GGS 791 Advanced Spatial Statistics

Spring 2019, 7:20-10:00 pm (Tuesdays), 2310 Exploratory Hall

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Office hours: Tuesdays 5:00-6:00pm, or by appointment

The purpose of this course is to discuss advanced statistical techniques in analyzing and modeling spatial data. Advanced techniques covered in this course 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. Spatial data possess unique properties and characteristics that classical or mainstream statistical tools may not be able to handle or analyze effectively and correctly. This course will focus on several types of advanced geostatistics and spatial statistics and models. They can be generally categorized into techniques analyzing point data and polygon data. For the analysis of point data, the emphases will be on the more advanced point pattern analytical methods and spatial interpolation techniques. For the analysis of polygon data, we will focus on spatial regression models. By finishing this course, students should have acquired a reasonable skill set to analyze spatial data captured as points and polygons statistically. (*Learning Objective #1*) This skill set is essential in conducting empirical research in geography and Earth sciences, using GIS and remote sensing technologies. A basic understanding of spatial data analysis, similar to GGS 560 will be the prerequisite for this course. Students without the 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 source is to help students acquire critical thinking skill about the use of (spatial) statistical tools. As different spatial statistical methods and tools will be discussed, understanding different conceptual problems and assumptions in analyzing spatial data are critical in selecting the appropriate tools or statistics. (*Learning Objective #2)* Students will be challenged throughout the course about the appropriateness of statistics, and the correctness of tools. To practice and apply critical statistical thinking skill, students will be asked to conduct an article review.

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 2012. *Geospatial Analysis*. (http://www.spatialanalysisonline.com/)

Major 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.

Brunsdon, Chris and Lex Comber, 2019. *An Introduction to R for Spatial Analysis and Mapping.* 2nd Edition. Sage Publication. (a new edition will appear in February)

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

Levine, N. 2013. *CrimeStat 4.0 User Manual*. https://nij.gov/topics/technology/maps/Documents/crimestat-files/CrimeStat-IV-allfiles-4.02.zip

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

3 mini projects	60 pts (20 pts each)
Article in-class Discussion	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: http://www.icpsr.umich.edu/CrimeStat/download.html
- GeoDa: https://spatial.uchicago.edu/software
- SAAR - Spatial Analysis using ArcGIS Engine and R: https://thesaar.github.io/

**Using R and/or Python are strongly encouraged.*

Reminders:
Academic Integrity: GMU is an Honor Code university; please see the University Catalog for a full description of the code and the honor committee process. Be careful when you seek help from other students in completing your exercises. Refer to the definition of plagiarism.

GMU Email Accounts: Students must activate their GMU email accounts to receive important University information, including messages related to this class.

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 a manuscript 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.