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Frank Klawonn

Introduction to Computer Graphics

Using Java 2D and 3D

Second Edition

Springer

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Preface to the Second Edition

The positive feedback to the first edition of the book and various encouraging requests to extend the list of topics contained in the book have led to this second edition. The new topics that are included in this second edition have been selected in a way to keep the character of the book as a textbook for undergraduate students explaining the basic concepts of computer graphics and enabling the students at the same time to implement and use these concepts in Java 2D and 3D without going into sophisticated details of programming.

Apart from minor changes in the text, the following new topics are included in this second edition of the book.

- Using functions of two variables for surface modelling is explained, especially for the purpose of representing hilly landscapes.
- The integration of text in 3D scenes.
- Particle systems are treated in more detail and an implementation of a simple particle system with a number of different control parameters in Java 3D is described.
- Billboard behaviours are explained for enforcing that objects are always oriented to the viewer that are of specific interest for text in 3D scenes and for particle systems.
- Dynamic surfaces are treated in more detail.
- The concept of level of detail (LOD) for rendering objects in different resolutions depending on the distance of the object to the viewer is explained.

As in the first edition, for all these new concepts, example programs in Java are provided and described.

I hope that this second edition will encourage even more readers to become interested in computer graphics, to understand the basic principles and to apply the concepts in their own programs.

Wolfenbüttel, Germany Frank Klawonn

Preface

Early computer graphics started as a research and application field that was the domain of only a few experts, for instance in the area of computer aided design (CAD). Nowadays, any person using a personal computer benefits from the developments in computer graphics. Operating systems and application programs with graphical user interfaces (GUIs) belong to the simplest applications of computer graphics. Visualisation techniques, ranging from simple histograms to dynamic 3D animations showing changes of winds or currents over time, use computer graphics in the same manner as popular computer games. Even those who do not use a personal computer might see the results of computer graphics on TV or in cinemas where parts of scenes or even a whole movie might be produced by computer graphics techniques.

Without powerful hardware in the form of fast processors, sufficiently large memory and special graphics cards, most of these applications would not have been possible. In addition to these hardware requirements efficient algorithms as well as programming tools that are easy to use and flexible at the time are required. Nowadays, a standard personal computer is sufficient to generate impressive graphics and animations using freely available programming platforms like OpenGL or Java 3D. In addition to at least an elementary understanding of programming, the use of such platforms also requires basic knowledge about the underlying background, concepts and methods of computer graphics.

Aims of the Book

The aim of this book is to explain the necessary background and principles of computer graphics combined with direct applications in concrete and simple examples. Coupling the theory with the practical examples enables the reader to apply the technical concepts directly and to visually understand what they mean.

Java 2D and Java 3D build the basis for the practical examples. Wherever possible, the introduced concepts and theory of computer graphics are immediately followed by their counterparts in Java 2D and Java 3D. However, the intention of this book is not to provide complete introductions to Java 2D or Java 3D, which would need a multivolume edition themselves without even touching the underlying theoretical concepts of computer graphics.

In order to directly apply computer graphics concepts introduced in this book, the book focusses on the parts of Java 2D and Java 3D that are absolutely relevant for these concepts. Sometimes a simple solution is preferred over the most general one so that not all possible options and additional parameters for an implementation will be discussed. The example programs are kept as simple as possible in order to concentrate on the important concepts and not to disguise them in complex, but more impressive scenes.

There are some selected additional topics—for instance the computation of shadows within computer graphics—that are introduced in the book, although Java 3D does not provide such techniques yet.

Why Java?

There are various reasons for using Java 2D and Java 3D as application platforms. The programming language Java becomes more and more popular in applications and teaching so that extensions like Java 2D/3D seem to be the most obvious choice. Many universities use Java as the introductory programming language, not only in computer science, but also in other areas so that students with a basic knowledge in Java can immediately start to work with Java 2D/3D. Specifically, for multimedia applications Java is very often the language of first choice.

Overview

The first chapters of the book focus on aspects of two-dimensional computer graphics like how to create and draw lines, curves and geometric shapes, handling of colours and techniques for animated graphics.

Chapter 5 and all following chapters cover topics of three-dimensional computer graphics. This includes modelling of 3D objects and scenes, producing images from virtual 3D scenes, animation, interaction, illumination and shading. The last chapter introduces selected special topics, for example special effects like fog, sound effects and stereoscopic viewing.

Guidelines for the Reader

In order to be able to apply the computer graphics concepts introduced in this book, the reader will need only very elementary knowledge of the programming language Java. The example programs in this book use Java 3D but also Java 2D in the first chapters, since two-dimensional representations are essential for computer graphics and the geometrical concepts are easier to understand in two dimensions than in three. The necessary background of Java 2D and Java 3D is included as application sections in this book.

Although the coupling of theory and practice was a main guideline for writing this book, the book can also be used as an introduction to the general concepts of computer graphics without focussing on specific platforms or learning how to use Java 2D or Java 3D. Skipping all sections and subsections containing the word "Java" in their headlines, the book will remain completely self-contained in the sense of a more theoretical basic introduction to computer graphics. For some of the computer graphics concepts introduced in this book it is assumed that the reader has basic knowledge about vectors, matrices and elementary calculus.

Supplemental Resources

Including the complete source code of all mentioned example programs would have led to a thicker, but less readable book. In addition, no one would like to take the burden of typing the source code again in order to run the examples. Therefore, the book itself only contains those relevant excerpts of the source code that are referred to in the text. The complete source code of all example programs and additional programs can be downloaded from the book web site at

http://public.ostfalia.de/~klawonn/computergraphics

This online service also provides additional exercises concerning the theoretical background as well programming tasks including sketches of solutions, teaching material in the form of slides and some files that are needed for the example programs. The links mentioned in the appendix and further links to some interesting web sites can also be found at the online service of this book.

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