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Introduction

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1.1. WHAT IS SPATIAL ANALYSIS?

Spatial data contain locational information as well as attribute information. That is, they are data for which some attribute is recorded at different locations and these locations are coded as part of the data. Spatial analysis is a general term to describe a technique that uses this locational information in order to better understand the processes generating the observed attribute values.

Spatial analysis is important because it is increasingly recognized that most data are spatial. Examples of common types of spatial data include census data, traffic counts, patient records, the incidence of a disease, the location of facilities and services, the addresses of school pupils, customer databases, and the distributions of animal, insect or plant species. Along with various attributes collected by hand or by different types of sensors, location is also being captured by an increasing variety of technologies such as GPS, WiMAX, LiDAR, and radio frequency identity (RFID) tags as well as by more traditional means such as surveys and censuses. Some of the resulting data sets can be extremely large. Satellites, for example, regularly record terrabytes of spatial data; LiDAR scanners can capture millions of geocoded data points in minutes; and GPS-encoded spatial video generally produces 24 frames per second each of which may have around a million geocoded pixels. The world is rapidly becoming one large spatial sensor with RFID tags, CCTV cameras and GPS linked devices recording the location of objects, animals and people.

Spatial data and the processes generating such data have several properties that distinguish them from their aspatial equivalents. Firstly, the data are typically not independent of each other. Attribute values in nearby places tend to be more similar than are attribute values drawn from locations far away from each other. This is a useful property when it comes to predicting unknown values because we can use the information that an unknown attribute value is likely to be similar to neighbouring, known values. The subfield of geostatistics has grown up based on this premise. However, if data values do exhibit spatial autocorrelation, this causes problems for statistical techniques that assume data are drawn from independent random samples. Special statistical methods, such as spatial regression models, have been developed to overcome this problem. Equally, it is often hard to defend the assumption of stationarity in spatial processes. That is, it is often assumed that the process generating the observed data is the same everywhere. Spatial non-stationarity exists where the process varies across space. Again, special statistics, such as Geographically Weighted Regression, have been developed to handle this problem.

1.2. TYPES OF SPATIAL ANALYSIS

While there are many different techniques of spatial analysis, they can be categorized into four main types:

1 Those spatial analytical techniques aimed at reducing large data sets to a smaller amount of more meaningful information. Summary statistics, various means of visualizing data and a wide body of data reduction techniques are often needed to make sense of what can be extremely large, multidimensional data sets.
2 Those techniques collectively known as exploratory data analysis which consist of methods to explore data (and also model outputs) in order to suggest hypotheses or to examine the presence of unusual values in the data set. Often, exploratory data analysis involves the visual display of spatial data generally linked to a map.
3 Those techniques that examine the role of randomness in generating observed spatial patterns of data and testing hypotheses about such patterns. These include the vast majority of statistical models used to infer the process or processes generating the data and also to provide quantitative information on the likelihood that our inferences are incorrect.
4 Those techniques that involve the mathematical modelling and prediction of spatial processes.

This book will cover examples of all four types of spatial analysis.

1.3. SPATIAL ANALYSIS IN PERSPECTIVE

It is difficult to say exactly when spatial analysis began in earnest but the beginnings are generally cited in the late 1950s and early 1960s, although much earlier examples of individual pioneering work can be found (e.g, Spottiswoode, 1861). Certainly, the decades of the 1960s and 1970s were periods when quantitative methodologies diffused rapidly within disciplines such as geography and regional science and when much pioneering and fundamental research was carried out. There then followed a period of relative decline for various reasons as outlined by Fotheringham (2006) when many of the newer paradigms in human geography were starkly anti-quantitative. Perhaps also many of the early examples of spatial analysis were overly concerned with form rather than with process and were rightly criticized for this focus. In addition, it is possible that expectations for quantitative methods may have initially been too high. For example, many believed that spatial modelling, when coupled with adequate data and rapidly increasing computing power, would lead society to 'solve' many of the pressing issues in urban and regional areas.

Significant advances in spatial analysis during the past two decades have brought about a new era of interest in the field. The period of relative decline has now been replaced by one of great enthusiasm for the potential of spatial analysis. This potential has been recognized and embraced by researchers from many fields, ranging from public health and criminal justice, to ecology and environmental studies, as evidenced by various contributions to this volume.

It is now widely recognized in a broad range of disciplines that spatial analysis has an important role to play in making sense of the large volumes of spatial data we now have available and the demand for spatial analysis has never been stronger. It thus is an important time to produce this *Handbook of Spatial Analysis* describing many of the major areas of spatial analysis.

1.4. OVERVIEW OF THE HANDBOOK

The book is designed to capture the state-of-the-art in a broad spectrum of spatial analytical techniques that can be applied to spatial data across a very wide range of disciplinary areas.

Our intent has been to provide a retrospective and prospective view of spatial analysis that covers:

- the reasons why the analysis of *spatial* data needs separate treatment;
- the main areas of spatial analysis;
- the key debates within spatial analysis;
- examples of the application of various spatial analytical techniques;
- problems in spatial analysis; and
- areas for future research.

Although there is inevitable (and desirable) variability in the structure and nature of the individual chapters, in a broad sense the contributions have the following aims:

- describe the current situation within the field, highlighting the main advances that have taken place, as well as current debates;
- describe the problems that still exist, indicating where future research may be best directed;
- indicate key works in the field and provide an extensive bibliography for the area;
- describe the use of the technique in several disciplines; and
- maintain a balance between concepts, theories and methods.

Rapid improvements in the development and availability of high-quality datasets, along with the power and features of geographic information systems that now increasingly provide capabilities for advanced forms of spatial analysis, have propelled the field forward. Consequently, the field of spatial analysis is currently in the midst of an exciting growth period, where many new tools and methods for analyzing spatial data are being developed, and where applications are being made in an increasing number of fields. This Handbook represents a summary of these developments and applications, as well as a sense of the intense interest that the field now enjoys.

REFERENCES

Spottiswoode, W. (1861). 'on typical mountain ranges: an application of the calculus of probabilities to physical geography'. *Journal of the Royal Geographical Society of London*, **31**: 149–154.