

Volume 6

Issue 4

October 2002

ISSN 1361-1682

Transactions in GIS



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Book Review

Concepts and Techniques of Geographic Information Systems by C P LO and ALBERT K W YEUNG
Prentice Hall, Upper Saddle Creek, NJ, 2002. 492pp. ISBN 0-13-080427-4, £34.99.

One of the signs of maturity of a discipline is the emergence of a large number of textbooks. By this measure, it appears that GIS as a discipline (whether it be GISystems or GIScience) may be entering adulthood. There are now at least 10 introductory books in English on the market and judging by the number of proposals that I and other colleagues are reviewing, several more in the pipeline. *Concepts and Techniques of Geographic Information Systems* is another fine example of a useful introductory text.

Lo and Yeung set themselves the ambitious goal to 'define the set of skills and concepts for GIS professionals' and 'to provide a complete coverage of the concepts and techniques pertaining to every stage of the systems development life cycle of GIS' (p. xi). The book presents 'information technology in general, and information resource management in particular' (p. xi). Although Prentice-Hall's promotional materials for this book say that it has an 'emphasis on spatial modeling and modeling with examples of applications' (sic.) and it 'shows students how to correctly use GIS to solve problems', the book has very little on applications of GIS or problem solving. The focus is on the concepts and techniques needed by GIS professionals. Thus, this book stands out for its intentional focus on professional education rather than taking the higher ground of, for example, *Geographic Information Systems and Science* (Longley et al. 2001) which concentrates on defining the foundations of GIScience.

The book is designed for a 15 week semester course for students with high school mathematics backgrounds in geometry, algebra and trigonometry plus some computer science and geography or other spatially-oriented disciplines. The collaboration of international authors currently in Canada (Albert Yeung) and the US (C P Lo) has led to the inclusion of important international perspectives. While this book deals with the range of topics normally included in introductory GIS courses, coverage of many subjects is satisfyingly deep for the advanced reader. It is broader in scope than other introductory texts such as Clarke's *Getting Started with Geographic Information Systems* (Clarke 1999) and Heywood et al.'s *An Introduction to Geographical Information Systems* (Heywood et al. 1998). Therefore, I would not recommend this book for lower division university students and in fact, some prior introduction to the field is probably needed to really make proper use of this book.

Although it cannot escape some unevenness of coverage, the book does a remarkable job of covering in substantial detail a number of very complex subjects

spread across a broad sweep of the domain of GIScience. The authors clearly faced the difficult problem of placing the web of connected topics into an appropriate sequence. There are many places where a topic is introduced briefly in one section, leaving the advanced reader wanting more, and then explored in much greater detail later. Sometimes, the connection between the original introduction and the later details is not clear. For example, in Chapter 2, surveying gets a much more thorough treatment than photogrammetry – I initially assumed this was a failing of the text – but much later (Chapter 8) photogrammetry is covered in such detail that many Geography students may be alarmed. This is the first place I wanted the equivalent of a hypertext link to the later section of the book. In a revision, these within book links need to be much more completely indexed.

Unlike many of the other introductory textbooks, this book lacks the pedagogic overhead of learning objectives and discussion questions with each chapter. These, perhaps, are in the lab manual (mentioned only in the introduction) which was not yet available for review. However, the references at the end of each chapter are quite rich and generally in relatively accessible sources. Most conference proceedings mentioned are major ones that most GI departments should have access to (e.g. AutoCarto, International Symposium on Spatial Data Quality, GIS/LIS).

The Introduction chapter does not unnecessarily belabor the applications perspective nor the definition of GIS. Clearly there is an expectation that the business of selling students on the value and meaning of GIS has been achieved before readers begin this book. Like many similar books, the challenge of covering history efficiently is addressed in this first chapter, though I always wonder whether beginning students really care. It is nice to see the first mention of topology within the context of the history section with a reference to Corbett's early paper on topology in cartography (Corbett 1979).

The second chapter is titled 'Maps and GIS' though it is much more than this. It might better be titled 'Maps and GI' or simply 'Location and GI'. Maps get little coverage here. It begins simply with an introduction to scale including a discussion of the concept of temporal scale. This is the first of many references to temporal issues. It is refreshing to see temporal concepts treated throughout the book alongside spatial concepts rather than treating them as an unrelated topic. Once past the simple scale and map theme topics, students face their first mathematical challenge in meaty sections on planar coordinate transformations, map projections, geodetic datums, UTM, state plane systems and even a brief introduction to land surveying and GPS. It is a hint of what's ahead and demonstrates that the authors decided not to shy away from the difficult details. The datums section describes in sufficient detail important information about the origins and differences between NAD 27 and NAD 83 and between horizontal and vertical datums.

The third chapter addresses 'Digital Representation of Geographic Data'. It includes a quick reference to important geographical foundations such as Berry's geographic matrix (Berry 1964) then introduces the concepts of objects and fields and rasters and vectors but does not spend time exploring the themes of modeling reality and spatial cognition often found in GIScience curricula. This chapter also includes a useful section on representing temporal relationships and a good level of detail on object-oriented data models and database systems.

The fourth chapter, 'Data Quality and Data Standards', provides a review of important issues relevant to working GIS professionals. Here is an introduction to

spatial autocorrelation and error propagation covered in much greater detail later (link!). Interoperability and OGC get one page here and one more page later in Chapter 12. Finally, keeping to the international theme, this chapter includes an extensive section on data standards both in the US and elsewhere.

Chapter 5, 'Raster-based GIS Data Processing', and Chapter 6, 'Vector-based GIS Data Processing', present parallel treatments of these fundamental themes. Topics are covered sufficiently to understand them conceptually, but most students will need associated hands-on exercises to become proficient. The raster chapter includes raster file formats and various topics related to acquiring raster data such as rectification, registration and mosaicking. Brief reference is made to various ways in which raster operations might be categorized, then the local, neighborhood, extended neighborhood and regional classification system is used to explore the range of operations. Logical overlay operations are thoroughly covered. The determination of slope is also covered here under extended neighborhood operations, though a very extensive chapter later on Digital Terrain Modeling might also be the right place for this. A very detailed section on color theory in this chapter seems out of place, it would seem more at home in the visualization chapter. Map algebra and cartographic modeling are discussed later in the chapter and some worked examples provide a brief though useful respite from the dense theory. Chapter 6 on vector processing covers an eclectic mix of vector topics including digitizing, scanning, editing, topology building, attribute data conversion, address geocoding, a selection of basic vector operations such as buffering and topological overlay and a good introduction to network analysis, picked up in much greater detail in Chapter 10 (Spatial Analysis).

Chapter 7, 'Visualization of Geographic Information and Generation of Information Products', is another eclectic mix which may make some cartographers uneasy due to the way in which cartographic principles are almost buried (though well treated) within a chapter that covers the spectrum from GIS as information communication channel, human-computer interaction and user interfaces, scientific visualization, 3D, animation, web cams, hypermaps, digital spatial libraries, to how cathode ray tubes (CRTs) work. The detail with which CRTs are covered is surprising, though there is some very useful information about screen resolution, dot pitch, refresh rate, and the performance of graphics cards and video memory that many of us must make decisions about during hardware specification tasks.

The next three chapters provide very deep detail on topics lightly introduced earlier. Instructors using this text will likely be very selective about what is included from these later chapters in a specific course and hands-on exercises would be needed. Chapter 8 on 'Remote Sensing and GIS Integration' does justice to this important and broad subject covering topics from orthophotography production, thermal infrared energy equations, radar imaging theory, photogrammetric considerations of satellite imaging systems, to image classifiers. Chapter 9, 'Digital Terrain Modeling', provides a similarly deep coverage of a range of topics including sampling terrain data, geometric characteristics of DEMs, construction of TINs (including their topological data structure), more on GPS, stereoplotter operation, sources and quality of existing DEM data, extraction of topographic features, viewshed analysis, terrain visualization (including tables summarizing various software packages for terrain modeling). It includes a very useful, though brief coverage of interpolation, surface fitting and trend surface analysis. Uncharacteristically for the book, this chapter ends with a brief summary of a number of application areas, though hydrological operations are

glaringly absent. In Chapter 10, 'Spatial Analysis and Modeling', the authors examine spatial analysis at a higher level than the simple map data manipulation in Chapters 5 and 6. Good coverage of topics that are often saved for advanced courses includes spatial autocorrelation indices, quadrat counts, nearest-neighbor analysis, gravity models and network analysis. A few detailed examples of integrating GIS with mathematical models rounds out the chapter.

The final two chapters wrap up with 'GIS Implementation and Project Management' and 'GIS Issues and Prospects'. The first of these offers an unexpectedly thorough but complete coverage of important topics within the broad umbrella of the chapter title. The value of a software engineering approach, stages of GIS project planning, system analysis, database design methodology (including several pages on E-R modeling, logical schema and normalization), application software design, system implementation and maintenance. The final chapter includes the obligatory nod to the frontiers of GIScience, making reference to the UCGIS research challenges and other research themes. An appendix of internet resources and a short but useful Glossary of GIS terms end the book.

While overall I am satisfied with the book, some structural problems are worth noting. In addition to the sequencing problems already mentioned, some sections, such as those on standards, graphics hardware and satellite systems, seem likely to date the book very quickly. The extended section on the Internet in the final prospects chapter seems already dated as the material covered is now not about the future but about the present migration of GIS to the Internet, and no mention is made of GML and UML. This rapid dating problem is partially addressed by the appendix of relevant websites, though reference to a book website might be a more effective means of providing this information. Perhaps Lo and Yeung are aiming for a biannual revision? As well, there are a very large number of screen shots of ESRI products and references are made frequently to specifics within that software. This may be perfectly fine for those of us who depend on that brand of technology and other software products do also get mention and occasional screen shots. However, I cannot assess whether others who focus on non-ESRI products would find the treatment biased.

In conclusion, would I use this book in one of my courses? Not in my first year level introductory class, but quite likely for my entrance level graduate course in which we bring a mixed group of students with various levels of theory, practical backgrounds and professional experience. The book is meaty with no academic sermons and, with the exception of a few sections that will date quickly, should stand the test of time as a valuable course reference on a GIS professional's bookshelf.

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