

Spatial Databases

Course Outline

Contact Information

Instructor: Peter Glenday,
Department of Geography and Environmental Management

Office: EV1-219

Office Hours: TBD

If you need to schedule an appointment outside of these drop-in hours, please contact me.

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From Monday to Friday, I make every effort to answer emails within 24hrs. Email sent on the weekend will normally be answered on the following Monday.

Teaching Assistants

Assistant	Email	Lab/Office hrs (Location)
		TBD
TBD	TBD	TBD

Course Presentation

Lecture: HH 334

Tuesdays, 11:30-2:20 pm

Reserved lab time: EV1-240 Galileo

Lab 101 Thurs. 2:30 - 4:20 pm

Lab 102 Fri. 11:30 - 1:20 pm

Overview

Geospatial data and information are used in a wide variety of planning, facilities management, business, resource management, location based services, and academic research. A key component of any spatially enabled solution is the underlying geospatial database that must be designed to support efficient data maintenance and analysis in a heterogeneous operating environment i.e., different users sharing common data whilst using a variety of client technologies to create, access, extract, transform, load and manage the data.

We are in an era of Big Data with exabytes of structured and unstructured geospatial data collected each day by citizens, public agencies and private enterprise. Consequently, managing, processing and using the data to derive

useful, actionable knowledge/information presents significant challenges, usually referred to as the four V's of big data: Volume; Velocity; Variety, and; Veracity. Traditional GIS and CAD methods of storing and processing data involved Shape, DXF, or LAS files or a proprietary geodatabase. Files and tiles (each feature layer having its own file replicated for multiple map sheets or tiles) are ill suited to storing, managing and processing large volumes data in multiuser, technologically heterogeneous environments.

With regards to conducting geospatial analysis, big data is big and it's more efficient to move small algorithms to the big data than moving large data volumes to the algorithms. In response to the desire to better manage geospatial data and move the algorithms to the big data, commercial Relational Database Management Systems (RDBMS) software vendors (Oracle, Microsoft, IBM, etc.) and open source e.g., PostgreSQL PostGIS geospatially enabled the RDBMS with Open Geospatial Consortium (OGC) native spatial datatypes and SQL to query the data. Moreover, the data model evolved from a file (.shp) containing geometry linked to attributes in a separate data file (.dbf) to an object model wherein the geometry is an attribute of the object (or record/row in a database) with multiple data management, processing, and end-user benefits.

This course is an introductory-level database design, implementation, management, and access course for students interested in organizing spatial and non-spatial data in geospatially enabled enterprise Relational Database Management Systems (RDBMS). Students will gain a basic understanding of database systems terminology, design principles, and issues facing database managers and analysts. We will also present a highlevel discussion of Not Only SQL (NoSQL) databases and Hadoop Distributed File System (HDFS) concepts as they relate to geospatial data. They will gain practical database experience utilizing commercial database management system software and geographic information systems software to design and use spatial and non-spatial data.

This course is a prerequisite to the Geography / Planning 487 courses and part of the requirements for the *Diploma of Excellence in GIS*. Prerequisite: Successful completion of Geography or Planning 281.

Objectives

The overarching goals of this course are: to develop a sound understanding of the principles and techniques of database design and development as they apply to geospatial data; apply these principles and techniques in designing and building geospatial databases; use geospatial databases to perform common types of queries and geospatial analyses; and publish spatial data to the internet.

Specifically, the objectives of this course are as follows:

1. To provide students with an introduction to the fundamental social and managerial dimensions of geospatial data creation and use.
2. To introduce students to enterprise geospatial database management systems, principles, terminology, architecture and technology,
3. To provide students with experience creating, documenting, editing, managing a database using a variety of software systems and tools, including:
 - ArcGIS, ArcCatalog, QGIS
 - Safe Software's Feature Manipulation Engine (FME)
 - Oracle Spatial & Graph, Oracle SQL Developer, Oracle SQL Modeler
 - Oracle JDeveloper
4. To introduce students to ArcGIS' and Oracle's commonly-used spatial analysis, query and information production procedures when connected to an RDBMS.

Upon completing this course, students will be able to:

- Develop and document a conceptual database design for a specific applied geospatial problem.
- Populate a database through a variety of means (e.g., data migration, conflation, and creation via analysis)
- Build and use key database components (e.g. attribute domains, topology rules, relationship classes) to maintain data integrity and facilitate database queries
- Possess knowledge regarding the development, operation and application of Enterprise Geospatial Database Management Systems for managing geospatial data originating from a variety of sources (CAD, GIS, GPS, Imagery & Open Source).

Text and Readings

There is no text for this course. Course notes, lecture presentations, links to readings and tutorials will be provided in this syllabus and on the **Desire2Learn** course web site (<http://learn.uwaterloo.ca>). Students are expected to make extensive use of the ArcGIS, Oracle Spatial and FME on-line help and web resources. Selected links will be provided on the course website.

Schedule

The class meets from 11:30-2:20pm on Tuesdays in HH 334. Class time will be used to introduce concepts and techniques related to spatial database design and development, demonstrate methods needed for the lab assignments, and deal with questions related to the lab exercises. Table 1 details the course schedule, lecture topics, required readings, resources, tutorials, assignment hand out and submission dates, and midterm and final test dates.

N.b. The instructor reserves the right to make changes to the schedule and content as necessary.

Learning modes and course format

This course builds upon the understanding of GIS concepts you gained in Geography / Planning 281 through a series of compulsory lectures, tutorials and lab sessions. Lectures will be used to discuss concepts, principles and techniques of geospatial database analysis, design and implementation coupled with access, query, and reporting processes using data held in a database. The third hour of the class will be used for workshops, lab demonstrations and/or for you to work on your assignments.

Hands-on work with ArcGIS, FME and Oracle Spatial, SQL Developer/Modeler will take place in the Galileo lab (EV1-240). The lab assignments are designed to build your skills in using GIS and database software systems and tools to strengthen your understanding of how geospatial analytics can be properly applied to real world problems. The Galileo lab (EV1-240) has been reserved GEOG/PLAN 387. See above for dates/times.

Note that developing a strong understanding of geospatial database concepts and the corresponding practical skills necessary to complete the assignments requires a significant investment of time. **In addition to the scheduled class and lab time, students should expect to spend at least 5 hours per week working on course assignments. These time requirements will vary from student-to-student.** Students who are unwilling or unable to make this time commitment should consider other courses.

Resources

Computer Labs

Make use of your scheduled lab time in the Galileo (EV1-240). You can also use the Geddes (EV2-1002A) lab for practical work when it's not booked for other courses.

Note: No food or drink is allowed in the labs. Failure to abide by this rule may result in your computer accounts being suspended.

Course Website

A website for this course has been created as part of the **Desire2Learn** (D2L) system. Students in the course can access the course website by going to the D2L homepage (<http://learn.uwaterloo.ca>) and entering their WATIMAID and password in the logon form displayed on this page. Once you are logged on to D2L, you will see a list of courses that you are registered in. Click on GEOG/PLAN 387 to select this course.

Getting Help

Students are expected to get into the habit of using the on-line resources as the first source of problem solving and help. I will be available in my office for consultation during regular office hours or by appointment. Additional help is available during the scheduled lab sessions and from the MAD help desk.

Evaluation

Lab assignments will account for 80% of the final mark and will be weighted as indicated in the course schedule table. There will be an in-class mid-term test (10%) and an in-class final test (10%) which in aggregate will be 20% of the final mark in the course.

Assignments must be submitted to the appropriate digital drop box on the course website by 11:55 p.m. on the specified due date. Late assignments will not be accepted and will receive a mark of 0. The assignments have been designed to be completed in the allotted timeframe. Exceptions may be made for documented medical reasons following the UW Academic policies listed below.

Table 1. Course Schedule

Date	Lecture Topics	Workshops/Demos	Readings & Resources	Tutorials	Assignments	
Jan. 03	Course Overview Evolution of GIS & Future Trends 3 tier architecture GIS	Structured & Semi-structured unstructured data Big data Assignment 1 briefing	ArcGIS 10.4 Creating a Geodatabase in ArcCatalog Loading External Data FME Workbench	Newell, R. & Theriault, DG (C.1990). Ten difficult problems building a GIS. Avail on course website Hart G. and Dolbear C. (2007). What's So Special about Spatial? In: The Geospatial Web. Springer, , pp.39-44.	ESRI Building a GeoDB 1-4 Introduction to Editing 1-2 ESRI Introduction to Editing 4-5 Building a GeoDB 6-8	
Jan. 10	Geospatial Data Models Geospatial Data Modeling Projections & Coordinate Reference Systems	Geospatial Data Standards Geospatial Metadata		Goodchild, M. (2001). A Geographer Looks at Spatial Information Theory. Güting, R (1994). An introduction to spatial database systems The VLDB Journal,3(4),pg.357-399		Hand out. Assignment 1. (10%) ESRI Geodatabase Basics
Jan. 17	Spatial vs Non spatial databases Database Types SQL Intro	Database management system architecture: conceptual, logical, and physical	Assignment 2 briefing FME Workbench Introduction to Oracle Spatial SQL Developer SQL Developer DM	Book: Chapter 1 of Pro Oracle Spatial 11g Avail. online via uwaterloo lib. Book: Preface & Chapter 1 of Applying and Extending Oracle Spatial Avail. online via uwaterloo lib.	Getting Started with FME Desktop: Part 1 and 2	
Jan. 23					Assignment 1 Due 11:55pm	
Jan. 24	Database Design Strategies System Dev Life Cycle (SDLC) CRUD	Data Models Entity-Relationship (E-R) Models Normalization Data Dictionary			Getting Started with FME Desktop: Part 3 and 4	Hand out. Assignment 2. (20%) Building a database

Date	Lectures		Workshops/Demos	Readings & Resources	Tutorials	Assignments
Jan. 31	Advanced Spatial SQL - Spatial Operators Spatial Indexes Spatial Filters	Short & Long Transactions Version Management	Oracle SQL Developer SQL Modeler FME .shp <-> Oracle	Smallworld Technical Paper No. 4 - Version Management in GIS - Applications and Techniques Oracle Technology Network http://www.oracle.com/technet/work/index.html	Tutorial: Getting Started with Oracle Spatial SQL Reference tool W3 Schools - SQL ref.	
Feb. 06						Assignment 2 Due 11:55pm
Feb. 07	Rasters in RDBMS	Raster query and processing	Oracle SDO_Georaster			Hand out. Assignment 3. (20%)
Feb.14	3D Surface Modeling	TINs, DEMs, Point Clouds	Assignment 4 briefing Searching and retrieving Open Source Geospatial Data	OSGeo http://www.osgeo.org/ OpenStreetMap http://www.openstreetmap.org/		In class test (10%) T/F & Written answer 50 minutes
Feb.21	No Lecture	Reading Week				
Feb.27						Assignment 3 Due 11:55pm
Feb.28	Network Modeling Schematics	Guest Lecture: TBD	Enterprise Geo DBMS for Network Utilities			Hand out. Assignment 4. Part A (10%) Enterprise Geospatial Database & Dashboards
Mar.07	Modeling the Built Environment	Building Info Models (BIMs) 3D City GML		CityGML http://www.citygml.org/ 3D City GML Database http://www.3dcitydb.net/		
Mar.13						Assignment 4 Part A due 11:55pm
Mar.14	Spatial Data Infrastructures (SDI)	Guest Lecture: TBD				Hand out. Assignment 4. Part B (20%) Enterprise Geospatial Database & Dashboards
Mar.21	Geospatial Web HTML5, CSS Javascript	Citizen Sensor Big data		The Geospatial Web Avail. online via uwaterloo lib. http://www.springerlink.com/content/uu3847/#section=26957 &page=1	Javascript HTML5 CSS GML	
Mar.28	Course Summary					In class test, 10% of overall grade
Mar.31						Assignment 4 Part B due 11:55pm

UW Academic Policies

Academic Integrity: To create and promote a culture of academic integrity, the behaviour of all members of the University of Waterloo is based on honesty, trust, fairness, respect and responsibility.

Grievance: A student who believes that a decision affecting some aspect of his/her university life has been unfair or unreasonable may have grounds for initiating a grievance. Read Policy 70 - Student Petitions and Grievances, Section 4, <http://www.adm.uwaterloo.ca/infosec/Policies/policy70.htm>

Discipline: A student is expected to know what constitutes academic integrity, to avoid committing academic offenses, and to take responsibility for his/her actions. A student who is unsure whether an action constitutes an offense, or who needs help in learning how to avoid offenses (e.g., plagiarism, cheating) or about “rules” for group work/collaboration should seek guidance from the course professor, academic advisor, or the Undergraduate Associate Dean. When misconduct has been found to have occurred, disciplinary penalties will be imposed under Policy 71 – Student Discipline. For information on categories of offenses and types of penalties, students should refer to Policy 71 - Student Discipline, <http://www.adm.uwaterloo.ca/infosec/Policies/policy71.htm>

Appeals: A student may appeal the finding and/or penalty in a decision made under Policy 70 - Student Petitions and Grievances (other than regarding a petition) or Policy 71 - Student Discipline if a ground for an appeal can be established. Read Policy 72 - Student Appeals, <http://secretariat.uwaterloo.ca/Policies/policy72.htm>

Ethics: The University of Waterloo requires all research conducted by its students, staff, and faculty which involves humans as participants to undergo prior ethics review and clearance through the Office of Research Ethics (<http://iris.uwaterloo.ca/ethics/>). The ethics review and clearance processes are intended to ensure that projects comply with the guidelines established through Tri-Council Policy Statement (TCPS).

Note for students with accessibility needs: AccessAbility Services, located in Needles Hall, Room 1132, collaborates with all academic departments/schools to arrange appropriate accommodations for students with accessibility-related needs without compromising the academic integrity of the curriculum. If you require academic accommodations to lessen the impact of your disability, please register with AccessAbility Services at the beginning of each academic term.

Illness or other emergency: Students with an illness, or other emergency, that prevents them from handing in an assignment on time or attending a test, must contact you to notify you of this problem prior to the deadline or test date (or as soon afterwards as is reasonably possible). Students with an illness must document evidence of that illness with a note from a doctor. For other emergencies, such as the death of a family member, students should be asked to meet with you as soon as possible in order to make arrangements to make up any missed assignment or test. Any questions or concerns that you have regarding these matters should be directed to the Department Chair or Associate Chair.

Religious Observances: Please inform the instructor at the beginning of term if special accommodation needs to be made for religious observances that are not otherwise accounted for in the scheduling of classes and assignments.

Turnitin Software: Plagiarism detection software (Turnitin) may be used to screen assignments in this course. This may be done to verify that use of all materials and sources in assignments is documented. Students will be given an option if they do not want to have their assignment screened by Turnitin. In the first week of the term, details will be provided about arrangements and alternatives for the use of Turnitin in this course.

Annotated bibliography: For advice on how to prepare an annotated bibliography, see:
<https://uwaterloo.ca/writing-centre/>