



Preface

Graphics & Visualization: Principles and Algorithms is aimed at undergraduate and graduate students taking computer graphics and visualization courses. Students in computer-aided design courses with emphasis on visualization will also benefit from this text, since mathematical modeling techniques with parametric curves and surfaces as well as with subdivision surfaces are covered in depth. It is finally also aimed at practitioners who seek to acquire knowledge of the fundamental techniques behind the tools they use or develop. The book concentrates on established principles and algorithms as well as novel methods that are likely to leave a lasting mark on the subject.

The rapid expansion of the computer graphics and visualization fields has led to increased specialization among researchers. The vast nature of the relevant literature demands the cooperation of multiple authors. This book originated with a team of four authors. Two chapters were also contributed by well-known specialists: Chapter 16 (Global Illumination Algorithms) was written by P. Dutré. Chapter 8 (Subdivision for Graphics and Visualization) was coordinated by A. Nasri (who wrote most sections), with contributions by F. A. Salem (section on Analysis of Subdivision Surfaces) and G. Turkiyyah (section on Subdivision Finite Elements).

A novelty of this book is the integrated coverage of computer graphics and visualization, encompassing important current topics such as scene graphs, subdivision surfaces, multi-resolution models, shadow generation, ambient occlusion, particle tracing, spatial subdivision, scalar and vector data visualization, skeletal animation, and high dynamic range images. The material has been developed, refined, and used extensively in computer graphics and visualization courses over a number of years.

Some prerequisite knowledge is necessary for a reader to take full advantage of the presented material. Background on algorithms and basic linear algebra

Some prerequisite knowledge is necessary for a reader to take full advantage of the presented material. Background on algorithms and basic linear algebra principles are assumed throughout. Some, mainly advanced, sections also require understanding of calculus and signal processing concepts. The appendices summarize some of this prerequisite material.

Each chapter is followed by a list of exercises. These can be used as course assignments by instructors or as comprehension tests by students. A steady stream of small, low- and medium-level of difficulty exercises significantly helps understanding. Chapter 3 (2D and 3D Coordinate Systems and Transformations) also includes a long list of worked examples on both 2D and 3D coordinate transformations. As the material of this chapter must be thoroughly understood, these examples can form the basis for tutorial lessons or can be used by students as self-study topics.

The material can be split between a basic and an advanced graphics course, so that a student who does not attend the advanced course has an integrated view of most concepts. Advanced sections are indicated by an asterisk [®]. The visualization course can either follow on from the basic graphics course, as suggested below, or it can be a standalone course, in which case the advanced computer-graphics content should be replaced by a more basic syllabus.

Course 1: Computer Graphics–Basic. This is a first undergraduate course in computer graphics.

- Chapter 1 (Introduction).
- Chapter 2 (Rasterization Algorithms).
- Chapter 3 (2D and 3D Coordinate Systems and Transformations). Section 3.9 (Quaternions) should be excluded.
- Chapter 4 (Projections and Viewing Transformations). Skip Section 4.5 (Extended Viewing Transformation).
- Chapter 5 (Culling and Hidden Surface Elimination Algorithms). Skip Section 5.4 (Occlusion Culling). Restrict Section 5.5 (Hidden Surface Elimination) to the Z-buffer algorithm.
- Chapter 6 (Model Representation and Simplification).
- Chapter 7 (Parametric Curves and Surfaces). Bézier curves and tensor product Bézier surfaces.

- Chapter 9 (Scene Management).
- Chapter 11 (Color in Graphics and Visualization).
- Chapter 12 (Illumination Models and Algorithms). Skip the advanced topics: Section 12.3 (The Lambert Illumination Model), Section 12.7 (The Cook–Torrance Illumination Model), Section 12.8 (The Oren–Nayar Illumination Model), and Section 12.9 (The Strauss Illumination Model), as well as Section 12.10 (Anisotropic Reflectance) and Section 12.11 (Ambient Occlusion).
- Chapter 13 (Shadows). Skip Section 13.4 (Shadow Maps).
- Chapter 14 (Texturing). Skip Section 14.4 (Texture Magnification and Minification), Section 14.5 (Procedural Textures), Section 14.6 (Texture Transformations), Section 14.7 (Relief Representation), Section 14.8 (Texture Atlases), and Section 14.9 (Texture Hierarchies).
- Chapter 17 (Basic Animation Techniques). Introduce the main animation concepts only and skip the section on interpolation of rotation (page 622), as well as Section 17.3 (Rigid-Body Animation), Section 17.4 (Skeletal Animation), Section 17.5 (Physically-Based Deformable Models), and Section 17.6 (Particle Systems).

Course 2: Computer Graphics–Advanced. This choice of topics is aimed at either a second undergraduate course in computer graphics or a graduate course; a basic computer-graphics course is a prerequisite.

- Chapter 3 (2D and 3D Coordinate Systems and Transformations). Review this chapter and introduce the advanced topic, Section 3.9 (Quaternions).
- Chapter 4 (Projections and Viewing Transformations). Review this chapter and introduce Section 4.5 (Extended Viewing Transformation).
- Chapter 5 (Culling and Hidden Surface Elimination Algorithms). Review this chapter and introduce Section 5.4 (Occlusion Culling). Also, present the following material from Section 5.5 (Hidden Surface Elimination): BSP algorithm, depth sort algorithm, ray-casting algorithm, and efficiency issues.
- Chapter 7 (Parametric Curves and Surfaces). Review Bézier curves and tensor product Bézier surfaces and introduce B-spline curves, rational B-spline curves, interpolation curves, and tensor product B-spline surfaces.

- Chapter 8 (Subdivision for Graphics and Visualization).
- Chapter 12 (Illumination Models and Algorithms). Review this chapter and introduce the advanced topics, Section 12.3 (The Lambert Illumination Model), Section 12.7 (The Cook–Torrance Illumination Model), Section 12.8 (The Oren–Nayar Illumination Model), and Section 12.9 (The Strauss Illumination Model), as well as Section 12.10 (Anisotropic Reflectance) and Section 12.11 (Ambient Occlusion).
- Chapter 13 (Shadows). Review this chapter and introduce Section 13.4 (Shadow Maps).
- Chapter 14 (Texturing). Review this chapter and introduce Section 14.4 (Texture Magnification and Minification), Section 14.5 (Procedural Textures), Section 14.6 (Texture Transformations), Section 14.7 (Relief Representation), Section 14.8 (Texture Atlases), and Section 14.9 (Texture Hierarchies).
- Chapter 15 (Ray Tracing).
- Chapter 16 (Global Illumination Algorithms).
- Chapter 17 (Basic Animation Techniques). Review this chapter and introduce the section on interpolation of rotation (page 620), as well as Section 17.3 (Rigid-Body Animation), Section 17.4 (Skeletal Animation), Section 17.5 (Physically-Based Deformable Models), and Section 17.6 (Particle Systems).

Course 3: Visualization. The topics below are intended for a visualization course that has the basic graphics course as a prerequisite. Otherwise, some of the sections suggested below should be replaced by sections from the basic graphics course.

- Chapter 6 (Model Representation and Simplification). Review this chapter.
- Chapter 3 (2D and 3D Coordinate Systems and Transformations). Review this chapter.
- Chapter 11 (Color in Graphics and Visualization). Review this chapter.
- Chapter 8 (Subdivision for Graphics and Visualization).
- Chapter 15 (Ray Tracing).

- Chapter 17 (Basic Animation Techniques). Review this chapter and introduce Section 17.3 (Rigid-Body Animation) and Section 17.6 (Particle Systems).
- Chapter 10 (Visualization Principles).
- Chapter 18 (Scientific Visualization Algorithms).

About the Cover

The cover is based on M. Denko's rendering *Waiting for Spring*, which we have renamed *The Impossible*. Front cover: final rendering. Back cover: three aspects of the rendering process (wireframe rendering superimposed on lit 3D surface, lit 3D surface, final rendering).

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