



POINT-BASED GRAPHICS

**The Morgan Kaufmann
Series in Computer Graphics**

EDITED BY
MARKUS GROSS
& HANSPETER PFISTER

Point-based Graphics

MARKUS GROSS

江苏工业学院图书馆
藏书章



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MORGAN KAUFMANN PUBLISHERS

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<i>Cover Design</i>	Chen Design
<i>Composition</i>	diacriTech
<i>Technical Illustration</i>	diacriTech
<i>Copyeditor</i>	Multiscience Press
<i>Proofreader</i>	Multiscience Press
<i>Indexer</i>	Multiscience Press
<i>Interior printer</i>	Hing Yip Printing Co.
<i>Cover printer</i>	Hing Yip Printing Co.

Morgan Kaufmann Publishers is an imprint of Elsevier.
30 Corporate Drive, Suite 400, Burlington, MA 01803, USA

This book is printed on acid-free paper.

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Library of Congress Cataloging-in-Publication Data

Gross, Markus, 1963-

Point-based graphics / Markus Gross, Hanspeter Pfister.
p. cm.

Includes bibliographical references and index.

ISBN 978-0-12-370604-1 (hardcover : alk. paper) 1. Computer graphics . 2. Three-dimensional display systems. I. Pfister, Hanspeter. II. Title.

T385.G769 2007

006.6—dc22

2007010612

ISBN: 978-0-12-370604-1

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Printed in China.

07 08 09 10 5 4 3 2 1

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C. Beatty, and Brian A. Barsky

The best one-volume introduction to point-based graphics ever, it addresses virtually every aspect of computer graphics from a point-based perspective: acquisition, representation, modeling, animation, rendering—everything from the history of point-based graphics to the latest research results. A broad and deep book destined to be the standard reference for years to come, edited and written by leaders in the field.

Dr. Henry Fuchs

Federico Gil Professor, Department of Computer Science, University North Carolina, Chapel Hill

Point-based representations have recently come into prominence in computer graphics across a range of tasks, from rendering to geometric modeling and physical simulation. Point-based models are unburdened by connectivity information and allow dynamically adaptive sampling, according to the application needs. They are well-suited for modeling challenging effects such as wide-area contacts, large deformations, or fractures. The lack of manifold connectivity and regularity among the samples, however, presents many new challenges in point-based approaches and requires the development of new toolkits to address them. This book, in a series of well-written chapters, covers all essential aspects of using point-based representations in computer graphics, from the underlying mathematics to data structures to GPU implementations—providing a state-of-the-art review of the field.

Prof. Leonidas J. Guibas

Computer Science Department, Stanford University

There is no simpler object than a zero dimensional point. Yet somehow, armed with millions of such simple primitives, researchers have constructed complex 3D models that we can see and manipulate on the screen. Point-Based Graphics brings us the rich history of work that has been done in this area of computer graphics. Editors Markus Gross and Hanspeter Pfister and their contributing authors present a complete set of all the detailed work that has exploded over the past decade resulting in many of the images we see today. This book provides both the theoretical foundations as well as the practical elements needed to build new applications with point-based graphics.

Michael F. Cohen

Principal Researcher, Microsoft Research

This book offers much more than what its title advertises. It provides not only an in-depth coverage of the new field of point-based graphics, but also a solid introduction to most modern techniques in computer graphics, from acquisition to rendering and animation. Written by leading experts on the topic, chapters include the introduction

of fundamental tools as well as in-depth case studies of state-of-the-art algorithms. I learned a lot reading the book and I expect to use it often as a reference.

Frédo Durand

Associate Professor, Computer Science and Artificial Intelligence Laboratory, Massachusetts Institute of Technology

Point-based graphics has seen a significant rebirth, which greatly changes the graphics arena. This book, focusing on the major, recent advances in point-based graphics, provides an excellent introduction and overview of the state of the art. It is particularly impressive for its breadth and depth, covering the foundations of the point primitive, modeling, processing, and rendering, as well as advanced topics, such as physics-based animation. Other distinctive features of the book are its world-renowned editors, Markus Gross and Hanspeter Pfister, and the high academic caliber of the contributors. Professionals and students alike will find the book intriguing and stimulating with sound and practical advice. It is a required reading for anyone who wants to keep pace with the rapid progress in this re-emerging and important area of research.

Dr. Arie E. Kaufman

Distinguished Professor & Chair, Computer Science Department, Stony Brook University (SUNY), Stony Brook, NY

To Lisa, Jana, and Adrian.

M. G.

To Jennifer, Lilly, and Audrey.

H. P.

About the Editors

DR. MARKUS GROSS



Dr. Gross is a professor of computer science, chair of the institute of computational science, and director of the Computer Graphics Laboratory of the Swiss Federal Institute of Technology (ETH) in Zürich. His research interests include point-based graphics, physically-based modeling, multiresolution analysis, and virtual reality. He has published more than 130 scientific papers on computer graphics and scientific visualization, and he authored the book “Visual Computing”, Springer, 1994. He holds various patents on core graphics

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Hanspeter Pfister is Associate Director and Senior Research Scientist at MERL—Mitsubishi Electric Research Laboratories—in Cambridge, MA. He is the chief architect of VolumePro, Mitsubishi Electric's real-time volume rendering hardware for PCs. His research interests include computer graphics, scientific visualization, and graphics architectures. His work spans a range of topics, including point-based graphics, appearance modeling and acquisition, computational photography, 3D television, and face modeling. Hanspeter Pfister received his Ph.D. in Computer Science in 1996 from the State University of New York at Stony Brook. He received

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Foreword

In any established field, doing something “different” presents a challenge. Even in computer graphics, an area that evolves rapidly, the notion of treating simple points as primitive modeling and display elements did not get off to a fast start. Nevertheless, every good idea has its time. Two timely factors that promote the idea of point-based graphics are procedural shape definition and automated shape acquisition. The former has the flexibility to produce as many or as few points as needed to accurately represent itself. The latter naturally produces a massive flood of points. The sheer complexity of such models begs for a representation that is inherently simple. Points are simple. However, effectively acquiring, editing, animating, rendering, and otherwise processing points requires a non-intuitive understanding of the representations and processes. That’s why this book is necessary.

Twenty years ago, when my students were experimenting with point-based representations of surfaces and volumes, they repeatedly asked “what would happen if we tried this crazy idea?” As demonstrated in this text, today’s discussions are conducted with more rigor and sophistication. While points themselves may be simple, a complete understanding of how they are processed and how collections of them should be interpreted requires sophisticated explanations. And there is no single “best” method for processing such point collections. The explanations in this book are broad; the authors cover a range of applications and techniques, and they cover these thoroughly.

The approaches described in this book may once have been considered outside the mainstream by experienced graphics practitioners. The editors and contributors themselves, however, are among the best and brightest in mainstream computer graphics research. To bring their expertise to bear on a single coherent volume is no small feat.

There are undoubtedly a few of us that enjoy ideas just because of their inherent beauty. Having migrated to computer graphics from a background in signal processing, I have a certain attachment to point-based graphics methods. Because of this interest, I have tracked the work of many of the book’s contributors for several years.

Their perseverance and ingenuity are an inspiration. Seeing their work collected in one place is a tremendous personal pleasure. More importantly for the reader, this text is a unique and valuable resource for those who wish to understand and make use of point-based graphics technology.

Turner Whitted
Microsoft Research