Image analysis and mathematical morphology, by J. Serra. Academic Press, London, 1982, xviii + 610 p. $90.00

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1 author:

Ian T Young
Delft University of Technology

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BOOK REVIEW

Image Analysis and Mathematical Morphology, by J. Serra. Academic Press, London, 1982, xviii + 610 p. $90.00.

Those of us who work in the field of image cytometry have been excited and increasingly impressed by the ability of systems such as the TAS, Magiscan, IBAS, and others to offer an approach for the rapid segmentation and measurement of images of tissues, cells, and chromosomes. The basic set of operations used by these systems seems to be the "right language" for expressing the ideas of segmentation, filtering, and, to a certain extent, measurement in digital images. Thus it was with a high degree of expectation that I (and others) awaited the publication of this book by Dr. J. Serra, one of the pioneer researchers in this field. His book, which is "directed to the triple audience of the users of the method (biologists, . . .), the specialists of picture processing and the theoreticians" represents an attempt to bring together in one volume the theoretical underpinnings of this subject in a form that could be used as a textbook for students as well as a reference book for professionals. This is a big order and one, in fact, that exceeds the needs of the audience of Cytometry. Dr. Serra recognized this fact, and therefore in his preface recommended chapters I, II, IX, X, XI, and XII (to which I would add chapter VII) for the reader primarily interested in the algorithms and their implementation for the analysis of cytological and histological images. Thus it is on these seven chapters that I would like to focus in this review.

It is with a sense of disappointment that I must report that as a text suitable for the audience of Cytometry, and that includes many researchers from the field of image processing, the book fails. This failure begins with the first technical discussions where the foundations for later developments should be simply and carefully laid. The first (and thus critical) technical discussion begins with the sentence, "Let X_h denote the translate of the set X by vector h; and let λX denote the homothetic of the set X after magnifying by the scalar λ (see Fig. I.2)" (page 8). There is simply no way to accept this type of writing as didactically sound. Except for students of certain branches of mathematics, the sentence is impenetrable. It is precisely this type of writing that discourages investigation by the scientist from another discipline (e.g., biology). On page 14 the author states what is presumably the central theorem for mathematical morphology: "The only transformations that are relevant to mathematic morphology. . . ." Yet this theorem is not proved anywhere! There is reference to a Theorem III-5, but it does not exist. I checked for a Theorem II-5; IV-5; the first theorem in chapter III, which is Theorem III-18; and the numbered III-5, which is a definition not a theorem, and none of them matched the theorem on page 14. Further, the theorem III-18, which is described as "fundamental," may be III-5 (in disguise), but it is couched in terminology that is so arcane as to once again be impenetrable. These type of issues, which are crucial to those who would read the book as a student or as someone from a background other than theoreticial mathematics, continue through the book. The first illustrated example of the Hit-or-Miss transformation on page 36 includes both the concepts of image transformation and image measurement (in this case, counting). Yet in this first example where the author should be trying carefully to build the reader's understanding and confidence, there appears a discrepancy. In image Y of the intercepts of image X (Fig. II.1) 21 points are shown in the figure, yet the text says the number is 20. Following that the notation for the essential Hit-or-Miss concept is defined. It is, however, inconsistent; first N[*] is given and then N(*) is described. The definition of erosion on page 39 is unnecessarily difficult. The definition of (or at least first encounter with) the concept of "closing" found on page 41 leaves the reader with the impression that a closing must be accomplished with a hexagon as the primitive structuring element. This is not true. Assuming for the moment that one is talking about digital images, then closing may be defined on the basis of structuring elements and/or connectivities other than that represented by the 6-connected hexagon. On page 60 the "reader knows", on page 37 two results are "of course" true, and on page 41 Y "obviously appears." None of these represents the type of writing that one expects in a book directed toward the (aforementioned) broad readership.

In the preface (page viii) Dr. Serra assures the reader that "every new idea is introduced with reference to preceding notions and not to the following ones." Yet on page 42 the notation for erosion $\ominus$ is used before it has been properly defined. The notions of indicator function k(x) and measure function Mes(*) on page 272 are not clearly and simply defined. They are used without explanation, and it is the burden of the reader, who has been advised by the author that is reasonable to go from chapter II directly to chapter IX, to hop back-and-forth between the index, the notation list, and parts of the intervening chapters to understand just what is going on. This impression, that the book is not "linearly organized" with each section building simply upon the preceding work, returns again and again. The reader has to read through to page 426 to finally find Dr. Serra's definition of a picture. And further, it is a definition given in an obtuse form, one that is not to be understood by either the student or the technically trained layman.

In other areas Dr. Serra's book ranges from passing as facts what are just his opinions to being plain wrong. He states that "the idea of curvatures is very poorly suited to digital images" (page 224). How does he explain, then, the significant number of curvature-based shape parameters that have been successfully used in digital image analysis in other laboratories? He argues that "there is no such thing as a random phenomenon" (page 231). I am sure that this would come as quite a surprise to those who come from theoretical fields such as quantum mechanics or experimental labs for particle physics or cell biology. On page 456 Dr. Serra gives a definition of image segmentation which he terms "classical" and which represents the attempt to partition the image into regions each of which has a "homogenous texture." While the idea of partitioning an object based upon texture is not new, the idea that this is *the* classical meaning of segmentation is nonsense. One segments the different sections of a randomly-oriented French flag on the basis of color, not texture. Unless one is prepared to adopt a notion that color (in flags, cells, or whatever) is a manifestation of texture, then his "classical" definition just does not hold. If one wishes to say that color and perhaps other attributes in an image, such as naturally occurring boundaries, are simply variations on the concept of texture, then, in fact, one has perverted the meaning of the word for private goals.

In an almost unrecognizable form, Dr. Serra discusses the sampling theorem. He states that his Theorem VII-2 generalizes the known one-dimensional result to two-dimensions and attributes the 1-D sampling theorem to Shannon and Kotelnikov. In fact, the two-dimensional form of the sampling theorem has long been known and appears in several places in the literature. The sampling theorem is properly attributed to Nyquist for his work in 1928. Further, in his discussion on page 434 comparing Fourier filtering with filtering based upon the opening, he incorrectly refers to the complex Fourier coefficients as energies (positive, real numbers) when they are, in fact, amplitudes (complex numbers). The difference is not trivial.

In the discussion in chapter VII on digital image measurement, the author gives formulas which can be used to estimate the perimeter of an object (page 228). Unfortunately these formulas do not give *good* estimates; the estimates are biased and have large variances. Several authors have worked successfully on this problem, and better estimation formulas have been known since at least 1979. Since a major goal of the work in image analysis is accurate parameter measurement, it is surprising that so little attention was paid to this issue in this book. For example, no analysis is performed on the relationship between sampling density and measurement results. At best helpful hints are given on page 224, the last of which, I suspect, is erroneous. Based upon results reported in three or four laboratories in the past year, it seems, as far as measurement is concerned, that it is almost impossible to oversample an image. I wonder, therefore, on what basis and experience the third hint is given.

While I have undoubtedly at this point conveyed my disappointment with various aspects of the book, there are certainly sections that I found quite rewarding. Chapter XI (the discussion of skeltons, exoskeletons, medial axis, etc.) is especially useful. The fundamental problems and paradox associated with the digital-image skeleton are recognized and addressed. Chapter XII brings together a number of the important ideas and shows how to apply them to gray-tone functions (pictures). Here the important ideas of Meyer, the "top-hat" transformation, watersheds, etc., are incorporated within the structure of mathematical morphology. Once again though, in both of these chapters there is for me a sense of disappointment. In both chapters the formalism and notation serve as a barrier to understanding rather than a bridge. While Prewitt's name is mentioned in connection with the exoskeleton (skiz) no reference is given to her work. The pivotal paper by Hilditch on digital skeletons is nowhere mentioned.

Finally, I would like to make some comments on the style of this book. Most technical books do not have a style; particularly in mathematically-oriented books, the words are usually filler between lines of equations. This is not the case here. Dr. Serra writes with a definite style, and in one sense that itself is to be respected. In another sense, however, it is a style that sets my teeth on edge. I find his continuing use of ellipses tedious, the many references to "Dear Reader" patronizing, and the discussion of the nature of truth sophomoric. Time and the history of science will decide if the group of exceedingly talented people working together at the Ecole des Mines de Paris deserve the honorific "Fountainbleau School" and not references in this book to other works as "pilferings" and "plagiarized versions."

In his book Statistical Theory of Communication, Professor Y.W. Lee of M.I.T. wrote that "a teacher should not attempt to cover the subject, but attempt to uncover it for the student." If I judge the suitability of Dr. Serra's book for readers of Cytometry or for students of image analysis with this standard, then I must conclude that he has failed.

Ian T. Young
Department of Applied Physics
Delft University of Technology
Delft, The Netherlands