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GGS 210
Introduction to Spatial Computing

1. General Information

Instructor: Dr. Ziheng Sun
Where: Exploratory Hall 2312
When: Thursday: 1:30pm – 4:10pm
Course website: Blackboard
Credits: 3
Prerequisites: None
Office Hours: see Blackboard Website
Email: zsun@gmu.edu

2. Course Description

Spatial computing, which focuses on analyzing spatial datasets of any scale, is a fundamental technique supporting many of our daily scenario applications. Via spatial computing, web maps like Google Maps and Apple Maps, smart phones with GPS enabled, have brought a lot of benefits and innovative conveniences and helped address many vital problems in our society. For example, today we always know where we are, where nearby points of interest such as restaurants are, and how to go there. Reporters use spatial computing to analyze the trends of socioeconomics and political polls. Scientists use spatial computing to analyze the changing pattern of research objects or phenomenon. Farmers use spatial computing to realize smart agriculture to increase crop yields while reducing costs and sustaining the environment. Large companies and institutes use spatial computing for site selection, asset tracking, facility management, navigation, and logistics.

This course introduces the theory and techniques of spatial computing to students. It will expose students to basic techniques for spatial data collection, storage, processing and mining. Students will learn how to work with geospatial objects, such as points, lines and polygons and will get hands-on experiences of operating them using Python. Some basic geometric algorithms like point-in-polygon and line-segment intersection will be presented. The simple principle of spatial navigation, such as the shortest path algorithm will be introduced. Existing technical challenges such as further automatically extracting information from geospatial data will be discussed. Students will obtain knowledge of analyzing geospatial data and get hands-on experiences in groups.

As part of the hands-on teaching, this course will provide a number of tutorials to programming in Python. Students will learn how to use Python for imperative and object-oriented programming to read and analyze simple spatial data. Advanced analysis concepts including regression, clustering and classification will be taught. In addition, intelligent spatial data mining, geospatial cyber security, personal location privacy, future spatial computing techniques will be anticipated.

3. Learning Outcomes

By the end of the course each student will be able to:

- Have broad knowledge of spatial data analysis
- Possess the ability to load, visualize and analyze spatial data
- Understand and be able to use basic geometric algorithms.
- Know about advanced data analysis techniques such as regression, clustering, outlier detection and classification.
- Be able to utilize Python packages for tasks of advanced spatial analysis and data science in future jobs or researches.
- Be able to effectively communicate ideas related to Spatial Data Management and Data Analysis with experts, non-experts, and other professionals in a work environment.
- Be able to appropriately apply the learn knowledge on real-world data.
- Analyze a given dataset in a team, using free tools such as Python, PySAL, and Weka.

4. Format

The course will be taught as a combination of lectures and tutorials.

5. Textbooks

None

6. Technology Requirements

Hardware

You will need access to a Windows or Macintosh computer with at least 2 GB of RAM and to a fast, reliable Internet connection (e.g., cable, DSL).
Consider the amount of computer hard disk space required to submit your assignments online and allow for the space needed to save your course assignments.

Software

Concepts and algorithms will be implemented using the programming language Python. An introduction to geo-statistics and data mining will be given using the statistical and data mining libraries in Python. All of these language and tools are free to download and use.

7. Course Outline (tentative)

In this course we will cover the following topics (please note that the topics and their order are subjected to change at the discretion of the instructor, any changes will be announced in class):

Date	Mod. #	Topic	Assignment
01/23	1	Motivation: Big Spatial Data and Location Revolution in Human Society	Assignment 1: Introduction
01/30	2	Intro to basic programming in Python, Spatial Data types. Tutorials on simple examples and applications.	Assignment 2: Getting started with Python
02/06	3	Spatial Algorithms: Point in Polygon; Line Segment Intersection	Assignment 3: Geometric Algorithms

02/13	4	Intro to Programming in Python: Assignment discussions Geometric Algorithms: assignment discussions	Assignment 2+3
02/20	5	Network algorithm: Shortest Path Algorithms Dijkstra's Algorithm	Assignment 4: Shortest Path
02/27	6	Advanced algorithms: Path and Motion Planning: Collision-free shortest path. Assignments Discussions. Midterm Q&A	Assignment 4
03/05	-	Midterm	
03/09-03/15	-	Spring Break (No Classes)	
03/19	7	Introduction of significance: birthday paradox. Gambler's paradox.	Assignment 5: Birthday paradox
03/26	8	Introduction to stochastics (discrete and continuous random variables) Stochastic Processes and Simulation	Assignment 6: Stochastics
04/02	9	Introduction to Data Mining: Overview of regression, outlier detection and classification Linear Regression	Assignment 7: Linear Regression
04/09	-	No Class (Instructor unavailable) Optional: Python Programming Session with Grad Students	
04/16	10	How not to analyze data: data dredging and the multiple-testing-problem Assignments discussions	Assignment 5+6+7
04/23	11	Overview of Spatial Clustering Algorithms: k-means	Assignment 8: K-means
04/30	12	Overview of Classification Classification: KNN	Assignment 9: Classification
05/07	13	Assignment Discussions. Introduction to Machine Learning and Artificial intelligence in GIS. Final Exam Q&A.	Assignment 8+9 due
05/06-05/13	-	Final Exam (Exact date and time to be defined by Office of the University Registrar)	

8. Grades

Each assignment and written exam will be given a numerical grade on a 0-100 scale. Some assignments may include bonus tasks. At the end of the term all the marks will be totaled as a weighted average according to the following weights:

Intermediate assignments	**20%**
Midterm Exam	**40%**
Final Exam	**40%**

Final grades at the end of the course will be assigned using **ONLY absolute achievements** not considering relative standing in the class.

9. Exams

The course includes a mandatory written mid-term and final exam. The material covered in the exams will be announced in class. A student who cannot write a course examination or complete a course assignment because of an incapacitating illness, severe domestic affliction or other compelling reasons can apply for extension of time to complete an assignment.

10. Assignments:

The course will include several written assignments on selected topics from the material covered in class and in the assigned reading.

Assignments should be done through the Blackboard course website.

Notice: Assignments should be submitted only through the Assignment submission section of the Blackboard system - **DO NOT** email assignments directly to the instructor.

11. Late Papers Submission:

Papers submitted **after the due date will not be accepted**. Exceptions to this policy may be made given serious circumstances at the discretion of the Instructor.

Notice: Deferral of term work is a privilege and not a right; there is no guarantee that a deferral will be granted. Please make sure you notify the instructor as soon as you know a deferral is required.

12. General guidelines for ASSIGNMENT preparation and submission

a. Grades of assignments will be based on:

- **Academic merit** of your answers.
- **Conciseness** and **completeness** of your answers. Please write to the point and explicitly address the question or task. Avoid using unnecessary graphics (figures, tables, graphs etc.) unless they serve a specific purpose. Make sure to use captions and to refer to the graphics you include in your written answer. Graphics without any reference or accompanying explanation will be disregarded.
- **Organization** and **presentation**. Remember that your assignment report is a reflection of your thinking and learning process. Please organize your report in a logical fashion so that your answers could be easily identified. A general format for your presentation should, as a minimum, include the following components: (1) Question number, (2) Your written answer and/or description and discussion of your results, and (3) Visualization of your results, e.g. images, graphs, tables, as necessary.

b. Please remember that your assignment is a professional document, and should therefore be formatted and constructed accordingly. All assignments are to be typed. Hand-written assignments will not be accepted.

c. Submission of a hardcopy will be made in class; submission of a softcopy will be made through Blackboard.

d. The electronic submission of your assignment report has to be in PDF format.

e. If more than one file is submitted, you may submit a single ZIP file containing all the assignment files.

f. Each assignment submission should include a cover page with the following information: assignment title, assignment number, student name, and submission date.

g. Please make sure you have a backup of all the materials you submit.

13. Course website

The course has a Blackboard website. This website will provide you a single portal through which you may obtain lecture notes, retrieve assignment data and, review links to additional materials, and receive special announcements. You are required to visit the course website once per day. Please notify ITU (and, if necessary, the instructor) if you encounter any problems accessing this website.

14. Electronic communication

All course related email correspondence, including submission of assignments, should be made through the course Blackboard website. Please **DO NOT** send emails to the instructors' @gmu.edu address.

15. Student Expectations:

- Academic Integrity: Students must be responsible for their own work, and students and faculty must take on the responsibility of dealing explicitly with violations. The tenet must be a foundation of our university culture. [See http://academicintegrity.gmu.edu/distance].
- Honor Code: Students must adhere to the guidelines of the George Mason University Honor Code [See http://oai.gmu.edu/the-mason-honor-code/].
- MasonLive/Email (GMU Email): Students are responsible for the content of university communications sent to their George Mason University email account and are required to activate their account and check it regularly. All communication from the university, college, school, and program will be sent to students solely through their Mason email account. [See https://masonlivelogin.gmu.edu].
- Patriot Pass: Once you sign up for your Patriot Pass, your passwords will be synchronized, and you will use your Patriot Pass username and password to log in to the following systems: Blackboard, University Libraries, MasonLive, myMason, Patriot Web, Virtual Computing Lab, and WEMS. [See https://password.gmu.edu/index.jsp].
- University Policies: Students must follow the university policies. [See http://universitypolicy.gmu.edu]. Responsible Use of Computing - Students must follow the university policy for Responsible Use of Computing. [See http://universitypolicy.gmu.edu/policies/responsible-use-of-computing].
- University Calendar: Details regarding the current Academic Calendar. [See http://registrar.gmu.edu/calendars/index.html].
- Students with Disabilities: Students with disabilities who seek accommodations in a course must be registered with the George Mason University Office of Disability Services (ODS) and inform their instructor, in writing, at the beginning of the semester. [See http://ods.gmu.edu].
- Students are always expected to follow courteous Internet etiquette. [See http://www.albion.com/netiquette/corerules.html for more details]

Student Services:

- University Libraries: University Libraries provides resources for distance students. [See http://library.gmu.edu/distance and http://infoguides.gmu.edu/distance_students].
- Writing Center: The George Mason University Writing Center staff provides a variety of resources and services (e.g., tutoring, workshops, writing guides, handbooks) intended to support students as they work to construct and share knowledge through writing. [See http://writingcenter.gmu.edu]. You can now sign up for an Online Writing Lab (OWL) session just like you sign up for a face-to-face session in the Writing Center, which means

YOU set the date and time of the appointment! Learn more about the Online Writing Lab (OWL).

- Counseling and Psychological Services: The George Mason University Counseling and Psychological Services (CAPS) staff consists of professional counseling and clinical psychologists, social workers, and counselors who offer a wide range of services (e.g., individual and group counseling, workshops and outreach programs) to enhance students' personal experience and academic performance. [See http://caps.gmu.edu].
- Family Educational Rights and Privacy Act (FERPA): The Family Educational Rights and Privacy Act of 1974 (FERPA), also known as the "Buckley Amendment," is a federal law that gives protection to student educational records and provides students with certain rights. [See http://registrar.gmu.edu/privacy].

Disclaimer: Any typographical errors in this Course Outline are subject to change and will be announced in class. The date of the final examination is set by the Registrar and takes precedence over the final examination date reported by the instructor.

Note: Recording is permitted only with the prior written consent of the professor or if recording is part of an approved accommodation plan.