

Miguel A. Otaduy · Ming C. Lin

High Fidelity Haptic Rendering

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Daniela Niemeyer



High Fidelity Haptic Rendering Ming C Lin:

High Fidelity Haptic Rendering Miguel A. Otaduy, Ming C. Lin, 2022-05-31 The human haptic system among all senses provides unique and bidirectional communication between humans and their physical environment Yet to date most human computer interactive systems have focused primarily on the graphical rendering of visual information and to a lesser extent on the display of auditory information Extending the frontier of visual computing haptic interfaces or force feedback devices have the potential to increase the quality of human computer interaction by accommodating the sense of touch They provide an attractive augmentation to visual display and enhance the level of understanding of complex data sets They have been effectively used for a number of applications including molecular docking manipulation of nano materials surgical training virtual prototyping and digital sculpting Compared with visual and auditory display haptic rendering has extremely demanding computational requirements In order to maintain a stable system while displaying smooth and realistic forces and torques high haptic update rates in the range of 500 1000 Hz or more are typically used Haptics present many new challenges to researchers and developers in computer graphics and interactive techniques Some of the critical issues include the development of novel data structures to encode shape and material properties as well as new techniques for geometry processing data analysis physical modeling and haptic visualization This synthesis examines some of the latest developments on haptic rendering while looking forward to exciting future research in this area It presents novel haptic rendering algorithms that take advantage of the human haptic sensory modality Specifically it discusses different rendering techniques for various geometric representations e g point based polygonal multiresolution distance fields etc as well as textured surfaces It also shows how psychophysics of touch can provide the foundational design guidelines for developing perceptually driven force models and concludes with possible applications and issues to consider in future algorithmic design validating rendering techniques and evaluating haptic interfaces

Haptic Rendering Ming C. Lin, Miguel Otaduy, 2008-07-25 For a long time human beings have dreamed of a virtual world where it is possible to interact with synthetic entities as if they were real It has been shown that the ability to touch virtual objects increases the sense of presence in virtual environments This book provides an authoritative overview of state of the art haptic rendering algorithms

Real-Time Massive Model Rendering Sung-eui Yoon, Enrico Gobbetti, David Kasik, Dinesh Manocha, 2022-06-01 Interactive display and visualization of large geometric and textured models is becoming a fundamental capability There are numerous application areas including games movies CAD virtual prototyping and scientific visualization One of observations about geometric models used in interactive applications is that their model complexity continues to increase because of fundamental advances in 3D modeling simulation and data capture technologies As computing power increases users take advantage of the algorithmic advances and generate even more complex models and data sets Therefore there are many cases where we are required to visualize massive models that consist of hundreds of millions of triangles and even billions of triangles However interactive

visualization and handling of such massive models still remains a challenge in computer graphics and visualization In this monograph we discuss various techniques that enable interactive visualization of massive models These techniques include visibility computation simplification levels of detail and cache coherent data management We believe that the combinations of these techniques can make it possible to interactively visualize massive models in commodity hardware Table of Contents Introduction Visibility Simplification and Levels of Detail Alternative Representations Cache Coherent Data Management Conclusions Bibliography

Sound Synthesis, Propagation, and Rendering Shiguang Liu,Dinesh Manocha,2022-03-24 This book gives a broad overview of research on sound simulation driven by a variety of applications Vibrating objects produce sound which then propagates through a medium such as air or water before finally being heard by a listener As a crucial sensory channel sound plays a vital role in many applications There is a well established research community in acoustics that has studied the problems related to sound simulation for six decades Some of the earliest work was motivated by the design of concert halls theaters or lecture rooms with good acoustic characteristics These problems also have been investigated in other applications including noise control and sound design for urban planning building construction and automotive applications Moreover plausible or realistic sound effects can improve the sense of presence in a virtual environment or a game In these applications sound can provide important clues such as source directionality and spatial size The book first surveys various sound synthesis methods including harmonic synthesis texture synthesis spectral analysis and physics based synthesis Next it provides an overview of sound propagation techniques including wave based methods geometric based methods and hybrid methods The book also summarizes various techniques for sound rendering Finally it surveys some recent trends including the use of machine learning methods to accelerate sound simulation and the use of sound simulation techniques for other applications such as speech recognition source localization and computer aided design

High Dynamic Range Video Karol Myszkowski,Rafal Mantiuk,Grzegorz Krawczyk,2022-05-31 As new displays and cameras offer enhanced color capabilities there is a need to extend the precision of digital content High Dynamic Range HDR imaging encodes images and video with higher than normal 8 bit per color channel precision enabling representation of the complete color gamut and the full visible range of luminance However to realize transition from the traditional toHDRimaging it is necessary to develop imaging algorithms that work with the high precision data Tomake such algorithms effective and feasible in practice it is necessary to take advantage of the limitations of the human visual system by aligning the data shortcomings to those of the human eye thus limiting storage and processing precision Therefore human visual perception is the key component of the solutions we discuss in this book This book presents a complete pipeline forHDR image and video processing fromacquisition through compression and quality evaluation to display At the HDR image and video acquisition stage specialized HDR sensors or multi exposure techniques suitable for traditional cameras are discussed Then we present a practical solution for pixel values calibration in terms of photometric or radiometric quantities which are

required in some technically oriented applications Also we cover the problem of efficient image and video compression and encoding either for storage or transmission purposes including the aspect of backward compatibility with existing formats Finally we review existing HDR display technologies and the associated problems of image contrast and brightness adjustment For this purpose tone mapping is employed to accommodate HDR content to LDR devices Conversely the so called inverse tone mapping is required to upgrade LDR content for displaying on HDR devices We overview HDR enabled image and video quality metrics which are needed to verify algorithms at all stages of the pipeline Additionally we cover successful examples of the HDR technology applications in particular in computer graphics and computer vision The goal of this book is to present all discussed components of the HDR pipeline with the main focus on video For some pipeline stages HDR video solutions are either not well established or do not exist at all in which case we describe techniques for single HDR images In such cases we attempt to select the techniques which can be extended into temporal domain Whenever needed relevant background information on human perception is given which enables better understanding of the design choices behind the discussed algorithms and HDR equipment

Table of Contents Introduction Representation of an HDR Image HDR Image and Video Acquisition HDR Image Quality HDR Image Video and Texture Compression Tone Reproduction HDR Display Devices LDR2HDR Recovering Dynamic Range in Legacy Content HDRI in Computer Graphics Software

High Dynamic Range Image Reconstruction Asla M. Sa, Paulo Cezar Carvalho, Luiz Velho, 2022-05-31 High dynamic range imaging HDRI is an emerging field that has the potential to cause a great scientific and technological impact in the near future Although new this field is large and complex with non trivial relations to many different areas such as image synthesis computer vision video and image processing digital photography special effects among others For the above reasons HDRI has been extensively researched over the past years and consequently the related scientific literature is vast As an indication that the field is reaching maturity tutorials and books on HDRI appeared Moreover this new resource has already reached interested practitioners in various application areas In this book we do not aim at covering the whole field of high dynamic range imaging and its applications since it is a broad subject that is still evolving Instead our intent is to cover the basic principles behind HDRI and focus on one of the currently most important problems both theoretically and practically That is the reconstruction of high dynamic range images from regular low dynamic range pictures

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Heterogeneous Spatial Data Giuseppe Patanè, Michela Spagnuolo, 2022-05-31 New data acquisition techniques are emerging and are providing fast and efficient means for multidimensional spatial data collection Airborne LIDAR surveys SAR satellites stereo photogrammetry and mobile mapping systems are increasingly used for the digital reconstruction of the environment All these systems provide extremely high volumes of raw data often enriched with other sensor data e g beam intensity Improving methods to process and visually analyze this massive amount of geospatial and user

generated data is crucial to increase the efficiency of organizations and to better manage societal challenges Within this context this book proposes an up to date view of computational methods and tools for spatio temporal data fusion multivariate surface generation and feature extraction along with their main applications for surface approximation and rainfall analysis The book is intended to attract interest from different fields such as computer vision computer graphics geomatics and remote sensing working on the common goal of processing 3D data To this end it presents and compares methods that process and analyze the massive amount of geospatial data in order to support better management of societal challenges through more timely and better decision making independent of a specific data modeling paradigm e g 2D vector data regular grids or 3D point clouds We also show how current research is developing from the traditional layered approach adopted by most GIS softwares to intelligent methods for integrating existing data sets that might contain important information on a geographical area and environmental phenomenon These services combine traditional map oriented visualization with fully 3D visual decision support methods and exploit semantics oriented information e g a priori knowledge annotations segmentations when processing merging and integrating big pre existing data sets

Mathematical Basics of Motion and Deformation in Computer Graphics, Second Edition Ken Anjyo, Hiroyuki Ochiai, 2022-06-01 This synthesis lecture presents an intuitive introduction to the mathematics of motion and deformation in computer graphics Starting with familiar concepts in graphics such as Euler angles quaternions and affine transformations we illustrate that a mathematical theory behind these concepts enables us to develop the techniques for efficient effective creation of computer animation This book therefore serves as a good guidepost to mathematics differential geometry and Lie theory for students of geometric modeling and animation in computer graphics Experienced developers and researchers will also benefit from this book since it gives a comprehensive overview of mathematical approaches that are particularly useful in character modeling deformation and animation

Rethinking Quaternions Ron Goldman, 2022-05-31 Quaternion multiplication can be used to rotate vectors in three dimensions Therefore in computer graphics quaternions have three principal applications to increase speed and reduce storage for calculations involving rotations to avoid distortions arising from numerical inaccuracies caused by floating point computations with rotations and to interpolate between two rotations for key frame animation Yet while the formal algebra of quaternions is well known in the graphics community the derivations of the formulas for this algebra and the geometric principles underlying this algebra are not well understood The goals of this monograph are to provide a fresh geometric interpretation for quaternions appropriate for contemporary computer graphics based on mass points to present better ways to visualize quaternions and the effect of quaternion multiplication on points and vectors in three dimensions using insights from the algebra and geometry of multiplication in the complex plane to derive the formula for quaternion multiplication from first principles to develop simple intuitive proofs of the sandwiching formulas for rotation and reflection to show how to apply sandwiching to compute perspective projections In addition to these theoretical issues we also address some

computational questions We develop straightforward formulas for converting back and forth between quaternion and matrix representations for rotations reflections and perspective projections and we discuss the relative advantages and disadvantages of the quaternion and matrix representations for these transformations Moreover we show how to avoid distortions due to floating point computations with rotations by using unit quaternions to represent rotations We also derive the formula for spherical linear interpolation and we explain how to apply this formula to interpolate between two rotations for key frame animation Finally we explain the role of quaternions in low dimensional Clifford algebras and we show how to apply the Clifford algebra for R^3 to model rotations reflections and perspective projections To help the reader understand the concepts and formulas presented here we have incorporated many exercises in order to clarify and elaborate some of the key points in the text Table of Contents Preface Theory Computation Rethinking Quaternions and Clifford Algebras References Further Reading Author Biography

[An Introduction to Laplacian Spectral Distances and Kernels](#) Giuseppe Patanè, 2022-05-31 In geometry processing and shape analysis several applications have been addressed through the properties of the Laplacian spectral kernels and distances such as commute time biharmonic diffusion and wave distances Within this context this book is intended to provide a common background on the definition and computation of the Laplacian spectral kernels and distances for geometry processing and shape analysis To this end we define a unified representation of the isotropic and anisotropic discrete Laplacian operator on surfaces and volumes then we introduce the associated differential equations i.e. the harmonic equation the Laplacian eigenproblem and the heat equation Filtering the Laplacian spectrum we introduce the Laplacian spectral distances which generalize the commute time biharmonic diffusion and wave distances and their discretization in terms of the Laplacian spectrum As main applications we discuss the design of smooth functions and the Laplacian smoothing of noisy scalar functions All the reviewed numerical schemes are discussed and compared in terms of robustness approximation accuracy and computational cost thus supporting the reader in the selection of the most appropriate with respect to shape representation computational resources and target application

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