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Book Review

Handbook of Applied Spatial Analysis: Software Tools, Methods and Applications by Manfred Fischer and Arthur Getis. Berlin, Springer, 2010. 811pp.

Handbook of Spatial Statistics by Alan E. Gelfand, Peter J. Diggle, Montserrat Fuentes, and Peter Guttorp. Boca Raton, FL, Chapman & Hall/CRC, 2010. 619pp.

The SAGE Handbook of Spatial Analysis by A. Stewart Fotheringham and Peter A. Rogerson. Thousand Oaks, CA, Sage, 2009. 528pp.

This set of three books presents state-of-the-art overviews of spatial statistics and spatial analysis, and are edited compilations from a wide range of experts in these fields. The lists of contributors are outstanding, with most having made seminal contributions to their respective fields. Spatial analysis has blossomed over the last 50 years, and since then an abundance of tantalizing techniques has emerged to better address and model complex geographical problems. New, interactive visualization methods coupled with robust statistical techniques facilitate the detection of spatiotemporal patterns.

The emphasis of the *Handbook of Applied Spatial Analysis* is not only on providing a rich palette of applications where spatial analytical methods have proven to be particularly informative but also on equipping graduate students and researchers with the necessary foundation to understand those methods. General themes covered include geographic information software tools (implementation of spatial analytical and geostatistical functionality in various software packages, such as ArcGIS, SAS, or GeoDA; extensions through programming languages such as R or Python; software development explicitly incorporating the time dimension, such as Stars, STIS, and Geosurveillance); spatial statistics and geostatistics (ranging from spatial autocorrelation to spatial clustering and spatial filtering); spatial econometrics (explicit integration of spatial structure in regression model specifications); and applications of spatial analytical methods to remote sensing, economic sciences, environmental sciences, and health sciences. The treatment of the geographic information software tools is probably what distinguishes this handbook from other similar books, providing students with an overview of existing platforms for applying spatial analysis and modeling. The spatial statistics section comprises a collection of short chapters that provide useful readings for a course on spatial analysis and modeling, at the end of each chapter an applied case study illustrates the theoretical underpinnings.

Similarly, the *Handbook of Spatial Statistics* provides a comprehensive and current survey of methods and models used by applied spatial statisticians. The

editors played a strong role in its production, even instructing the authors about the material to cover. The result is an exceptionally well-organized volume, with a strong continuity of tone, terminology, and structure among the chapters. Most of the chapters contain applications that are appreciated and that demonstrate the methods well. Many readers probably may wish that the data and computer codes for these examples were made available by the publisher. Topics addressed in this book start with a history of the discipline, followed by continuous spatial variation, discrete spatial variation, spatial point patterns, spatiotemporal processes, and ''additional topics.'' The ''Continuous spatial variation'' section begins with a clear and concise introduction to geostatistics, presenting an approach to kriging based on regression and generalized least squares rather than on Lagrange multipliers. The regression approach has become much more popular among statisticians and is probably more easily understood by students. The remaining chapters cover such emerging themes as spectral domain analysis and nonparametric analysis, hierarchical modeling, nonstationarity, network design monitoring, and asymptotics. The ''Discrete spatial variation'' section contains two chapters about Markov random fields and conditional and intrinsic autoregressive models. The ''Spatial point patterns'' section covers mathematical theory, typologies of point processes, and exploratory and parametric modeling techniques. The ''Spatio-temporal processes'' section addresses the theory and practice of models in space and time, and discusses topics such as nonseparability and state-space models. The final section examines additional topics that did not neatly fit in any specific section.

The SAGE Handbook of Spatial Analysis contains 25 chapters, with the last two addressing challenges in the future of spatial analysis. The two editors, as prestigious researchers in spatial analysis and statistics, carefully selected various topics, techniques, and methods that cover the major areas of spatial analysis: the special nature and handling needs of spatial data (e.g., spatial autocorrelation, the modifiable areal unit problem, spatial weights); the role of geographic information systems (GISs), geovisualization, and geovisual analytics; spatial data analytic techniques (e.g., spatial data mining, geostatistics and spatial interpolation, geographically weighted regression, spatial regression, Bayesian spatial analysis, spatial microsimulation); spatial sampling, statistical inference for geographical processes and detection of clustering in spatial data; fuzzy sets in spatial analysis; monitoring changes in spatial patterns; case–control clustering for mobile populations; neural networks for spatial data analysis; geocomputation; applied retail location models using spatial interaction tools; and, spatial analysis on a network. *The SAGE Handbook of Spatial Analysis* is one of the most comprehensive edited volumes about spatial analysis published to date. Its contributors come from diverse backgrounds, including geography, geomatics, computer science and engineering, biostatistics, ecology, biology, and economics. The editors state that the volume's primary goal is to ''provide a retrospective and prospective view of spatial analysis.'' Each chapter is designed to describe the current progress, problems/issues, and future research in the field, and in some, application examples of methods are

given. Because of the diverse discipline backgrounds of the contributors, the style of writing and technical presentation varies from chapter to chapter, ranging from a discussion of general issues and technical overviews to complicated statistical and mathematical formulas.

One commonality of these three books is their treatment of an interdisciplinary subject in an interdisciplinary way. Each has weaknesses and strengths, but together they supplement and complement each other. With a few notable exceptions, the emphasis of the *Handbook of Applied Spatial Analysis* is not on visualization, and the book does not address explicitly the development of spatial analytical tools for location, network and three-dimensional (3D) modeling, urban analysis, and social network modeling, the last becoming an increasingly important field. Although the section about remote sensing comprises three chapters particularly relevant to non-remote sensing scientists, the book would have benefited from combining them into a single, larger chapter.

Meanwhile, many topics that frequently appear in the quantitative geography literature, such as spatial econometrics, or ''local'' statistics, such as local indicator of spatial associations (LISAs) and geographically weighted regression, are not included in the *Handbook of Spatial Statistics*. Unfortunately for the readers of this journal, its well-written but token chapter about spatial econometrics is not very successful or satisfying: it contains a brief review of common econometric models but is a poor survey of recent developments in this field. Furthermore, much like Cressie's 1991 *Statistics for Spatial Data*, the technical expertise required for understanding the content of the *Handbook of Spatial Statistics* generally is that of a master's in statistics or economics.

Finally, for those readers without a strong statistical and mathematical background, the complicated statistical and mathematic formulas in some chapters of *The SAGE Handbook of Spatial Analysis* may be somewhat daunting. Most chapters fail to include the most recent original research, focusing on literature reviews of current issues and methods. Some interesting advances are reported, and potential future research agendas are identified by contributors through their literature reviews. Because of the review nature of this book and because of space limitations, details of methods and ideas presented in some chapters may be found by some readers to be insufficient. However, most chapters provide an extensive bibliography for the topics covered.

These preceding weaknesses are offset by a number of strengths. A significant chapter in the *Handbook of Applied Spatial Analysis* by Pierre Goovaerts compares and contrasts different geostatistical software for exploratory data analysis, variogram modeling, and interpolation. Another chapter describes PySAL, an open source library for spatial analysis maintained at Arizona State University. This book dedicates seven excellent chapters to spatial econometrics, which by far is its most theoretical section. Some of these chapters could offer more with illustrations, especially for students unfamiliar with the field of econometrics. A notable exception is the chapter about geographically weighted regression. The book benefits from an

excellent section dealing with health sciences and species distribution modeling. The fields of ecology and spatial epidemiology are both increasingly important benefactors of spatial analysis, while novel spatial analytical functions, which can handle large spatiotemporal datasets, are highly needed. In that respect, Roger Bivand discusses R, a prominent programming language in ecology and disease modeling, in two separate chapters in the first part of the book that are cross-referenced within the book.

Meanwhile, for researchers desiring to expand their understanding of the current literature in spatial statistics, the *Handbook of Spatial Statistics* furnishes a discussion of a diverse set of topics that regularly appear in mainstream statistics journals. It includes a chapter about the spectral domain by Montserrat Fuentes that is written with such clarity and motivation as to make the subject accessible to students with a firm grasp of only basic geostatistics. Other chapters about hierarchical and non-Gaussian modeling of geostatistical data present a clear demonstration of the advances made by Bayesian computational techniques in a way that is comprehensible to many graduate students. Adrian Baddeley contributes a clear and insightful chapter about the practice of point process modeling, nicely bringing together theory, sampling, exploratory data analysis, inferential modeling, and validation. A provocative chapter by David Brillinger outlines the use of stochastic differential equations to model spatial trajectories (such as animal movements). This technique is clever and should spur the modeling creativity of many geographers. Other appealing chapters include one about modeling multivariate spatial models via a Bayesian approach to cokriging, a review chapter by Alan Gelfand about the modifiable areal unit problem (MAUP), and a review chapter by Jonathan Wakefield and Hilary Lyons about the ecological fallacy problem.

Finally, *The SAGE Handbook of Spatial Analysis* furnishes a good summary of past developments and applications of spatial analysis methods and techniques that are widely used in many disciplines, such as geography, geology, biology, ecology, environment studies, social sciences, and health. With the increasing availability of larger volumes of spatial data and the rapid development of computing and GIS technology, the field of spatial analysis has grown rapidly in recent decades. This edited book helps address how best to use those large volumes of spatial data and to take advantage of the power of computing and GIS technology, and contributes to resolving challenges and contextualizing research topics of the spatial analysis research community.

Recommendations for these books are as follows:

- *Handbook of Applied Spatial Analysis*: This edited volume is noteworthy in how it brings together work by a variety of experts, and any graduate students or researchers applying or developing spatial analytical tools should find several appealing chapters. Overall, this book is an important contribution to the field of spatial analysis and modeling.
- *Handbook of Spatial Statistics*: Graduate students in geography wishing to pursue spatial analysis should be able to use this edited volume as a bridge

between their introductory classes and the literature at the frontiers of applied spatial statistics.

- *The SAGE Handbook of Spatial Analysis*: This edited volume provides a good summary of past developments and applications, and is a welcome addition to the growing spatial analysis literature, especially for those who want to have a ready reference and overview about different issues and methods in spatial analysis. The diversity of issues addressed potentially is of interest to interdisciplinary audiences, and the volume should be essential reading for researchers and graduate students who engage in spatial data analysis.

In other words, these three books should find prominent places on the bookshelves of serious quantitative spatial analysts.

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