

Spatial Analysis Methods and Practice

This is an introductory textbook on spatial analysis and spatial statistics through GIS. Each chapter presents methods and metrics, explains how to interpret results and provides worked examples. Topics include:

- Describing and mapping data through exploratory spatial data analysis
- Analyzing geographic distributions and point patterns
- Spatial autocorrelation
- Cluster analysis and multivariate data
- Geographically weighted regression and linear regression
- Spatial econometrics

The worked examples link theory to practice through a single real-world case study, with software and illustrated guidance.

- Exercises are solved twice: first through ArcGIS and then GeoDa.
- Through a simple methodological framework the book describes the dataset, explores spatial relations and associations and builds models.
- Results are critically interpreted, and the advantages and pitfalls of using various spatial analysis methods are discussed.

This is a valuable resource for graduate students and researchers analyzing geospatial data through a spatial analysis lens – including those using GIS in the environmental sciences, geography and social sciences.

After completing his postdoctoral studies in the United States, George Grekousis now teaches geography-related courses as an associate professor in China. His interdisciplinary research focuses on spatial analysis, geodemographics, and artificial intelligence. Dr. Grekousis has been awarded several grants from well-known international bodies, and his research has been published in several leading journals, including *Computers, Environment and Urban Systems*, *PLOS One*, and *Applied Geography*.

“... the perfect introduction to the emerging field of spatial data science. It is clearly written, with realistic and carefully worked-out examples and based on a sound pedagogical approach.”

– Luc Anselin, Director, Center for Spatial Data Science at the University of Chicago, and creator of the GeoDa software

“Highly valuable and timely book for multidisciplinary professionals and students who aim to work with spatial problems yet do not yet have the tools to study and solve these. The book provides an excellent introduction to the concepts and tools to think and analyze spatially, complemented by practical, realistic examples of how to apply this knowledge. The book has sufficient depth and rigor to allow students at all levels to learn for themselves and reach a good comprehension of a wide variety of aspects within this scientific domain.”

– Professor Walter T. de Vries, Technical University of Munich

“... an excellent blend of key theoretical concepts and applications. It covers a wide range of spatial topics and concepts while progressively building up in difficulty. The engaging examples, demonstrative code, and laboratory follow-up exercises make this book suitable for both self-learners and traditional academic settings. Highly recommended.”

– Giorgos Mountrakis, State University of New York College of Environmental Science and Forestry

“... introduces contemporary spatial analysis in a way that takes the reader from an elementary position to advanced topics such as spatial econometrics. An excellent course text for students of GIS, spatial statistics, quantitative geography, and ecology. This is one of the first syntheses of spatial analysis that develops the subject around the basic notion that spatial relationships lie at the heart of understanding the correlations that define our geographic world. Essential reading for beginning students as well as those who wish to refresh their knowledge with respect to newer tools such as geographically weighted regression and spatial econometrics ... introduces spatial analysis to those with very little training in statistics while at the same time developing applications using standard software for spatial analysis based on the ArcGIS and Geoda software systems. An excellent primer for anyone following a full course in spatial analysis. Spatial analysis is a tough subject to teach, but Grekousis guides the reader through the basic ideas about understanding how correlations define our geographic world, introducing the full range of spatial tools and models.”

– Michael Batty, Centre for Advanced Spatial Analysis (CASA), University College London (UCL)

“A much welcomed and timely addition to the bookshelf of practitioners interested in the quantitative analysis of geographical data. The book offers a clear and concise exposition to basic and advanced methods and tools of spatial analysis, solidifying understanding through worked real-world case studies based on state-of-the-art commercial (ArcGIS) and public-domain domain (GeoDA) software. Definitely a book to be routinely used as a reference on the practical implementation of key analytical methods by people employing geographical data across a wide spectrum of disciplines.”

– Phaedon Kyriakidis, Cyprus University of Technology

Spatial Analysis Methods and Practice

Describe—Explore—Explain through GIS

GEORGE GREKOUSIS

Sun Yat-Sen University (SYSU)

With solved examples in ArcGIS, GeoDa and GeoDa Space



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Preface

As spatial data are more and more widely available, and as location-based services, from smartphone applications to smart cities monitoring, are becoming standard to everyday's humans' interaction and communication, a growing number of researchers, scientists and professionals, far crossing the typical boundaries of geography discipline, realize the need for in-depth analysis of georeferenced data. Although geographical information systems map and link attributes to locations, spatial data hide much more treasure than a glossy mapping representation. To unlock this information, spatial analysis is necessary, as it provides the methods and tools to transform spatial data into knowledge, assisting in enhanced decision making and better planning. As such, a tremendous demand for accurately analyzing georeferenced data (including big data) across a wide range of disciplines exists.

To respond to this demand, *Spatial Analysis Methods and Practice* is an introductory book in spatial analysis and statistics through GIS. The book presents spatial data analysis methods and geoinformation analysis techniques to solve various geographical problems, following a "Describe–Explore–Explain" approach. Each chapter focuses on a single major topic, introduces the related theory, explains how to interpret metrics' outputs in a meaningful way and, finally, provides worked examples.

The topics covered include:

- Chapter 1: Think Spatially: Basic Concepts of Spatial Analysis and Space Conceptualization (Exercises solved with ArcGIS, GeoDa)
- Chapter 2: Exploratory Spatial Data Analysis Tools and Statistics (Exercises solved with ArcGIS, GeoDa)
- Chapter 3: Analyzing Geographic Distributions and Point Patterns (Exercises solved with ArcGIS)
- Chapter 4: Spatial Autocorrelation (Exercises solved with ArcGIS, GeoDa)
- Chapter 5: Multivariate Data in Geography: Data Reduction and Spatial Clustering (Exercises solved with ArcGIS, GeoDa, Matlab)
- Chapter 6: Modeling Relationships: Regression and Geographically Weighted Regression (Exercises solved with ArcGIS, Matlab)
- Chapter 7: Spatial Econometrics (Exercises solved with GeoDa space)

The book offers both a theoretical (*Theory*) and a practical (*Lab*) section for each chapter and adopts a “learn-by-doing” approach. *Theory* presents in detail concepts, methods and metrics, while *Lab* applies these metrics in solved step-by-step examples through ArcGIS and GeoDA. Matlab scripts are also offered for two labs.

Theory

Spatial analysis methods and techniques are described in a comprehensive and consistent way through the following subsections:

- *Definition*: Each subsection begins with the definitions of the methods to be presented. This allows for easy tracing of the definition of a new theory, concept or metric.
- *Why Use*: The “why use” statement follows. It offers an initial understanding of the importance of a method or metric and also presents the type of problems that these methods and metrics are more suitable to be applied.
- *Interpretation*: It is used to explain how we should interpret the outcomes of spatial analysis methods and metrics and goes one step further from just reporting numbers or maps without any further critical discussion.
- *Discussion and Practical Guidelines*: This section discusses the pros and cons of each method and metric. It also provides valuable tips on how to implement them from a practical perspective. For example, guidelines are offered to assist on how to select the appropriate parameters’ values (of statistics/metrics/tools), thus avoiding accepting uncritically the default values offered by software. Experimenting through various parameters’ values and settings allows for better insight on the impact of each parameter to the final outcome. Potential case studies are also presented.
- *Concluding Remarks*: A list of important remarks and guidelines is presented at the end of each chapter, summarizing the key topics of the theory.
- *Questions and Answers*: A set of 10 questions and answers is presented for self-evaluation.

Lab

Lab focuses on gaining hands-on practical experience through well-designed solved examples. All the main metrics included in *Theory* are presented in the *Lab* of each chapter. This allows readers to gain knowledge on how to perform spatial analysis and report results through step-by-step ArcGIS or GeoDa

commands. This section also highly emphasizes how to critically interpret results so that spatial analysis leads to knowledge extraction assisting in enhanced decision making and spatial planning.

A single worked example runs through the whole book. By working on a single case study, readers can delve deeper into the different approaches applied in spatial analysis. Chapter-by-chapter readers will gain a better understanding of the study region and thus interpretation of results would be easier and more meaningful.

The general structure of each lab is as follows:

- *Overall Progress*: A workflow is presented at the beginning of each lab showing the progress of the entire project. The exercises that each lab is consisted of along with the tools to be used and the expected outcomes are also presented graphically.
- *Scope of Analysis*: The problem to be solved is described.
- *Actions*: Step-by-step software guidance is provided to describe how to solve the problem and report results.
- *Interpreting Results*: Results are interpreted from the spatial analysis perspective and in relation to the problem at hand.

The book is a valuable resource to a wide audience and is not strictly addressed to geographers. Analysts, teachers, instructors, students of various majors and researchers from interdisciplinary fields who are eager to analyze geospatial data can benefit from this book. It provides the necessary concepts, methods, metrics and the technical skills through geospatial analysis tools (ArcGIS, GeoDa, and GeoDa Space) to study a variety of real-world problems pertaining to socioeconomic issues, locational analysis and planning, human and urban analysis, and efficiently assisting public policy and decision making. No previous knowledge of spatial analysis is required.

I am grateful for the help and advice of so many scholars, but as omissions and mistakes are inevitable, I would greatly appreciate messages pointing out corrections or suggestions, so that this book further improves. Errata will be published on the book's website.

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