

Machine Learning in Python for Environmental Science

Number of credits: 3

Course Objectives / Overview

This is a introductory course designed to introduce the basics of Python programming as well as the application of emerging machine learning methods to solve real-world problems in Earth and Environmental Sciences. It is intended for students with little or no experience in programming so that possible steep learning curve is anticipated. Lectures include two overarching components: first, students will learn how to program with Python, and second, students will learn how to apply some machine learning tools to analyze data and visualize results in the environmental science domain. These two components will be bridged with homework plus hands-on exercises utilizing both analytical and programming skills to examine and interpret environmental variations and features. The acquired skills can be more generally applied to other scientific data with signals in time, space or feature. A teaching assistant will lead the Q/A session each week to answer questions and help to debug codes.

Prerequisites are courses on statistics such as MEES698B (Environmental Statistics I) / MEES713 (Environmental Statistics II) / others related to statistics.

Expected Course Learning Outcomes

- 1. Develop and troubleshoot Python programs.
- 2. How to formulate research questions as computer code.

3. Create powerful data visualization that are appropriate to the data being analyzed.

4. Learn machine learning and data science fundamentals.5. Build and train machine learning models for real-world environmental problems.

MEES *** Spring 2024

INSTRUCTOR DETAILS:

Jian Zhao <u>Email: jianzhao@umces.edu</u> Phone: 410-221-8368

Hongsheng Bi Email: hbi@umces.edu Phone: 410-326-7249

CLASS MEETING DETAILS:

Dates: Times: Two classes per week + Q/A session. Originating Site: IVN bridge number: (*******) Phone call in number: (***) Room phone number: (******)

CURRICULUM FULFILLMENT: MEES *** fulfills a **PD** (PD, ISG, elective, etc.) MEES requirement.

Prerequisites

MEES698B (Environmental Statistics I) Or MEES713 (Environmental Statistics II) Or took courses for statistics

Teaching Assistant

One TA for Q/A session.

Course Assessment / Grading

Final grade will be based on performance on hands-on exercises in class (10%), homework (50%), and final project and presentation (40%).

Tentative Weekly Course Schedule

Week	Class Dates	Торіс	Lead	Assignment
			Instructor	
	Class 1	i) Overview, goals, and	All	
		format of the course		
		··· · · · · · · ·		
		11) Introduction to Jupyter		
		Notebooks, Python &		
Week 1		Python Installation		
week 1	Class 2	Duthon Fundamentals:	Zhao	Homowork 1.
		Syntax Data Types Data	Ziido	Reading
		Syntax, Data Types, Data Structures		reference books
	Ω/A session	Answer questions: help to	ТА	
		debug codes	111	
	Class 3	i) Data Structures.	Zhao	
		ii) Strings: Manipulation,		
		Indexing, and Searching.		
Week 2	<u> </u>	M 41 4 10 4	71	11 1.2
	Class 4	Mathematical Operators	Znao	Homework 2
		NumPy Module		
	O/A session	Answer questions: help to	ТА	
	X'II DODDIOII	debug codes.		
		0		

	Class 5	Flow Control:	Zhao	
		Conditionals, Loops, User		
Week 3		Input.		
	Class 6	i) Data storage and	Zhao	Homework 3
		handling		
		11) File I/O: ASCII,		
		NetCDF and HDF for		
		Earth Sciences Data;		
		how to read image files		
	Q/A session	Answer questions; help to	IA	
		debug codes.		
	Class 7	i) NumPy Arrays;	Zhao	
		ii) Data Visualization: 1-D;		
Week 4		2-D & 3-D plotting; multi-		
		panel plots; Basemap;		
		Animations		
	Class 8	Data Visualization: 1-D; 2-	Zhao	Homework 4
		D & 3-D plotting; multi-		
		panel plots; Basemap;		
		Animations		
	Q/A session	Answer questions; help to	ΊA	
		debug codes.		
Week 5	Class 9	Machine Learning Basics	All	
	<u>C1</u> 10		771	1.7
	Class 10	Python Library (NumPy	Zhao	Homework 5
		Library, Pandas Library)		
	Q/A session	Answer questions; help to	ТА	
		debug codes.		
			771	
Week 6	Class 11	Pandas Data Manipulation	Zhao	
		Dandas Data Insut/Outsut		
		(1)		
			1	1

	Class 12	Data science; Fundamental Statistics.	Zhao	Homework 6
	Q/A session	Answer questions; help to debug codes.	ТА	
Week 7	Class 13	i) Supervised Learning ii) Regression Models	Zhao	
	Class 14	i) Regression Models ii) Classification	Zhao	Homework 7
	Q/A session	Answer questions; help to debug codes.	ТА	
Week 8	Class 15	i) Decision Trees ii) Random Forests	Zhao	
	Class 16	i) Random Forests	Zhao	Homework 8; Announce Final Project
	Q/A session	Answer questions; help to debug codes.	ТА	
Week 9		Spring Break Week No Class		
Week 10	Class 17	Boosting Machines	Zhao	
	Class 18	Support Vector Machines	All	Homework 9
	Q/A session	Answer questions; help to debug codes.	ТА	
Week 11	Class 19	Deep Learning	All	
	Class 20	Neural Networks (1)	All	Homework 10

	Q/A session	Answer questions; help to debug codes.	TA	
Week 12	Class 21	Neural Networks (2)	All	
	Class 22	Unsupervised Learning	All	Homework 11
	Q/A session	Answer questions; help to debug codes.	ТА	
Week 13	Class 23	Dimensionality Reduction	Zhao	
	Class 24	Principal Component Analysis	Zhao	Homework 12
	Q/A session	Answer questions; help to debug codes.	ТА	
Week 14	Class 25	Clustering	Zhao	
	Class 26	Advanced application: Image recognition & classification	Bi	Homework 13
	Q/A session	Answer questions; help to debug codes.	TA	
Week 15	Class 27	Advanced application: One-stage detector for Image recognition & classification	Bi	
	Class 28	Advanced application: Two-stage detector for Image recognition & classification	Bi	
	Q/A session	Answer questions; help to debug codes.	ТА	

Week 16	Class 29	Wrap-up and project presentations	All	
	Class 30	Wrap-up and project presentations	All	

Required textbooks, reading and/or software or computer needs

The following books can be used as references.

1) Automate the Boring Stuff with Python, 2nd Edition: Practical Programming for Total Beginners 2nd Edition. Author: Al Sweigart

It is available at Library of University of Maryland, College Park

2) Python Programming and Visualization for Scientists Author: Alex DeCaria

3) Introduction to Machine Learning with Python : A Guide for Data Scientists, Authors: Andreas, C. Müller & Sarah Guido, O'Reilly.

It is available at Library of University of Maryland, College Park

Course Communication

[You should specify how you will send information to students (e.g. MOODLE announcement) and how you want students to contact you (e.g. MOODLE, email, Google Drive) to discuss questions or other information.]

Lectures and class recordings will be accessible at elms.umd.edu or moodle. Instructors can also be reached by email.

Resources

[Course website: www.moodle.com/xxxxx]

Campus Policies

The University of Maryland Center for Environmental Science has drafted and approved <u>various academic and</u> <u>research-related policies</u> by which all students and faculty must abide. Please visit the following website for more information on the University of Maryland Center for Environmental Science Code of Academic Integrity and Policy <u>III-1.00</u>: Policy on Faculty, Student and Institutional Rights and Responsibilities for Academic Integrity.

Course-Specific Policies and Expectations

[Separate from the campus-wide policies linked earlier, you may want to outline any additional course policies of which students need to be aware. Also include late work policy, etc.]

Zoom: Video On

This interactive class is a 'video on' class. Those who need to attend without video should request permission from the instructor.