A Classification of Geographical Information Systems Literature and Applications

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1989
Listing of Catmogs in print

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1: Collins, Introduction to Markov chain analysis. 3.00
2: Taylor, Distance decay in spatial interactions. 3.00
3: Clark, Understanding canonical correlation analysis. 3.00
4: Openshaw, Some theoretical and applied aspects of spatial interaction shopping models. (fiche only) 3.00
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20: Silk, Analysis of covariance and comparison of regression lines. 3.00
21: Todd, An introduction to the use of simultaneous-equation regression analysis in geography. 3.00
22: Pong-wai Lai, Transfer function modelling: relationship between time series variables. 3.00
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24: Killen, Linear programming: the Simplex method with geo-graphical applications. 3.00
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26: Rich, Potential models in human geography 3.00
27: Pringle, Causal modelling: the Simon-Blalock approach. 3.00
28: Bennett, Statistical forecasting. 3.50
29: Dewdney, The British census.

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Part 2 GIS APPLICATIONS

2.1 Natural Environment
(a) Land Cover
(b) Agriculture
(c) Forestry
(d) Hydrology
(e) Soils/geomorphology
(f) Environmental Hazards
(g) Digital terrain models

2.2 Built Environment
(a) Land Use
(b) Cadastral/property
(c) Utilities
(d) Transport

2.3 Human Environment
(a) Geodemography
(b) Employment
(c) Health

2.4 Policy Applications

2.5 Remote Sensing

2.6 Teaching GIS

2.7 Map Libraries/Catalogues
INTRODUCTION

The past few years have seen a rapid growth of interest in Geographical Information Systems (GIS), although their origins go back at least twenty years. These origins are diverse and include computer-assisted cartography, computer-aided design (CAD), remote sensing (RS), computer graphics, and spatial statistics. It is only recently that hardware and software developments have brought a comprehensive range of data generation and capture methods, data manipulation and analytical methods, and data presentation and display techniques into single, readily applied systems. The specific generation and capture methods, data manipulation and analytical methods, and data hardware and software developments have brought a comprehensive range of data systems (GIS), although their origins go back at least twenty years. These origins are the GIS concept. As such these systems have found very broad application within human and physical geography, within urban and regional planning and many related areas including environmental and resource management, public utilities and retailing. Arguably, GIS have potential relevance to all analytical and policy (or management) processes that use spatially referenced data.

As the field has developed rapidly so too has its literature. Yet in their nature, the new forms of geographical information cut across many traditional subject divisions. Remotely sensed data, for example, may have relevance to human and physical analyses. Equally, information derived as a by-product of an administrative process, say land-use planning, serve analytical or policy advice processes. For those wishing to study the development of GIS, both the rapid growth of theoretical and applied literature and its organising concepts pose a considerable challenge. The same problem of diversity and lack of classification in the subject literature faces those wishing to apply the new technology to policy-making and management tasks with the added complication of making choices about hardware and software systems.

The lack of organisation in GIS literature stems partly from a rapid growth of interest and partly from the diversity of the contributing fields and technologies. The recent growth in such systems is due largely to two factors. The rust is an explosion in the amount of spatially referenced data that is now collected and which can be made available to users. The second has been developments in computer hardware and software technologies which are continually offering more computational power at lower cost. It is also important to note the contributions of associated fields. For example, satellite remote sensing is a technology which has grown up alongside GIS, yet in the early stages there was surprisingly little interaction between the two disciplines. As remote sensing has matured, however, so the volume of data available and the sophistication of image processing techniques has inevitably led to a degree of convergence with GIS and there is now a significant number of software systems that support both image processing and raster GIS capabilities. Such systems allow relatively free exchange of data between modules. Increasingly, agencies utilizing GIS see the potential of remote sensing as a powerful source of data for environmental monitoring and management. In contrast, computer-assisted cartography (CAC), may be seen as having an impact on the data structures and display technology involved in GIS, as the need for high quality map production has pushed forward innovations in digitizing, storage and plotting. The emphasis of CAC, however, has been very much on producing finished maps and less on spatial data manipulation.

Computer-assisted design (CAD) and database management systems (DBMS) have also had an influence on GIS development, particularly in regard to spatial data structuring and manipulation, and the integration of topographic with related, descriptive textual and numeric data. Developments in computer-aided design have set standards for interactive graphics and spatial data editing. Developments in database management software, notably the evolution of relational database management systems, have had an important influence on the shape of modern GIS, introducing greater sophistication in data modelling and improving efficiency in data management and retrieval. CAD and DBMS have tended to be mainly, though not exclusively, concerned with vector-based systems.

Given these diverse contributions to development, it is not surprising that the sources of information on which GIS users need to rely has lacked coherence, and it is only recently that the field has achieved some degree of organisation and identity. This has been greatly helped by international conferences; the arrival of an international journal dedicated to GIS; and by an acceleration of government supported research initiatives by research councils in the UK and the USA (e.g. ESRC’s Regional Research Laboratories, and the National Science Foundation’s National Center for Geographic Information and Analysis).

The very broad abilities of GIS to store, manipulate and display geographically referenced data sets, ranging from remote sensing (satellite and aerial photography) imagery to thematic maps of socio-economic data, has led directly to new forms of ‘information geography’. But in addition to coding, storing and retrieving land related data, GIS can be used as an analytical tool in assessing, transforming and manipulating data and has thus provided a mechanism to study temporal and spatial trends in environmental processes and to evaluate potential future scenarios. Increasingly, GIS are being used in both private and public sectors in the management (monitoring) and modelling of land resources, both directly (e.g. mapping) and also to provide inputs to policy decision making processes. The ability to simulate the effects on management plans of alternative conditions and constraints has led to a recent increase in the use of GIS in areas such as urban and regional development planning and agricultural development. Such applications often involve inputs from a wide range of differing fields, such as legal (e.g. protected conservation areas), physical (e.g. soil, hydrology), human (e.g. settlement areas, population) and economic (e.g. industrial site location).
disciplines. A major consequence of the integration of data from several fields in such interdisciplinary analysis has been a breakdown in the traditional, dichotomous divisions between human and physical geography. This trend can be readily observed in many of the 'application-based' studies in journals covering a broad spectrum of geographical theory.

The preceding comments point to the main influences which we feel are relevant to an understanding of GIS. For readers seeking a more comprehensive introduction, the Report of the Committee of Enquiry into the Handling of Geographic Information, Chaired by Lord Chorley (DOE 1987), and the Report of the NERC Working Group on Geographical Information (NERC 1988) are recommended.

Our experience suggests that most readers entering the field of GIS will do so through one of two routes. Either there will be an initial interest in some aspect of the theory or technology, such as spatial modelling, geographical data structures or computer graphics, or an interest in some substantive area of GIS application such as land or resource management, urban and regional planning, transportation or housing. Accordingly, we have classified the entries in this bibliography under two main themes; theory and methodology on the one hand, and application 'areas' or 'topics' on the other. The richness of much GIS material and the wide range of potential applications means that judgements have been necessary as to the primary theme and these have not always been straightforward. We hope that no author will feel misrepresented and comments from users of the catalogue would be welcome, both in terms of suggestions on organization and contributions.

For the methodological and theoretical references we have chosen a schema which relates to the broadly defined stages identifiable in any data-processing system. This provides an organising framework which is to some degree independent of the state of current GIS technology and applications. It is therefore likely to have enduring utility and to be meaningful to a wide range of interests. A data processing system must support three types of task: data generation or capture, data structuring or organisation and data manipulation (including output). Data generation (section 1.2) refers to the creation of hard-copy information, as in map digitisation or keying-in of manual records, and on the other hand the direct encoding of observations through analogue sensors such as RS satellites. One of the central features of modern GIS is their ability to organise data into meaningful structures, referred to as database models. Database modelling serves a number of ends, most important of which are the gains in storage and access efficiency achieved by a good design. The particular nature of geographic data has led to much experimentation with alternative data modelling strategies. This complexity arises from the distinction between topographic and attribute data; the large size of a typical topographic database; and the need fully to represent geographic objects in terms of their individual characteristics and their topological and taxonomic relationships. This is reflected by the number of references in the data organisation section (1.3).

Data stored in an information system is normally there to be manipulated in some way (not just archived) and the broadest function of such a system can be thought of as converting data into more meaningful information. Information may be created by a simple combination of data items in response to a user's query or by more complex manipulations. Manipulation includes, for example, the processes of transformation, aggregation and modelling. It also includes graphical display since a computerised map display is a complex information product created from lower level information. The references in section 1.4 document algorithm developments for such operations as polygon overlay, fractal enhancement, contouring, raster image smoothing and geographical search.

In each of sections 1.2 to 1.4 a further classification is made on the basis of the distinction between vector, raster and non-locational data. These are considered to be primary themes of interest at each data processing stage, each with a distinguishable body of literature. Under the data organisation heading, data quality and standards and data transfer are important issues which cut across the three-fold structure classification and therefore appear as separate sub-headings. Similarly data conversion forms a distinct section within the manipulation literature.

Three other sections complete the methodology and theory classification. References concerned with general GIS issues are listed together in section 1.1 and include historical reviews; comparative systems evaluations; overviews of general concepts and implementation issues; and GIS related texts. Section 1.5, on software, documents references concerned with specific systems, ranging from turn-key suites to experimental prototypes. Eight categories of software are distinguished. There is surprisingly little written specifically about GIS related hardware issues and these references form a final section (1.6) in part one.

Part Two is a necessarily more pragmatic attempt at classification. GIS applications, we suggest, fall primarily under three headings relating to different perspectives of geographic space and its use. Natural environmental applications (section 2.1) handle data relating to land cover, agriculture, forestry, hydrology, soils, environmental hazards and terrain. Applications focusing on the built environment (section 2.2), on the other hand, use land use, cadastral, utilities and transportation data. The third type of application is concerned with the human environment (section 2.3) and includes systems which manage geodemographic, employment and health information. In addition, a number of studies take a wider view of systems application, adopting a policy-making perspective and incorporating data from multiple sources. These are covered in section 2.4. Remote sensing references are included under a separate heading (section 2.5) and represent a selection from the large literature on this subject. The final two headings cover references to applications with particular functional perspectives: teaching GIS (section 2.6), and map libraries and catalogues (section 2.7).

In developing this classification we wish to make no more than a contribution to the systematisation of the field. We expect our headings to be ephemeral but have found the
material listed here of value and believe that others in this fast developing field may find it equally so. What is listed is in some ways a sample, for some of the headings already have extensive literatures. In principle we have selected items which we feel make some contribution to the understanding of GIS. This includes background texts in fields such as computer graphics and spatial modelling; references covering GIS issues in related technical or application fields, for example GIS and remote sensing; and references to specifically GIS work. References to related fields per se, for example, RS or cartography, are not included. Also we make no particular qualitative judgments by implication in our selection or exclusion of material.

References


The authors

Ian Bracken is technical director of the Wales and South West Regional Research Laboratory and Gary Higgs, David Martin and Chris Webster are research associates. The Laboratory is funded by the Economic and Social Research Council and is located in the Department of Town Planning, University of Wales College of Cardiff, PO Box 906, Cardiff CF1 3YN, UK.

Abbreviations used in the bibliography

General:-

Mem.  Memorial
Photo.  Photogrammetry
Proc.  Proceedings
Symp.  Symposium

Organisations:

<table>
<thead>
<tr>
<th>Organisation</th>
<th>Description</th>
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<tbody>
<tr>
<td>AAG</td>
<td>American Association of Geographers</td>
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<tr>
<td>ACSM</td>
<td>American Congress on Surveying and Mapping</td>
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<td>AFT</td>
<td>American Farmland Trust</td>
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<tr>
<td>AM/FM</td>
<td>Automated Mapping/Facilities Management</td>
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<td>ASPRS</td>
<td>American Society for Photogrammetry and Remote Sensing</td>
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<td>AURISA</td>
<td>Australian Urban and Regional Information Systems Association</td>
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<td>BCS</td>
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<td>British Geological Survey</td>
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<td>BURISA</td>
<td>British Urban and Regional Information Systems Association</td>
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<td>CERMA</td>
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<td>CORINE</td>
<td>Co-ordinated Information on the European Environment</td>
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<td>CRSC</td>
<td>Centre for Remote Sensing, University of Utah</td>
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<tr>
<td>EARSeL</td>
<td>European Association of Remote Sensing Laboratories</td>
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<td>ERIM</td>
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<td>ESRI</td>
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<td>European Space Agency</td>
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<td>Her Majesty's Stationary Office</td>
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<td>ICA</td>
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<td>Institute</td>
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<tr>
<td>IEEE</td>
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<tr>
<td>IGARSS</td>
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<td>IGU</td>
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<td>International Soil Science Society</td>
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<td>LAMSAC</td>
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<td>LARS</td>
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<td>NASA</td>
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<td>NERC</td>
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<td>NUTIS</td>
<td>NERC Unit for Thematic Information Systems, Reading</td>
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<td>OPCS</td>
<td>Office of Population Censuses and Surveys</td>
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<td>RICS</td>
<td>Royal Institute of Chartered Surveyors</td>
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<td>RRL</td>
<td>Regional Research Laboratories (UK)</td>
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<td>RSS</td>
<td>Remote Sensing Society</td>
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<tr>
<td>SAUS</td>
<td>School of Advanced Urban Studies, University of Bristol</td>
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<tr>
<td>SORSA</td>
<td>Spatially Oriented Referencing Systems Association</td>
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<tr>
<td>SUNY</td>
<td>State University of New York</td>
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<tr>
<td>URISA</td>
<td>Urban and Regional Information Systems Association</td>
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<tr>
<td>USGS</td>
<td>United States Geological Survey</td>
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**Journals of relevance to Geographical Information Systems, Remote Sensing and Database Management Systems:**


**Symposia/International Conferences:**

Part One: GIS Methods and Theory.

1.1 General

1.1 (a) Concepts Overviews.


Department of the Environment (1975) General review of local authority management information systems. London, HMSO.


1.1 (b) History


### 1.1 (c) Implementation overviews.


1.1 (e) GIS-related texts.


1.2 Data Generation/Capture.


1.2 (a) Vector.


1.2 (b) Raster.


1.2 (c) Non-locational.


1.3 Data Organization.

1.3 (a) Data Structures


Peuquet, D. J. (1986) Advanced data structures for the interpretation of image and cartographic data in geo-based information systems. Santa Barbara, USC.


1.3 (a) (i) Vector Data Structures.


1.3 (a) (ii) Raster Data Structures.


1.3 (b) Data Quality and Standards.


1.3 (c) Data Transfer.


1.4 Data Manipulation.


1.4 (c) Non-locational.


1.4 (d) Data Conversion.


1.4 (e) Graphics


Monmonier, M. S. (1975) Class intervals to enhance the visual correlation of choroplethic maps, *Canadian Cartographer*, 12, 161-78.

1.5 Software Systems.


1.5 (a) Automated Mapping.


LASERTRAK (1986) Laser-Scan automated map production system. Cambridge, Laser-Scan Laboratories Ltd.


National Transfer Standards (1986) Report of a working party to produce national standards for the transfer of digital map data. Southampton, Ordnance Survey (Research and Development 1).


1.5 (b) Thematic Mapping.


Campbell, J. (1984)


1.5 (c) Vector GIS


1.5 (d) Raster GIS.


1.5 (e) Integrated GIS.


1.5 (f) Image Processing


1.5 (g) Software/Algorithms.


Douglas, D. and Peucker, T. (1973) Algorithms for the reduction of the number of points required to represent a digitized line or its caricature. Canadian Cartographer, 10, 112-3.


1.5 (h) Intelligent Knowledge-Based Systems.


1.6 Hardware.


Part Two: GIS Applications

2.1 Natural Environment


2.1 (a) Land Cover


2.1 (b) Agriculture


2.1 (c) Forestry


Coggeshall, M. E. and Hoffer, R. M. (1973) Basic forest cover mapping using digital remote sensor data and ADP techniques. LARS, Purdue University, West Lafayette, IN. Information Note 030573.
Fleming, M. D. (1977) Computer aided analysis techniques for an operational system to map forest lands utilizing LANDSAT MSS data. LARS, Purdue University, West Lafayette, IN. Information Note 112277.


2.1 (d) Hydrology


Reed, C. and Brooks, W. (1980) The wetland analytical mapping system (WAMS) and map overlay and statistical system (MOS) production environment. Proc. Annual Meeting ACSM/ASPRS, St. Louis, MO., 308-14. Falls Church, VA., ACSM.


2.1 (e) Soils/geomorphology


2.1 (f) Environmental Hazards


2.1 (g) Digital Terrain Models


2.2 Built Environment

2.2 (a) Land Use.


2.2 (b) Cadastral/Property


Halligan, F. L. (1984) TACIMS: A topographic and cadastral information management system for Jeddah. Proc. of the Fall Meeting of ACSM (ASPRS), San Antonio, Texas, 305-12, Falls Church, VA., ASPRS.


2.2 (c) Utilities


2.2 (d) Transport


2.3 Human Environment

2.3 (a) Geodemography


2.3 (c) Health


2.4 Policy Applications


American Society of Photogrammetry (1983) Manual of remote sensing. 2nd. edn. Falls Church, VA., ASPRS.


Colwell, R. N. (1969) Analysis of remote sensing data for evaluating forest and range resources. School of Forestry and Conservation, University of California.


Young, J. A. T. (1986) A UK geographic information system for environmental monitoring, resource planning and management capable of integrating and using satellite remotely sensed data. Monograph 1. Nottingham, RS


2.6 Teaching GIS


2.7 Map Libraries/Catalogues


listing of Catmogs in print

30: Silk, The analysis of variance. 3.50
31: Thomas, Information statistics in geography. 3.00
32: Kellerman, Centrographic measures in geography. 3.00
33: Haynes, An introduction to dimensional analysis for geographers. 3.00
34: Beaumont & Gatrell, An introduction to Q-analysis. 3.50
35: The agricultural census - United Kingdom and United States. 3.00
36: Aplin, Order-neighbour analysis. 3.00
37: Johnston & Semple, Classification using information statistics. 3.00
38: Openshaw, The modifiable areal unit problem. 3.00
39: Dixon & Leach, Survey research in underdeveloped countries. 5.00
40: Clark, Innovation diffusion: contemporary geographical approaches. 3.00
41: Kirby, Choice in field surveying. 3.00
42: Pickles, An introduction to likelihood analysis. 4.00
43: Dewdney, the UK census of population 1981. 5.00
44: Pickles, Geography and humanism. 3.00
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46: Fotheringham & Knudsen, Goodness-of-fit statistics. 3.50
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48: Tinkler, Introductory matrix algebra. 4.00
49: Sibley, Spatial applications of exploratory data analysis. 3.00
50: Coshall, The application of nonparametric statistical tests in geography 7.50
51: O’Brien, The statistical analysis of contingency table designs 3.50
52: Bracken, Higgs, Martin and Webster, A classification of geographical information systems literature and applications 5.00

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