



# Preface

This book is a product of several graphics courses I have taught at Indiana University and the University of Utah. All graphics books must choose between teaching the low-level details “under the hood” of graphics programs or teaching how to use modern graphics APIs, such as OpenGL, Direct3D, and Java3D. This book chooses the former approach. I do not have a good justification for this choice other than that I have taught both styles of courses, and the students in the “low-level” courses seemed to understand the material better than the other students and even seemed to use the APIs more effectively. There are many reasons this might be true, and the effect may not transfer to other teachers or schools. However, I believe that teaching the fundamentals is usually the right approach, whether in graphics, another academic discipline, or a sport.

## How to Use this Book

The book begins with nine chapters that roughly correspond to a one-semester course which takes students through the graphics pipeline and basic ray tracing. It has students implement everything—i.e., it is not a “learn OpenGL” style text. However, the pipeline presented is consistent with the one implemented in graphics hardware, and students who have used the book should find OpenGL or other common APIs familiar in many ways.

The second part of the book is a series of advanced topics that are not highly ordered. This allows a variety of second-semester courses and a few weeks of advanced topics in a first semester course.

For the first semester, I would suggest the following as a possible outline of initial assignments:

1. Math homework at the end of Chapter 2 followed by at least one in-class exam.
2. Line rasterization.
3. Triangle rasterization with barycentric color interpolation.
4. Orthographic wireframe drawing.
5. Perspective wireframe drawing.
6. BSP-tree with flat-shaded triangles and wireframe edges with only trivial z-clipping and with mouse-driven viewpoint selection.
7. Finite-precision z-buffer implementation with only trivial z-clipping.

Following these assignments, the instructor could do assignments on ray tracing or could have the students add shadow-maps, Phong lighting, clipping, and textures to their z-buffers, or they could move the students into programming with a 3D API.

## About the Cover

The cover image is from *Tiger in the Water* by J. W. Baker (brushed and air-brushed acrylic on canvas, 16" by 20", [www.jwbart.com](http://www.jwbart.com)).

The subject of a tiger is a reference to a wonderful talk given by Alain Fournier (1943–2000) at the Cornell Workshop in 1998. His talk was an evocative verbal description of the movements of a tiger. He summarized his point:

Even though modelling and rendering in computer graphics have been improved tremendously in the past 35 years, we are still not at the point where we can model automatically a tiger swimming in the river in all its glorious details. By automatically I mean in a way that does not need careful manual tweaking by an artist/expert.

The bad news is that we have still a long way to go.

The good news is that we have still a long way to go.



## Online Resources

The web site for this book is <http://www.cs.utah.edu/shirley/fcg2/>. I will maintain an errata list there as well as links to people using the book in classes. Although I do not provide slides for the course, Rich Riesenfeld has graciously agreed to make his excellent slides available, and a pointer to those slides will be available at the book's web site. Most of the figures in this book are in Adobe Illustrator format. I would be happy to convert specific figures into portable formats on request. Please feel free to contact me at [shirley@cs.utah.edu](mailto:shirley@cs.utah.edu).

## Changes in this Edition

There are many small changes in the material from the first edition of this book, but the two large changes are the addition of a bibliography and the addition of new chapters written by colleagues. These colleagues are people I think are clear thinkers and communicators, and I invited them each to write a chapter with arm-twisting designed to get certain key topics covered. Most of them have used the book in a class and were thus familiar with its approach. The bibliography is not meant to be extensive, but is instead a place for readers to get started. I am sure there are omissions there, and I would like to hear about any crucial references we have missed. The new chapters are:

1. **Signal Processing** by Stephen Marschner, Cornell University.
2. **Curves** by Michael Gleicher, University of Wisconsin.
3. **Using Graphics Hardware** by Peter Willemsen, University of Minnesota Duluth.
4. **Building Interactive Graphics Applications** by Kelvin Sing, University of Washington Bothell
5. **Visual Perception** by William B. Thompson, University of Utah.
6. **Tone Reproduction** by Erik Reinhard, University of Central Florida.
7. **Computer Animation** by Michael Ashikhmin, SUNY at Stony Brook.

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Brandon Mansfield was very helpful in improving the content of the discussion of hierarchical bounding volumes for ray tracing.

I am extremely thankful to J. W. Baker helping me to get the cover I envisioned. In addition to being a talented artist, he was a great pleasure to work with personally.

Many works were helpful in preparing this book, and most of them appear in the notes for the appropriate chapters. However, a few pieces that influenced the content and presentation do not, and I list them here. I thank the authors for their help. These include the two classic computer graphics texts I first learned the basics from as a student: *Computer Graphics: Principles & Practice* Foley, Van Dam, Feiner, and Hughes (1990), and *Computer Graphics* (Hearn & Baker, 1986). Other texts include all of Alan Watt's excellent books, Hill's *Computer Graphics Using OpenGL*, Angel's *3D Computer Graphics with OpenGL*, Hughes Hoppe's University of Washington dissertation, and Rogers' two classic graphics texts.

This book was written using the *Latex* document preparation software on an Apple Powerbook. The figures were made by the author using the *Adobe Illustrator* package. I would like to thank the creators of those wonderful programs.



I'd like to thank the University of Utah for allowing me to work on this book during sabbatical.

I would like to especially thank Alice and Klaus Peters for encouraging me to write this book and for their great skill in making the process of writing a book a pleasure for the author.

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