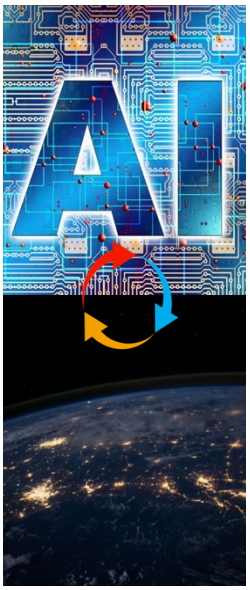
# GEOG 4592/6592:
# Advanced Geospatial Artificial Intelligence
*Spring 2024*

## Course Description

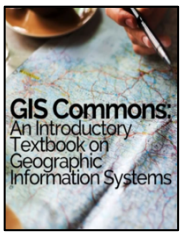


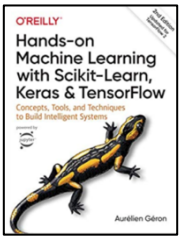

Artificial Intelligence (AI) has received tremendous attention from academia, industry, and the general public in recent years. From a geospatial point-of-view, GeoAI, as an interdisciplinary field of Geography/GIScience and AI, advocates the idea of developing and utilizing AI techniques to address a variety of problems related to both the natural environment and our human society. In this course, we will explore different deep learning models and their applications on geospatial problems. We use discuss multiple neural network architectures such as convolutional neural networks, recurrent neural networks, graph neural networks, and so on. 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) as well as multiple deep learning libraries (e.g., PyTorch, PyTorchGeometry) to implement deep learning models.

## Course Information

- **Course number**: GEOG 4592/6592
- **Credits**: 3
- **Lectures:** TR, 15:55-17:10, 01/08/2024 – 04/29/2024
- **Location:** Geography-Geology Building, Room 321
- **Instructor**: Dr. Gengchen Mai
    - **Email**: gengchen.mai25@uga.edu
    - **Office hours**: Tuesday 14:30-15:30
    - **Office**: Geography-Geology Building, Room 312
- **Teaching Assistant**: Arman Oliazadeh
    - **Email**: ao49206@uga.edu
    - **Office hours**: Monday 16:00 – 17:00
    - **Office**: Geography-Geology Building, Room 313

## 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
  **(referred as "ML" in the syllabus)**

## Course Website

The website of this course is available on UGA ELC Website.

## Prerequisites

This course does not have a formal prerequisite yet. However, ideally, you should have taken GEOG 4591/6591: Intro to GeoAI and have working knowledge about python programming and basic machine learning knowledge before taking this upper level course. If not, you may consider taking the following courses first:

- Basic programming background: CSCI 1300-1300L, CSCI 1301, C1360, CSCI 2720, CSCI 2725, GEOG 4590/6590, ATSC 4100/6100, or equivalent
- GeoAI/Machine Learning/Data Science: GEOG4920/6920, GEOG4591/6591, GEOG8350, CSCI 3360, CSCI 4380/6380, CSCI(STAT) 6375, or equivalent

## Software Environment

- Anaconda (a python-based software suite)
- Jupyter Notebook,
- Google Colab

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 | 01/09<br>01/11 | - **Lecture 1:** Introduction - Couse logistics<br>- **Lecture 1:** Introduction - Deep learning for geospatial tasks | *ML 10* |
| Week 2 | 01/16<br>01/18 | - **Lecture 2:** Deep learning - core ideas and basics I<br>- **Lecture 2:** Deep learning - core ideas and basics II | *ML 10* |
| Week 3 | 01/23<br>01/25 | - **Lecture 3:** Google Colab and PyTorch I - Basic<br>- **Lecture 3:** Google Colab and PyTorch II - Demo<br>**(Instructor Leave for a conference)** | *ML 10* |
| Week 4 | 01/30<br>02/01 | - **Lecture 4:** Deep learning for vector data and Hyperparameter Tuning I - Basic<br>- **Lecture 4:** Deep learning for vector data and Hyperparameter Tuning II – Demo<br>**(Instructor Leave for a conference)** | *Lab reading materials* |
| Week 5 | 02/06<br>02/08 | - **Lecture 5:** Convolutional Neural Network (CNN) I - Basic Concepts<br>- **Lab 1**: Building a deep neural network model for predicting housing prices at different locations **(Paper Presentation #1)** | *GIS: Raster (Ch. 1)* |
| Week 6 | 02/13<br>02/15 | - **Lecture 5:** CNN I - Building CNN for geospatial images<br>- Demo **(Paper Presentation #2)**<br>- **Lab 1: Continue**<br>**(Instructor Leave for a conference)** | *ML 14* |
| Week 7 | 02/20<br>02/22 | - **Lecture 6:** CNN II - Data augmentation and transfer learning **(Paper Presentation #3)**<br>- Project Consultant **(Paper Presentation #4, #5, #6, #7)** | *ML 14* |
| Week 8 | 02/27<br>02/29 | - **Lecture 6:** CNN II - Transfer learning on image data Demo<br>- Guest Speaker: Dr. Zhuo Zheng, Postdoc at Stanford Computer Science<br>- **Final Project Proposal Due** | *ML 15* |
| Week 9 | 03/05<br>03/07 | - **Spring break – No class** | - |

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|---|---|---|---|
| Week 10 | 03/12<br>03/14 | - **Lecture 7:** Recurrent neural networks (RNN) I - Basic concepts<br>- **Lab 2**: Classifying remote sensing images with data augmentation and transfer learning **(Paper Presentation #8)** | |
| Week 11 | 03/19<br>03/21 | - **Lecture 8:** RNN II - Attention mechanism<br>- **Lab 2**: Continue **(Paper Presentation #9)** | |
| Week 12 | 03/26<br>03/28 | - **Lecture 9:** RNN III: RNN for Trajectory Encoding<br>- **Lab 3**: RNN for analyzing geospatial data **(Paper Presentation #10)** | |
| Week 13 | 04/02<br>04/04 | - **Lecture 10:** Transformer: Self-attention + Position Encoding<br>- **Lab 3**: Continue **(Paper Presentation #11)** | |
| Week 14 | 04/09<br>04/11 | - **Lecture 11:** Spatially Explicit AI and Location Encoding<br>- **Lab 4**: Redesign Lab 1 model by adding location encoders to make spatially explicit AI model **(Paper Presentation #12)** | |
| Week 15 | 04/16<br>04/18 | **AAG Week: No Thursday class** | |
| Week 16 | 04/23<br>04/25 | **- Guest Speaker: Dr. Zhaonan Wang, Postdoc at UIUC Geography and GIS**<br>- **Lab 4**: Continue | |
| Week 18 | 04/30 | - Work on final project | |
| Week 19 | 05/02 | - Final Project Presentation (15:30 – 18:30) | |

***Course project paper is due on May 6, 2024, 23:59 (at midnight).**

***Spring 2024 grades due is May 15, 2024, 12:00 pm.**

## Course Requirements

### 1. Lab assignments (40%)

There will be 4 lab assignments in total led by TA. Your will learn how to use different deep learning models in different geospatial projects.

### 2. Student research paper presentation (10%) and participation (5%)

Each student will read one scientific paper on relevant topic and present it in class (**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/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. Invited Talk Summary (5%)

There will be 2+ invited talks at UGA GeoAI talk series. All students are required to attend at least one of them and submit **a one-page summary (12 font, 1.5 line space) of one invited talk** after it.

### 4. Course project (45%)

The course project can be about using any deep learning-based 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.

**Note**: Undergraduate students can choose to finish a final project assignment instead of a course project. If so, the student needs to submit a critic about the paper assigned to him/her for research paper presentation instead of a project proposal.

**Submission**:

1) Write a project proposal/research paper critic (**1-2 pages, dual in Week 8**). The instructor will provide feedback on the proposed project idea. **(10%)**
2) Finish the proposed project and submit a scientific paper of it (**4-12 pages including references**). Submit the paper in ELC. **(25%)**
3) Make a final presentation of the project. **(10%)**

Both project proposal and final paper should use IJGIS word template or Overleaf LaTeX template. Please **submit a single PDF for each submission**.

The presentation will be graded by all other students, teaching assistant, and the instructor. The weight for each group is - **all other students (40%), teaching assistant (20%), and the instructor (40%)**. The **maximum and minimum score from students will not be considered**.

## Grade weighting scheme (Course Project)

| Component | Weight |
|---|---|
| **Lab assignment (4)** | 40% |
| **Research Paper Presentation (1)** | 10% |
| **Participation** | 5% |
| **Invited Talk Summary (1)** | 5% |
| **Course project proposal** | 10% |
| **Course project paper** | 20% |
| **Course project presentation** | 10% |

## OR Grade weighting scheme (Final Assignment for Undergraduate Students)

| Component | Weight |
|---|---|
| **Lab assignment (4)** | 40% |
| **Research Paper Presentation (1)** | 10% |
| **Participation** | 5% |
| **Invited Talk Summary (1)** | 5% |
| **Research Paper Critic** | 10% |
| **Final Assignment Report** | 20% |
| **Final Assignment presentation** | 10% |

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.