.tandfonline.com/doi/full/10.1080/02626667.2019.1680846**](https://www.tandfonline.com/doi/full/10.1080/02626667.2019.1680846)
    - **SVM:** [**https://www.sciencedirect.com/science/article/pii/S0957417411006415**](https://www.sciencedirect.com/science/article/pii/S0957417411006415)
* **Runoff prediction**
  + - **kNN and SVM:** [**https://www.mdpi.com/2073-4441/11/2/200/htm**](https://www.mdpi.com/2073-4441/11/2/200/htm)
    - **ANN, SVM and RF:** [**https://link.springer.com/article/10.1007/s11600-022-00749-z**](https://link.springer.com/article/10.1007/s11600-022-00749-z)
    - **SVM and ANN:** [**https://www.sciencedirect.com/science/article/pii/S095741740800674X?casa\_token=aS2jHOjn4okAAAAA:n1VTYv\_QCkGehYUkYvoAE716EbH\_vc4KAuL84yT5GawRRnUL2wHb2fJT8rF9YTiy5th37tusW99L**](https://www.sciencedirect.com/science/article/pii/S095741740800674X?casa_token=aS2jHOjn4okAAAAA:n1VTYv_QCkGehYUkYvoAE716EbH_vc4KAuL84yT5GawRRnUL2wHb2fJT8rF9YTiy5th37tusW99L)
* **Water quality prediction**
  + - **SVM and ANN:** [**https://iwaponline.com/wqrj/article/53/1/3/38171/Water-quality-prediction-using-machine-learning**](https://iwaponline.com/wqrj/article/53/1/3/38171/Water-quality-prediction-using-machine-learning)

**SVM, kNN, naive Bayes:** [**https://www.hindawi.com/journals/abb/2020/6659314/**](https://www.hindawi.com/journals/abb/2020/6659314/)

#### Late Work or Make-up Exams Policies

Discussions and presentations are due and take place during class on the day indicated by the schedule. Written reports are due before class on the day indicated by the schedule. Late reports will not be accepted unless the student has a family emergency or serious health issue.

If an emergency prevents a student from coming to class, the student should notify either instructor as soon as possible to determine how the situation will be handled.

### University Policies

#### Statement on COVID-19 Policies

##### Face Coverings

In response to COVID-19, and in alignment local, state, and U.S. Center for Disease Control guidelines, face coverings are required at all times in all UNR indoor public spaces, including classroom, laboratory, studio, creative space, or any type of in-person instructional activity, and public spaces. Furthermore, individuals who have not been fully vaccinated against COVID 19 are required to wear a face covering at all times while on campus, including all indoor and outdoor public spaces.

A “face covering” is defined as a “covering that fully covers a person’s nose and mouth, including without limitation, cloth face mask, surgical mask, towels, scarves, and bandanas” (State of Nevada Emergency Directive 024).

Students that cannot wear a face covering due to a medical condition or disability, or who are unable to remove a mask without assistance may seek an accommodation through the Disability Resource Center.

##### Social Distancing

In alignment with State of Nevada guidelines, social distancing is no longer required.

##### Disinfecting Your Learning Space

Disinfecting supplies are provided for you to disinfect your learning space. You may also use your own disinfecting supplies.

##### COVID-19, COVID-19 Like Symptoms, and Contact with Someone Testing Positive for COVID-19

Students testing positive for COVID 19, exhibiting COVID 19 symptoms regardless of vaccination status will not be allowed to attend in-person instructional activities and must leave the venue immediately. Students should contact the [Student Health Center](https://med.unr.edu/student-health-center) or their health care provider to receive care and who can provide the latest direction on quarantine and self-isolation. Contact your instructor immediately to make instructional and learning arrangements.

**Accommodations for COVID 19 Quarantined Students**

For students who are required to quarantine or self-isolate due to 1) COVID 19 infection or 2) exposure while not vaccinated, instructors must provide opportunities to make-up missed course work, including assignments, quizzes or exams. In courses with mandatory attendance policies, instructors must not penalize students for missing classes while quarantined.

##### Failure to Comply with Policy (including as outlined in this Syllabus) or Directives of a University Employee

In accordance with section 6,502 of the University Administrative Manual, a student may receive academic and disciplinary sanctions for failure to comply with policy, including this syllabus, for failure to comply with the directions of a University Official, for disruptive behavior in the classroom, or any other prohibited action. “Disruptive behavior" is defined in part as behavior, including but not limited to failure to follow course, laboratory or safety rules, or endangering the health of others. A student may be dropped from class at any time for misconduct or disruptive behavior in the classroom upon recommendation of the instructor and with approval of the college dean. A student may also receive disciplinary sanctions through the Office of Student Conduct for misconduct or disruptive behavior, including endangering the health of others, in the classroom. The student shall not receive a refund for course fees or tuition.

#### Statement on Academic Dishonesty

"The University Academic Standards Policy defines academic dishonesty, and mandates specific sanctions for violations. See the University Academic Standards policy: [UAM 6,502.](https://www.unr.edu/administrative-manual/6000-6999-curricula-teaching-research/instruction-research-procedures/6502-academic-standards)"

#### Statement of Disability Services

*Use either the traditional or online statement, in addition to the last sentence regarding third party materials.*

##### For Traditional and Seated Classrooms:

“Any student with a disability needing academic adjustments or accommodations is requested to speak with me or the [Disability Resource Center](http://www.unr.edu/drc) (Pennington Achievement Center Suite 230) as soon as possible to arrange for appropriate accommodations.”

##### For Online Courses:

“If you are a student who would normally seek accommodations in a traditional classroom, please contact me as soon as possible. You may also contact the Disability Resource Center for services for online courses by emailing [drc@unr.edu](mailto:drc@unr.edu) or calling 775-784-6000. Academic accommodations for online courses may be different than those for seated classrooms; it is important that you contact us as soon as possible to discuss services. The University of Nevada, Reno supports equal access for students with disabilities. For more information, visit the [Disability Resource Center](http://www.unr.edu/drc).”

**This course may leverage 3rd party web/multimedia content, if you experience any issues accessing this content, please notify your instructor.**

#### Statement on Audio and Video Recording

##### Student-created Recordings

"Surreptitious or covert video-taping of class or unauthorized audio recording of class is prohibited by law and by Board of Regents policy. This class may be videotaped, or audio recorded only with the written permission of the instructor. In order to accommodate students with disabilities, some students may have been given permission to record class lectures and discussions. Therefore, students should understand that their comments during class may be recorded."

##### Instructor-created Recordings

Class sessions may be audio-visually recorded for students in the class to review and for enrolled students who are unable to attend live to view. Students who participate with their camera on or who use a profile image are consenting to have their video or image recorded. If you do not consent to have your profile or video image recorded, keep your camera off and do not use a profile image. Students who un-mute during class and participate orally are consenting to have their voices recorded. If you do not consent to have your voice recorded during class, keep your mute button activated and only communicate by using the "chat" feature, which allows you to type questions and comments live.

#### Statement on Maintaining a Safe Learning and Work Environment

The University of Nevada, Reno is committed to providing a safe learning and work environment for all. If you believe you have experienced discrimination, sexual harassment, sexual assault, domestic/dating violence, or stalking, whether on or off campus, or need information related to immigration concerns, please contact the University's Equal Opportunity & Title IX office at 775-784-1547. Resources and interim measures are available to assist you. For more information, please visit the [Equal Opportunity and Title IX](https://www.unr.edu/equal-opportunity-title-ix) page**.**

*In addition to the required information listed above, it is strongly recommended that the syllabus include:*

* Methods for communicating with students outside the classroom regarding matters such as class cancellations, meeting times, or room changes
* More detail about what constitutes academic dishonesty, with a concrete list or examples of "dos and don'ts" in the context of the class
* **Statement for academic success services:** "Your student fees cover usage of the [University Math Center](https://www.unr.edu/university-math-center) (https://www.unr.edu/university-math-center), (775) 784-4433; [University Tutoring Center](https://www.unr.edu/tutoring-center) (https://www.unr.edu/tutoring-center), (775) 784-6801; and [University Writing & Speaking Center](https://www.unr.edu/writing-speaking-center) (https://www.unr.edu/writing-speaking-center), (775) 784-6030. These centers support your classroom learning; it is your responsibility to take advantage of their services. Keep in mind that seeking help outside of class is the sign of a responsible and successful student."