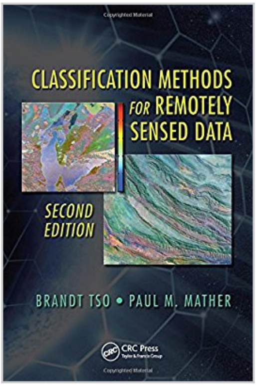

Classification Methods for Remotely Sensed Data, Second Edition

By Paul Mather, Brandt Tso

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Since the publishing of the first edition of *Classification Methods for Remotely Sensed Data* in 2001, the field of pattern recognition has expanded in many new directions that make use of new technologies to capture data and more powerful computers to mine and process it. What seemed visionary but a decade ago is now being put to use and refined in commercial applications as well as military ones.

Keeping abreast of these new developments, **Classification Methods for Remotely Sensed Data, Second Edition** provides a comprehensive and up-to-date review of the entire field of classification methods applied to remotely sensed data. This second edition provides seven fully revised chapters and two new chapters covering support vector machines (SVM) and decision trees. It includes updated discussions and descriptions of Earth observation missions along with updated bibliographic references. After an introduction to the basics, the text provides a detailed discussion of different approaches to image classification, including maximum likelihood, fuzzy sets, and artificial neural networks.

This cutting-edge resource:

- Presents a number of approaches to solving the problem of allocation of data to one of several classes
- Covers potential approaches to the use of decision trees
- Describes developments such as boosting and random forest generation
- Reviews lopping branches that do not contribute to the effectiveness of the decision trees

Complete with detailed comparisons, experimental results, and discussions for each classification method introduced, this book will bolster the work of researchers and developers by giving them access to new developments. It also provides students with a solid foundation in remote sensing data classification methods.

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Editorial Review

Review

… a very useful addition to the shelf of anyone engaged in remote sensing image analysis. It is suitable for both students and practitioners.
?Michael Collins, in *GEOMATICA*, Vol. 63, No. 4

From the Author
This book provides a comprehensive survey of image classification techniques. Beginning with a general, introductory review of basic principles, the book aims to bring together information from a range of sources and set it in the context of basic principles. There is an emphasis on new methods, including the use of artificial neural networks, procedures based on fuzzy theory, techniques of texture quantisation, the use of Markov random fields in modelling context, and the use of multiple classifiers.

From the Inside Flap
Chapter 2 Pattern Recognition Principles

In the context of pattern recognition, a pattern is a vector of features describing an object. This pattern is made up of measurements on a set of features, which can be thought of as the axes of a k-dimensional space, called the feature space. The aim of pattern recognition is to establish a relationship between a pattern and a class label. The relationship between the object and the class label may be one-to-one (producing a hard classification) or one-to-many (producing a fuzzy classification). The features describing the object may be spectral reflectance or emittence values from optical or infrared imagery, radar backscatter values, secondary measurements derived from the image (such as texture), or geographical features such as terrain elevation, slope and aspect. The object may be a single pixel or a set of adjacent pixels forming a geographical entity, such as an agricultural field. Finally, the class labels may be known or unknown in the sense that the investigator may, in the case of a known label set, be able to list all of the categories present in the area of study. In other cases, the investigator may wish to determine the number of separable categories and their location and extent. Using this information, the separable classes are assigned labels or names based on the investigator's knowledge of the geographical characteristics of the area of study.

These two methods of labelling are known as the supervised and unsupervised approaches, though some approaches to pattern recognition use a combination of both. Supervised methods require the user to collect samples to ¡¥train¡¦ or teach the classifier to determine the decision boundaries in feature space, and such decision boundaries are significantly affected by the properties and the size of the samples used to train the classifier. For instance, if one decides to use the minimum distance between a pixel and the mean of each class as the classification criterion, one has firstly to collect samples to construct estimates of the class means. The acceptability of the results will depend on how adequately these class means are estimated.

The label set selected for supervised classification experiments identify information classes. The investigator should have sufficient knowledge of the type and the number of information classes that are represented in the study area to allow him or her to collect training samples of pixels from the image that are representative of the information classes. In contrast, unsupervised pattern recognition methods are less dependent on user interaction. Normally, unsupervised classifiers ¡¥learn¡¦ the characteristics of each class (and, possibly, even the number of classes) directly from the input data. For instance, if the criterion used to label an object is the minimum distance between the object and the class means, this distance being measured in feature space, the unsupervised procedure will estimate the mean for each class and will refine this mean estimate iteratively (most unsupervised classifiers are iterative in operation). At each iteration, the previous set of estimates of the class means is refined until the process converges, usually when the means remain in the same place in feature space over successive iterations. The results output by unsupervised methods are called clusters or, sometimes, data classes. The pattern recognition process is complete when each cluster is identified, that is, linked to a specific information class by the user.

Although the unsupervised approach appears to be more elegant and automatic than the supervised procedures, the accuracy of unsupervised methods is generally lower than that achieved by supervised methods. In complex classification experiments, information classes often overlap. In the spectral domain, this implies that the reflectance, emittence, or backscatter characteristics of different classes may be similar. In the spatial domain, the implication is that any one object (a pixel or a field, for example) may contain areas representative of more than one information class. This is the mixed pixel problem. Spectral and spatial overlap of classes is the main barrier to the achievement of high classification accuracy. Even so, some interesting unsupervised algorithms are worthy of investigation as they may reveal useful information concerning the structure of the data set. Such methods can be thought of as exploratory data analyses or even data mining. A further problem with! pixel-based classifiers is that radiance (carrying information) that apparently reaches the sensor from a given pixel actually includes contributions from neighbouring pixels, due to atmospheric effects and the properties of the instrument optics (chapter 1). Townshend et al. (2000) show that, by considering this effect, improvements in accuracy can be achieved. They note that only where pixel size is small relative to the area of land cover units will this effect be unimportant.

For more than a decade, pattern recognition methods applied to remotely sensed imagery have mainly been based on conventional statistical techniques, such as the maximum likelihood or minimum distance procedures, using a pixel-based approach. Although these traditional approaches can perform well, their general ability for resolving inter-class confusion is limited. As a result, in recent years, and following advances in computer technology, alternative strategies have been proposed, particularly the use of artificial neural networks, decision trees, methods derived from fuzzy set theory, and the incorporation of secondary information such as texture, context, and terrain features.

This chapter introduces the principles of pattern recognition, starting from the concept of feature space and its two major manipulation techniques, namely, supervised and unsupervised procedures. Details of the statistical classifiers are then described. Algorithms based on artificial neural networks, decision trees, the fuzzy rule base concept, and the incorporation of secondary information are discussed in later chapters, and are reviewed only briefly in this chapter. Techniques for detecting temporal change are covered in this chapter, while the mixed pixel problem is considered in chapter 4.

Users Review

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Lisa Alaniz:

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