Spatially Integrated Social Science: Background & Objective

Spatially Integrated Social Science

Edited by Michael F. Goodchild and Donald G. Janelle

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Background

The National Science Foundation funded CSISS (1999-2005) to enhance national research infrastructure for the social and behavioral sciences. CSISS provided opportunities to engage social and behavioral scientists in the explicit recognition of spatial perspectives and use of spatial analytic tools. This book was devised as a conduit for the main CSISS ideals into academia. The concept for the book was developed in summer 2000 and was released to the public by Oxford University Press in 2004.

The notion of "spatial social science" is in its formative stages. It is drawing momentum from rapidly expanding applications of new geographic information technologies, improved software, and newly available geographically referenced data of relevance to social science issues. We anticipate that spatial thinking and analysis will expand greatly over the next few years and we hope that this book will assist this important transition.

In identifying contributors, we looked for authors of articles with relevant content who were widely cited, supported from major peer-reviewed funding programs, and noted for use of spatial approaches within their sciplines. Though the authors represent several disciplines, they have one major attribute in common – the application of spatial thinking in their research designs and execution.

Objective

This book illustrates how the spatial perspective adds value and insight to social science research, beyond what traditional non-spatial approaches might reveal and makes available outstanding examples on the uses of spatial thinking. 21 chapters illustrate how spatial analysis fosters theoretical understanding and empirical testing. Each chapter exemplifies the founding principle for the Center for Spatially Integrated Social Science (CSISS) – that the analysis of social phenomena in space and time enhances our understanding of social processes. The chapters offer substantive empirical content for illustrating the interpretation of specific spatial analytic approaches suited to advanced research in the social sciences. It is our hope that the book will help cultivate an integrated approach to social science research that recognizes the importance of location, space, spatiality, and place. Aside from demonstrating applications of spatial analysis in research, it is anticipated that this book will also be suited as an advanced-level text for a trans-disciplinary audience.

CSISS Best Practice Publications:
Spatially Integrated Social Science

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Spatially Integrated Social Science: Chapter 1

Thinking Spatially in the Social Sciences

Michael F. Goodchild and **Donald G. Janelle**

Abstract

This introduction offers a framework for the conceptual integration of chapters that are intended to illustrate the practice and value of spatial thinking in the social sciences. We begin with an illustration of how the organization of information in non-spatial and spatial formats yields different interpretations, and of how failure to include locational information can shortchange our interpretations of social process. While different disciplines pose different research questions and have different traditions of analysis, we argue that a spatial perspective provides a common thread based on methods of descriptive and exploratory analysis. Specific attention is called to the importance of place-based analysis, the scientific value of spatially explicit models and theory, the utility of geographic information systems (GIS), and the value of space as a basis for integrating knowledge. GIS and spatial statistics are highlighted as appropriate exploratory tools for integrating diverse databases, and for analyzing and visualizing geographical patterns and processes.

Spatially Integrated Social Science: Chapter 2

Inferring the Behavior of Households from Remotely Sensed Changes in Land Cover: Current Methods and Future Directions

Bruce Boucek and **Emilio F. Moran**

Abstract

Research on land use and land cover change relating to landscape ecology, deforestation, desertification, and, more recently, links between climate change and health, frequently focuses on meso- and macro-scales where the spatial resolution is global, regional, or macro-regional. In this paper authors review efforts to empirically and spatially examine processes taking place at micro-scale (e.g., the household), discuss methods used under different conditions of settlement pattern, contributions to theory-building offered by these methods, and methodological advances in examining households, families, and other small social units. The micro-scale analyses reviewed here include three different settings that pose contrasting problems to the use of spatially-explicit methods: 1) urban areas; 2) rural areas wherein people live in villages and commute to their landholdings; and 3) rural areas wherein people reside on the land they use. The most detailed discussion concerns the conceptual, methodological, and empirical findings of our research group in the Brazilian Amazon. In this work we have linked demographic, social survey research, Landsat time series satellite data, and aerial photography, to construct a temporally and spatially fine-grained analysis of changes in land cover at both landscape and individual property scales so as to achieve inferences about the behavior of households. We conclude with a discussion of the distinct challenges and problems posed by conducting household scale land use and land cover change research in various settings. Methodological, technological, and theoretical advances are also presented that will enhance our ability to engage in such analyses, as well as broaden the range of theories and questions that are possible to address.

Spatially Integrated Social Science: Chapter 3

Geovisualization of Human Activity Patterns Using 3D GIS: A Time-Geographic Approach

Mei-Po Kwan and **Jiyeong Lee**

Abstract

The study of human activities and movements in space and time has long been an important research area in social science. One of the earliest spatially integrated perspective for the analysis of human activities patterns and movement in space-time is time-geography. Despite the usefulness of time-geography, there are very few studies that actually implemented its constructs because of a lack of detailed individual-level data and analytical tools. With the increasing availability of georeferenced individual-level data and improvement in the representational and geocomputational capabilities of Geographical Information Systems (GIS), the operationalization of time-geographic constructs has become more feasible recently. This chapter illustrates the value of time-geographic methods in the description and analysis of human activity patterns using GIS-based three-dimensional (3D) geovisualization methods. These methods are used to study gender/ethnic differences in space-time activity patterns using an activity diary data set collected in the Portland (Oregon) metropolitan area. The study shows that geovisualization methods are not only effective in revealing the complex interaction between the spatial and temporal dimensions in structuring human spatial behavior. They are also effective tools for exploratory spatial data analysis that can help the formulation of more realistic computational or behavioral models.

Spatially Integrated Social Science: Chapter 4

Agent-Based Modeling: From Individual Residential Choice to Urban Residential Dynamics

Itzhak Benenson

Abstract

Householder residential choice and residential mobility are among the touchstones of theoretical and applied study of urban systems. Agent-Based (AB) models of these processes imitate the explicit behavior of individual migrating householders; they thereby integrate modern social spatial science with urban theory and applications. Spatially explicit agent-based models account for the real-world heterogeneity of urban infrastructure and population, and enable comprehension and forecasting of urban spatial population dynamics based on high-resolution municipal and census GIS databases. From the perspective of AB modeling, regional or global urban dynamics represent outcomes of agent behavior yet influence those agents' characteristics and behavior in turn.

The chapter reviews state-of-the-art AB modeling of urban residential dynamics, including a review of the social foundations and empirical studies that provide the basis for the model's validation. The analysis demonstrates the macro-level outcomes of the co-adaptive local behavior of multiple agents in terms of the evolution of residential segregation, neighborhood formation, and emergence/decline of socio-cultural groups. The simulation of residential dynamics in the Yaffo area in Tel Aviv (population: 30,000) provides an example of the application of the AB model to the real-world problems.

Spatially Integrated Social Science: Chapter 5

Too Much of the Wrong Kind of Data: Implications for the Practice of Micro-Scale Spatial Modeling

David O'Sullivan

Abstract

There has been considerable recent excitement in the spatial modeling community about the potential for micro-scale simulation methodologies such as cellular automata (CA) and agent-based models (ABM). An important issue, frequently overlooked in the enthusiasm for these techniques, is their voracious appetite for detailed data. Although detailed geo-referenced digital data are now routinely available, they are often not suitable for use in models built at the micro-scale of individual households, buildings and tracts. Instead, data are available in aggregated and anonymized geographical forms. It is argued that this is an issue with practical implications for contemporary spatial modeling, which also raises questions about the purpose of such models. It is further suggested that the issues raised bring into question the traditional cycle of pattern-matching and recalibration as a methodology for evaluation of the success of such models. The discussion of these issues is conducted with reference to recent applied work by the author on pedestrian behavior and gentrification.

Spatially Integrated Social Science: Chapter 6

Identifying Ethnic Neighborhoods with Census Data: Group Concentration and Spatial Clustering

John R. Logan and **Wenquan Zhang**

Abstract

Minorities and immigrants have always established distinctive settlement areas in American cities. These "ethnic neighborhoods" are most often identified and studied through fieldwork, where the researcher typically begins with the knowledge that a given locale is socially recognized as being the place of residence of a particular ethnic group. But to answer some kinds of questions (such as: How are ethnic neighborhoods different from other locales? What distinguishes their residents from group members who live elsewhere?) requires systematic methods of identifying neighborhoods and defining their boundaries. This chapter shows how two indicators of a group's residential pattern can be combined for this purpose. One, widely used in thematic maps, is the concentration of group members at the level of census tracts. Another is the spatial clustering of the concentrations. The method is illustrated for Chinese and Filipinos in the Los Angeles metropolitan region in 1990. It is shown that the location and character of ethnic neighborhoods varies widely within the region, from "immigrant enclaves" that primarily serve the needs of disadvantaged newcomers to "ethnic communities" serving the more affluent and better-established members of ethnic groups.

Spatially Integrated Social Science: Chapter 7

Spatial Analyses of Homicide with Areal Data

Steven F. Messner and **Luc Anselin**

Abstract

This chapter highlights the ways in which the application of recently developed techniques for spatial analysis contributes to our understanding of homicide. We begin with a brief historical review of the role of geographic space in the sociological study of crime and then discuss generic methodological issues involved in the study of areal units. The logic of important techniques for spatial analysis is explained and illustrated using two empirical case studies of variation in homicide rates across U.S. counties. One case study involves the use of techniques of Exploratory Spatial Data Analysis (ESDA), and the other applies spatial regression modeling. The analyses yield suggestive evidence of diffusion processes and also reveal the incompleteness of well-accepted baseline models of homicide rates. The chapter concludes with a brief discussion of pressing issues for future research on the spatial dynamics of crime.

Spatially Integrated Social Science: Chapter 8

Spatial (Dis)Advantage and Homicide in Chicago Neighborhoods

Robert J. Sampson and **Jeffrey D. Morenoff**

Abstract

This study links police records, vital statistics, census data, and an original survey of 8,872 Chicago residents to assess the spatial interdependence of neighborhood-level homicide rates. Structural characteristics in 1990 and survey measures from 1995 are used to model variations in the event rate of homicide for 1996-1998 across 343 neighborhoods. Spatial proximity to homicide risk is strongly and positively related to variations in homicide rates, adjusting for internal structural characteristics, social processes, and even prior homicide. Concentrated disadvantage, along with low levels of social control and cohesion, predict higher rates of homicide. In addition to the extreme inequality of neighborhood resources, both economic and social in nature, spatial dynamics are therefore consequential for explaining urban violence.

Spatially Integrated Social Science: Chapter 9

Measuring Spatial Diffusion of Shots Fired Activity Across City Neighborhoods

George Tita and **Jacqueline Cohen**

Abstract

Social scientists interested in crime often ask one of two questions: "Why does the distribution of crime differ over place?" or "Why does the level of crime within a place change over time?" Examining these questions separately, however, ignores a potentially richer understanding arising from space/time interactions in crime. This chapter extends earlier work by Cohen and Tita (1999) on a general method for identifying changes in spatial and temporal patterns of homicide that are compatible with various forms of diffusion. Building on Anselin's work on "local indicators of spatial association" (LISA statistics), the method explores the dynamics of changes over time in patterns of spatial concentration in homicide across neighborhoods within a city. The method distinguishes between contagious diffusion between adjoining units and hierarchical diffusion that spreads broadly through commonly shared influences. The current analysis examines patterns of spatial diffusion in non-lethal precursors to gun violence reflected in calls to police reporting "shots fired" incidents.

Spatially Integrated Social Science: Chapter 10

The Spatial Structure of Urban Political Discussion Networks

Munroe Eagles, **Paul Bélanger**, and **Hugh W. Calkins**

Abstract

Social network analyses have increased in popularity in recent years, partly because the snowball sampling technique they employ "liberated" scholars from their reliance on geographically constrained research designs in their investigations of interpersonal influence on political behavior. While refreshingly sociological in their approach, such innovations in survey research have ironically further contributed to the intellectual devaluation of space in quantitative analyses of political behavior. In this chapter, we take up the challenge of bringing geography back in to the analysis of sociometric data. Using a truncated snowball sample survey of South Bend, Indiana residents in which we have geocoded respondents, we show that there are identifiable patterns in the geographic structure of urban political discussion networks, as measured by the distance separating discussion partners ("dyad distance"). Specifically, dyad distance is shown to vary as a function of the main respondent's education, age, income, race, the intimacy of the relationship, and the setting in which discussion partners met. However, the distance separating discussion partners does not appear to significantly enhance the transmission of political influence, net of other factors.

Spatially Integrated Social Science: Chapter 11

Mapping Social Exclusion and Inclusion in Developing Countries: Spatial Patterns of São Paulo in the 1990s

Gilberto Câmara, **Aldaiza Sposati**, **Dirce Koga**, **Antonio Miguel Monteiro**, **Frederico Roman Ramos**, **Eduardo Camargo**, and **Suzana Druck Fuks**

Abstract

This chapter examines the use of spatial analytical techniques to explore the patterns of social exclusion for the Brazilian city of São Paulo, based on indices of social exclusion/inclusion calculated from census data. We used global and local spatial autocorrelation indices to identify clusters of social exclusion and social inclusion in São Paulo. Spatial regression techniques measured the relation between the various phenomena that comprise social exclusion, and helped establish how the conditioning factors of social exclusion vary within the city. We also used geostatistical techniques for producing surfaces of spatio-temporal trends in the evolution of crime in São Paulo. These examples show how spatial analytical techniques can enhance the understanding of social exclusion and inclusion patterns in large cities of the developing world.

Spatially Integrated Social Science: Chapter 12

Business Location and Spatial Externalities: Tying Concepts to Measures

Stuart H. Sweeney and **Edward J. Feser**

Abstract

Spatial externalities among businesses, though notoriously difficult to measure, are a central concern in urban and regional economics. Traditionally they - along with closely related concepts such as agglomeration economies - have been studied empirically with hedonic models, production and cost functions, and simplified growth models. More recently, researchers have begun using direct measures of proximity among businesses to shed light on the influence of externalities on industrial location, regional growth, and localized technological change. The shift has been aided by an explosion in spatially-referenced economic data, advances in spatial statistics, and the advent of affordable and user-friendly GIS and related software.

As existing indicators of concentration and spatial association have been adapted for the economic domain and new ones developed, the pool of measures useful for business location research generally, and externalities more specifically, has expanded. In this chapter, we systematically review and compare a set of leading indicators of business co-location using standard data sets and evaluation criteria. Ultimately, our aim is to assess the capabilities and limits of the measures for understanding spatial business externalities. More generally, we discuss a number of common challenges associated with drawing inferences from cross-sectional spatial data.

Spatially Integrated Social Science: Chapter 13

Updating Spatial Perspectives and Analytical Frameworks in Urban Research

Qing Shen

Abstract

A spatial perspective that encompasses geographic, technological, and socioeconomic, dimensions is required for understanding many problems in contemporary cities. In this chapter the author first presents a spatial perspective that views geographic location, transportation mode and communications means, and relevant socioeconomic characteristics as factors jointly determining functional distance and hence the spatial positions of places and people. The theoretical discussion of this perspective is followed by an empirical analysis of commuting data for the Boston Metropolitan Area to illustrate the wide range of factors influencing spatial interaction. The author then applies this spatial perspective to address key issues in two important areas of urban research. One area is urban low-income labor markets, focusing on questions concerning access to employment opportunities in dispersing metropolitan economies. Using an analytical framework coherent with the spatial perspective described here, it is found that workers' spatial position in an urban labor market in the United States is determined primarily by their transportation mode, not by their residential location. The other area is telecommuting, focusing on the effects of telecommunications on travel behavior and residential location choice. By examining the roles of geographic, technologic, and socioeconomic factors in forming and traversing the physical and virtual components of activity space, it is shown that analytical capacity can be created for understanding spatial impacts of telecommunications under different scenarios.

Spatially Integrated Social Science: Chapter 14

Spatial Analysis of Regional Income Inequality

Sergio J. Rey

Abstract

Questions surrounding regional economic convergence have commanded a great deal of recent attention in the economics literature. As in other recent cases in the social sciences, the application of spatially explicit methods of data analysis to the convergence question has yielded important insights on regional economic growth. By contrast, the literature on regional income inequality, although somewhat older than the convergence literature, has been slower to adopt new spatially explicit methods of data analysis.

This chapter helps to speed that adoption by investigating the role of spatial dependence and spatial scale in the analysis of regional income inequality in the United States over the 1929-2000 period. The findings reveal a strong positive relationship between measures of inequality in state incomes and the degree of spatial autocorrelation. Additionally, a geographically based decomposition of inequality highlights a strong positive relationship between the interregional inequality share (as opposed to intraregional inequality) and spatial clustering. Finally, a new approach to inference in regional inequality analysis is suggested and demonstrated as providing a formal explanatory framework to complement the broad, but descriptive, approaches in the existing literature.

Spatially Integrated Social Science: Chapter 15

Shaping Policy Decisions with Spatial Analysis

Ted K. Bradshaw and **Brian Muller**

Abstract

Methods of spatial analysis have developed rapidly over the past decade; nonetheless, in our experience, the growing capacity of spatial analytical techniques continues in large part to be underutilized in policy decision making or planning. On the one hand, there is rapid growth in computing power and availability of specialized software; on the other hand, local policymakers by and large rely on experience, intuition and consultation and at most simple spreadsheet-based analysis or descriptive maps in making spatially explicit decisions. In this paper, we examine two examples of how spatial analysis can contribute to policy discussion. First, we report on recent work exploring the spatial distribution of small business loan guarantees in California cities. In this case, our findings led to identification of potential locations for an expanded state guarantee program. Second, we discuss applications of an urban growth model in Monterey and Santa Cruz counties. Using sub-models to evaluate the cost of public services and viability of the local agricultural economy, we compare impacts and trade-offs among different types of urban forms. We conclude that expanded technological capacity, greater ability to include qualitative data, more institutional and organizational demand, and the opportunity for greater public participation are all helping policy makers to better use spatial analysis.

Spatially Integrated Social Science: Chapter 16

Geographical Approaches for Reconstructing Past Human Behavior from Prehistoric Roadways

John Kantner

Abstract

Roadways were the ties that bound ancient societies together, for they facilitated economic interaction, symbolized social and political ties, and reflected the worldviews of the people who constructed them. Archaeologists therefore have much to gain from the analysis of road systems created by past societies. This study begins with a discussion of geographical approaches used by archaeologists to examine prehistoric roadways, with a special emphasis on the utility of Geographic Information Systems (GIS) in these analyses. The 1000-year-old roads of the Chaco Anasazi of the southwestern United States provide a case study illustrating how spatial analytical techniques for studying road networks strengthen our reconstructions of past regional behavior. Scholars debate the function of these Chacoan roadways, with some archaeologists claiming they facilitated exchange, others arguing that they served local social and political roles, and still other researchers contending that the roads were regional representations of Chacoan cosmology. To evaluate these hypotheses, results of a GIS-facilitated cost-path analysis are described. This analysis demonstrates that Chaco Anasazi roadways did not facilitate regional economic interactions, and that they instead reflected a concern with cosmology as well as local sociopolitical landscapes. The case study illustrates the importance of spatial analytical approaches for addressing archaeological problems.

Spatially Integrated Social Science: Chapter 17

Time, Space, and Archaeological Landscapes: Establishing Connections in the First Millennium BC

Patrick Daly and **Gary Lock**

Abstract

This chapter describes the integration of spatial technologies into the theory and practice of landscape archaeology. Using the long-term fieldwork of the Hillforts of the Ridgeway Project (Oxfordshire, England) as a vehicle, we show how recent theoretical approaches aimed at understanding the temporal and spatial structuration of sites and landscape can be formalised through the use of GIS. The Project area comprises a series of different sorts of prehistoric sites which excavation has shown to span most of the first millennium BC although differing phases of use and significance for each site create a complex web of connections through time and space. The methodologies developed here are based on a multi-scalar approach so that different sorts of data representing different scales of social practice can be incorporated into the analyses. Ranging from individual artefacts within layers of cultural deposition within features, to complex arrangements between features within sites and landscapes, GIS functionality can be used to establish connections and suggest meaningful structuring in new and powerful ways. This moves traditional post-excavation analysis away from the site specific and situates it within a more holistic landscape approach.

Spatially Integrated Social Science: Chapter 18

Spatial Perspectives in Public Health

Anthony C. Gatrell and **Janette E. Rigby**

Abstract

A full understanding of the health of the population requires perspectives from a wide range of disciplines, covering the social, environmental and natural sciences. Since those at risk of disease, or with varying health status, occupy, and move among, a variety of locations, and since the factors that shape their health also have particular spatial configurations, it is unsurprising that a spatial perspective on public health is essential. Here, we show how such a perspective illuminates the understanding of three broad disease areas–HIV/AIDS; breast cancer; and skin disease. We consider a range of spatial analytic methods that shed light on disease distribution. The set of spatial analytic methods covered here includes those for creating maps in non-geographical spaces, as well as techniques for detecting spatial clustering among area and point pattern data.

We next ask how a spatial perspective helps understand the social patterning of health inequalities, considering such inequalities at both regional and local scales. Here, we suggest the appropriateness of a GIS perspective, used to shed light on differential access to health care facilities as well as proximity to sources of environmental contamination.

Spatially Integrated Social Science: Chapter 19

The Role of Spatial Analysis in Demographic Research

John R. Weeks

Abstract

A general framework is proposed for the application of spatial analysis to demographic research as a way of integrating and better understanding the different transitional components of the overall demographic transition – the epidemiological transition, the fertility transition, the migration transition, urban transition, the age transition, and the family and household transition. This framework is discussed in the context of a review of the still relatively sparse literature on spatial analysis in demography. The discussion then turns to the kinds of data that are required for spatial demographic analysis, the kinds of statistical approaches that are available to researchers, and the way in which GIS can help to integrate each of these components for the testing of theories and building of models. The chapter concludes with an example of this type of research, drawing upon the author's study, which is aimed at an improved understanding of the Arab fertility transition through the testing of explicitly spatial theories about the timing and tempo of fertility change. Specifically, this research applies GIS, remote sensing, and spatial statistics to the fertility transition in rural and urban Egypt.

Spatially Integrated Social Science: Chapter 20

Spatial Interaction Models of International Telecommunication Flows

Jean-Michel Guldmann

Abstract

Spatial interaction modeling is used to analyze international telephone flows, in conjunction with a new data set for 4137 country-to-country routes, involving 103 origin and 204 destination countries. These data are matched with several country-related technological and socio-economic data, making up a very rich set of exploratory variables, that allows for analyses of the effects of telecommunication equipment, including Internet access, trade and tourism, income per capita, geographical distance, isolation, and contiguity, language, cultural, religious, political, and geographical commonalities, and the international spatial structure. The results point to both the stimulation and substitution effects of new technologies (Internet, ISDN), suggesting that electronic mail via the Internet may substitute for international telephone flows. The results also underscore the critical role of a country's level of telecommunication equipment, size of the business sector, exports and imports, and tourists attraction, the importance of membership in trade, political, and cultural groups, the impacts of language and religion commonalities, and, of course, the role of geography, as measured by great-circle distances, contiguity, time zone differences, island status, and spatial structure variables.

Spatially Integrated Social Science: Chapter 21

Planning Scenario Visualization and Assessment: A Cellular Automata Based Integrated Spatial Decision Support System

Roger White, **Bas Straatman**, and **Guy Engelen**

Abstract

We present two closely related models designed to support urban and regional planning and policy development. The first, consisting of a Cellular Automaton based integrated dynamic spatial simulation model, augmented with decision support tools, supports the development and assessment of policies for improving the quality of the lived environment in the Netherlands. The whole of the Netherlands is modeled. The second model was developed for the Visions project of the European Union to support the creation of consistent, integrated visions for a sustainable Europe for the years 2020 and 2050. It is derived from the first model, but differs in that user-supplied scenarios drive the spatial simulation. An important component is a set of tools that facilitates translation of qualitative "story-line" scenarios into the quantitative ones that drive the land use model. Only the Green Heart region of the Netherlands is modeled. An example of the use of the model to develop a Visions scenario is given.