Department of Geography and Geoinformation Science
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GGS 210

Introduction to Spatial Computing

1. General Information

Instructor:	Dr. Andreas Züfle
Where:	Exploratory Hall 2312
When:	Tuesday, Thursday: 12:00pm – 1:15pm
Course website:	Blackboard
Credits:	3
Prerequisites:	None
Office Hours:	see Bb site

2. Course Description

The transformational potential of Spatial Computing is evident. Using Virtual Globes, such as Google Maps and Microsoft Bing Maps, and using hand-held GPS devices integrated in smart phone, our society has benefitted immensely from spatial technology. Using this technology, we always know, precisely, where we are, where nearby points of interest such as restaurants are, and how to reach these points of interest. Large organizations use Spatial Computing for site-selection, asset tracking, facility management, navigation, and logistics. Scientists use GPS to track endangered species to better understand behavior, and farmers use GPS for precision agriculture to increase crop yields while reducing costs.

This course introduces students to Geo-Spatial Data Analysis. It will expose students to basic techniques for data collection and storage, data processing and data mining using location data. Students will learn to work with geospatial objects, such as points, lines and polygons and will get hands-on experience in processing spatial data. Basic geometric algorithms for point-in-polygon tests and line-segment intersection tests will be presented. Techniques for spatial navigation, such as shortest path algorithm in free space and in spatial networks will be presented. Technical challenges such as storing, reading and parsing geospatial will be discussed and students will be hands-on experience analyzing geo-spatial data in groups.

To analyze data, this course will provide a tutorial to programming in Python. Students will learn how to use Python for imperative and object-oriented programming to read and analyze spatial data. Advanced analysis concepts including regression, clustering and classification of data will be taught. In addition, awareness will be raised for spatial privacy threats, and possible risks associated with uncontrolled publishing of location-based data.

3. Learning Outcomes

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

- Have a broad knowledge of data analysis techniques for spatial data.
- Have the ability to load, visualize and analyze spatial data in a database.
- Understand and apply basic geometric algorithms.
- Have knowledge about data analysis techniques such as regression, clustering, outlier detection and classification.
- utilize existing Python packages for advanced spatial analysis and data science for your future job and research.
- Articulate and effectively communicate concepts and ideas related to Spatial Data Management and Data Analysis to experts, non-experts, and other professionals in a work environment.
- Have the ability to appropriately apply the knowledge acquired in the course for real-world data.
- Analyze a given dataset in a team, using free tools such as Python, Weka and R.

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 broadband Internet connection (e.g., cable, DSL).

For the amount of computer hard disk space required to submit your assignments online, consider and allow for the space needed to save your course assignments.

Software

Algorithmic concepts will be illustrated using the programming language Python. An introduction to geo-statistics will be given using the programming language R, and an introduction to data mining will be given using the data mining tool Weka. All of these languages and tools are free to download.

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
01/22	1	Motivation: Big Spatial Data (McKinsey Big Data Report, Harvard Business Review, Big Spatial Data and Data Mining)	
01/24	2	Intro to Spatial Data: Points, Lines, Polygons. Examples and applications.	Assignment 1: Introduction
01/29	3	Intro to Programming in Python	
01/31	4	Intro to Programming in Python (cont.)	Assignment 2: Getting Started with Python
02/05	-	No Class (Instructor unavailable) Optional: Python Programming Session with Grad Students	
02/07	5	Geometric Algorithms: Point in Polygon Tests	
02/12	6	Geometric Algorithms: Line Segment Intersection	Assignment 3: Geometric Algorithms
02/14	7	Intro to Programming in Python: Assignment discussions	Assignment 2: Geometric Algorithms
02/19	8	Geometric Algorithms (cont.) Assignment discussions	

02/21	9	Network Shortest Path Search: Shortest Path Algorithms	
02/26	10	Network Shortest Path Search: Dijkstra's Algorithm	Assignment 3: Shortest Path Search
02/28	11	Path and Motion Planning Algorithms: Collision-free shortest path	
03/05	12	Assignments Discussions. Midterm Q&A	
03/07	-	Midterm	
03/12 03/14	-	Spring Break (No Classes)	
03/19	13	Introduction to Data Mining: Overview of Regression, Clustering, Outlier Detection and Classification	
03/21	14	Introduction to Stochastics (Discrete and Continuous Random Variables)	Assignment 5: Stochastics
03/26	15	Intuition of Significance: Birthday Paradox. Gambler's Paradox.	
03/28	16	Introduction to Data Analysis in R	Assignment 6: Functions in R
04/02	17	Stochastic Processes and Simulation in R	
04/04	18	Linear Regression	Assignment 7: Linear Regression
04/09	19	How not to analyze data: Data dredging and the multiple-testing-problem	
04/11	20	Assignments Discussions	
04/16	21	Spatial Clustering: Overview	Assignment 7: Clustering
04/18	22	Spatial Clustering: k-means and agglomerative clustering	
04/23	23	Classification: Overview	Assignment 8: Classification
04/25	24	Classification: Decision Trees	
04/30	25	Assignment Discussions.	Assignment 7+8 due
05/02	26	Introduction to Machine Learning and Artificial Intelligence in GIS. Final Exam Q&A	
05/08- 05/15	-	Final Exam (Exact Date and Time to be defined by the 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**.

Please note: 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.

Please note: 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 expected to follow courteous Internet etiquette at all times; see http://www.albion.com/netiquette/corerules.html for more information regarding these expectations.

2. 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.