Western University – Faculty of Engineering
Department of Civil and Environmental Engineering

CEE 4420A – DATA SCIENCE FOR GEOTECHNICAL ENGINEERS (With CEE 9730) - Course Outline 2024/25

The objective of the course is for students to develop a hands-on understanding of the field of data science, with a focus on opportunities and more importantly limitations pertaining to applications in geotechnical engineering. Students will work in groups on two projects over the course of the term, which will be scoped with guidance from the course instructor. The projects will be peer-assessed by other groups, who will grade each other on a) legibility and quality of code and dataset as well as corresponding documentation; b) a presentation on the construction of the dataset and performance of the algorithm.
Topics include:
Introduction to Python programming and the Numpy, scikit-learn, and PyTorch packages
Learning algorithms, unsupervised algorithms, feature engineering
Various flavours of deep learning, and generative adversarial networks.
Each topic will be introduced alongside recent research in the field of geotechnical engineering where possible.

Calendar Copy:
Application of Python programming, learning algorithms, unsupervised algorithms, feature engineering, deep learning and generative adversarial networks in geotechnical engineering.

Prerequisites:
Prerequisite(s): CEE 2219A/B, CEE 3322A/B, Data Science 3000A/B.

Antirequisites:
None

Corequisites:
None

Note: It is the student's responsibility to ensure that all Prerequisite and Corequisite conditions are met or that special permission to waive these requirements has been granted by the Faculty. It is also the student's responsibility to ensure that they have not taken a course listed as an Antirequisite. The student may be dropped from the course or not given credit for the course towards their degree if they violate the Prerequisite, Corequisite or Antirequisite conditions.

Contact Hours:
2 lecture hours/week (required);
2 tutorial hours/week;
Tutorials are not mandatory but students seeking assistance with projects or clarification on lecture material are strongly encouraged to attend.
Additional self-study: 4 hours/week.

Instructor:
Bing Li, Ph.D., P.Eng., SEB3010C
bing.li@uwo.ca
Office hours: after class or by appointment

Textbook:
None

Other References:
Neural Networks and Deep Learning by Michael Nielsen
The Hundred-Page Machine Learning Book by Andriy Burkov
https://towardsdatascience.com is an excellent general resource
The International Society for Soil Mechanics and Geotechnical Engineering maintains an excellent archive of active research in this area (http://140.112.12.21/issmge/ml_ref.htm)

Units:
Both SI and FPS unit systems may be used in lectures, laboratories, tutorials and examinations.

Specific Learning Objectives:
The lectures and tutorial assignments will prepare students to do the following [GA Indicator]:

1. Apply Python programming language for reading in, processing, and plotting large datasets [ET 2]
2. Identify and format appropriate input and output formats for a range of machine learning models [**PA 1, PA 2**]
3. Identify and implement appropriate machine learning models (decision trees, support vector machines, deep neural networks) for a given engineering problem [**I 1**]
4. Understand and differentiate between various buzzwords such as machine learning, data science, big data, artificial intelligence, etc. [KB 3]
5. Understand and critique limitations of various machine learning models [**I 3,** LL 1]
6. Work in teams to tackle geotechnical engineering datasets from data science perspective [**ITW 1, ITW 2, ITW 3**]
7. Prepare, critique, present and document code and report on details and performance of machine learning models. [**CS 1, CS 2, CS 3**]

The instructor may expand or revise material presented in the course as appropriate.

General Learning Objectives:
E=Evaluate, T=Teach, I=Introduce; (I) = Intoduction, (D) = Developing, (A) = Advanced level

Knowledge Base	E (I)	Engineering Tools	T	Impact on Society	
Problem Analysis	T	Team Work	T	Ethics and Equity	
Investigation	T	Communication	T	Economics and Project Management	
Design		Professionalism		Life-Long Learning	T

Accreditation Units:
Engineering Science = 100%

Evaluation:
The final mark will be determined as follows:

Assessment	Weight
Assignment 1	5%
Assignment 2	15%
Assignment 3	15%
Assignment 4	15%
Final project documentation of code and dataset	25%
Final project presentation	25%

(a) **Students who have failed this course previously must repeat all components of the course**. No special permissions will be granted enabling a student to retain laboratory, assignment or test marks from previous years. Previously completed assignments and laboratories cannot be resubmitted.

1. Assignments:

The 4 assignments will cover a range of course topics. Assignments are to be submitted prior to the due date to OWL.

2. Final Project:

Students will complete a final project in groups of up to 3 students. The following are possible project ideas, but students are also encouraged to develop their own ideas following their interests.

Project option 1:

Time series prediction with MLRA data (series of pore pressure sensors). The students will attempt to predict the pore pressure in these sensors using air temperature, rainfall, and air pressure. Could be done using decision tree or RNN.

Project option 2:

Image classification of cracked vs uncracked rocks. Likely requires CNN, data will come from MIT rock mechanics research group high-speed data. The students will be provided with high-speed video images of a rock undergoing fracturing from uniaxial loading, students will develop a classifier for whether there is a crack on the rock. Students will additionally attempt to label the regions corresponding to cracked rock.

Project option 3:

Image segmentation of cityscapes into e.g. pedestrians, cars, buildings, etc.

I. Missed/Late Accommodation Policy:

1. Students missing a test/assignment/lab or examination you will report the absence by submitting Academic Consideration Request form through STUDENT ABSENCE PORTAL.
2. Documentation must be provided as soon as possible.

II. Exam Accommodation:

1. If you are unable to write a final examination, report your absence using the Academic Consideration Request Form through STUDENT ABSENCE PORTAL.
2. Be prepared to provide the Undergraduate Services Office with supporting documentation (see next page for information on documentation) the next day, or as soon as possible (in cases where students are hospitalized). The following circumstances are not considered grounds for missing a final examination or requesting special examinations: common cold, headache, sleeping in, misreading timetable and travel arrangements.
3. In order to receive permission to write a Special Examination, you must obtain the approval of the Chair of the Department and the Associate Dean and in order to apply you must submit an the Academic Consideration Request Form through STUDENT ABSENCE PORTAL.
   PLEASE NOTE: It is the student's responsibility to check the date, time and location of the Special Examination.

III. Late Assignments:

1. Students must advise the course instructor if they are having difficulty completing an assignment on time (prior to the due date of the assignment).
2. Students should be prepared to submit the Academic Consideration Request Form and provide documentation if requested to do so by the course instructor (see reverse side for information on documentation).
3. If granted an extension, a revised due date should be established with the course instructor. The approval of the Chair of your Department (or the Assistant Dean, First Year Studies, if you are in first year) is not required if assignments will be completed prior to the last day of classes.
4. This course has 10 assignments with only 8/10 assignments counted towards your final grade. Academic consideration will not be granted for missed assignments. If students miss 2/10 assignments, the remaining 8 assignments will be used in the calculation of the final grade. If students miss more than 2 assignments, they will receive a grade of zero on each missed assignment.

5. This course employs flexible deadlines for assignments. The assignment deadlines can be found above in the course outline. For each assignment, students are expected to submit the assignment by the deadline listed. Should illness or extenuating circumstances arise, students are permitted to submit their assignment up to 72 hours past the deadline without academic penalty. Should students submit their assessment beyond 72 hours past the deadline, a late penalty of XX% per day will be subtracted from the assessed grade. As flexible deadlines are used in this course, requests for academic consideration will not be granted. If you have a long-term academic consideration or an accommodation for disability that allows greater flexibility than provided here, please reach out to your instructor at least one week prior to the posted deadline.
6. Extensions beyond the end of classes must have the consent of the instructor, the department Chair and the Associate Dean, Undergraduate Studies. Documentation is mandatory.

Note: Forged notes and certificates will be dealt with severely. To submit a forged document is a scholastic offence (see below).

IV. Medical Accommodation:

1. Requests for Academic Consideration Request Form through STUDENT ABSENCE PORTAL.
2. Requests for academic consideration must include the following components:
    a. Self-attestation signed by the student (*This is only accepted for the first/one absence*)
    b. Medical note
    c. Indication of the course(s) and assessment(s) affected by the request
    d. Supporting documentation as relevant
3. Requests without supporting documentation are limited to one per term per course.
4. **Students must request academic consideration as soon as possible and no later than 48 hours after the missed assessment.**
5. Once the request and supporting documents have been received and reviewed, appropriate academic consideration, if granted, shall be determined by the instructor in consultation with the academic advisor, in a manner consistent with the course outline. Academic consideration may include extension of deadlines, waiver of attendance requirements for classes/labs/tutorials, or re-weighting of course requirements. Some forms of academic consideration, such as arranging Special Examinations, assigning a grade of Incomplete, or granting late withdrawals without academic penalty, may only be granted by the Academic Advising office of the Faculty of Engineering.

V. Religious Accommodation:

When scheduling unavoidably conflicts with religious holidays, which (a) require an absence from the University or (b) prohibit or require certain activities (i.e., activities that would make it impossible for the student to satisfy the academic requirements scheduled on the day(s) involved), no student will be penalized for absence because of religious reasons, and alternative means will be sought for satisfying the academic requirements involved. If a suitable arrangement cannot be worked out between the student and instructor involved, they should consult the appropriate Department Chair and, if necessary, the student's Dean.

It is the responsibility of such students to inform themselves concerning the work done in classes from which they are absent and to take appropriate action.

VI. Academic Integrity:

In the Faculty of Engineering, we encourage students to create a culture of honesty, trust, fairness, respect, responsibility, and courage, befitting the professional degree you are pursuing.

Please visit Academic Integrity Western Engineering for more information

VII. Academic Offences:

Plagiarism means using another's work without giving credit. The university has rules against plagiarism and other scholastic offences. Western Engineering has a zero-tolerance policy on plagiarism. The minimum penalty is zero on the course work and a repeat offence will earn you zero on the course. A third offence may lead to expulsion from the university.
Scholastic Discipline for Undergraduate Students & Cheating, Plagiarism and Unauthorized Collaboration: What Students Need to Know

Students must write their reports, essays and assignments in their own words. Whenever students take an idea or a passage from another author, they must acknowledge their debt both by using quotation marks where appropriate and by proper referencing such as footnotes or citations. University policy states that cheating, including plagiarism, is a scholastic offence. The commission of a scholastic offence is attended by academic penalties, which might include expulsion from the program. If you are caught cheating, there will be no second warning.

All required papers may be subject to submission for textual similarity review to commercial plagiarism detection software under license to the University for the detection of plagiarism. All papers submitted will be included as source documents on the reference database for the purpose of detecting plagiarism of papers subsequently submitted to the system. Use of the service is subject to the licensing agreement, currently between the University of Western Ontario and Turnitin.com (http://www.turnitin.com). Scholastic offences are taken seriously and students are directed to read the appropriate policy, specifically, the definition of what constitutes a Scholastic Offence, in the relevant section of the Academic Handbook:
http://www.uwo.ca/univsec/pdf/academic_policies/appeals/scholastic_discipline_undergrad.pdf

VIII. Faculty of Engineering AI Policy:

The use of generative Artificial intelligence (GenAI) tools won't be discouraged in the Faculty of Engineering. As we pride ourselves on building the future we can't hide from the use of GenAI tools to contribute to the understanding of the course materials. However, the use of GenAI tools in any assignment or contribution during the course will have to be disclosed, as a resource.
GenAI tools use won't be permitted in any type of examination or other assessments where the faculty have prohibited their use. If use of GenAI tools is detected by the instructor in these instances, academic offences penalties might be imposed against the student.

IX. Use of English Policy:

In accordance with Senate and Faculty Policy, students may be penalized up to 10% of the marks on all assignments, tests, and examinations for improper use of English. Additionally, poorly written work except for the final examination may be returned without grading. If resubmission of the work is permitted, it may be graded with marks deducted for poor English and/or late submission.

X. Accessibility:

Western is committed to achieving barrier free accessibility for persons with disabilities studying, visiting and working at Western. As part of this commitment, there are a variety of services, groups and committees on campus devoted to promoting accessibility and to ensuring that individuals have equitable access to services and facilities. To help provide the best experience to all members of the campus community, please visit the Accessibility Western University for information on accessibility-related resources available at Western.

Students with disabilities may arrange for academic accommodation at Western. For a more detailed explanation, please visit Academic Support & Engagement -Academic Accommodation.

XI. Inclusivity, Diversity, and Respect:

The Faculty of Engineering at Western University is committed to creating equitable and inclusive learning environments that value diverse perspectives and experiences. We recognize that university courses often marginalize students based on social identity characteristics such as, but not limited to, Indigeneity, race, ethnicity, nationality, ability, gender identity, gender expression, sexuality, age, language, religion, and socioeconomic status. Understanding this, we strive to facilitate equitable experiences and inclusion within the classroom by respecting and integrating multiple ways of knowing, being, and doing. Please visit the Office of Equity, Diversity and Inclusion.

XII. Health and Well-Being:

- Health & Wellness Services – Students - Offers appointment-based medical clinic for all registered part-time and full-time students.
- Mental Health Support - Provides professional and confidential services, free of charge, to students needing assistance to meet their personal, social and academic goals. Services include consultation, referral, groups and workshops, as well as brief, change-oriented psychotherapy.
- Crisis Support - For immediate assistant, please visit Thames Hall Room 2170 or call 519-661-3030. The crisis clinic operates between 11:00 am - 4:30 pm. For after-hours crisis support, click here.
- Gender-Based Violence and Survivor Support - Western is committed to reducing incidents of gender-based and sexual violence and providing compassionate support to anyone who has gone through these traumatic events. If you have experienced gender-based or sexual violence (either recently or in the past), you will find information about support services for survivors, including emergency contacts, here. To connect with a case manager or set up an appointment, please contact support@uwo.ca.

Important Contacts:

Engineering Undergraduate Services	SEB 2097	519-661-2130	engugrad@uwo.ca
Civil & Environmental Engineering	SEB 3005	519-661-2139	civil@uwo.ca
Office of the Registrar/Student Central	WSSB 1120	519-661-2100	

Important Links:

- WESTERN ACADEMIC CALENDAR
- ACADEMIC RIGHTS AND RESPONSIBILITIES