



Department of Geography and Geoinformation Science

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GGS 470

Applied GIS Algorithms

1. General Information

Instructor:	Dr. Andreas Züfle
Where:	Exploratory Hall 2310
When:	Monday, Wednesday 4:30-5:45pm. Aug 29, 2016 - Dec 15, 2016
Course website:	Blackboard
Credits:	3.000
Prerequisites:	Programming Languages: Python, Java or C++
Office Hours:	see Bb site

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. This course covers advanced tools of querying large sets of spatial and spatio-temporal data. The first part of the course covers classical problems on spatial data, such as: Range-Queries, Nearest-Neighbor Queries, Distance-Ranking, Reverse Queries and Shortest-Path Queries. To scale to large data, emphasis is on the underlying index structures, such as Quadrees, kD-trees, and Rtrees.

In the second part of the course, current research papers on querying large spatial data sets will be discussed. In groups of 3-5 people, new concepts for efficient query processing will be discussed and implemented. Each group will, together with the instructor, develop a research paper to document their results. 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.

3. Learning Outcomes

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

- Express a broad knowledge-base on fundamentals, theory and techniques of GIS algorithms.
- Understand the basic concept of complexity theory.
- Assess the efficiency of a GIS algorithm by theoretically analyzing the run-time of the algorithm, as well as the complexity of the underlying problem.
- Articulate and effectively communicate concepts and ideas related to Spatial Data Management to experts, non-experts, and other professionals in a work environment.
- appropriately apply the knowledge acquired in the course for various hypothetical and real-world data.
- Apply spatial access methods to efficiently store and retrieve spatial data, including points, lines and polygons
- Employ efficient graph algorithms for GIS problems located on spatial networks such as road traffic networks.
- Efficiently solve geographic related problems on an algorithmic level.

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
08/29	1	Introduction to Algorithms	Paper 1: Properties of Algorithms
08/31	2	Introduction to Complexity Theory	
09/05		Labor Day, university closed	
09/07	4	Tutorial Paper 1	
09/12	5	Dynamic Index Structures	Paper 2: Linked Lists
09/14	6	Static Index Structures	
09/19	7	1D Data Sorting Algorithms: $O(n^2)$ Algorithms	Paper 3: Sorting
09/21	8	1D Data Sorting Algorithms: $O(n \cdot \log(n))$ Algorithms	
09/26	9	Tutorial: Paper 2	

09/28	10	1D Searching Algorithms: B-Tree	Paper 4: Searching
10/03	11	1D Searching Algorithms: Linear Hashing	
10/05	12	Tutorial Paper 3	
10/10		No class – Thanksgiving Recess	
10/12	13	Tutorial Paper 4	
10/17	14	Midterm Exam	
10/19	15	Indexing Spatial Point Data: From Binary-Trees to Quad-Trees	Paper 5: Spatial Indexing
10/24	16	Indexing Spatial Point Data: The R-Tree	
10/26	17	Indexing Spatial Point Data: Local-Sensitive Hashing	
10/31	18	Tutorial Paper 5	
11/02	19	Efficient Spatial Algorithms: Index Supported Range Search	Paper 6: Efficient Spatial Algorithms
11/07	20	Efficient Spatial Algorithms: Index Supported k-Nearest Neighbor Search	
11/09	21	Efficient Spatial Algorithms: Reverse k-Nearest Neighbor Search	
11/14	22	Tutorial Paper 6	
11/16	23	Lines and Polygons	Paper 7: Lines and Polygons
11/21	24	Line and Polygon Intersection	
11/23		Thanksgiving recess	
11/28	25	Tutorial Paper 7	
11/30	26	Graph Algorithms	Paper 8: Graph Algorithms
12/05	27	Graph Algorithms (cont.)	
12/07	28	Tutorial Paper 8	
12/14	29	Final Exam	

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	30%
Midterm Exam	30%
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 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.