SSCI 582, Spatial Databases

Syllabus

Units: 4

Term Day Time: Spring 2022
Lecture: Wednesdays and Fridays, 10:00 am – 11:50 am PT

Location: AHF 145D & DEN@Dornsife

Instructor: Jennifer N Swift, Ph.D. GISP
Office: AHF B57D
Regular Office Hours: Tues and Wed 4-5:00 pm PT. Also available most days and times by appointment via email.
Contact Info: jswift@usc.edu
Zoom: Provided via D2L

Library Help: Andy Rutkowski
Office: VKC 36B
Office Hours: Thu 10:00 am-12:00 pm PT
Contact Info: arutkows@usc.edu
Zoom: Provided via D2L

IT Help: Richard Tsung
Office: AHF 145D
Office Hours: By appointment
Contact Info: spatial_support@usc.edu

Course Scope and Purpose

Geographic information systems (GIS) are fundamentally information systems, typically built on database management technologies. Although GIS offers special facilities for storing and manipulating spatial data, much of the functionality provided by GIS is shared with conventional database software and its ubiquitous Structured Query Language (SQL). Thus, understanding database principles is the foundation for mastering the technical aspects of GIS.

This course provides a high-level tour of the theoretical underpinnings of databases containing both spatial and tabular data, as these are integrated into GIS. The core objective of the course is a practical one: to understand the fundamental principles of the design and implementation of well-conceived spatial databases, especially Esri geodatabases and SQL server databases, and be able to manipulate them both inside and outside of GIS.

In this course, we examine the fundamentals of relational, object-oriented, and unstructured databases. A major benefit of the relational model is that it provides a metaphor that is closer to the way humans think about data than did previous database models. Yet within GIS, some authors have argued that the object-oriented model provides an inherently more suitable basis for storing geographical data than the relational model. The unstructured model is increasingly being used to support applications including big data storage and retrieval (e.g. Twitter, Facebook, Google). The influence of object-oriented concepts has become steadily more dominant throughout virtually every aspect of modern computing. Anyone wishing to pursue a career in GIS, in fact in any aspect of computing, should gain an understanding of both the relational and object-oriented models with respect to spatial databases.

By both necessity and design, this course serves several different audiences. This course is a required course for the Spatial Data Management and Spatial Computing tracks in the M.S. in Geographic Information Science & Technology, the GIS track in the M.S. in Transportation Systems Management, and as an elective course in the M.S. in Spatial Economics and Data Analysis, M.S. in Spatial Data Science, and Geographic Information Science & Technology and the Geospatial Leadership Graduate Certificate Programs. The different student audiences are provided with a variety of options to work with core geospatial datasets throughout the semester that best coincide with their personal academic and career goals.

Learning Objectives

When you have completed this course, you will be able to:

- Define a geographical realm of interest, model that realm diagrammatically and narratively, and implement the model in a geodatabase.
- Use SQL statements to interrogate spatial databases to accomplish data loading, maintenance, map production, and analysis.
- Discuss the complexity of the geographic world and techniques for modeling it in a computer.
- Explain the strengths and limitations of various databases and non-relational structures for spatial data, including those supported by Esri's ArcGIS platform and open-source systems.

Prerequisite(s): SSCI 581 or permission of the instructor
Co-Requisite(s): None

Class Conduct

Harassment, sexual misconduct, interpersonal violence, and stalking are not tolerated by the university. All faculty and most staff are considered Responsible Employees by the university and must forward all information they receive about these types of situations to the Title IX Coordinator. The Title IX Coordinator is responsible for assisting students with supportive accommodations, including academic accommodations, as well as investigating these incidents if the reporting student wants an investigation. The Title IX office is also responsible for coordinating supportive measures for transgender and nonbinary students such as faculty notifications, and more. If you need supportive accommodations, you may contact the Title IX Coordinator directly (titleix@usc.edu or 213-821-8298) without sharing any personal information with me. If you would like to speak with a confidential counselor, Relationship and Sexual Violence Prevention Services (RSVP) provides 24/7 confidential support for students (213-740-9355 (WELL); press 0 after hours).

Course Structure

The main theoretical concepts are provided through lectures, discussion and a directed reading of the textbooks and supplementary readings. Additional readings will be assigned to expand on the text when needed. The course will generally unfold on a biweekly or triweekly basis. When possible, assignments will be given in advance, but usually they will be posted on or before Mondays.

Workload – This is a four credit, one semester course. Students should expect to spend 10-15 hours per week completing the work in this course.

Technological and Communication Requirements

ArcGIS Pro, MS SQL Server Management Studio, and PostGIS are provided online via the SSI Server; hence, you do not need to install these systems on your own computer. Instead, every student must have the following technology requirements:

- A computer with a fast Internet connection.
- A functional webcam and a microphone for use whenever a presentation or meeting is scheduled.
- An up-to-date web browser to access the SSI Server.

You might need to record short videos explaining your project work, but I will show you how to use free, available online tools to do so.

SSI Server and Tech Support – This course utilizes the SSI Server which is a virtual desktop giving access to many different professional software. If you are unable to connect to the server or experience any type of technical issues, send an email using your USC account to SSI Tech Support at spatial_support@usc.edu making sure to copy (cc) me on the email.

Communications – This course is an on campus, in person course that accommodates remote/distance learning as well (DEN), so our interactions will be synchronous and asynchronous (not at the same time). All materials to be handed in will be submitted via D2L. It is each student's responsibility to stay informed about what is going on in our course. In addition to email about time-sensitive topics, any important announcements will be posted on the Announcement page in D2L. Be sure to check these each time you log onto D2L.

I will send via email through D2L any notices that are time sensitive. Please be sure that you read as soon as possible all email sent from D2L or from me. Do not ignore course emails until the day before assignments are due. Also double check to be sure that email sent from the D2L account does not go into your junk mail! While I am usually on-line and will probably respond to emails from students very quickly, I will endeavor to respond to all email within 24 hours of receipt, aiming for no more than 72-hours delay. In the rare case when I expect to be off-line for more than 72 hours, I will post an announcement on the D2L site.

Discussion forums – On the D2L site, I will post a series of discussion threads relevant to various sections of the course. Discussions provide a key means for student-to-student discussion and collaboration that can replicate the face-to-face contact you may have experienced in traditional classrooms. Here students can provide support to each other while working on your assignments, sharing hints and helpful tips, as you would in a classroom laboratory. Please post your questions about assignments there, as you would ask them publicly in the classroom. I monitor the discussion threads and offer comments when necessary, but more importantly, consider the discussion board a key way to connect with your classmates and share your discoveries.

Required Readings and Supplementary Materials

The required textbook for this course is:

- Yeung, A. K. W., and G. B. Hall. 2007. *Spatial Database Systems: Design, Implementation and Project Management*. Dordrecht: Springer. While you may purchase this book if you wish to own a bound copy, it is available online through the USC Libraries. Sign on to the USC Libraries and search for this title. Used copies of this book are widely available online, so there is no need to pay the full retail price.

Supplementary readings will be assigned from various sources including:

- Auziņš, A., E. Jānis, V. Alīna, and D. Reinis. 2018. Object-Relational Database Structure Model and Structure Optimisation. *Applied Computer Systems* 23(1): 28-36.

- Blaser, M. 2014. Ontology and indigeneity: on the political ontology of heterogeneous assemblages. *Cultural Geographies* 21(1): 49-58.

- Burrough, P. A., R. McDonnell, R. A. McDonnell, and C. D. Lloyd. 2015. Spatial data and their models: formal abstractions of reality. In *Principles of geographical information systems, 3rd ed.* (pp. 21-44). Oxford, UK: Oxford University Press.

- Couclelis, H. 1992. People Manipulate Objects (But Cultivate Fields): Beyond the Raster-Vector Debate in GIS. In A.U. Frank, I. Campari, and U. Formentini (Eds.), *Therories and methods of spatio-temporal reasoning in geographic space* (pp. 65-77). London, UK: Springer.

- Dangermond, J., and M. F. Goodchild. 2020. Building Geospatial Infrastructure. *Geo-saptial Information Science* 23 (1): 1-9

- Dietrich, S. W., and S. D. Urban. 2011. Introduction to Object Database. In *Fundamentals of Object Databases Object-Oriented and Object-Relational Design* (pp. 1-30). San Rafael, California: Morgan & Claypool.

- Harrington, J. L. 2011. Simple SQL Retrieval In *SQL Clearly Explained*, *3rd ed.* (pp. 77-105 and pp. 363-399). Amsterdam, Netherlands: Morgan Kaufmann Elsevier.

- Hunter, G. J. 2002. Understanding Semantics and Ontologies: They're Quite Simple, Really - If You Know What I Mean. *Transactions in GIS* 6(2): 83-87.

- Lee, J.-G. and M. Kang. 2015. Geospatial Big Data: Challenges and Opportunities. *Big Data Research* 2(2): 74-81.

- Li, Z. 2018. NoSQL Databases. *The Geographic Information Science & Technology Body of Knowledge, 2nd Quarter 2018 ed.* John P. Wilson (Ed).

- Li, W., M. Batty, and M. F. Goodchild. 2020. Real-Time GIS for Smart Cities. *International Journal of Geographic Information Science* 34(2): 311-324.

- Parent, C., S. Spaccapietra, and E. Zimányi. 2006. Introduction. In *Conceptual modeling for traditional and spatio-temporal applications: The MADS approach*. Berlin, Germany: Springer Science & Business Media.

- Shekhar, S., and S. Chawla. 2003. Spatial Concepts and Data Models. In *Spatial Databases: A Tour, 1st ed.* (pp. 22-51). Upper Saddle River, NJ: Prentice Hall.

- Shekhar, S., and S. Chawla. 2003. Spatial Query Languages. In *Spatial Databases: A Tour, 1st ed.* (pp. 52-82) Upper Saddle River, NJ: Prentice Hall.

- Shekhar, S., and S. Chawla. 2003. Spatial Storage and Indexing. In *Spatial Databases: A Tour, 1st ed.* (pp. 83-113). Upper Saddle River, NJ: Prentice Hall.

As well, for several of the assignments in this course, you will conduct online library research to find articles that apply specific techniques in an application area of your choice.

Description and Assessment of Assignments

Weekly Assignments

Your grade in this course will be determined on the basis of several different assessments.

Resume Assignments – 2 worth a total of 5 points. We require all current students to post and maintain a public resume, short biography and recent photo on our shared SSI Student Community D2L site. Please prepare your resume in the SSI template which will be provided to you. A second resume assignment provides you a chance to add any newly learned tools and project products in this course to your resume. Unless you opt out, your resume will be

included in the Spatial Sciences Institute Graduate Programs Resume Book. This resume book is compiled annually and, along with our web presence, is used to promote our programs, and more importantly, your skills, experience and professional aspirations.

Projects – 5 worth a total of 40 points. The hands-on, project-based Projects will be used to practice the techniques discussed in abstract terms in the text. At the completion of each Project, you will prepare a brief written report to demonstrate that you have completed it.

Reading and Research Assignments – 4 worth a total of 20 points. These assignments call on students to critically analyze required readings, identify relevant case studies employing the methodologies and concepts we cover in class, and to discuss them with the instructor and their classmates during synchronous meetings and/or online discussion forums via D2L.

Discussions – 5 worth a total of 15 points. Structured discussions will focus on combinations of theory and practice. You will post new message and replies to messages posted by your classmates (i.e. two per forum) at specified times throughout the semester.

Comprehensive Exam – 1 worth a total of 20 points.

Grading Breakdown

Assessment	Number	Points Each	Total Points
Resume Assignment 1	1	2	2
Resume Assignment 2	1	3	3
Projects	5	8	40
Reading & Research Assignments	4	5	20
Discussions	5	3	15
Comprehensive Exam	1	20	20
Total	17	-	100

Assignment Submission Policy

Unless otherwise noted, assignments must be submitted via D2L by the due dates specified in the Course Schedule below and on the assignment instructions. Unless otherwise noted, all Reading & Research Assignments and Homework Assignments are *due by 11:59 pm Pacific Time (PT) on the due date*. Your attention to on-time assignment submission is essential.

Penalties apply for late assignments as follows:

- All assignments will be penalized 2 points up to FOUR days late. No points will be given for submissions more than FOUR days late. Note that all assignments worth 2 points will receive 0 points if submitted late.

- Additionally, no written work will be accepted for grading after 5 pm PT on the last day of classes.

Schedule Breakdown

	Topic	Readings and Assignments	Deliverables/Due Dates
Module 1: Database Fundamentals			
Week 1 1/10	Introduction	Burrough et al. (2015) Yeung & Hall (2007) Ch1 Resume Assignment 1 Reading & Research Assignment 1	Resume Assignment 1: Friday, 1/14
Week 2 1/17* *Monday, 1/17 is a university holiday	Elements and concepts of database management systems	Yeung & Hall (2007) Ch2 p. 21-40 Discussion 1 Project 1	Reading & Research Assignment 1: Wednesday, 1/19
Module 2: Database Design and Management			
Week 3 1/24	Database architecture and data models	Couclelis (1992) Dietrich and Urban (2011) Yeung & Hall (2007) Ch2 p. 41-54 and Ch3 p. 55-78 Project 2 Discussion 2	Discussion 1: Wednesday, 1/26 Project 1: Friday, 1/28
Week 4 1/31	Data modeling: entity-relationship diagrams	Yeung & Hall (2007) Ch3 p. 65-79 Shekhar & Chawla (2003) p. 22-51 Reading & Research Assignment 2	Discussion 2: Wednesday, 2/2
Week 5 2/7	Use of Structured Query Language (SQL)	Harrington (2011) Ch.4 Auziņš et al. (2018) Discussion 3	Reading & Research Assignment 2: Wednesday, 2/9
Module 3: Basics of Spatial Databases			
Week 6 2/14	Semantics, ontology and spatial database infrastructure: Esri Geodatabases (I)	Blaser (2014) Hunter (2002) Yeung & Hall (2007) Ch4 p. 93-114 Project 3 Reading & Research Assignment 3	Discussion 3: Wednesday, 2/16 Project 2: Friday, 2/18
Week 7 2/21* *Monday, 2/21 is a university holiday	Database mechanics	Yeung & Hall (2007) Ch3 p. 79-92	Reading & Research Assignment 3: Wednesday, 2/23

	Topic	Readings and Assignments	Deliverables/Due Dates
Module 4: Spatial Data Optimization and Spatial Access			
Week 8 2/28	Spatial data quality and standards: Esri Geodatabases (II)	Yeung & Hall (2007) Ch5 Reading & Research Assignment 4 Project 4	Project 3: Friday, 3/4
Week 9 3/7	Spatial queries and spatial indexing	Shekhar & Chawla (2003) p. 52-113 Yeung & Hall (2007) Ch4 p. 115-125 Discussion 4	Reading & Research Assignment 4: Wednesday, 3/9
Week 10 3/21	Time in spatial databases	Parent et al. (2006)	Discussion 4: Wednesday, 3/23
Module 5: Modern Databases			
Week 11 3/28	Introduction to open-source object-oriented databases and NoSQL databases	Li (2018) Project 5 Discussion 5	Project 4: Friday, 4/1
Week 12 4/4	Spatial Big Data	Lee & Kang (2015)	Discussion 5: Wednesday, 4/6
Week 13 4/11	GIS for smart cities	Li et al. (2020) Resume Assignment 2	
Week 14 4/18	Geospatial Infrastructure	Dangermond & Goodchild (2020)	Resume Assignment 2 Wednesday, 4/20
Week 15 4/25 Friday, 4/29 is the last day of class	Future of Spatial Databases & Comprehensive Exam Review		Project 5: Friday, 4/29
Final Exams 5/4-5/11	Comprehensive Exam		Comprehensive Exam: Monday, May 9, 8-10 am PT

Statement on Academic Conduct and Support Systems

Academic Conduct

Plagiarism – presenting someone else's ideas as your own, either verbatim or recast in your own words – is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in SCampus in Part B, Section 11, "Behavior Violating University Standards" policy.usc.edu/scampus-part-b. Other forms of academic dishonesty are equally unacceptable. See additional information in SCampus and university policies on Research and Scholarship Misconduct.

Students and Disability Accommodations

USC welcomes students with disabilities into all of the University's educational programs. The Office of Student Accessibility Services (OSAS) is responsible for the determination of appropriate accommodations for students who encounter disability-related barriers. Once a student has completed the OSAS process (registration, initial appointment, and submitted documentation) and accommodations are determined to be reasonable and appropriate, a Letter of Accommodation (LOA) will be available to generate for each course. The LOA must be given to each course instructor by the student and followed up with a discussion. This should be done as early in the semester as possible as accommodations are not retroactive. More information can be found at osas.usc.edu. You may contact OSAS at (213) 740-0776 or via email at osasfrontdesk@usc.edu

Support Systems

Counseling and Mental Health - (213) 740-9355 – 24/7 on call
studenthealth.usc.edu/counseling
Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention.

National Suicide Prevention Lifeline - 1 (800) 273-8255 – 24/7 on call
suicidepreventionlifeline.org
Free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week.

Relationship and Sexual Violence Prevention Services (RSVP) - (213) 740-9355(WELL), press "0" after hours – 24/7 on call
studenthealth.usc.edu/sexual-assault
Free and confidential therapy services, workshops, and training for situations related to gender-based harm.

Office for Equity, Equal Opportunity, and Title IX (EEO-TIX) - (213) 740-5086
eeotix.usc.edu
Information about how to get help or help someone affected by harassment or discrimination, rights of protected classes, reporting options, and additional resources for students, faculty, staff, visitors, and applicants.

Reporting Incidents of Bias or Harassment - (213) 740-5086 or (213) 821-8298
usc-advocate.symplicity.com/care_report
Avenue to report incidents of bias, hate crimes, and microaggressions to the Office for Equity, Equal Opportunity, and Title for appropriate investigation, supportive measures, and response.

The Office of Student Accessibility Services (OSAS) - (213) 740-0776
osas.usc.edu
OSAS ensures equal access for students with disabilities through providing academic accommodations and auxiliary aids in accordance with federal laws and university policy.

USC Campus Support and Intervention - (213) 821-4710
campussupport.usc.edu
Assists students and families in resolving complex personal, financial, and academic issues adversely affecting their success as a student.

Diversity, Equity, and Inclusion - (213) 740-2101
diversity.usc.edu
Information on events, programs and training, the Provost's Diversity and Inclusion Council, Diversity Liaisons for each academic school, chronology, participation, and various resources for students.

USC Emergency - UPC: (213) 740-4321, HSC: (323) 442-1000 – 24/7 on call
dps.usc.edu, emergency.usc.edu
Emergency assistance and avenue to report a crime. Latest updates regarding safety, including ways in which instruction will be continued if an officially declared emergency makes travel to campus infeasible.

USC Department of Public Safety - UPC: (213) 740-6000, HSC: (323) 442-120 – 24/7 on call
dps.usc.edu
Non-emergency assistance or information.

Office of the Ombuds - (213) 821-9556 (UPC) / (323-442-0382 (HSC)
ombuds.usc.edu
A safe and confidential place to share your USC-related issues with a University Ombuds who will work with you to explore options or paths to manage your concern.

*Occupational Therapy Faculty Practice - (323) 442-334*0 or otfp@med.usc.edu
chan.usc.edu/otfp
Confidential Lifestyle Redesign services for USC students to support health promoting habits and routines that enhance quality of life and academic performance.

Resources for Online Students

The Course D2L page and the GIST Community Blackboard page have many resources available for distance students enrolled in our graduate programs. In addition, all registered students can access electronic library resources through the link https://libraries.usc.edu/. Also, the USC Libraries have many important resources available for distance students through the link: https://libraries.usc.edu/faculty-students/distance-learners. These include instructional videos, remote access to university resources, and other key contact information for distance students.