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Digital Analysis of Remotely Sensed Imagery

Jay Gao

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"Jay Gao's book on the analysis of remote sensing imagery is a well-written, easy-to-read, and informative text best serving graduate students in geosciences, and practitioners in the field of digital image analysis. Although Dr. Gao states that he has targeted his book at upper-level undergraduates and lower-level postgraduate students, its rigor and depth of mathematical analysis would challenge most students without prior experience in remote sensing and college-level mathematics. The book covers a lot of ground quickly, beginning with a basic explanation of pixels, digital numbers and histograms and advancing rapidly through a description of the most well-known satellite systems to data storage formats, rectification and classification. It best serves students who have already taken an introductory course in remote sensing. Following a three-chapter description of the basics the remaining eleven chapters are dedicated to the description of the most common image processing systems and the details of the image analysis functions which can be carried out. The largest portion of the text covers classification – spectral and spatial, neural networks, decision trees and expert systems – and is an invaluable reference to anyone interested in understanding image analysis terminology and the algorithms behind these different systems. The last chapter of the text is addressed to practitioners wishing to integrate remote sensing image data with GIS and/or GPS data. The text is nicely structured so that individual chapters can easily be skipped when their content is not of interest to the reader without impairing the understanding of later chapters.

"The first three chapters of the book cover introductory material that the reader should be familiar with for the most part, but also includes a very handy summary of today's satellite systems. Chapter one addresses basic material, such as pixel DN, coordinates, feature space, histograms, and spatial, spectral, temporal and radiometric resolution normally covered in an introductory course in remote sensing. Chapter two presents a very informative and up-to-date overview of today's satellite instruments including meteorological, oceanographic, earth resources, hyperspectral and radar instruments. Instrument and orbital parameters are presented in tabular form and make it easy to look up technical details such as spectral and spatial resolution, orbit type, repeat cycle and other instrument characteristics quickly. Written explanations are clear, readable and provide lots of interesting insight and useful tidbits of information such as potential problems and the cost of imagery. For technicians and programmers the third chapter provides details on storage formats, including descriptions of BSQ, BIL and BIP binary formats, and the most common graphics formats like GIF, TIFF and JPEG together with data compression techniques. Non-technicians can skip this chapter since image processing software will generally take care of format conversions internally without a need for understanding the nuances of each.

"Chapters four will be of interest to anyone considering the purchase of image processing software, or trying to understand the differences between systems. Gao provides a useful overview of existing software – IDRISI, ERDAS Imagine, ENVI, ER Mapper, PCI, eCognition and GRASS. A brief history of each provides useful background, and a discussion of the features of each together with a comparison (also given in tabular form) is informative to anyone considering a purchase.

"Chapter five can also be viewed as a stand-alone reference on rectification, but also serves as an excellent overview of the problems of dealing with mapping on a curved surface and has particular application for geographers and cartographers. It discusses the sources of geometric distortion, coordinated systems and projections, how image rectification is done – including the use of ground control points and implications for the order of transformation employed. There is a nice example showing how accuracy is influenced by the

number of GCPs employed for SPOT and Landsat TM. For non-technical students the transformation mathematics can be skipped. A rather minimal section on image subsetting and mosaicking is included. Chapter six continues in much the same vein as the previous chapter, but discussing image enhancement – techniques that improve the visual quality of an image. The terms introduced here, such as density slicing, linear enhancement, stretching, and histogram equalization, will be familiar to users of image processing software and Gao provides a useful explanation of each in turn. Other application-oriented utilities such as band ratioing, vegetation indices, IHS and Tasseled Cap transformations and principal component analysis are presented in a form which is understandable to students with good mathematical grounding.

"The remainder of the text deals, to a large extent, with the topic of classification. Chapter seven initially discusses elements of image interpretation, but then devotes the chapter to a detailed presentation of the most common (and affordable) of these - spectral analysis. Gao presents the different algorithms used to define spectral distance, and then devotes text to a discussion of the inner workings of unsupervised classification systems. The section on supervised classification is a very useful reference for anyone undertaking this process – describing how to set about the classification process, the differences between the different classifiers, and how to choose an appropriate one. The concepts of fuzzy logic and sub-pixels classifiers are also presented briefly.

"From this point on, the text becomes much more specialized and technical and is geared towards graduate students, those carrying out research projects, and those interested in algorithmic detail. Chapter 8 is the first dealing with artificial intelligence and describes the fundamentals of neural networks. It provides sufficient information for a technically-minded non-specialist to understand the workings of such a system and serves as a good introduction to someone who is considering this field of research. Chapter nine offers an explanation of decision trees with both a descriptive verbal approach and with mathematical algorithmic detail. Chapter ten addresses spatial classifiers – in particular the analysis of texture. This chapter again leans more heavily towards mathematics and the detail is more suited to readers with a strong technical bent. Gao goes on to discuss the process of image segmentation and thence the fundamentals of object-oriented classification. There is a useful overview of two popular software packages – eCognition and Feature Analyst – together with a discussion of the strengths and weaknesses of object-based classification. Chapter eleven presents an overview of expert systems. This is an advanced field of artificial intelligence and is an ambitious undertaking to describe in fifty or so pages. It is an interesting read for someone trying to gain a superficial knowledge of the workings of such a system and the associated terminology, but for anyone wishing to work in the field, a much more in-depth coverage is necessary.

"At this point, the student who was just trying to understand the basics of image processing and classification (and who skipped chapters eight through eleven) should resume reading as the last three chapters provide very helpful practical information. Chapter twelve provides a useful discussion on the methodology for assessing the accuracy of a classification and includes sources of inaccuracy and interpretation of an error matrix. It provides worked examples of accuracy assessments using simple math. This is a valuable addition to the text and presents an important process that is often overlooked in reporting classification results. Chapters thirteen and fourteen also deal with very practical matters. Chapter thirteen describes procedures for handling the analysis of temporal changes via a variety of change detection algorithms, and chapter fourteen introduces the use of GIS and GPS data in image analysis.

"Dr. Gao has written an excellent text describing technical information in a very readable manner. His book will serve as a good text for a course in remote sensing/image analysis, assuming that the student has received instruction in the fundamentals of remote sensing and been introduced to some image processing software. Students wishing to become adept at the practicalities of fundamental image processing skills and classification can easily skip the mid section of the text, whereas those who are keen to learn about more sophisticated classifiers will gain the fundamentals of these from this section. Overall I found the book very

informative and a pleasure to read."

Reviewed by Helen M. Cox, PhD.
Associate Professor,
Department of Geography,
California State University, Northridge

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