Book Review:
Quantitative Methods and Socio-Economic Applications in GIS

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Introduction

Integration of quantitative methods on social science research has progressed in studying the complex human or social systems. Geographic Information System (GIS) is the main tool that has capability to integrate and analyze various datasets on spatial aspects. Not only geography researchers who are interested on the interaction of human activity and spatial dimension, but also other social-related fields share the same interests (Figure 1).

Concept and theory before GIS age are quite difficult to explore spatially in the real-world applications for practitioner. However, GIS has capability to integrate quantitative methods with spatial analysis. In this book, the author, Prof. Fahui Wang, has provided both concept and theoretical backgrounds on human geography, city and regional planning of public policy. In addition, the author also demonstrates the example in the real-world applications based on GIS environment largely performed by ArcGIS.
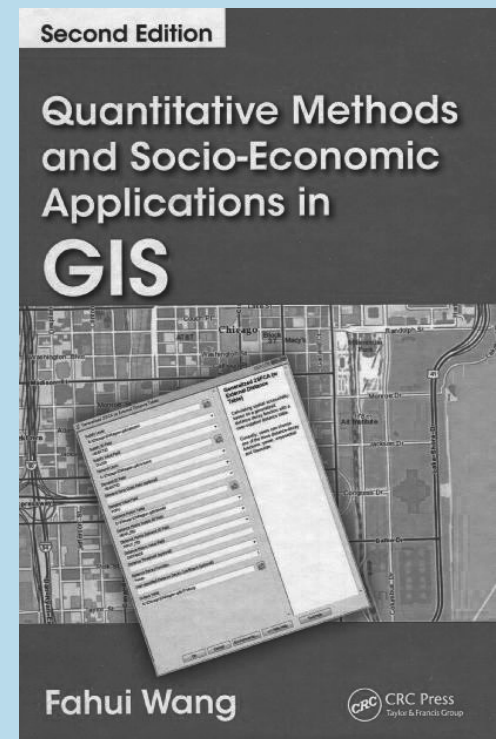

Figure 1. The reviewed book. (Wang, F. 2015)

The second edition of the book has made three substantial improvements over the first edition. First, the author developed and provided ArcGIS tools as additional resources to automate operational processes in many methods and models. Second, developed programs were implemented for more advanced tasks. Lastly, the concept of geodatabase was used for the data format to improve the data management for the analyses. The book has been divided into three sections oriented toward advanced applications.

About author

Prof. Fahui Wang is James J. Parsons Professor at department of Geography and Anthropology, Louisiana state university (Figure 2). He earned BS in Geography, Peking university, an MA Economics and PhD in City and Regional Planning from the Ohio State University. His researches interests focus on human geography using GIS, computational methods, spatial Statistics as a tool to explore spatially-integrated social sciences, public policy and planning. He is on the editorial boards of several international journals such as Annals of the Association of American of American Geography, Applied Geography and the Chinese Geographical Science.

This book is made up of twelve chapters and split into three sections which include:

Section I: GIS and basic spatial analysis tasks

The first part deals with a fundamental background on simple spatial analysis using ArcGIS. This section consists of three chapters focusing on mapping population density, computing distances and travel time and interpolation methods from discrete data. Chapter one introduces data management and basic on spatial analysis tools in GIS that will inspire readers to gain necessary ideas on applications in ArcGIS to cope with spatial and attribute data. Analysis of the population density pattern across concentric rings has been picked

up to demonstrate the analytical tools as a case study of Baton Rouge, Louisiana. Discussions on measuring distance and time are carried on the Chapter two to analyze how the human activities change with distance from reference locations of interests. Although the concept is simply explained, the chapter two's concepts are used throughout this book. Based on distance decay rule, detection of physical or socio-economic objects occurs while the distance increases away from reference points. Application concept of distance and travel time is demonstrated by calculating accessibility to public hospitals in Louisiana implemented in ArcGIS. Calculated distances have been compared the results between Euclidean and Manhattan distances, while O-D (Origin-Destination) cost matrix tool is used to calculate traveling time origins and destinations.

Chapter three covers two generic tasks in GIS-based spatial analysis that are mainly related to spatial smoothing and spatial interpolation. Spatial smoothing used a larger spatial window size to average values, while spatial interpolation is to estimate unknown values from known values at some locations. In order to reduce spatial variability, spatial smoothing accounts on its nearby locations applicable for many applications in population problems. In this book, Floating Catchment Area (FCA) method and kernel density estimation have been illustrated in details of applications. On the other hand, interpolation in case of point and area-based cases has also been addressed with the real application in the case of Guangxi, China (Figure 3).

Section II: Basic quantitative methods and applications

Site selection is important analysis for support a decision of retail store investment which is one of the common tasks for trade area analysis. In chapter four, the author describes the fundamental theories in business geography associated with the real-world applications. The analog methods

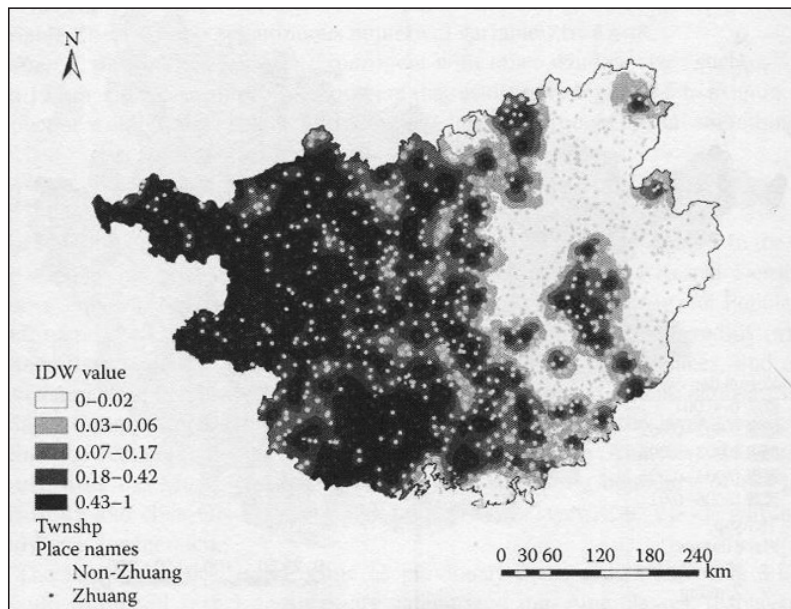**Figure 2.** Prof. Fahui Wang. (LSU Department of Geography & Anthropology, 2018).

Figure 3. Spatial interpolation of Zhuang place names in Guangxi by the IDW method (Wang, 2015).
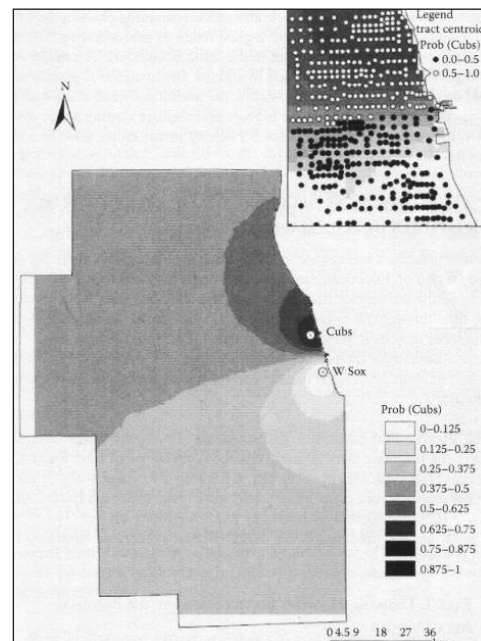

Figure 4. Probability of choosing the Cubs by the huff model. (Wang, 2015)

implemented by earlier geographers in the field of retail geography have been possibly implemented in the GIS era. Fundamental methods for trade area analysis have been demonstrated in ArcGIS such as analog methods and regression model, and proximal area method. In addition, Gravity models for delineating trade areas such as Reilly's law, Huff model have been also demonstrated for defining fan bases of Cubs and the case study of white sox in Chicago region (Figure 4).

Accessibility is one of the important considerations to the spatial analysis tasks that have been covered in Chapter five such as frequency and satisfaction of using a service. Based on theory, FCA methods, Gravity-based and generalized two-step floating catchment area (2SFCA) models have been discussed with the use of real data to analyze accessibility to primary care physician in Chicago. To overcome the fallacies of earlier versions of the floating catchment area (FCA) method which are related to demand or supply exceeding the threshold of distance of 2SFCA method have been developed by Luo and Wang (2003) as shown in Figure 5.

Economic activities can be estimated spatially with the concept of urban density patterns to reveal central business district. In Chapter six, the author have discussed about how to define the best fitting function to capture density patterns for urban and regional structures. Interestingly, GIS and implemented regression models have been discussed on an analysis of polycentric models requiring the identification of multiple centers.

The statistical methods to eliminate variable collinearity and uncovering latent variables have been discussed in Chapter seven. Principal components and factor analysis are useful statistics on reduction of data dimensions in order to easy interpret and removing multicollinearity for subsequent regression analysis. On the other hand, cluster analysis attempts to classify

observations into categories based on their similarity. The author links these statistical concepts to social area analysis in application of spatial patterns to reveal socio-economic factors controlling these extracted spatial patterns.

In chapter eight, the author illustrated spatial statistics that have their unique on analysis of the pattern, process and relationship in spatial data. For instance, one can use the concepts to map historical trends of population centers in specific area using Centrographic measures. In addition, spatial cluster analysis has its capability to detect unusual concentrations or nonrandomness of spatial events. For instance, criminal concentrations can be detected using hotspot analysis that are also demonstrated in the chapter associated with case of cluster homicide rates using spatial statistics named the local Moran's I.

Section III: Advanced quantitative methods and applications
The section III discusses about selected case studies which are related to clustering, land use modeling and optimization, and Montecarlo techniques on modeling of traffic. This section is suitable for the advanced researchers to gain more experiences in the multidisciplinary fields.

Regionalization methods and application in analysis of cancer data have been discussed in Chapter nine. The author demonstrates the modeling of late-stage breast cancer data in Zip code areas in the Chicago region in 2000 (Figure 6). In chapter ten, application of Garin-Lowry model in simulation of urban population and employment patterns have been demonstrated using the fundamental concept in system of linear equations.

In chapter eleven, linear programing has been used to optimize technique in socio-economic analysis and urban planning. This chapter illustrates how linear programing problems are solved in ArcGIS and other popular software (R and SAS).
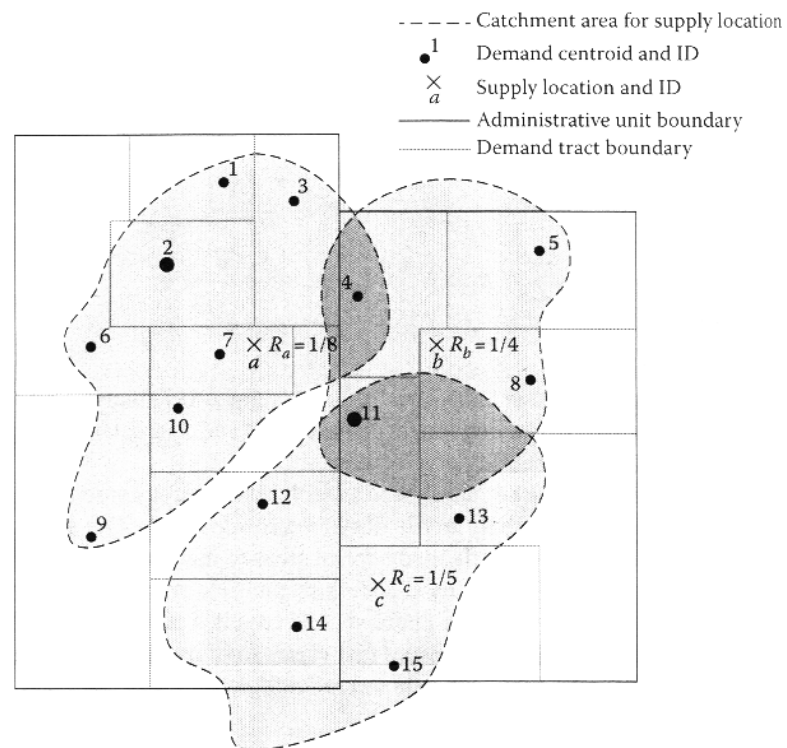

Figure 5. Two-step floating catchment area (2SFCA) method in travel time. (Luo & Wang, 2003).
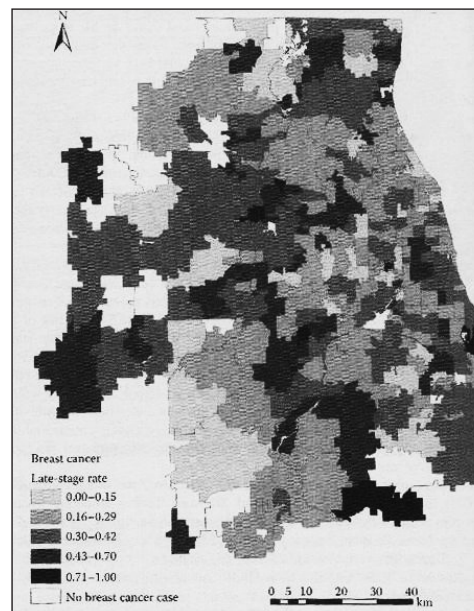

Figure 6. Late-stage breast cancer rates in zip code areas in the Chicago region in 2000. (Wang, 2015).

Application in urban traffic simulation have been demonstrated and discussed in the last chapter. Brief introduction of Montecarlo method are given for its applications in spatial analysis. The example of traffic simulation in Baton Rouge has been selected with the use of a prototype program of traffic simulation modules for education (TSME).

Summary and discussion

The author, Prof. Fahui Wang, has blended GIS, spatial analysis and quantitative methods associated with real-world applications. Students, researchers, practitioners in many fields of study such as geography, other social science-related fields (e.g. sociology, anthropology, business management, city and regional planning, public administrations) would attain a great benefit from this book on their works. The author addressed a progress in the GIS field. The earlier developed theories and concepts before the beginning of the GIS age can now be applied and synthesized in the system. To evaluate the scenarios in the social problems, most potential readers will be definitely inspired by the ideas of integration on fundamental concepts to real-world situations in GIS. In addition to real world applications, coordinate metadata and qualitative data that are attached to social media dataset can be accessed from internet have increased possibility to integrate with the quantitative method in GIScience both for reanalysis and real-time applications. Big data infrastructures make it possible for researchers to investigate on specific phenomena related to spatio-temporal analysis (Martin, 2017). Therefore, the ideas of applications fundamental theory of spatial sciences to real world are illustrated through this book and recommended to any readers.

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