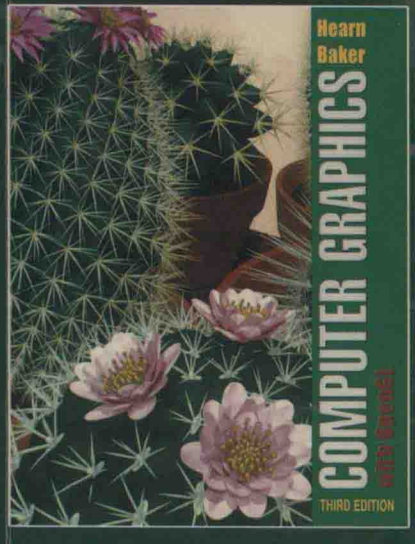
国外计算机科学教材系列

计算机图形学

（第三版）

Computer Graphics with OpenGL, Third Edition



英文版

[美] Donald Hearn
M. Pauline Baker 著

PEARSON Prentice Hall

電子工業出版社
Publishing House of Electronics Industry
http://www.phei.com.cn

经典教材

计算机图形学（第三版）

Computer Graphics with OpenGL, Third Edition

英文版

本书的第三版介绍了设计、使用和理解计算机图形系统及其应用的基本原理，并且提供了一些OpenGL编程实例。书中详细讨论了图形系统的软件和硬件组成，并且将二维和三维图形的相关内容集成到一起。对于没有计算机图形学背景知识的读者，作者提供了有关的基础概念，描述了如何创建从简单的线条图到复杂的真实场景的图片。

本书主要包含的新特性：

- 对OpenGL计算机图形核心编程库GLU及辅助库GLUT提供了完整和综合的解释
- 包含了100多个内容广泛的编程实例，展示了OpenGL函数的使用
- 提供了20多个完整的C++程序，给出了使用C++编写的实例
- 将三维和二维计算机图形方法的讨论结合在一起
- 包含了最新的计算机图形技术与应用

Donald Hearn

从1985年开始任教于伊利诺伊大学Urbana-Champaign分校的计算机科学学院。Hearn博士担任过多门课程的教学工作，其中包括计算机图形学、科学计算可视化、计算科学、数学和应用科学等。他还指导过多个研究项目并在该领域发表了大量的学术论文。

M. Pauline Baker

印第安那大学－普度大学计算机科学学院和信息学院的教授。Baker博士担任着可视化和交互空间渗透技术实验室主任一职，同时她也是一位杰出的科学家。Baker博士正在研究使用计算机图形和虚拟现实技术进行科学数据挖掘。在此之前，她还担任过伊利诺伊大学NCSA的可视化和虚拟环境实验室副主任。

限中国大陆地区销售

PEARSON Prentice Hall

PHEI

责任编辑：冯小贝
封面设计：毛惠庚

本书贴有激光防伪标志，凡没有防伪标志者，属盗版图书

ISBN 7-5053-9614-5 定价：79.00元

ISBN 7-5053-9614-5

9 787505 396142 >

PEARSON Prentice Hall

国外计算机科学教材系列

计算机图形学（第三版）

Computer Graphics with OpenGL, Third Edition

英文版

PHEI

国外计算机科学教材系列

计算机图形学

（第三版）

（英文版）

Computer Graphics with OpenGL, Third Edition

[美] Donald Hearn
M. Pauline Baker 著

電子工業出版社
Publishing House of Electronics Industry
北京 · BEIJING

内容简介

本书是一本内容丰富、取材新颖的计算机图形学著作，并在其前一版的基础上进行了全面扩充，增加了许多新的内容，覆盖了近年来计算机图形学的最新发展和成就。全书层次分明、重点突出，并附有OpenGL编程实例以及各种效果图，是一本难得的优秀教材。

本书共分为16章，全面系统地讲解了计算机图形学的基本概念和相关技术。作者首先对计算机图形学进行综述；然后讲解了二维图形的对象表示、算法及应用，三维图形的相关技术、建模和变换等；接着介绍了光照模型、颜色模型和动画技术。本书还新增了有关层次建模和图形文件格式的介绍，最后的附录给出了计算机图形学中用到的基本数学概念。

本书可作为相关专业本科生和研究生的教材或参考书，也可作为计算机图形学技术人员的参考资料。

版权贸易合同登记号　图字：01-2003-8828

图书在版编目（CIP）数据

计算机图形学 =Computer Graphics with OpenGL: 第三版 /（美）赫恩（Hearn, D.）等著.
-北京：电子工业出版社，2004.3
（国外计算机科学教材系列）
ISBN 7-5053-9614-5

Ⅰ.计… Ⅱ.赫… Ⅲ.计算机图形学-教材-英文 Ⅳ.TP391.41

中国版本图书馆CIP数据核字（2004）第003799号

责任编辑：冯小贝
印　　刷：北京兴华印刷厂
出版发行：电子工业出版社
　　北京市海淀区万寿路173信箱　邮编：100036
经　　销：各地新华书店
开　　本：787 × 980　1/16　　印张：55　字数：1232千字　彩插12页
印　　次：2004年3月第1次印刷
定　　价：79.00元

凡购买电子工业出版社的图书，如有缺损问题，请向购买书店调换；若书店售缺，请与本社发行部联系。联系电话：（010）68279077。质量投诉请发邮件至zlts@phei.com.cn，盗版侵权举报请发邮件至dbqq@phei.com.cn。

出 版 说 明

21世纪初的5至10年是我国国民经济和社会发展的重要时期，也是信息产业快速发展的关键时期。在我国加入WTO后的今天，培养一支适应国际化竞争的一流IT人才队伍是我国高等教育的重要任务之一。信息科学和技术方面人才的优劣与多寡，是我国面对国际竞争时成败的关键因素。

当前，正值我国高等教育特别是信息科学领域的教育调整、变革的重大时期，为使我国教育体制与国际化接轨，有条件的高等院校正在为某些信息学科和技术课程使用国外优秀教材和优秀原版教材，以使我国在计算机教学上尽快赶上国际先进水平。

电子工业出版社秉承多年来引进国外优秀图书的经验，翻译出版了“国外计算机科学教材系列”丛书，这套教材覆盖学科范围广、领域宽、层次多，既有本科专业课程教材，也有研究生课程教材，以适应不同院系、不同专业、不同层次的师生对教材的需求，广大师生可自由选择和自由组合使用。这些教材涉及的学科方向包括网络与通信、操作系统、计算机组织与结构、算法与数据结构、数据库与信息处理、编程语言、图形图像与多媒体、软件工程等。同时，我们也适当引进了一些优秀英文原版教材，本着翻译版本和英文原版并重的原则，对重点图书既提供英文原版又提供相应的翻译版本。

在图书选题上，我们大都选择国外著名出版公司出版的高校教材，如Pearson Education培生教育出版集团、麦格劳－希尔教育出版集团、麻省理工学院出版社、剑桥大学出版社等。撰写教材的许多作者都是蜚声世界的教授、学者，如道格拉斯·科默（Douglas E. Comer）、威廉·斯托林斯（William Stallings）、哈维·戴特尔（Harvey M. Deitel）、尤利斯·布莱克（Uyless Black）等。

为确保教材的选题质量和翻译质量，我们约请了清华大学、北京大学、北京航空航天大学、复旦大学、上海交通大学、南京大学、浙江大学、哈尔滨工业大学、华中科技大学、西安交通大学、国防科学技术大学、解放军理工大学等著名高校的教授和骨干教师参与了本系列教材的选题、翻译和审校工作。他们中既有讲授同类教材的骨干教师、博士，也有积累了几十年教学经验的老教授和博士生导师。

在该系列教材的选题、翻译和编辑加工过程中，为提高教材质量，我们做了大量细致的工作，包括对所选教材进行全面论证；选择编辑时力求达到专业对口；对排版、印制质量进行严格把关。对于英文教材中出现的错误，我们通过与作者联络和网上下载勘误表等方式，逐一进行了修订。

此外，我们还将与国外著名出版公司合作，提供一些教材的教学支持资料，希望能为授课老师提供帮助。今后，我们将继续加强与各高校教师的密切联系，为广大师生引进更多的国外优秀教材和参考书，为我国计算机科学教学体系与国际教学体系的接轨做出努力。

电子工业出版社

教材出版委员会

Preface

Computer graphics remains one of the most exciting and rapidly growing areas of modern technology. Since the appearance of the first edition of this book, computer graphics has become a standard feature in applications software and computer systems in general. Computer-graphics methods are routinely applied in the design of most products, in training simulators, in the production of music videos and television commercials, in motion pictures, in data analysis, in scientific studies, in medical procedures, and in numerous other applications. A great variety of techniques and hardware devices are now in use or under development for these diverse application areas. In particular, much of today's computer-graphics research is concerned with improving the effectiveness, realism, and speed of picture generation. To produce a realistic view of a natural scene, a graphics program must simulate the effects of actual light reflections and refractions from physical objects. Therefore, the current trend in computer graphics is to incorporate improved approximations of physics principles into graphics algorithms, to better simulate the complex interactions between objects and a lighting environment.

Features of the Third Edition

The material in this third edition evolved from notes used in a variety of courses we have taught over the years, including introductory computer graphics, advanced computer graphics, scientific visualization, special topics, and project courses. When we wrote the first edition of this book, many graphics courses and applications dealt only with two-dimensional methods, so we separated the discussions of two-dimensional and three-dimensional graphics techniques. A solid foundation in two-dimensional computer-graphics procedures was given in the first half of the book, and three-dimensional methods were discussed in the second half. Now, however, three-dimensional graphics applications are commonplace, and many initial computer-graphics courses either deal primarily with three-dimensional methods or introduce three-dimensional graphics at an early stage. Therefore, a major feature of this third edition is the integration of three-dimensional and two-dimensional topics.

We have also expanded the treatment of most topics to include discussions of recent developments and new applications. General subjects covered in this third edition include: current hardware and software components of graphics

systems, fractal geometry, ray tracing, splines, illumination models, surface rendering, computer animation, virtual reality, parallel implementations for graphics algorithms, antialiasing, superquadrics, BSP trees, particle systems, physically based modeling, scientific visualization, radiosity, bump mapping, and morphing. Some of the major expansion areas are animation, object representations, the three-dimensional viewing pipeline, illumination models, surface-rendering techniques, and texture mapping.

Another significant change in this third edition is the introduction of the OpenGL set of graphics routines, which is now widely used and available on most computer systems. The OpenGL package provides a large and efficient collection of device-independent functions for creating computer-graphics displays, using a program written in a general-purpose language such as C or C++. Auxiliary libraries are available in OpenGL for handling input and output operations, which require device interactions, and for additional graphics procedures such as generating cylinder shapes, spherical objects, and B-splines.

Programming Examples

More than twenty complete C++ programs are provided in this third edition, using the library of graphics routines available in the popular OpenGL package. These programs illustrate applications of basic picture-construction techniques, two-dimensional and three-dimensional geometric transformations, two-dimensional and three-dimensional viewing methods, perspective projections, spline generation, fractal methods, interactive mouse input, picking operations, menu and submenu displays, and animation techniques. In addition, over one hundred C++/OpenGL program segments are given to demonstrate the implementation of computer-graphics algorithms for clipping, lighting effects, surface rendering, texture mapping, and many other computer-graphics methods.

Required Background

We assume no prior familiarity with computer graphics, but we do assume that the reader has some knowledge of computer programming and basic data structures, such as arrays, pointer lists, files, and record organizations. A variety of mathematical methods are used in computer-graphics algorithms, and these methods are discussed in some detail in the appendix. Mathematical topics covered in the appendix include techniques from analytic geometry, linear algebra, vector and tensor analysis, complex numbers, quaternions, basic calculus, and numerical analysis.

This third edition can be used both as a text for students with no prior background in computer graphics and as a reference for graphics professionals. The emphasis is on the basic principles needed to design, use, and understand computer-graphics systems, along with numerous example programs to illustrate the methods and applications for each topic.

Suggested Course Outlines

For a one-semester course, a subset of topics dealing with either two-dimensional methods or a combination of two-dimensional and three-dimensional topics can be chosen, depending on the requirements of a particular course. A two-semester course sequence can cover the basic graphics concepts and algorithms in the first semester and advanced three-dimensional methods in the second. For the

self-study reader, early chapters can be used to provide an understanding of graphics concepts, supplemented with selected topics from the later chapters.

At the undergraduate level, an introductory computer-graphics course can be organized using selected material from Chapters 2 through 6, 11, and 13. Sections could be chosen from these chapters to cover two-dimensional methods only, or three-dimensional topics could be added from these chapters along with limited selections from Chapters 7 and 10. Other topics, such as fractal representations, spline curves, texture mapping, depth-buffer methods, or color models, could be introduced in a first computer-graphics course. For an introductory graduate or upper-level undergraduate course, more emphasis could be given to three-dimensional viewing, three-dimensional modeling illumination models, and surface-rendering methods. In general, however, a two-semester sequence provides a better framework for adequately covering the fundamentals of two-dimensional and three-dimensional computer-graphics methods, including spline representations, surface rendering, and ray tracing. Special-topics courses, with an introductory computer-graphics prerequisite, can be offered in one or two areas, selected from visualization techniques, fractal geometry, spline methods, ray tracing, radiosity, and computer animation.

Chapter 1 illustrates the diversity of computer-graphics applications by taking a look at the many different kinds of pictures that people have generated with graphics software. In Chapter 2, we present the basic vocabulary of computer graphics, along with an introduction to the hardware and software components of graphics systems, a detailed introduction to OpenGL, and a complete OpenGL example program. The fundamental algorithms for the representation and display of simple objects are given in Chapters 3 and 4. These two chapters examine methods for producing basic picture components such as polygons and circles; for setting the color, size, and other attributes of objects; and for implementing these methods in OpenGL. Chapter 5 discusses the algorithms for performing geometric transformations such as rotation and scaling. In Chapters 6 and 7, we give detailed explanations of the procedures for displaying views of two-dimensional and three-dimensional scenes. Methods for generating displays of complex objects, such as quadric surfaces, splines, fractals, and particle systems are discussed in Chapter 8. In Chapter 9 we explore the various computer-graphics techniques for identifying the visible objects in a three-dimensional scene. Illumination models and the methods for applying lighting conditions to a scene are examined in Chapter 10. Methods for interactive graphics input and for designing graphical user interfaces are given in Chapter 11. The various color models useful in computer graphics are discussed in Chapter 12, along with color-design considerations. Computer-animation techniques are explored in Chapter 13. Methods for the hierarchical modeling of complex systems are presented in Chapter 14. And, in Chapter 15, we survey the major graphics file formats.

Acknowledgments

Many people have contributed to this project in a variety of ways over the years. To the organizations and individuals who furnished pictures and other materials, we again express our appreciation. We also acknowledge the many helpful comments received from our students in various computer-graphics and visualization courses and seminars. We are indebted to all those who provided comments, reviews, suggestions for improving the material covered in this book, and other input, and we extend our apologies to anyone we may have failed to mention. Our thanks to Ed Angel, Norman Badler, Phillip Barry, Brian Barsky,

Hedley Bond, Bart Braden, Lara Burton, Robert Burton, Greg Chwelos, John Cross, Steve Cunningham, John DeCatrel, Victor Duvaneko, Gary Eerkes, Parris Egbert, Tony Faustini, Thomas Foley, Thomas Frank, Don Gillies, Andrew Glassner, Jack Goldfeather, Georges Grinstein, Eric Haines, Robert Herbst, Larry Hodges, Carol Hubbard, Eng-Kiat Koh, Mike Krogh, Michael Laszlo, Suzanne Lea, Michael May, Nelson Max, David McAllister, Jeffrey McConnell, Gary McDonald, C. L. Morgan, Greg Nielson, James Oliver, Lee-Hian Quek, Laurence Rainville, Paul Ross, David Salomon, Günther Schrack, Steven Shafer, Cliff Shaffer, Pete Shirley, Carol Smith, Stephanie Smullen, Jeff Spears, William Taffe, Wai Wan Tsang, Spencer Thomas, Sam Uselton, David Wen, Bill Wicker, Andrew Woo, Angelo Yfantis, Marek Zaremba, Michael Zyda, and the many anonymous reviewers. We also thank our editor Alan Apt, Toni Holm, and the Colorado staff for their help, suggestions, encouragement, and, above all, their patience during the preparation of this third edition. And to our production editors and staff, Lynda Castillo, Camille Trentacoste, Heather Scott, Xiaohong Zhu, Vince O'Brien, Patricia Burns, Kathy Ewing, and David Abel, we extend our sincere appreciation for their many talented contributions and careful attention to detail.

Contents