

Preface

PREFACE TO THE FOURTH EDITION

The first edition came out in 1990, and was welcomed by many researchers and practitioners. However, in the subsequent two decades, the subject moved on at a rapidly accelerating rate, and many topics that hardly deserved a mention in the first edition had to be solidly incorporated in subsequent editions. It seemed particularly important to bring in significant amounts of new material on mathematical morphology, 3-D vision, invariance, motion analysis, object tracking, artificial neural networks, texture analysis, X-ray inspection, foreign object detection, and robust statistics. There are thus new chapters or appendices on these topics, and they have been carefully integrated with the existing material. The greater proportion of the new material has been included in Parts 3 and 4. So great has been the growth in work on 3-D vision and its applications that the original single chapter on 3-D vision had to be expanded into the set of *five* chapters on 3-D vision and motion forming Part 3, together with a further *two* chapters on surveillance and in-vehicle vision systems in Part 4. Indeed, these changes have been so radical that the title of the book has had to be modified to reflect them. At this stage, Part 4 encompasses such a range of chapters—covering applications and the components needed for constructing real-time visual pattern recognition systems—that it is difficult to produce a logical ordering for them: notably, the topics interact with each other at a variety of different levels—theory, algorithms, methodologies, practicalities, design constraints, and so on. However, this should not matter in practice, as the reader will be exposed to the essential richness of the subject, and his/her studies should be amply rewarded by increased understanding and capability.

It is worth remarking that, at this point in time, computer vision has attained a level of maturity that has made it substantially more rigorous, reliable, generic, and—in the light of the improved hardware facilities now available for its implementation (not least, FPGA and GPU types of solution)—capable of real-time performance. This means that workers are more than ever before using it in serious applications, and with fewer practical difficulties. It is intended that this edition of the book will reflect this radically new and exciting state of affairs at a fundamental level.

A typical final-year undergraduate course on vision for electronic engineering or computer science students might include much of the work of Chapters 1–10 and 14, 15, plus a selection of sections from other chapters, according to requirements. For MSc or PhD research students, a suitable lecture course might go on

to cover Part 3 in depth, including several of the chapters in Part 4,¹ with many practical exercises being undertaken on an image analysis system. Here, much will depend on the research program being undertaken by each individual student. At this stage, the text will have to be used more as a handbook for research, and indeed, one of the prime aims of the volume is to act as a handbook for the researcher and practitioner in this important area.

As mentioned in the original Preface, this book leans heavily on experience I have gained from working with postgraduate students: in particular, I would like to express my gratitude to Mark Edmonds, Simon Barker, Daniel Celano, Darrel Greenhill, Derek Charles, Mark Sugrue, and Georgios Mastorakis, all of whom have in their own ways helped to shape my view of the subject. In addition, it is a special pleasure to recall very many rewarding discussions with my colleagues Barry Cook, Zahid Hussain, Ian Hannah, Dev Patel, David Mason, Mark Bateman, Tieying Lu, Adrian Johnstone, and Piers Plummer, the last two named having been particularly prolific in generating hardware systems for implementing my research group's vision algorithms. Next, I am immensely grateful to Majid Mirmehdi for reading much of the manuscript and making insightful comments and valuable suggestions. Finally, I am indebted to Tim Pitts of Elsevier Science for his help and encouragement, without which this fourth edition might never have been completed.

SUPPORTING MATERIALS

Elsevier's website for the book contains resources to help students and other readers using this text. For further information, go to the publisher's website:

[http://www.elsevierdirect.com/companion.jsp?ISBN = 9780123869081](http://www.elsevierdirect.com/companion.jsp?ISBN=9780123869081)

E. R. DAVIES

*Royal Holloway,
University of London*

PREFACE TO THE FIRST EDITION (1990)

Over the past 30 years or so, machine vision has evolved into a mature subject embracing many topics and applications: these range from automatic (robot) assembly to automatic vehicle guidance, from automatic interpretation of documents to verification of signatures, and from analysis of remotely sensed images to checking of fingerprints and human blood cells; currently, automated visual inspection is undergoing very substantial growth, necessary improvements in

¹The importance of the appendix on robust statistics should not be underestimated once one gets onto serious work, although this will probably be outside the restrictive environment of an undergraduate syllabus.

quality, safety and cost-effectiveness being the stimulating factors. With so much ongoing activity, it has become a difficult business for the professional to keep up with the subject and with relevant methodologies: in particular, it is difficult to distinguish accidental developments from genuine advances. It is the purpose of this book to provide background in this area.

The book was shaped over a period of 10–12 years, through material I have given on undergraduate and postgraduate courses at London University, and contributions to various industrial courses and seminars. At the same time, my own investigations coupled with experience gained while supervising PhD and post-doctoral researchers helped to form the state of mind and knowledge that is now set out here. Certainly it is true to say that if I had had this book 8, 6, 4, or even 2 years ago, it would have been of inestimable value to myself for solving practical problems in machine vision. It is therefore my hope that it will now be of use to others in the same way. Of course, it has tended to follow an emphasis that is my own—and in particular one view of one path toward solving automated visual inspection and other problems associated with the application of vision in industry. At the same time, although there is a specialism here, great care has been taken to bring out general principles—including many applying throughout the field of image analysis. The reader will note the universality of topics such as noise suppression, edge detection, principles of illumination, feature recognition, Bayes' theory, and (nowadays) Hough transforms. However, the generalities lie deeper than this. The book has aimed to make some general observations and messages about the limitations, constraints, and tradeoffs to which vision algorithms are subject. Thus, there are themes about the effects of noise, occlusion, distortion and the need for built-in forms of robustness (as distinct from less successful *ad hoc* varieties and those added on as an afterthought); there are also themes about accuracy, systematic design, and the matching of algorithms and architectures. Finally, there are the problems of setting up lighting schemes which must be addressed in complete systems, yet which receive scant attention in most books on image processing and analysis. These remarks will indicate that the text is intended to be read at various levels—a factor that should make it of more lasting value than might initially be supposed from a quick perusal of the Contents.

Of course, writing a text such as this presents a great difficulty in that it is necessary to be highly selective: space simply does not allow everything in a subject of this nature and maturity to be dealt with adequately between two covers. One solution might be to dash rapidly through the whole area mentioning everything that comes to mind, but leaving the reader unable to understand anything in detail or to *achieve* anything having read the book. However, in a practical subject of this nature, this seemed to me a rather worthless extreme. It is just possible that the emphasis has now veered too much in the opposite direction, by coming down to practicalities (detailed algorithms, details of lighting schemes, and so on): individual readers will have to judge this for themselves. On the other hand, an author has to be true to himself and my view is that it is better for a reader or

student to have mastered a coherent series of topics than to have a mish-mash of information that he is later unable to recall with any accuracy. This, then, is my justification for presenting this particular material in this particular way and for reluctantly omitting from detailed discussion such important topics as texture analysis, relaxation methods, motion, and optical flow.

As for the organization of the material, I have tried to make the early part of the book lead into the subject gently, giving enough detailed algorithms (especially in Chapters 2 and 6) to provide a sound feel for the subject—including especially vital, and in their own way quite intricate, topics such as connectedness in binary images. Hence, Part 1 provides the lead-in, although it is not always trivial material and indeed some of the latest research ideas have been brought in (e.g., on thresholding techniques and edge detection). Part 2 gives much of the meat of the book. Indeed, the (book) literature of the subject currently has a significant gap in the area of intermediate-level vision; while high-level vision (AI) topics have long caught the researcher's imagination, intermediate-level vision has its own difficulties which are currently being solved with great success (note that the Hough transform, originally developed in 1962, and by many thought to be a very specialist topic of rather esoteric interest, is arguably only now coming into its own). Part 2 and the early chapters of Part 3 aim to make this clear, while Part 4 gives reasons why this particular transform has become so useful. As a whole, Part 3 aims to demonstrate some of the practical applications of the basic work covered earlier in the book, and to discuss some of the principles underlying implementation: it is here that chapters on lighting and hardware systems will be found. As there is a limit to what can be covered in the space available, there is a corresponding emphasis on the theory underpinning practicalities. Probably, this is a vital feature, since there are many applications of vision both in industry and elsewhere, yet listing them and their intricacies risks dwelling on interminable detail, which some might find insipid; furthermore, detail has a tendency to date rather rapidly. Although the book could not cover 3-D vision in full (this topic would easily consume a whole volume in its own right), a careful overview of this complex mathematical and highly important subject seemed vital. It is therefore no accident that Chapter 16 is the longest in the book. Finally, Part 4 asks questions about the limitations and constraints of vision algorithms and answers them by drawing on information and experience from earlier chapters. It is tempting to call the last chapter the Conclusion. However, in such a dynamic subject area, any such temptation has to be resisted, although it has still been possible to draw a good number of lessons on the nature and current state of the subject. Clearly, this chapter presents a personal view but I hope it is one that readers will find interesting and useful.