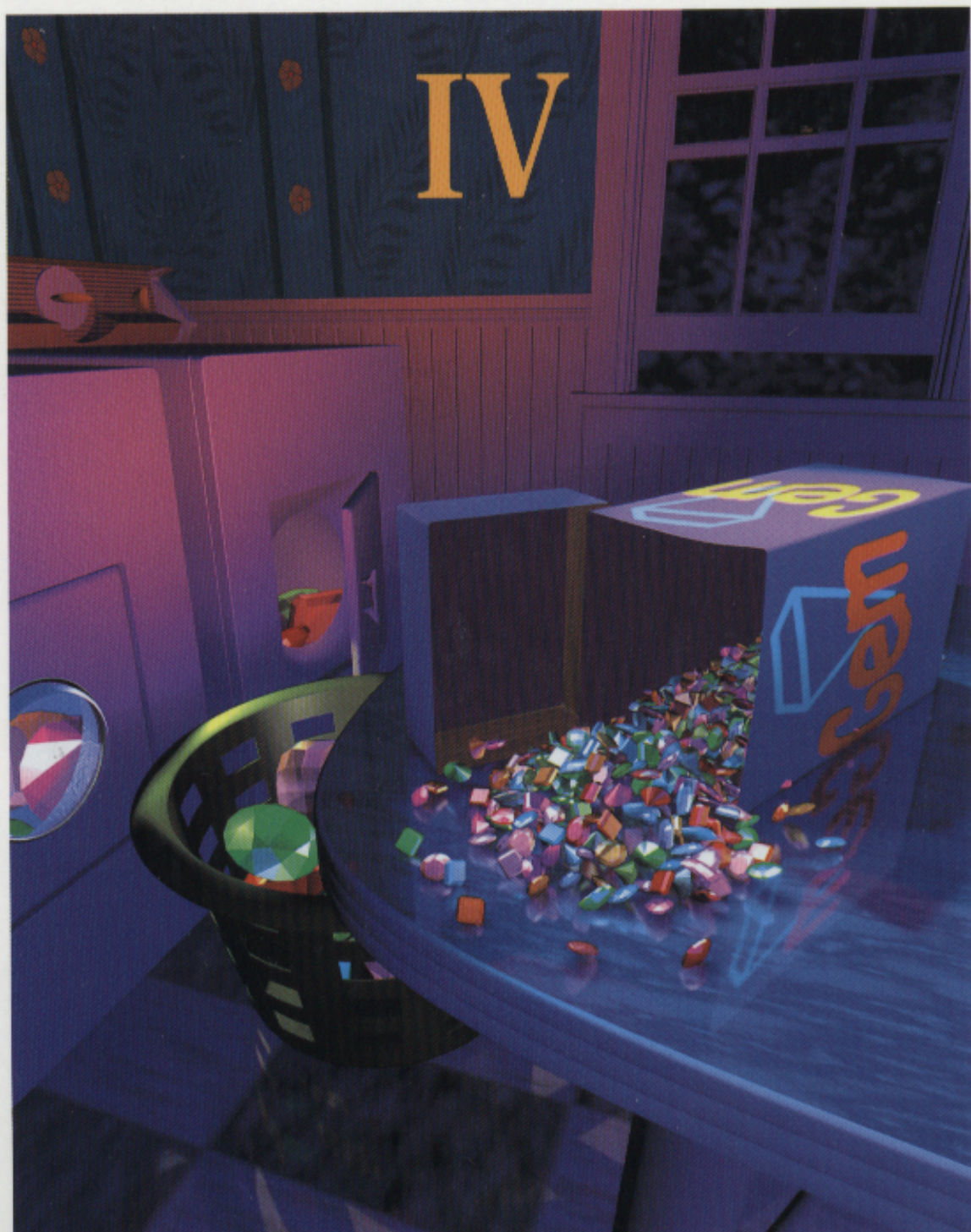


GRAPHICS GEMS

EDITED BY PAUL S. HECKBERT



GRAPHICS GEMS

IV

Edited by Paul S. Heckbert

*Computer Science Department
Carnegie Mellon University
Pittsburgh, Pennsylvania*



Morgan Kaufmann is an imprint of Academic Press

A Harcourt Science and Technology Company

San Diego San Francisco New York Boston
London Sydney Tokyo

ACADEMIC PRESS

A Harcourt Science and Technology Company
525 B Street, Suite 1900, San Diego, CA 92101-4495 USA
<http://www.academicpress.com>

Academic Press
24-28 Oval Road, London NW1 7DX United Kingdom
<http://www.hbuk/ap/>

Morgan Kaufmann
340 Pine Street, Sixth Floor, San Francisco, CA 94104-3205
<http://mkp.com>

This book is printed on acid-free paper. (∞)

Copyright © 1994 by Academic Press, Inc.
All rights reserved.

No part of this publication may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopy, recording, or any information storage and retrieval system, without permission in writing from the publisher.

All brand names and product names mentioned in this book are trademarks or registered trademarks of their respective companies.

33 TZA 3659-4.1



7000 K 351

Library of Congress Cataloging-in-Publication Data

Graphics Gems IV / edited by Paul S. Heckbert.

p. cm. --(The Graphics Gems Series)

Includes bibliographical references and index.

ISBN 0-12-336156-7 (with Macintosh disk). — ISBN 0-12-336155-9 (with IBM disk).

I. Computer graphics. I. Heckbert, Paul S., 1958-

II. Title: Graphics Gems 4. III. Title: Graphics Gems four.

IV. Series.

T385.G6974 1994

006.6'6--dc20

93-46995
CIP

Printed in the United States of America
99 00 01 02 03 MB 9 8 7 6 5 4



Contents

Author Index	ix
Foreword <i>by Andrew Glassner</i>	xi
Preface	xv
About the Cover	xvii
I. Polygons and Polyhedra	1
I.1. Centroid of a Polygon <i>by Gerard Bashein and Paul R. Detmer</i>	3
I.2. Testing the Convexity of a Polygon <i>by Peter Schorn and Frederick Fisher</i>	7
I.3. An Incremental Angle Point in Polygon Test <i>by Kevin Weiler</i>	16
I.4. Point in Polygon Strategies <i>by Eric Haines</i>	24
I.5. Incremental Delaunay Triangulation <i>by Dani Lischinski</i>	47
I.6. Building Vertex Normals from an Unstructured Polygon List <i>by Andrew Glassner</i>	60
I.7. Detecting Intersection of a Rectangular Solid and a Convex Polyhedron <i>by Ned Greene</i>	74
I.8. Fast Collision Detection of Moving Convex Polyhedra <i>by Rich Rabbitz</i>	83
II. Geometry	111
II.1. Distance to an Ellipsoid <i>by John C. Hart</i>	113
II.2. Fast Linear Approximations of Euclidean Distance in Higher Dimensions <i>by Yoshikazu Ohashi</i>	120
II.3. Direct Outcode Calculation for Faster Clip Testing <i>by Walt Donovan and Tim Van Hook</i>	125
II.4. Computing the Area of a Spherical Polygon <i>by Robert D. Miller</i>	132
II.5. The Pleasures of “Perp Dot” Products <i>by F. S. Hill, Jr.</i>	138
II.6. Geometry for <i>N</i> -Dimensional Graphics <i>by Andrew J. Hanson</i>	149
III. Transformations	173
III.1. Arcball Rotation Control <i>by Ken Shoemake</i>	175
III.2. Efficient Eigenvalues for Visualization <i>by Robert L. Cromwell</i>	193

III.3.	Fast Inversion of Length- and Angle-Preserving Matrices by <i>Kevin Wu</i>	199
III.4.	Polar Matrix Decomposition by <i>Ken Shoemake</i>	207
III.5.	Euler Angle Conversion by <i>Ken Shoemake</i>	222
III.6.	Fiber Bundle Twist Reduction by <i>Ken Shoemake</i>	230
IV.	Curves and Surfaces	239
IV.1.	Smoothing and Interpolation with Finite Differences by <i>Paul H. C. Eilers</i>	241
IV.2.	Knot Insertion Using Forward Differences by <i>Phillip Barry and Ron Goldman</i>	251
IV.3.	Converting a Rational Curve to a Standard Rational Bernstein-Bézier Representation by <i>Chandrajit Bajaj and Guoliang Xu</i>	256
IV.4.	Intersecting Parametric Cubic Curves by Midpoint Subdivision by <i>R. Victor Klassen</i>	261
IV.5.	Converting Rectangular Patches into Bézier Triangles by <i>Dani Lischinski</i>	278
IV.6.	Tessellation of NURB Surfaces by <i>John W. Peterson</i>	286
IV.7.	Equations of Cylinders and Cones by <i>Ching-Kuang Shene</i>	321
IV.8.	An Implicit Surface Polygonizer by <i>Jules Bloomenthal</i>	324
V.	Ray Tracing	351
V.1.	Computing the Intersection of a Line and a Cylinder by <i>Ching-Kuang Shene</i>	353
V.2.	Intersecting a Ray with a Cylinder by <i>Joseph M. Cychosz and Warren N. Waggenspack, Jr.</i>	356
V.3.	Voxel Traversal along a 3D Line by <i>Daniel Cohen</i>	366
V.4.	Multi-Jittered Sampling by <i>Kenneth Chiu, Peter Shirley, and Changyaw Wang</i>	370
V.5.	A Minimal Ray Tracer by <i>Paul S. Heckbert</i>	375
VI.	Shading	383
VI.1.	A Fast Alternative to Phong's Specular Model by <i>Christophe Schlick</i>	385
VI.2.	R.E versus N.H Specular Highlights by <i>Frederick Fisher and Andrew Woo</i>	388
VI.3.	Fast Alternatives to Perlin's Bias and Gain Functions by <i>Christophe Schlick</i>	401
VI.4.	Fence Shading by <i>Uwe Behrens</i>	404

VII. Frame Buffer Techniques	411
VII.1. XOR-Drawing with Guaranteed Contrast <i>by Manfred Kopp and Michael Gervautz</i>	413
VII.2. A Contrast-Based Scalefactor for Luminance Display <i>by Greg Ward</i>	415
VII.3. High Dynamic Range Pixels <i>by Christophe Schlick</i>	422
VIII. Image Processing	431
VIII.1. Fast Embossing Effects on Raster Image Data <i>by John Schlag</i>	433
VIII.2. Bilinear Coons Patch Image Warping <i>by Paul S. Heckbert</i>	438
VIII.3. Fast Convolution with Packed Lookup Tables <i>by George Wolberg and Henry Massalin</i>	447
VIII.4. Efficient Binary Image Thinning Using Neighborhood Maps <i>by Joseph M. Cychosz</i>	465
VIII.5. Contrast Limited Adaptive Histogram Equalization <i>by Karel Zuiderveld</i>	474
VIII.6. Ideal Tiles for Shading and Halftoning <i>by Alan W. Paeth</i>	486
IX. Graphic Design	495
IX.1. Placing Text Labels on Maps and Diagrams <i>by Jon Christensen, Joe Marks, and Stuart Shieber</i>	497
IX.2. Dynamic Layout Algorithm to Display General Graphs <i>by László Szirmay-Kalos</i>	505
X. Utilities	519
X.1. Tri-linear Interpolation <i>by Steve Hill</i>	521
X.2. Faster Linear Interpolation <i>by Steven Eker</i>	526
X.3. C++ Vector and Matrix Algebra Routines <i>by Jean-François Doué</i>	534
X.4. C Header File and Vector Library <i>by Andrew Glassner and Eric Haines</i>	558
Index	571



Author Index

Format: *author, institution, chapter number: p. start page.*

Author's full address is listed on the first page of each chapter.

- Chandrajit Bajaj*, Purdue University, West Lafayette, IN, USA, IV.3: p. 256.
Phillip Barry, University of Minnesota, Minneapolis, MN, USA, IV.2: p. 251.
Gerard Bashein, University of Washington, Seattle, WA, USA, I.1: p. 3.
Uwe Behrens, Bremen, Germany, VI.4: p. 404.
Jules Bloomenthal, George Mason University, Fairfax, VA, USA, IV.8: p. 324.
Kenneth Chiu, Indiana University, Bloomington, IN, USA, V.4: p. 370.
Jon Christensen, Harvard University, Cambridge, MA, USA, IX.1: p. 497.
Daniel Cohen, Ben Gurion University, Beer-Sheva, Israel, V.3: p. 366.
Robert L. Cromwell, Purdue University, West Lafayette, IN, USA, III.2: p. 193.
Joseph M. Cychosz, Purdue University, West Lafayette, IN, USA, V.2: p. 356,
VIII.4: p. 465.
Paul R. Detmer, University of Washington, Seattle, WA, USA, I.1: p. 3.
Walt Donovan, Sun Microsystems, Mountain View, CA, USA, II.3: p. 125.
Jean-François Doué, HEC, Paris, France, X.3: p. 534.
Paul H. C. Eilers, DCMR Milieudienst Rijnmond, Schiedam, The Netherlands,
IV.1: p. 241.
Steven Eker, City University, London, UK, X.2: p. 526.
Frederick Fisher, Kubota Pacific Computer, Inc., Santa Clara, CA, USA, I.2: p. 7,
VI.2: p. 388.
Michael Gervautz, Technical University of Vienna, Vienna, Austria, VII.1: p. 413.
Andrew Glassner, Xerox PARC, Palo Alto, CA, USA, I.6: p. 60, X.4: p. 558.
Ron Goldman, Rice University, Houston, TX, USA, IV.2: p. 251.
Ned Greene, Apple Computer, Cupertino, CA, USA, I.7: p. 74.
Eric Haines, 3D/Eye Inc., Ithaca, NY, USA, I.4: p. 24, X.4: p. 558.
Andrew J. Hanson, Indiana University, Bloomington, IN, USA, II.6: p. 149.
John C. Hart, Washington State University, Pullman, WA, USA, II.1: p. 113.
Paul S. Heckbert, Carnegie Mellon University, Pittsburgh, PA, USA, V.5: p. 375,
VIII.2: p. 438.
F. S. Hill, Jr., University of Massachusetts, Amherst, MA, USA, II.5: p. 138.

- Steve Hill*, University of Kent, Canterbury, UK, X.1: p. 521.
- R. Victor Klassen*, Xerox Webster Research Center, Webster, NY, USA, IV.4: p. 261.
- Manfred Kopp*, Technical University of Vienna, Vienna, Austria, VII.1: p. 413.
- Dani Lischinski*, Cornell University, Ithaca, NY, USA, I.5: p. 47, IV.5: p. 278.
- Joe Marks*, Digital Equipment Corporation, Cambridge, MA, USA, IX.1: p. 497.
- Henry Massalin*, Microunity Corporation, Sunnyvale, CA, USA, VIII.3: p. 447.
- Robert D. Miller*, E. Lansing, MI, USA II.4: p. 132.
- Yoshikazu Ohashi*, Cognex, Needham, MA, USA, II.2: p. 120.
- Alan W. Paeth*, Okanagan University College, Kelowna, British Columbia, Canada, VIII.6: p. 486.
- John W. Peterson*, Taligent, Inc., Cupertino, CA, USA, IV.6: p. 286.
- Rich Rabbitz*, Martin Marietta, Moorestown, NJ, USA, I.8: p. 83.
- John Schlag*, Industrial Light and Magic, San Rafael, CA, USA, VIII.1: p. 433.
- Christophe Schlick*, Laboratoire Bordelais de Recherche en Informatique, Talence, France, VI.1: p. 385, VI.3: p. 401, VII.3: p. 422.
- Peter Schorn*, ETH, Zürich, Switzerland, I.2: p. 7.
- Ching-Kuang Shene*, Northern Michigan University, Marquette, MI, USA, IV.7: p. 321, V.1: p. 353.
- Stuart Shieber*, Harvard University, Cambridge, MA, USA, IX.1: p. 497.
- Peter Shirley*, Indiana University, Bloomington, IN, USA, V.4: p. 370.
- Ken Shoemake*, University of Pennsylvania, Philadelphia, PA, USA, III.1: p. 175, III.4: p. 207, III.5: p. 222, III.6: p. 230.
- László Szirmay-Kalos*, Technical University of Budapest, Budapest, Hungary, IX.2: p. 505.
- Tim Van Hook*, Silicon Graphics, Mountain View, CA, USA, II.3: p. 125.
- Warren N. Waggenspack, Jr.*, Louisiana State University, Baton Rouge, LA, USA, V.2: p. 356.
- Changyaw Wang*, Indiana University, Bloomington, IN, USA, V.4: p. 370.
- Greg Ward*, Lawrence Berkeley Laboratory, Berkeley, CA, USA, VII.2: p. 415.
- Kevin Weiler*, Autodesk Inc., Sausalito, CA, USA, I.3: p. 16.
- George Wolberg*, City College of New York/CUNY, New York, NY, USA, VIII.3: p. 447.
- Andrew Woo*, Alias Research, Inc., Toronto, Ontario, Canada, VI.2: p. 388.
- Kevin Wu*, SunSoft, Mountain View, CA, USA, III.3: p. 199.
- Guoliang Xu*, Purdue University, West Lafayette, IN, USA, IV.3: p. 256.
- Karel Zuiderveld*, Utrecht University, Utrecht, The Netherlands, VIII.5: p. 474.