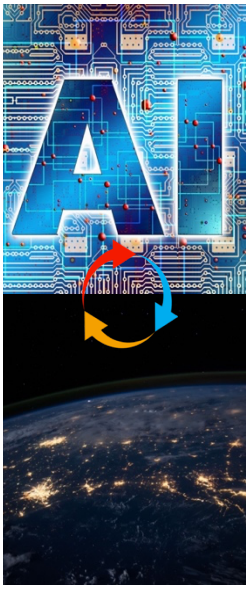
GRG 356T:
Introduction to Geospatial Artificial Intelligence

Course Description



The rapid increase in high-quality data, advanced machine learning algorithms, and the availability of fast hardware have largely contributed to a renewed interest in Artificial Intelligence (AI) from academia, industry, and the general public in recent years. From a geospatial point-of-view, GeoAI, as an interdisciplinary field of Geography/GIScience and AI, advocates the idea of developing and utilizing AI techniques to address a variety of problems related to both the natural environment and our human society. In this course, we will AI and machine learning methods and will focus on their applications on geospatial problems. We will start from the fundamental techniques related to preparing GIS data for machine learning models, and then move to discussing machine learning concepts and how to use machine learning to address spatial problems. This course has an emphasis on both theoretical concepts and hands-on skills, and we will use a high-level programming language (e.g., Python) to implement machine learning models.

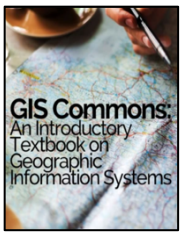
Course Information

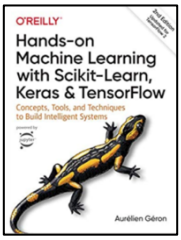
- **Course number**: GRG 356T
- **Credits**: 3
- **Lectures:**
    - Tuesday, 12:30 --14:00, PMA 7.112
    - Thursday, 12:30 --14:00, RLP 1.404
- **Instructor**: Dr. Gengchen Mai
    - **Email**: gengchen.mai@austin.utexas.edu
    - **Office hours**: Tuesday 14:10 – 15:10
    - **Office**: RLP 3.430

Instructor Bio:

Dr. Gengchen Mai is currently a Tenure-Track Assistant Professor at the Department of Geography and the Environment, University of Texas at Austin. He got his Ph.D. in Geographic Information Science from Department of Geography, UC Santa Barbara. Before becoming a faculty, he was a Postdoctoral scholar at Stanford Artificial Intelligence Laboratory, Department of Computer Science, Stanford University. Before joining UT, he was an Assistant Professor at University of Georgia. Dr. Mai's research is Spatially Explicit Artificial Intelligence, Geo-Foundation Models, Geographic Knowledge Graphs, etc. As one of the leading researchers in Geospatial AI, Dr. Mai has published not only in top-tier AI/GIScience/Remote Sensing journals such as ISPRS Journal of Photogrammetry and Remote Sensing, International Journal of Geographical Information Science, GeoInformatica, AI Magazine, etc. but also top ML/AI/GIScience conference proceedings such as ICML (Ranked #3 in AI by Google Scholar), ICLR (Ranked #2 in AI by Google Scholar), ACM SIGIR (Ranked #3 in Database & IS by Google Scholar), ACM SIGSPATIAL, ACM K-CAP, etc. According to Google Scholar, his works have been cited over 2680 times up to July 2024 with h-index is 27. Dr. Mai is the receipt of many prestigious awards including AAG 2021 Dissertation Research Grants, AAG 2022 William L. Garrison Award for Best Dissertation in Computational Geography, AAG 2023 J. Warren Nystrom Dissertation Award, Top 10 WGDC 2022 Global Young Scientist Award, the Jack and Laura Dangermond Graduate Fellowship. According to the historical records of AAG award recipients, he is now the sole recipient in history to have received three AAG doctoral dissertation awards since 2000.

Textbook





- Michael Schmandt (2009): GIS Commons: An Introductory Textbook on Geographic Information Systems **(**free textbook at https://giscommons.org/; **referred as "GIS" in the syllabus**)

- Aurélien Géron (2019): Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems
  (ebook available from UT Library; **referred as "ML" in the syllabus**)

Course Website

The website of this course is available on UT Canvas.

Prerequisites

This course does not have a formal prerequisite yet. However, before taking this upper level course, you may consider taking the following courses first:

- GIS background: GRG 460G or equivalent
- Basic programming background: GRG 350E, CS 105C, CS 314, CS 312, CS 312H, CS 313E, CS 105P, I 304, I 310D, INF 380P, or equivalent

Software Environment

- Anaconda (a python-based software suite)
- Jupyter Notebook.

They have been installed on lab computers for you to use. However, students are also expected to download and install them on their personal computers. Both are free packages.

Tentative Course Schedule*

Week	Date	Topics	Reading
Week 1	08/27 08/29	- Course introduction I - Python, Jupyter Notebook, and Google Colab	Python 1, 2, 3
Week 2	09/03 09/05	- Python fundamentals I - Python fundamentals II	Python 5, 6, 7
Week 3	09/10 09/12	- Python fundamentals III - Lab 1: Use geopy to calculate geodesic distances between locations	Python 8, 9, 10
Week 4	09/17 09/19	- Spatial data models & formats - Lab 1: Continue (**Paper Presentation**)	GIS *Concepts (Ch. 1)*
Week 5	09/24 09/26	- Vector data analysis - Lab 2: vector data analysis (**Paper Presentation**)	GIS *Data Model: Vector (Ch. 1)*
Week 6	10/01 10/03	- Raster data analysis - Lab 2: Continue	GIS *Data Model: Raster (Ch. 1)*
Week 7	10/08 10/10	- Machine learning fundamentals I (**Paper Presentation**) - Lab 3: raster data analysis (**Paper Presentation**)	ML Preface, 1
Week 8	10/15 10/17	- Machine learning fundamentals II - Integrating GIS and ML in geospatial projects - Lab 3: Continue (**Paper Presentation**)	ML 4
Week 9	10/22 10/24	- Regression - Lab 4: Making predictions using GIS, regression, and machine learning (**Paper Presentation**)	ML 2
Week 10	10/29 10/31	**ACM SIGSPATIAL 2024 – No Class**	ML 6
Week 11	11/05 11/07	- Decision tree and random - **Project Proposal Presentation**	ML 7
Week 12	11/12 11/14	- Geospatial clustering I - Lab 5: Integrating GIS and random forest for land use classification on remote sensing imagery (**Paper Presentation**)	ML 9

Week 13	11/19 11/21	- Geospatial clustering II - Lab 5 Continue & Project Consultant (**Paper Presentation**)	ML 9
Week 14	11/26 11/28	**Thanksgiving – No classes**	
Week 15	12/03 12/05	- Neural Network - Course summary	
Week 16	12/10	- **Final Project Presentation**	

Course Requirements

1. Lab assignments (40%)

There will be 5 lab assignments in total led by instructor/TA. Your will learn how to use different machine learning models in different geospatial projects.

2. Student research paper presentation (15%) and participation (5%)

Each student will read one scientific paper on relevant topic and present it in class (**5-8 min presentation + 2 min Q&A**). You will receive a paper list early in the semester to choose the paper to present and the date of presentation:

- Undergraduate: each student can pick a general GeoAI review paper
- Graduate: each student can pick a GeoAI technical paper

Please submit the **PDF file of your presentation**. To share with the class, please also **post the original article on a designated discussion board**. The due date is your presentation day. For technical papers, your presentation should introduce the research problem, research objective, methodology, and findings/results addressed in the article, as well as your critique if any. The presentation will be graded by the instructor.

3. Course project (40%)

The course project can be about using any GeoAI models on a specific geospatial research problem.

The project needs to be conducted by:

- A team of no more than 3 undergraduate students;
- Or one graduate student.

Submission:

1) Make a short project proposal presentation on Week 11 (**5-8 min + 3 min QA**). **(10%)**
2) Make a final presentation of the project on Week 16 (**10 min + 5 min QA**). **(30%)**

The presentation will be graded by teaching assistant, and the instructor. The weight for each group is - **teaching assistant (30%), and the instructor (70%)**.

Grade weighting scheme

Component	Weight
Lab assignment (5)	40%
Research Paper Presentation (1)	15%
Participation	5%
Course project proposal presentation	10%
Course project presentation	30%

Final Letter Grades: The final letter grade will be determined according to the scale below.

A : [90,100]	**C :** [74, 77)
A-: [88,90)	**C-:** [70, 74)
B+: [86, 88)	**D+:** [67, 70)
B : [83, 86)	**D :** [64, 67)
B-: [80, 83)	**D-:** [60, 64)
C+: [77, 80)	**F:** <60

Due Dates: All Assignments must be completed on time. Submittal of assignments after due dates is accepted but with a penalty as 10% of the percentage grade for each day they are late (note: anytime passing the due time will be counted as late for one day, and anytime passing the first late day will be counted as late for two days, and so forth). Submissions that are late for more than 5 days will not be accepted. Late in-class assignments will not be accepted. In each case, exceptions are possible only with documentation of a medical or family emergency.

Academic Honesty: Cheating and plagiarism will automatically earn zero (0) points for the assignment or exam. All academic work must meet the standards contained in "A Culture of Honesty." Each student is responsible to inform themselves about those standards before performing any academic work.