

USC Dornsife

Dana and David Dornsife
College of Letters, Arts and Sciences
Spatial Sciences Institute

SSCI 575, Spatial Data Science

Syllabus

Units: 4

Term Day Time: Fall 2022, Wed and Fri from 11:00-12:50pm

Location: AHF 145D and DEN@Dornsife

Instructor: Yi Qi, PhD

Office: AHF B55J

Regular Office Hours: Thursday 1-3pm PT. Also available by appointment via email.

Contact Info: yi.qi@usc.edu, 213-821-1589

Library Help: Andy Rutkowski

Office: LIPA B40-A

Office Hours: Thu 10am - 12 pm or by appointment

Contact Info: arutkows@usc.edu

IT Help: Dornsife Technology Services

Office: SHS 260

Contact Info: spatial_support@usc.edu, 213-740-2775

Course Scope and Purpose

Could we have prepared for an earthquake evacuation using data geotagged tweets? How are our movement patterns relate to spreading of a pandemic? Questions such as these are becoming more commonplace in spatial analysis as data sources increase in variety and the questions we ask are more interdisciplinary. This course aims to provide students with theoretical and practical knowledge that pertain to spatial machine learning methods frequently used in spatial analysis. Students will gain experience in statistical, algorithmic and practical applications of modern spatial machine learning methods that complement and enhance traditional (spatial) statistical approaches to spatial analysis. Students will be introduced to statistical computing in the context of machine learning. R and Python will be frequently utilized in class examples and projects.

The course is structured as a series of theoretical and hands-on lectures, where students will learn theory and algorithms behind commonly used machine learning methods and apply them to spatial analysis problems. The course will use Geographic Information Systems (GIS) as the main computational framework for representing spatial data and all class examples will be studied within the context of GIS. This course features a series of hands-on projects where students will use cutting-edge methods to solve a spatial data science problem that span multiple disciplines, such as public health, the house market, and natural disaster response, to name a few. Students will also perform research and reading assignments, where they will be studying state of the research into different aspects of spatial machine learning and making connections with research and foundational ideas covered in class.

Learning Outcomes

On completion of this course, students should be able to:

- Identify different types of machine learning methods in terms of their formulation
- Apply appropriate type of machine learning methods to spatial problems
- Improve machine learning model performance through the use of diagnostics
- Explain differences between spatially implicit and explicit machine learning methods
- Perform medium to large scale analysis on imperfect field data for creating data driven models of social and natural phenomena
- Work with unconventional spatial data sources and integrate machine learning into their analysis pipeline
- Implement the spatial machine learning workflow for complex problems and systematically solve a multidisciplinary problem
- Describe algorithmic differences between different machine learning methods

- Perform exploratory analysis to delineate best methods for the data and problem at hand

Students may vary in their competency levels on these abilities. You can expect to acquire these abilities only if you honor all course policies, attend classes regularly, complete all assigned work in good faith and on time, and meet all other course expectations of you as a student.

Prerequisite(s): None

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)

COVID-19 policy -- Students are expected to comply with all aspects of USC's COVID-19 policy including, but not limited to, vaccination, indoor mask mandate, and daily TrojanCheck. Failure to do so may result in removal from the class and referral to Student Judicial Affairs and Community Standards. Students are recommended to keep safe physical distancing, whenever possible, to prevent any possible transmission. Please contact your instructor if you have any safety concerns.

Diversity and Inclusion – It is my intent that students from all diverse backgrounds and perspectives be well served by this course, that students' learning needs be addressed both in and out of class, and that the diversity that students bring to this class be viewed as a resource, strength and benefit. It is my intent to present materials and activities that are respectful to everyone, and you are also expected to respect of others regardless of their race, ethnicity, gender identity and expressions, cultural beliefs, religion, sexual orientation, national origin, age, abilities, ideas and perspectives, or socioeconomic status. Your suggestions are encouraged and appreciated. Feel free to let me know ways to improve the effectiveness of the course for you personally or for other students.

Course Structure

The main theoretical concepts are introduced in class via lectures, discussions and after class via reading assignments. Practical exercises utilize R, Python, and the ArcGIS platform for problem-solving. Assignments require coding in both languages, and working knowledge of R and Python will be assumed.

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 is provided online via the GIST Server; hence, you do not need to install it 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 Server

If a student does not have access to any of these, please speak with the instructor at the start of the semester. Also, see the USC ITS Student Toolkit here:

<https://keepsteaching.usc.edu/students/student-toolkit/>

Desire2Learn (D2L) – This course will utilize the Desire2Learn (D2L) learning management system which allows students to access course content, upload assignments, participate in discussion forms, among other learning experiences. The D2L platform provides flexibility in the learning experience where students can participate in the course residentially or remotely, synchronously (meeting together at the same time) or asynchronously (accessing videos and course content outside of class).

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 – All assignments given and all materials to be handed in will be submitted via D2L. The instructor will also create and monitor discussion forums through which students can discuss issues and assignments as needed. Students should read all email sent from D2L or from course instructor(s) as soon as possible. Also, students who do not regularly use their USC email accounts should double-check to be sure that mail sent from both the D2L accounts and the instructor's account (noted above) to your USC account is forwarded to an address used regularly and does not go into junk mail. The instructor will endeavor to respond to all email within 24 hours of receipt, aiming for no more than 72 hours delay. In the rare case that an instructor is off-line for an extended period of time, an announcement will be posted to the class D2L site. Due to the synchronous and asynchronous nature of this

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course, it is each student's responsibility to stay informed and connected with others in our course. In addition to email, students are expected to login to D2L regularly to check for announcements.

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 textbooks for this course are:

- Hastie, T., Tibshirani, R., & Friedman, J. (2009). *The elements of statistical learning: Data mining, inference, and prediction*. Berlin, Germany: Springer Science & Business Media. [Official Link to PDF](#)
- Haining, R.P. (2003). *Spatial data analysis: Theory and practice*. Cambridge, UK: Cambridge University Press. (an online copy is available via USC library)

Assigned supplementary readings are below (asterisk (*) indicates optional reading):

- Janowicz, K., Gao, S., McKenzie, G., Hu, Y., & Bhaduri, B. (2019). GeoAI: Spatially explicit artificial intelligence techniques for geographic knowledge discovery and beyond. *International Journal of Geographical Information Science*, 34(4), 625-636.
- Duque, J.C., Ramos, R., & Suriñach, J. (2007). Supervised regionalization methods: A survey. *International Regional Science Review*, 30(3), 195-220.
- Oshan, T. M., Li, Z., Kang, W., Wolf, L. J., & Fotheringham, A. S. (2019). mgwr: A Python implementation of multiscale geographically weighted regression for investigating

process spatial heterogeneity and scale. ISPRS International Journal of Geo-Information, 8(6), 269.

- Battaglia, P.W., Hamrick, J. B., Bapst, V., Sanchez-Gonzalez, A., Zambaldi, V., Malinowski, M., ... Gulcehre, C. (2018). Relational inductive biases, deep learning, and graph networks. arXiv preprint, arXiv:1806.01261.
- Tong, D., & Murray, A.T. (2012). Spatial optimization in geography. Annals of the Association of American Geographers, 102(6), 1290-1309.

Description and Assessment of Assignments

Weekly Assignments

There are several different kinds of assignments with at least one due weekly. These are described in the Weekly Folders on D2L. Due dates are shown in the summary that follows.

Resume Assignments – 2 worth a total of 5 points. All students are required to post and maintain a public resume, biography, and headshot on the SSI Student Community Blackboard site. Unless a student opts out, their resume will be included in the Spatial Sciences Institute Graduate Programs Resume Book, which is used to promote the program and highlight student skills, experiences, and professional aspirations. An updated resume will be submitted at the end of the course of study

Projects – 4 worth a total of 40 points. The projects will be the major tool used to evaluate your learning in this course. The projects will be linked to course Modules. In support of these projects, students will complete end-to-end data science workflows. Students will gain insight to executing a data science workflow with clear deliverables.

Reading and Research Discussions – 5 worth a total of 25 points. These assignments call on students to critically analyze required readings, and discuss them with the instructor and their classmates during synchronous meetings and/or online discussion forums via D2L.

Students are expected to answer critical thinking questions that provide students with an opportunity to apply their competencies to exploratory, open-ended scenarios.

Mid-Term Exam – 1 worth of a total of 10 points. The mid-term will cover material learned in the first half of the semester. It may be mixed format and may consist of multiple choice, short answer, and hands-on calculations.

Final Exam – 1 worth a total of 20 points. The final exam will cover material learned over the duration of the semester. It may be mixed format and may consist of multiple choice, short answer, and hands-on calculations.

Grading Breakdown

Assessment	Number	Points Each	Total Points
Weekly Assignments			
Resume Assignment	2	2.5	5
Projects	4	10	40
Reading Assignments	5	5	25
Mid-Term Exam	1	10	10
Final Exam	1	20	20
Total	13	--	100

Assignment Submission Policy

Unless otherwise noted, all assignments must be submitted via D2L *by 11:59 pm Pacific Time (PT) on due dates specified in the Course Schedule below*. Your attention to on-time assignment submission is essential if I am to meet my goal to return comments on your submitted assignments before the next one is due. Sometimes this is impossible, so I will post a notice on anticipated delays if needed.

Strict 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.

Any exceptions to these turn-in assignments are only made by me in coordination with individual students. An example of an exception would be a student's illness or injury that reasonably prohibits course involvement/participation.

Schedule

	Topic	Readings and Assignments	Deliverables/Due Dates
Week 1 8/22	Is Spatial Special? Introduction to Spatial Data Science and GeoAI	Resume Assignment 1	No deliverables
Week 2 8/29	Introduction to the Spatial Data Science Workflow	Reading & Research Discussion 1 (RRD 1)	Resume Assignment 1 Due: 8/29
Week 3 9/5 (9/5 is university holiday)	Spatial Data Representation	Project 1	
Week 4 9/12	Spatial Data Wrangling		RRD 1 Due: 9/12
Week 5 9/19	Exploratory Spatial Data Analysis		
Week 6 9/26	Spatially Explicit Unsupervised Learning	Reading & Research Discussion 2 (RRD 2)	Project 1 Due: 9/26
Week 7 10/3	Spatially Explicit Supervised Learning (Linear Models)	Project 2	
Week 8 10/10 (10/13-10/14 is a university holiday)	Spatially Explicit Neural Networks I	Reading & Research Discussion 3 (RRD 3)	RRD 2 Due: 10/10
Week 9 10/17	Spatially Explicit Neural Networks II		
Week 10 10/24	Model Assessment and Selection	Project 3	Project 2 Due: 10/24 Mid-Term Exam
Week 11 10/31	Spatial Optimization	Reading & Research Discussion 4 (RRD 4)	RRD 3 Due: 10/31

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Week 12 11/7 (11/11 is a university holiday)	Prescriptive Spatial Machine Learning	Reading & Research Discussion 5 (RRD 5)	
Week 13 11/14	Data Mining for Emerging Data Sources	Project 4	Project 3 Due: 11/14
Week 14 11/21 (11/23-11/27 is a university holiday)	Sentiment Analysis in Spatial Analysis		RRD 4 Due: 11/21
Week 15 11/28 (Class ends on 12/2)	Course Review	Resume Assignment 2	Resume Assignment 2 and RRD 5 Due: 11/28
Week 16 12/5	No Class	No Class	Project 4 Due: 12/5 Final Exam

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) 442-3340 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.