be used to solve practical problems, by reviewing ways in which to integrate remote sensing with ecological models, agriculture, urban-heat islands, global carbon cycles, and improving our understanding of land–atmosphere interactions.

This book represents a tour de force by Liang. It provides a systematic and contemporary review of the theory and methods of estimating land surface variables from optical remote sensing. The concise synthesis of concepts, theories, methods and applications is not only stimulating to read, but also invaluable as a comprehensive reference on the subject. Written in an economical style and without much discussion, the structure and argument is coherent and commendably clear, the illustrations are helpful and the compact disc contains relevant computer programs and sets of data. With over 1300 references to the scientific literature, readers can delve further into most topics. The book is extremely well produced, with a good layout, clear type, a useful list of acronyms and a comprehensive index. It is timely and refreshing, fills a gap in the market, will make a valuable addition to university libraries, and is highly recommended to students, academics and scientists.

J. HOGG

AN INVITATION TO 3-D VISION: FROM IMAGES TO GEOMETRIC MODELS. By Y. MA, S. SOATTO, J. KOŠECKÁ and S. S. SASTRY *Springer-Verlag, New York, USA*, 2004. ISBN 0 387 00893 4. 162 × 242 mm. xx + 526 pages. 170 illustrations. Price £61·50 hardback.

THIS IS PRIMARILY a textbook of core principles, taking the reader from the most basic concepts of machine vision, such as image formation, to detailed applications, such as autonomous vehicle navigation. Perhaps, most importantly, it begins by explaining why machine vision is "hard", in the sense that any mathematical model of a real image by necessity must be a crude one, making the matching of features between two images even more problematic, at least on the surface. This serves to put the book in its proper context, as one dealing primarily with the geometric principles of machine vision and, to a lesser extent, with photometry and basic image processing techniques. Thus, the emphasis is on camera calibration and scene reconstruction and their applications. It is a clearly written book, and assumes no previous knowledge of machine vision. Everything that is required is introduced, particularly in the first of the three parts of the book, with main appendices covering topics such as optimisation and Kalman filtering. Each chapter also has its own set of appendices, which serve to develop certain topics in greater detail, so as not to detract from the flow of discussion in the chapter itself, along with exercises that allow the reader to develop certain details. The treatment is mathematically rigorous and consistent, but not impenetrable, as most things are introduced quite clearly. Everything you need to know to get started in machine vision is here, in an entirely self-contained work.

The first part of the book contains necessary background material on rigid-body motion, image formation and some basic image processing, such as feature matching. This also serves to develop some of the mathematical background used in later chapters.

The second part of the book presents many of the classical results from the projective geometry of two views, for example the properties of the essential matrix and its decomposition into four pose solutions, and just why this ambiguity arises. As this is a book of core principles, one will not see some topics that are covered in other books, such as those by Hartley and Zisserman (2001) and Kanatani (1993). There is

little reference, for example, to conics in projective geometry, apart from those associated directly with camera internal calibration. However, this is not a complaint, as it is entirely appropriate for people approaching the topic for the first time. The emphasis certainly is on geometry, but also with a physical understanding, for example, just what is an epipolar plane? There are also many good examples in the text, such as recovering pose from the essential matrix or a planar homography.

What is also very useful is the presentation of algorithms in point form, particularly in the final part of the book, in which the reconstruction of 3D models from images is discussed.

An extensive discussion of camera calibration using planar homographies is presented, where calibration data points all lie in one plane, and the internal camera calibration is assumed to be known. It is only here that one might wish for a clearer treatment: it would perhaps have been better to present the ''linearised'' solution for a planar homography, or a direct expansion of a vector cross-product, rather than the more cumbersome Kronecker product, involving a skew-symmetric matrix. If not implemented carefully, such an approach impedes algorithm development, even with a programming environment such as Matlab, which incidentally is used throughout the text.

There is an extensive and interesting discussion on the role of the internal calibration matrix ($\boldsymbol{K}$) and its determination via the Kruppa equations. This, then leads the reader into a discussion of the fundamental matrix, and the role of the internal camera calibration is developed. The essential matrix, the calibrated counterpart of the fundamental matrix, is introduced earlier, to emphasise the role of geometry. There is also a good discussion of stratification here, how to proceed from a purely projective reconstruction to an Euclidean one, and what information is needed to do so.

Multiple-view geometry is the topic of the third part of the book, and here, too, the treatment is particularly clear. Rather than use the conventional trifocal and quadrifocal tensors, the authors develop a more intuitive, matrix-based approach, leading to the same results as the tensor-based approach. In particular, the various rank conditions for the multiple-view matrices are developed. This also opens the path to scene reconstruction from several views.

As mentioned earlier, the final part of the book covers applications of the material presented in earlier chapters. In particular, realistic approaches to topics, such as multiple-view reconstruction, are discussed.

The book is aimed at graduate or advanced undergraduate students in electrical engineering, computer science, applied mathematics, or indeed anyone interested in machine vision or close range photogrammetry. This reviewer feels that anyone interested in machine vision or photogrammetry could read *An Invitation to 3-D Vision* and gain something from it. In many ways, he wishes that he had seen it when first starting out into machine vision. The book is highly recommended.

D. E. HOLMGREN

REFERENCES

HARTLEY, R. I. and ZISSERMAN, A. W., 2001. *Multiple View Geometry in Computer Vision*. Second Edition. Cambridge University Press, Cambridge. 672 pages.

KANATANI, K., 1993. *Geometric Computation for Machine Vision*. Oxford University Press, Oxford. 488 pages.

