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Making Images with Mathematics

Springer

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To my wife Olga

Preface

Aim of the Book

Information visualization creates images from abstract data by interpreting them geometrically. It may require skills of making images with raw mathematics while the graphics content is now mostly created by using sophisticated licensed software. As a result, fewer and fewer developers are capable of using procedurally based visualization in which mathematical formulas are used for defining complex geometric shapes, transformations, and motions as well as for coloring the geometry.

The book explains how to see geometry and colors beyond simple mathematical formulas and teaches how to represent geometric shapes and motions from first principles by digital sampling mathematical functions.

The book may serve as a self-contained text for a one-semester computer graphics and visualization course for computer science and engineering students, as well as a reference manual for researchers and developers.

Book Organization

The book has seven chapters.

The Chap. 1 "From Ancient Greeks to Pixels" explains how we see the world and how the computer makes images. Beginning with Ancient Greek Geometry, it travels to modern geometry, introduces the subject of computer graphics and visualization, explains how the graphics pipeline works, and how a geometric point turns into a color spot on the computer screen.

The Chap. 2 "Defining Geometric Shapes" presents the mathematical foundations of shape modeling. Curves, surfaces, and solid objects are considered as a set of points which are obtained by sampling various types of mathematical functions. Using the concept of sweeping, many varieties of shapes are defined based on only a few simple foundation principles.

The Chap. 3 "Transformations" considers how the same formulas, used for making shapes, can define their transformations. The rationale for using matrix transformations is explained, and affine and projection matrix transformations are presented. Generalization of geometric sweeping implemented with matrices is further discussed.

The Chap. 4 “Motions” explains how the previously introduced mathematical formulas, defining shapes and transformation matrices, can be extended to time-dependent models of moving shapes. Motions of rigid shapes and shape morphing transformations are considered. Besides pseudo-physical motions, definitions based on Newtonian physics are also introduced.

In the Chap. 5 “Adding Visual Appearance to Geometry”, we consider how colors can be added to geometry, and how its photorealistic appearance can be achieved. The formulas, previously used for defining geometry, now will define variable colors as a new modality of immersion into the world of geometric definitions.

In the Chap. 6 “Putting Everything Together”, the ways of making interactive, real-time, and immersive visualization environments are considered including technical and physiological design and implementation issues. Still the same transformations, and actually the same basic mathematical principles, will be used in the fast visualization methods.

Finally, the Chap. 7 “Let’s Draw” introduces to the reader a few commonly used freeware software tools—OpenGL, POV-Ray, VRML, and X3D—which will let the readers apply theoretical principles into practice without requesting expensive hardware and software solutions. Also, the readers will learn how immersive visual mathematics can be implemented using the function-based extension of VRML and X3D, which allows for defining geometric shapes and their appearances with analytical functions. Finally, the Shape Explorer tool will be presented to the reader as a multi-platform companion viewer for all the examples used in the book.

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Singapore, Singapore Alexei Sourin
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