1/9/2023

GGS 791 Advanced Spatial Statistics

Spring 2023, 4:30-7:10 pm (Mondays), 2103 Exploratory Hall

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Office hours: Mondays 3-4pm, or by appointment

This course discusses advanced statistical techniques in analyzing and modeling spatial data. These techniques fall into three general categories: 1) descriptive spatial statistics, including point pattern analyses, and spatial autocorrelation statistics; 2) spatial interpolation and geostatistical methods; and 3) spatial regression models. These statistical methods are needed because spatial data possess unique properties and characteristics that classical or traditional statistical tools may not be able to handle or analyze spatial data effectively and correctly. These methods can alternately be categorized into techniques analyzing point data (with or without attributes) and polygon data.

By finishing this course, students should have acquired a reasonable skill set to analyze spatial data statistically. (*Learning Objective #1*) This skill set is essential in conducting empirical research in geography and Earth sciences, using data that may be collected for or used by GIS and remote sensing. A basic understanding of spatial data analysis, similar to the content covered in GGS 560 is the prerequisite for this course. Students without the expected spatial data analysis background but with sufficient statistical background should review the material of GGS 560 or refer to one of the background texts.

The secondary objective of this course is to help students acquire critical thinking skill to use spatial data and spatial statistical tools. Each spatial statistical method is built on certain assumptions and relies on certain concepts to analyze spatial data. Students should develop critical thinking skill to determine which method is the most appropriate given the data and research question. (*Learning Objective #2)* Students will be challenged throughout the course about the appropriateness of using specific methods given the situations. To practice and apply critical statistical thinking skill, students will be asked to conduct an article review.

Textbook: No required text for the course. Relevant literature will be provided in respective sections.

Background Texts:

A) Wong, D. W. S. and J. Lee. 2005. *Statistical Analysis of Geographic Information*. Wiley

B) de Smith, M., M. F. Goodchild, and P. Longley 2018. *Geospatial Analysis*. (6th edition) (http://www.spatialanalysisonline.com/)

Major General References:

C) Lloyd, C. D. 2012. *Local Models for Spatial Analysis*. CRC Press.

Bailey, T. C. and A. C. Gatrell.1995. *Interactive Spatial Data Analysis*. Longman.

Bivard, R. S., E. J. Pebesma, and V. Gómez-Rubio. 2008. *Applied Spatial Data Analysis with R.* Springer. (**using R**)

Brunsdon, Chris and Lex Comber. 2019. *An Introduction to R for Spatial Analysis and Mapping.* 2nd Edition. Sage Publication. (**using R**)

Chun, Y. and D. A. Griffith. 2013. *Spatial Statistics and Geostatistics: Theory and Applications for Geographic Information Science and Technology.* Sage. (**using R**)

Levine, N. 2013. *CrimeStat 4.0 User Manual*. https://nij.ojp.gov/topics/articles/crimestat-spatial-statistics-program-analysis-crime-incident-locations#program

1/9/2023

Grading policy: (tentative, and see sections for details)

3 mini projects	60 pts (20 pts each)
In-class Discussion of article(s)	10pts
Article review	30 pts
Total	100pts

Topics (subject to change with notice):

1) Review (specific content will be dependent upon the assessment conducted prior to the first class): ~ 3-4 weeks
   - A) 1, 6, 8; C) 1, 4, 8.1- 8.7.1 (also 2 & 3, but less important)
   - properties of spatial/georeferenced data
   - simple point pattern analyses (quadrat and nearest neighbor analyses)
   - measuring spatial autocorrelation (global and local)
   - issues on spatial data quality
2) Advanced Point Pattern Analysis: ~ 2 weeks
   - A) 6.4; C) 8.7.2, 8.10.2, 8.12, 8.13
   - K-function analysis
   - Spatial Scan Statistics
   - Kernel density estimation
3) Spatial Interpolation Techniques: ~ 3 weeks
   - C) 6,7
   - Deterministic spatial interpolation techniques
   - Spatial autocorrelation and variograms
   - Statistical spatial interpolation techniques
     i. Simple kriging
     ii. Ordinary kriging
     iii. Universal kriging
     iv. Co-kriging
4) Spatial Statistical Thinking: Article Review Demonstration 1 week or less
5) Spatial Regression Models: ~ 3 weeks
   - C) 5
   - Trend surface modeling
   - Spatial weights matrix specifications
   - Spatial autoregressive models
   - Spatial expansion models
   - Family of Geographically Weighted Regressions
   - Multi-level (hierarchical linear models – HLM) (“optional”)

Primary software (see Appendix A in Lloyd):

- ArcGIS : Spatial Statistical, Geostatistical Analyst
- CrimeStat: https://nij.ojp.gov/topics/articles/crimestat-spatial-statistics-program-analysis-crime-incident-locations
- GeoDa: https://spatial.uchicago.edu/software
- Using R: https://cran.r-project.org/web/views/Spatial.html
- Python: using PySAL – Python Spatial Analysis Library (https://pysal.org/)
- Mathlab: https://www.spatial-econometrics.com/

3 Mini Projects (tentative, to be finalized after the first day of class)

The class covers three main topics: advanced point pattern analysis, spatial interpolation, and spatial regression. For each topic, students would complete a mini project to demonstrate their understanding and comprehension of the techniques and methods related to that topic. For each mini project, the student is responsible for the entire process, from identifying and processing an appropriate dataset, formulating the **meaningful** research question(s), conducting the analyses, and drawing conclusion. The bottom line is to show your thorough understanding of the techniques or methods discussed in the lecture, or covered in the text or literature. A dataset may be used in more than one mini project in this class.

Alternate ideas for the mini projects are possible. For instance, many software packages include suites of spatial statistical tools, but the accuracy/correctness of these tools is rarely validated. Therefore, an option for the mini project is to evaluate the accuracy of these software tools systematically. A sample for reference can be found in Bivand and Wong (2018) in *TEST*. Other ideas should be approved by the instructor before going forward.

Article Review

In the "Spatial Statistical Thinking", we will critical review one or more manuscripts in class to demonstrate how to think critically in **applying** spatial statistics. Then each student should identify a published article **using** spatial statistical techniques, and critically review that article. Note that these articles are not those about developing new methods or techniques, but just applying spatial methods. The review may include the followings:

- A summary of the research, including the research question(s), data employed and the research methodology and techniques
- Is the overall methodology logical and can provide answer(s) to the research questions(s)?
- Are the data appropriate or most suitable for the research problem?
- Are the analytical methods appropriate? Procedurally, are they executed logically?
- Are the data analyzed and interpreted correctly?
- Is/Are the conclusion(s) supported by the analytical results?

You can look for article from any journal, but below are some (biased) suggestions:

Applied Geography; Papers in the Applied Geography conference proceedings; Geographical Bulletin; Health and Place; International Journal of Applied Geospatial Research; International Journal of Health Geographics; The Professional Geography; Southeastern Geographer; Urban Geography.

Other Policies:

University Catalog: The University Catalog, http://catalog.gmu.edu, is the central resource for university policies affecting student, faculty, and staff conduct in university academic affairs. Other policies are available at http://universitypolicy.gmu.edu/. All members of the university community are responsible for knowing and following established policies.

Academic Integrity: Mason is an Honor Code university (http://oai.gmu.edu/mason-honor-code/); please see the University Catalog for a full description of the code and the honor

committee process. The principle of academic integrity is taken very seriously and violations are treated gravely. What does academic integrity mean in this course? Essentially this: when you are responsible for a task, you will perform that task. When you rely on someone else's work in an aspect of the performance of that task, you will give full credit in the proper, accepted form. Another aspect of academic integrity is the free play of ideas. Vigorous discussion and debate are encouraged in this course, with the firm expectation that all aspects of the class will be conducted with civility and respect for differing ideas, perspectives, and traditions. When in doubt (of any kind) please ask for guidance and clarification.

Sexual Harassment/Title IX: As a faculty member, I am designated as a "Non-Confidential Employee," and must report all disclosures of sexual assault, sexual harassment, interpersonal violence, stalking, sexual exploitation, complicity, and retaliation to Mason's *Title IX Coordinator per university policy 1412. If you wish to speak with someone confidentially, please contact the Student Support and Advocacy Center (703-380-1434) or Counseling and Psychological Services (703-993-2380). You may also seek assistance from Mason's Title IX Coordinator (703-993-8730; titleix@gmu.edu).*

Mason Diversity Policy:

Please refer to the university non-discrimination policy and diversity statement.
https://universitypolicy.gmu.edu/policies/non-discrimination-policy/
https://stearnscenter.gmu.edu/knowledge-center/general-teaching-resources/mason-diversity-statement/

Student Responsibilities:

Please refer to the university policies and expectations.
https://catalog.gmhttps://catalog.gmu.edu/archives/2017-2018/policies/student-rights-responsibilities/u.edu/archives/2017-2018/policies/student-rights-responsibilities/

Mason Email Accounts: Students must use their GMU email account to receive important University information, including messages related to this class. See http://masonlive.gmu.edu for more information.

Office of Disability Services: If you are a student with a disability and you need academic accommodations, please contact the Office of Disability Services (ODS) at 993-2474, http://ods.gmu.edu. All academic accommodations must be arranged through the ODS.

Mason Resources:

The Writing Center: http://writingcenter.gmu.edu
University Libraries, Ask a Librarian: http://library.gmu.edu/ask
Counseling and Psychological Services: http://caps.gmu.edu
University Catalog: http://catalog.gmu.edu
University Policies: http://universitypolicy.gmu.edu
Academic Calendar (drop/withdrawal deadlines): https://registrar.gmu.edu/calendars/

Course Materials and Student Privacy:

- All course materials posted to Blackboard or other course site are private; by federal law, any materials that identify specific students (via their name, voice, or image) must not be shared with anyone not enrolled in this class.
- Video-recordings of class meetings that include audio or visual information from other students are private and must not be shared.
- Live Video Conference Meetings (e.g. Collaborate or Zoom) that include audio or visual information from other students must be viewed privately and not shared with others in your household.

- Some/All of our synchronous meetings in this class will be recorded to provide necessary information for students in this class. Recordings will be stored on Blackboard [or other secure site] and will only be accessible to students taking this course during this semester.

*The instructor reserves the right to modify this syllabus, but will notify students about the change.