Spring 2025 Advanced Environmental Geomatics 11:573:462

Case Study: Geospatial Artificial Intelligence (GeoAI) and Machine Learning Data Analysis

ENRS 237 M-Th 10:20-11:40am

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Course website on canvas.rutgers.edu

One of the most exciting recent advancements in the field of geospatial information science is the development of geospatial artificial intelligence or GeoAI. GeoAI is or can potentially applied to everything from the detection and identification of real-world objects in aerial imagery to the "mining" of spatial-temporal patterns of "Big Data" sets.

Class format and expectations: The class will be taught in a practicum format with an emphasis on student-driven learning through practical hands-on individual and group projects. The course will require self-directed effort on the part of the students to learn how to use a variety of GeoAI tools and data mining approaches in the ESRI toolbox and R package. There will be a targeted focus of the Imagery AI toolset for object detection and pixel classification deep learning algorithms. We will also work with the ArcPro image analysis tools to generate our own maps of migratory stopover habitat. The class will be held in person twice per week for instruction and project consulting.

The class will culminate in a larger group project with the objective of applying deep learning to automate feature extraction from a variety of imagery sources. This will require students to identify an information need, research algorithmic approaches, translate that into a workflow, then code or implement it (see Course G&O below). The students will use ArcGIS Online/StoryMaps to document and communicate their projects.

The faculty and staff at Rutgers are committed to your success. Students who are successful tend to seek out resources that enable them to excel academically, maintain their health and wellness, prepare for future careers, navigate college life and finances, and connect with the RU community. Resources that can help you succeed and connect

with the Rutgers community can be found at success.rutgers.edu, and nearly all services and resources that are typically provided in-person are now available remotely.

Students are expected to uphold Rutger's policies concerning Academic Integrity. Please consult https://nbprovost.rutgers.edu/academic-integrity-students

Class Goals and objectives:

Given an open-ended problem, it is the course's goal that students will be expected to:

1) Identify components of a spatial problem;
2) Propose a workflow that identifies appropriate analytical approaches, tools, data, etc. needed to address the spatial problem;
3) Be able to execute an acceptable solution;
4) Be able to evaluate the results and assess how to improve the outcome in the future;
5) Be able to communicate the results to others.

The class will strengthen project planning/implementation, spatial/image analysis and written/oral/graphic/web communication skills.

Course Work/Grading:

Article Review and Critique. Each student will read, summarize and critique a paper related to the application of GeoAI and/or deep learning or data mining to address real world issues. (refer to Background Resources). Due date: January 30 (25 points)

Each student will work on the individual assignments.

Spatial statistics pattern detection (10 points)

K-Nearest Neighbor Classification (10 points)

Random Forest Classification (20 points)

Deep Learning to Classify Pixels (10 points)

Deep Learning to Classify Objects (10 points)

Finetuning Deep Learning models (10 points)

Team Project. Train/Refine a Deep Learning model to develop a novel information product (75 points). Each student will participate in one team project. Deliverables:

1) Individual/group project reports outlining objectives, methods, and results.

2) Completed geospatial model/analysis outputs including documentation
3) Final report on class project in both hard-copy and web-based format
4) Self-critique of your contributions to group projects

Individual Project: Story Map. Each student will develop a story map related to the group project. (25 points)

Late assignments will be deducted by 10% of total pts for each day late.

Tentative Schedule

Since the students are asked to help design the process and agenda for the semester, it is expected that THIS SCHEDULE WILL CHANGE.

January 23 Introduction & Class Logistics

Homework: Complete Fundamentals of AI & ML screen grab Knowledge Check and submit to CANVAS
Introduction to AI https://learn.microsoft.com/en-us/training/modules/get-started-ai-fundamentals/1-introduction

Introduction to Machine Learning https://learn.microsoft.com/en-us/training/modules/fundamentals-machine-learning/1-introduction

Jan 27-30	*Cluster/Hot Spot analysis*
Feb 3-Feb 6	*Unsupervised Classification*
Feb 10-13	*Training Random Forest Classification*
Feb 17-20	*Applying Random Forest Classification*
Feb 24-27	Neural Networks and Deep Learning
Mar 3-6	Deep Learning to Classify Pixels & Objects
Mar 10-13	Deep Learning: fine tuning models
March 17-20	Spring Break
Mar 24	Class Project Work Day: Discuss topics and teams
Mar 27	Topic: GIS Ethics
Mar 31	Class Project Work Day/Consulting
Apr 3	Topic: Will AI Save or Ruin the planet?
Apr 7	Class Project Work Day/Consulting
Apr 10	Topic: Will AI replace GIS jobs?
Apr 14	Class Project Work Day/Consulting
Apr 17	Story Maps
Apr 21-24	Class Project Work Day/Consulting
Apr 28-May 1	Class Project Work Day/Consulting
May 5	Final Presentation

Readings: The following is an initial list of readings with due date.

January 27
Arthur Getis. Spatial Statistics. Chap 16. Geographical information systems, 1, 239-251..pdf https://www.geos.ed.ac.uk/~gisteac/gis_book_abridged/files/ch16.pdf

Stephanie E Hampton, Carly A Strasser, Joshua J Tewksbury, Wendy K Gram, Amber E Budden, Archer L Batcheller, Clifford S Duke, and John H Porter. 2013.
Big data and the future of ecology. *Front Ecol Environ* 2013; 11(3): 156–162, doi:10.1890/120103

January 30

Krzysztof Janowicz, Song Gao, Grant McKenzie, Yingjie Hu & Budhendra

Bhaduri (2020) GeoAI: spatially explicit artificial intelligence techniques for geographic knowledge discovery and beyond, International Journal of Geographical Information Science, 34:4, 625-636, DOI: 10.1080/13658816.2019.1684500

Feb 3
Glenn De'ath; Katharina E. Fabricius. 2000. Classification and Regression Trees: A Powerful Yet Simple Technique for Ecological Data Analysis. Ecology, Vol. 81, No. 11. pp. 3178-3192

Feb 10
LEO BREIMAN. 2001. Random Forests. Machine Learning, 45, 5–32, 2001

Feb 24
Yann LeCun Yoshua Bengio & Geoffrey Hinton. 2015. Deep learning. Nature doi:10.1038/nature14539

March 27
A GIS Code of Ethics. GIS Certification Institute. https://www.gisci.org/Ethics/Code-of-Ethics

Apr 3 selected readings on AI and energy demands
https://www.nytimes.com/2024/08/26/climate/ai-planet-climate-change.html
https://www.nytimes.com/2024/10/22/climate/ai-big-tech-emissions.html
https://www.newyorker.com/news/daily-comment/the-obscene-energy-demands-of-ai

April 10 selected readings
https://www.nytimes.com/2023/06/02/opinion/ai-coding.html
https://www.linkedin.com/advice/0/what-do-you-automation-artificial-intelligence-cvvbc#:~:text=As%20automation%20and%20artificial%20intelligence,face%20of%20these%20technological%20advancements.

https://www.linkedin.com/pulse/future-gisgeospatial-ai-linda-stevens#:~:text=Where%20is%20that%20data?,answer%20and%20maps%20pop%20up!&text=I%20know%20the%20first%20thing,understanding%20are%20in%20our%20hands.
https://www.geoweeknews.com/blogs/chatgpt-artificial-intelligence-is-the-geospatial-industry-going-to-be-affected-by-the-current-ai-boom

Background Resources

https://www.geeksforgeeks.org/introduction-convolution-neural-network/

https://pro.arcgis.com/en/pro-app/latest/tool-reference/feature-analysis/an-overview-of-the-standard-feature-analysis-toolbox.htm

https://pro.arcgis.com/en/pro-app/latest/tool-reference/raster-analysis/an-overview-of-the-analyze-patterns-toolset.htm

https://pro.arcgis.com/en/pro-app/latest/tool-reference/spatial-statistics/an-overview-of-the-spatial-statistics-toolbox.htm

https://pro.arcgis.com/en/pro-app/latest/tool-reference/spatial-analyst/an-overview-of-the-spatial-analyst-toolbox.htm

https://spatialstats-analysis-1.hub.arcgis.com/

https://pro.arcgis.com/en/pro-app/latest/help/analysis/image-analyst/classify.htm

https://pro.arcgis.com/en/pro-app/latest/tool-reference/image-analyst/an-overview-of-the-segmentation-and-classification-tools-in-image-analyst.htm

https://pro.arcgis.com/en/pro-app/latest/tool-reference/image-analyst/understanding-segmentation-and-classification.htm

https://pro.arcgis.com/en/pro-app/latest/tool-reference/image-analyst/an-overview-of-the-deep-learning-toolset-in-image-analyst.htm

ESRI Story Maps

StoryMaps https://storymaps.arcgis.com/en/how-to/

Storytelling with Maps: Workflows and Best Practices
https://www.esri.com/arcgis-blog/products/story-maps/mapping/how-to-make-a-story-map/

StoryMap App templates https://storymaps.arcgis.com/en/app-list/

http://storymaps.esri.com/downloads/Building%20Story%20Maps.pdf

https://storymaps.arcgis.com/en/resources/