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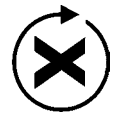

Oliver Deussen • Bernd Lintermann

Digital Design of Nature

Computer Generated Plants and Organics

With 190 Figures

Springer

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Oliver Deussen
University of Konstanz
Computer and Information Science
78457 Konstanz
Germany
e-mail: deussen@inf.uni-konstanz.de

Bernd Lintermann
ZKM Center for Art and Media
Lorenzstraße 19
76135 Karlsruhe
Germany

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Preface

What is computer graphics and what are the conceptual tasks of research in this area? To the average person the term still conveys more or less the design of logos and the manipulation of pictures with the help of image-editing programs. However, during the past four decades, computer graphics has evolved into an innovative multifaceted field of research and computing that affects many other sciences. In many areas and for many problems we can best convey an understanding through images that trigger our sense with the highest capability: our eye. And, what is more, aside from algorithms, formulas, and tables, the computer graphics scientist often is able to create beauty. Though it is a beauty of its own, it often fascinates the viewer, especially when complex aesthetic images emerge from simple mathematical concepts.

Also, there are only a few other areas that advance as dynamically as informatics and especially computer graphics. While CPU capacity still increases and is almost doubled every 18 months, the rendering speed and efficiency of graphics boards has increased even more during recent years. Today, images can be rendered in real time that some years ago still required several hours of computing. Parallel to the rapid improvement of computer hardware, many new algorithms were developed that today form the basis for some fundamental changes and achievements in graphics.

Along with its technical tasks and conceptual formulation, computer graphics at the same time challenges fundamental questions. With the rendering of images, for example, the functioning of human perception and the information processing in the brain have to be analyzed and understood in order to communicate the image content as closely as possible to what is perceived as reality by the human eye. Especially the ability to create synthetic nonphotorealistic images, meaning those that are intended to not look like photographs, stimulates researchers from cognitive psychology and physiology.

Within computer graphics, the area of modeling and rendering synthetic plants and landscapes that is covered in this book is a rather interdisciplinary field. Here a knowledge of botany and ecology is necessary, and aside from the mathematical and physical laws, artistic aspects are of utmost importance. It is this combination of knowledge, skills, and creativity that makes the work in computer graphics especially challenging and diversified.

This book at is the result of research that was started in 1995. Actually the goal was to create a system for the rendering of organic architectural designs and forms. However, we quickly realized that the methods we had developed also served as excellent tools for the synthetic rendering of plants. The system

expanded and was refined during the following years, so that we were able to set up a small company that specializes in generating plant models and in the development of efficient tools for rendering.

The main part of our work still remains investigating the underlying processes of the different methods and approaches. Meanwhile, single plants developed into entire landscapes, and a variety of different images were created. However, regardless of the valuable insights won in these processes, the end is still not in sight. In computer graphics, from time to time we still expect a sort of gold-mining euphoria when newly found insights result in a huge set of new possibilities. Who really is that privileged?

Fortunately, we enjoyed support and assistance during the writing of this book, and we would like to thank all those who helped to improve its quality. Intense discussions with renowned scientists and colleagues pointed us in the right direction. Thomas Strothotte from the University of Magdeburg was the one to make us realize the value and infinite possibilities of nonphotorealistic computer graphics. This exciting discipline holds a great fascination and thus has found its expression at the end of this book.

The ZKM Center for Media Arts and Technology in Karlsruhe (Germany) supported us faithfully many years and gave us the opportunity to develop our small company. Bernd received there innovative support for the artworks he created during the past few years. Aside from techniques for advanced rendering and modeling of plants he now focuses on related algorithms in multimedia artworks.

Under the guidance of Almut Gerhardt-Dircksen, we were able to expand our humble knowledge in botany. Her advice was invaluable during the writing of the respective chapter on plants, and we certainly hope that the botany community will now read this book without raising eyebrows. Mark Stamminger edited the chapter on rendering and confirmed our theory that the vast area of realistic image generation can be sketched in a few pages without oversimplification of essential information. Heino Hellwig viewed the chapter about the mathematical descriptions of plants. Our special thanks goes to Klaus Hoedt, Ursula Zimpfer, and Ronan Nugent who patiently proofread the German and English manuscript. We also would like to thank Hermann Engesser for his competent and supportive consultation on behalf of Springer-Verlag.

Of course, a book that discusses computer graphics and its beauty should also please in its appearance. Thanks to the LaTeX layout style of Ottfried Cheong Schwarzkopf we were spared many hours of laborious work.

Oliver Deussen and Bernd Lintermann

Karlsruhe and Konstanz, October 2004

Foreword

It has been over 40 years since Stanislaw Ulam published his pioneering work on computer models of branching structures. In the period that followed, plant modeling has become an area of active interdisciplinary research. On one hand, biologists are interested in plant models as a means for better understanding the fundamental mechanisms that govern plant development and structure. Plant scientists are also investigating the use of models for computer-assisted decision-making in horticulture, agriculture, and forestry. On the other hand, the computer graphics community is interested in plants as elements of scenery for computer animations and games. State-of-the-art plant models, combined with advanced rendering methods, are now producing astounding results. Synthetic images of individual plants and landscapes are increasingly difficult to distinguish from photographs, and art-inspired non-photorealistic techniques successfully mimic drawings and paintings of plants. Complicated scenes with plants for computer games are generated in a fraction of a second.

Many of the underlying methods have been obtained by the authors of this book, Oliver Deussen and Bernd Lintermann. Their popular plant-modeling system xfrog introduced an innovative graphical user interface that empowered computer scientists and artists alike to create tree models with unprecedented realism. These models have been incorporated in some of the most captivating scenes with plants, created to date. Xfrog, however, is but a stepping stone to the broad discussion of plant-modeling issues presented in this book. Other topics include the synthesis of large scenes with plants, generation of plants at interactive rates as needed for computer games, non-photorealistic rendering of plants, and the use of plant-inspired techniques in art installations. The broad coverage of plant modeling in computer graphics, and the inclusion of many original results, so far available only in specialist papers, make this book a valuable contribution to the practice of visual plant modeling.

Przemyslaw Prusinkiewicz

Calgary, Canada, November 2004

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