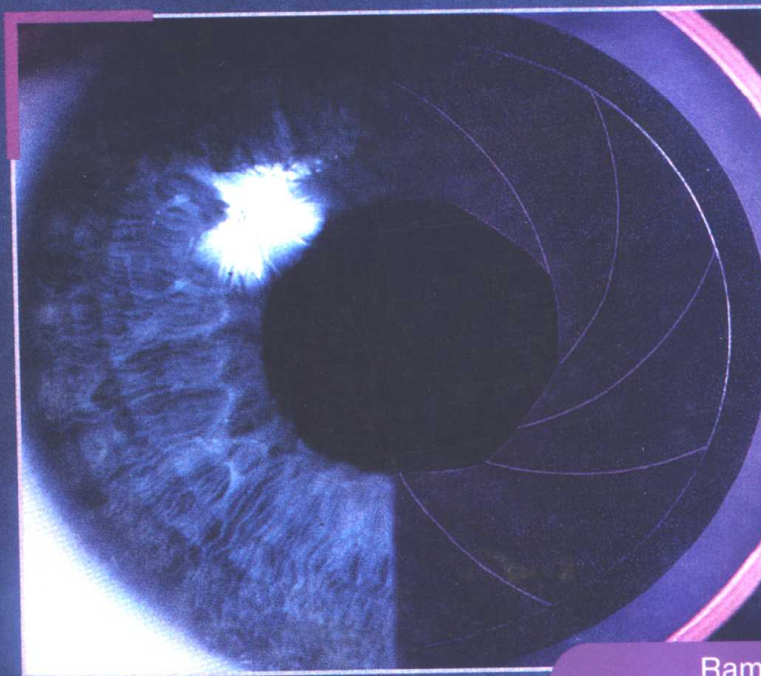


机器视觉

(英文版)

MACHINE VISION



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出版者的话

文艺复兴以降，源远流长的科学精神和逐步形成的学术规范，使西方国家在自然科学的各个领域取得了垄断性的优势；也正是这样的传统，使美国在信息技术发展的六十多年间名家辈出、独领风骚。在商业化的进程中，美国的产业界与教育界越来越紧密地结合，计算机学科中的许多泰山北斗同时身处科研和教学的最前线，由此而产生的经典科学著作，不仅擘划了研究的范畴，还揭开了学术的源变，既遵循学术规范，又自有学者个性，其价值并不会因年月的流逝而减退。

近年，在全球信息化大潮的推动下，我国的计算机产业发展迅猛，对专业人才的需求日益迫切。这对计算机教育界和出版界都既是机遇，也是挑战；而专业教材的建设在教育战略上显得举足轻重。在我国信息技术发展时间较短、从业人员较少的现状下，美国等发达国家在其计算机科学发展的几十年间积淀的经典教材仍有许多值得借鉴之处。因此，引进一批国外优秀计算机教材将对我国计算机教育事业的发展起积极的推动作用，也是与世界接轨、建设真正的世界一流大学的必由之路。

机械工业出版社华章图文信息有限公司较早意识到“出版要为教育服务”。自1998年开始，华章公司就将工作重点放在了遴选、移译国外优秀教材上。经过几年的不懈努力，我们与Prentice Hall, Addison-Wesley, McGraw-Hill, Morgan Kaufmann等世界著名出版公司建立了良好的合作关系，从它们现有的数百种教材中甄选出Tanenbaum, Stroustrup, Kernighan, Jim Gray等大师名家的一批经典作品，以“计算机科学丛书”为总称出版，供读者学习、研究及收藏。大理石纹理的封面，也正体现了这套丛书的品位和格调。

“计算机科学丛书”的出版工作得到了国内外学者的鼎力襄助，国内的专家不仅提供了中肯的选题指导，还不辞劳苦地担任了翻译和审校的工作；而原书的作者也相当关注其作品在中国的传播，有的还专诚为其书的中译本作序。迄今，“计算机科学丛书”已经出版了近百个品种，这些书籍在读者中树立了良好的口碑，并被许多高校采用为正式教材和参考书籍，为进一步推广与发展打下了坚实的基础。

随着学科建设的初步完善和教材改革的逐渐深化，教育界对国外计算机教材的需求和应用都步入一个新的阶段。为此，华章公司将加大引进教材的力度，在“华章教育”的总规划之下出版三个系列的计算机教材：除“计算机科学丛书”之外，对影印版的教材，则单独开辟出“经典原版书库”；同时，引进全美通行的教学辅导书“Schaum's Outlines”系列组成“全美经典学习指导系列”。为了保证这三套丛书的权威性，同时也为了更好地为学校和老师服务，华章公司聘请了中国科学院、北京大学、清华大学、国防科技大学、复旦大学、上海交通大学、南京大学、浙江大学、中国科技大学、哈尔滨工业大学、西安交通大学、中国人民大学、北京航空航天大学、北京邮电大学、中山大学、解放军理工大学、郑州大学、湖北工学院、中国国

家信息安全测评认证中心等国内重点大学和科研机构在计算机的各个领域的著名学者组成“专家指导委员会”，为我们提供选题意见和出版监督。

这三套丛书是响应教育部提出的使用外版教材的号召，为国内高校的计算机及相关专业的教学度身订造的。其中许多教材均已为M. I. T., Stanford, U.C. Berkeley, C. M. U. 等世界名牌大学所采用。不仅涵盖了程序设计、数据结构、操作系统、计算机体系结构、数据库、编译原理、软件工程、图形学、通信与网络、离散数学等国内大学计算机专业普遍开设的核心课程，而且各具特色——有的出自语言设计者之手、有的历经三十年而不衰、有的已被全世界的几百所高校采用。在这些圆熟通博的名师大作的指引之下，读者必将在计算机科学的宫殿中由登堂而入室。

权威的作者、经典的教材、一流的译者、严格的审校、精细的编辑，这些因素使我们的图书有了质量的保证，但我们的目标是尽善尽美，而反馈的意见正是我们达到这一终极目标的重要帮助。教材的出版只是我们的后续服务的起点。华章公司欢迎老师和读者对我们的工作提出建议或给予指正，我们的联系方式如下：

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To

Sudha

—*Ramesh Jain*

My Grandmother

—*Rangachar Kasturi*

Gizmo

—*Brian G. Schunck*

About the Authors

Ramesh Jain is currently a Professor of Electrical and Computer Engineering, and Computer Science and Engineering at the University of California at San Diego. Before joining UCSD, he was a Professor of Electrical Engineering and Computer Science and the founding Director of the Artificial Intelligence Laboratory at the University of Michigan, Ann Arbor. He was also the founder and chairman of Imageware Inc. His current research interests are in multimedia information systems, image databases, machine vision, and intelligent systems.

Ramesh is a Fellow of IEEE, AAI, and Society of Photo-Optical Instrumentation Engineers, and member of ACM, Pattern Recognition Society, Cognitive Science Society, Optical Society of America, and Society of Manufacturing Engineers. He is currently the Editor-in-Chief of *IEEE Multimedia*, and is on the editorial boards of *Machine Vision and Applications*, *Pattern Recognition*, and *Image and Vision Computing*. He received his Ph.D. from IIT, Kharagpur, in 1975 and his B.E. from Nagpur University in 1969.

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Brian G. Schunck has worked for several years on the development of systems for machine vision and image processing. He was educated in computer science at the University of California, Irvine, where he received the B.S. magna cum laude in 1976. He studied electrical engineering, systems theory, and artificial intelligence at M.I.T., where he received the Master's and E.E. degrees in 1979 for work on control algorithms for robotic manipulators and the doctorate in 1983 for research on image flow. He was an assistant professor in the Department of Electrical Engineering and Computer Science and a member of the Artificial Intelligence Laboratory at the University of Michigan, Ann Arbor. Currently he is the Director of Vision Software at Adept Technology.

Brian's current interests include statistical methods for machine vision and industrial inspection; contour, surface, and volume models for computer vision and medical image processing; structure and motion estimation for mobile robots; reverse engineering part models from range data; computer graphics; user interfaces; and marine navigation.

Brian Schunck is a member of the IEEE, ACM, the Society for Industrial and Applied Mathematics, the American Statistical Association, the American Society for Photogrammetry and Remote Sensing, the Society for Manufacturing Engineers, and the Society for Automotive Engineers.

Preface

This book grew out of our efforts to provide a balanced coverage of essential elements of machine vision systems to students in our undergraduate and early graduate classes. The field of machine vision, or computer vision, has been growing at a fast pace. The growth in this field, unlike most established fields, has been both in breadth and depth of concepts and techniques. To make the situation more confusing, the number of new applications has also been growing. Machine vision techniques are being applied in areas ranging from medical imaging to remote sensing, industrial inspection to document processing, and nanotechnology to multimedia databases.

As in most developing fields, not all aspects of machine vision that are of interest to active researchers are useful to the designers of a vision system for a specific application. A designer needs to know basic concepts and techniques to be successful in designing or evaluating a vision system for a particular application. It may not be necessary to know the latest, often controversial, results from leading research centers. On the other hand, the techniques learned by a designer should not be ephemeral.

This text is intended to provide a practical introduction to machine vision. We made efforts to provide all of the details to allow vision algorithms to be used in practical applications. Intentionally omitted are theories of machine vision that do not appear to have sufficient practical applications at this time. We want this to be a useful introduction to machine vision rather than a state-of-the-art collection of research on machine vision.

The text is intended to be used in an introductory course in machine vision at the undergraduate or early graduate level and should be suitable for students with no prior knowledge of computer graphics or signal processing. Students should have a working knowledge of mathematics through calculus of two variables, including matrices and linear spaces, and familiarity with basic probability theory, computer programming, and elementary data structures. Numerical and statistical methods and advanced algorithms are described as needed as well as material on geometry in two and three dimensions. For some sections in the book, more mathematical background is needed. Such sections can be omitted by readers not interested in the rigorous formalization. We have made efforts to provide intuitive concepts, even for mathematical sections, that will help a reader understand the basic elements without the details.

An introductory text is based on material from several sources. This book also contains material from research papers, books, and other places. We have made no attempt to exhaustively list all original sources. We do provide some pointers to readers who are interested in exploring topics more deeply in each chapter. The references at the end of the book provide a list of sources that were directly used in the preparation of the book.

We strongly encourage readers to send any comments and corrections by mail to one of the authors or electronically to jain@ece.ucsd.edu.

Ramesh Jain
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Numerous students directly contributed to the preparation of this book. The most important help and contributions came from David Kosiba. David helped us in all aspects of the book, including many of the illustrations and the concept for the cover art. This book has been influenced significantly by his energy, interest in machine vision, and perseverance. Sue Lott and Dino Terzides also helped with the illustrations. Other students who went out of their way to provide help included Sandy Bartlett, James Han, Patrick Kelly, Dan Sebald, Nilesh Patel, Francis Quek, Todd Elvins, Arun Katkere, Saied Moezzi, and Jennifer Schlenzig. We sincerely appreciate the secretarial support provided by Suzie Mostoller at Penn State, Kathy Dewitt at

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