



Department of Geography and Geoinformation Science

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GGS 399

GIS Algorithms

1. General Information

Instructor:	Dr. Andreas Züfle
Where:	Exploratory Hall 2310
When:	Monday 4:30-7:10pm
Course website:	Blackboard
Credits:	3 Credits
Prerequisites:	Any Programming Language: Python, Java or C++
Office Hours:	Thursday 4:30-6pm

2. Course Description

Both the current trends in technology such as smart phones, general mobile devices, stationary sensors and satellites as well as a new user mentality of utilizing this technology to voluntarily share information produce a huge flood of geo-spatial data. Using this flood of data is a tremendous market: A "\$600 billion potential annual consumer surplus from using personal location data globally" is projected by McKinsey Global Institute. Efficient algorithms are required to store and process such large sets of geospatial data.

This course covers advanced tools of querying large sets of spatial and spatio-temporal data. The first part of this course introduces algorithms and computational complexity. In the second part, the course covers classical problems on spatial data, such as: Range-Queries, Nearest-Neighbor Queries and Distance-Ranking. To scale to large data, emphasis is on the underlying index structures, such as Locality Sensitive Hasing (LSH), Quadtrees, kD-trees, and Rtrees.

In the third part of the course, current research papers on efficient algorithms for spatial data will be discussed. In groups of 2-4 students, students will study papers on a selected topic. The groups will present the topic, discuss existing solutions, and, together with the instructor, discuss potential future directions. Following a crash-course on scientific paper writing using LaTeX, students will prepare a research report as the final deliverable for this course. Depending on the topic, this research report may be a survey of existing algorithms, or the presentation of a new algorithm.

Depending on the quality of the concept, experimental results and the judgement of the instructor, the aim is to submit these research papers to scientific conferences and journals.

3. Learning Outcomes

By the end of the course each student will:

- Have a broad knowledge-base on fundamentals, theory and techniques of GIS algorithms.
- Have a basic understand of complexity theory of algorithms and the O-Notation.
- Know how to apply spatial access methods to efficiently store and retrieve spatial data.
- Be able to articulate and effectively communicate concepts and ideas related to Spatial Data Management to experts, non-experts, and other professionals in a work environment.
- Have the ability to appropriately apply the knowledge acquired in the course for various hypothetical and real-world data.
- Know how to write scientific research papers using LaTeX.
- Have experience in writing scientific research papers, through reading of existing papers, and through hand-on paper writing by supervision of the instructor and in collaboration with other undergraduate and graduate students.

4. Format

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

5. Textbooks

No required textbook. A number of reading assignments are distributed via the course Website.

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 take an online course, consider and allow for the space needed to: 1) install the required and recommended software and, 2) save your course assignments.

Software

This course will require implementation of algorithms using a high-level programming language such as Java, Python or C++.

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
08/27	1	Introduction: Big Spatial Data	
09/03		Labor Day – University Closed	
09/10	2	Introduction to Efficient Algorithms Research Topics: Overview	Lab 1: Properties of Algorithms
09/17	3	Introduction to Complexity Theory Research Paper Handout	Lab 2: Complexity
09/24	4	Indexing: Sorted Arrays, Binary Trees, AVL Trees, B-Tree	Lab 3: Indexing
10/01	5	Spatial Indexing: R-Tree, kd-Tree, Quad-Tree Research Topic Assignment	Lab 4: Spatial Indexing
10/08	6	Efficient Spatial Algorithms: Range Queries, Nearest Neighbor Queries, Spatial Ranking Research Topic Discussions	Lab 5: Spatial Queries
10/15	7	Spatial Network Algorithms: Shortest Paths Algorithms Research Brainstorming	Lab 6: Shortest-Path Queries
10/22	8	Lab Tutorials and Midterm Q&A Research Brainstorming	
10/29	9	Midterm Exam	
11/05	10	Midterm Review Research Brainstorming	

11/12	11	Research Brainstorming In-class poster presentations for GIS-Day	Research Posters due.
11/14		<i>GIS Day: Poster Presentations!</i>	
11/19	12	Introduction to LaTeX Discussion of Research Results	Lab 7: Scientific Paper Writing
11/26	13	Introduction to ShareLaTeX More Research Discussions	
12/03	14	Final Project Presentations	
12/03	15	<i>Reading Days (no class)</i>	
12/04	16	Final Project Presentations (cont.)	

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	10%
Midterm Exam	40%
Final Project	50%

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 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 may include the writing of algorithms, in a programming language of choice of the student. Choice of programming language is subject to permission of the instructor. Common high-level languages such as Java, Python and C++ will be permitted.

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.