Geog 573: Advanced Geocomputing & Geospatial Big Data Analytics

(listed as a special topic course 675 in Spring 2019)

Credit: 4 units (3 units for the special topic course)
Lectures (380 Science Hall): Tuesday & Thursday 4:00 PM-5:15 AM
Labs (380 Science Hall): Tuesday & Thursday 4:00 PM-5:15 AM (Dates will be announced in the class)

Instructor: Prof. Song Gao
Office Hours: Tuesday 1:00-2:00 PM, Thursday 1:00-2:00 PM, or by appointment (421 Science Hall)
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Overview

Geospatial Big Data is an extension to the concept of Big Data with emphasis on the geospatial component and under the context of geography or geosciences. It is used to describe the phenomenon that large volumes of georeferenced data (including structured, semi-structured, and unstructured data) about various aspects of the Earth environment and society are captured by millions of environmental and human sensors in a variety of formats such as remote sensing imageries, crowdsourced maps, geotagged videos and photos, transportation smart card transactions, mobile phone data, location-based social media content, and GPS trajectories. This course will introduce the theory, techniques, and analytical methods for Big Data GIS. Methods for storing, processing, analyzing, and visualizing various types of geospatial big data using advanced Python programming will be introduced. The course is designed for students who have programming experience or have finished Geog378 previously and want to reinforce the programming skills and learn AI and machine learning methods for solving geospatial big data problems. This course includes lectures and lab exercises. The knowledge and skills learned in this course further prepare students for an emerging career of (Geospatial) Data Science.

Course Learning Objectives

- Understand the fundamental concepts in geospatial big data
- Understand the characteristics involved in developing computational models and analytical methods for geospatial big data;
- Know the challenges in storing, managing, processing, analyzing, visualizing and verifying the quality of data
- Know the major high-performance platforms for big data processing
- Be familiar with Python programming for (spatiotemporal) data analysis and machine leaning tasks
- Work and collaborate in teams and get things done under time pressure.

Modules

Module 1: (Geospatial) Big Data basics and core concepts: understand the core concepts and characteristics, the ecosystem of geospatial big data platforms.

Module 2: (Geospatial) Big Data technologies and tools: introduce main stream computing platforms and technologies for processing (geospatial) big data.

Module 3: Advanced GIS and machine learning algorithms (learn several advanced GIS algorithms such as constructing minimum bounding geometry, classification, spatial clustering algorithms, and network data analysis)

Module 4: Open-source geospatial big data analysis and applications: utilize open-source machine learning libraries and scalable platforms to analyze various types of geospatial big data including but not limit to remote sensing image data, LiDAR point cloud, textual documents, GPS trajectories, road networks.

Modules	Week	Lectures	Labs
Module 1: Foundations	1	Introduction to Big Data Paradigm and Geospatial Big Data	Structure and unstructured geospatial data conversion
	2	Geospatial big data storage and processing solutions	
Module 2: Technology and Tools	3	Hadoop and MapReduce	MapReduce Programming
	4	Spark and Stream Data Processing	
Module 3: Advanced GIS Algorithms	5	Vector Data Algorithms (e.g., Spatial data clustering)	Minimum Bounding Geometry
	6	Raster Data Algorithms (e.g., classification, change detection)	
	7	Network Data Algorithms (e.g., shortest path, centrality)	OSM Street Network
	8	Geospatial Big Data Visualization Methods and Tools	
	9	Spatiotemporal Data Analytics	Spatiotemporal Data Processing
Module 4: Open-source geospatial big data analysis and applications	10	Machine learning and deep Learning for remote sensing imagery analytics	
	11	LiDAR Point Cloud analytics	Machine learning for Prediction
	12	GPS Trajectory Data analytics	
	13	Textual Documents analytics (e.g., topic modeling)	
	14	Final project presentation	

Course Materials

Textbook:

- *Introduction to GIS Programming and Fundamentals with Python and ArcGIS,* Chaowei Yang et al., 2017, CRC Press.

Recommended Readings:

- Yang, Chaowei, and Qunying Huang. Spatial cloud computing: a practical approach. CRC Press, 2013.
- Géron, Aurélien. *Hands-on machine learning with Scikit-Learn and TensorFlow: concepts, tools, and techniques to build intelligent systems*. O'Reilly Media, Inc., 2017.
- Richert, Willi. Building machine learning systems with Python. Packt Publishing Ltd, 2013.
- Chollet, Francois. *Deep learning with python*. Manning Publications Co., 2017.
- Law, Michael, and Amy Collins. *Getting to Know ArcGIS Pro*. Esri Press, 2016.

All lecture slides and notes are available on the *Canvas*. Notice that our communication will be almost exclusively through the messaging platform on *Canvas*. It is advised that you set up your email alerts in Canvas to send you daily updates about assignments, communication from your instructors, TAs, and changes to the course. See instructions at: https://guides.instructure.com/m/4212/l/710344-how-do-i-set-my-canvas-notification-preferences-as-a-student

Grading

60% Lab Assignments + 40% Final Project

Course grades will be based on the laboratory assignments (60% of total grade), and one final project (40% of total grade). Lab assignments will require Python programming based on lecture material. Lab assignments are not scheduled weekly and dates will be announced during the lectures. There is no final exam for this course. But you will have one final project to solve a problem related to your area of study or topic of interest using big-data-driven analysis methods that you learn in this course.

Grading Scale:

Score	Grade	Grade Points Per Credit
> or = 90	A (Excellent)	4
86 ~ 89.99	AB (Intermediate grade)	3.5

80 ~ 85.99	B (Good)	3
76 ~ 79.99	BC (Intermediate grade)	2.5
70 ~ 75.99	C (Fair)	2
60 ~ 69.99	D (Poor)	1
< 60	F (Failure)	0

More information: https://registrar.wisc.edu/grades_and_gpa.htm

Attendance (Required)

You must attend all lectures & lab sessions and complete all course assignments and quizzes on time. You should appropriately comment all code you submit for a grade. Please seek assistance when you have a question or problem through office hours and/or your peers.

Communication & Accommodation

The University of Wisconsin-Madison supports the right of all enrolled students to a full and equal educational opportunity. The Americans with Disabilities Act (ADA), Wisconsin State Statute (36.12), and UW-Madison policy (Faculty Document 1071) require that students with disabilities be reasonably accommodated in instruction and campus life. Reasonable accommodations for students with disabilities is a shared faculty and student responsibility. Students are expected to inform faculty of their need for instructional accommodations by the end of the third week of the semester, or as soon as possible after a disability has been incurred or recognized. Faculty will work either directly with the student or in coordination with the McBurney Center to identify and provide reasonable instructional accommodations. Disability information, including instructional accommodations as part of a student's educational record, is confidential and protected under FERPA. If you face any personal or professional difficulties or require accommodation or a disability, please feel free to contact me as soon as possible.

Academic Integrity

Academic Integrity is critical to the mission of the University of Wisconsin-Madison, a research institution with high academic standards and rigor. All members of the University community play a role in fostering an environment in which student learning is achieved in a fair, just, and honest way. Plagiarism is prohibited in lab assignments and quizzes. Any offense results in a zero for the grade and disclosure of the impropriety to the Department and University.