Hierarchical B-Spline Refinement

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ABSTRACT

Refinement is usually advocated as a means of gaining finer control over a spline curve or surface during editing. For curves, refinement is a local process. It permits the change of control vertices and subsequent editing of fine detail in one region of the curve while leaving control vertices in other regions unaffected. For tensor-product surfaces, however, refinement is not local in the sense that it causes control vertices far from a region of interest to change as well as changing the control vertices that influence the region. However, with some care and understanding it is possible to restrict the influence of refinement to the locality at which an editing effect is desired. We present a method of localizing the effect of refinement through the use of *overlays*, which are hierarchically controlled subdivisions. We also introduce two editing techniques that are effective when using overlays: one is direct surface manipulation through the use of *edit points* and the other is *offset referencing* of control vertices.

CR Categories and Subject Descriptors: I.3.5 [Computer Graphics]: Computational Geometry and Object Modeling — Curve, surface, solid, and object representations; Geometric algorithms, languages, and systems; Hierarchy and geometric transformations; Modeling packages.

Key Words and Phrases: Splines, free-form surface editing, refinement, subdivision.

1. Introduction

The material in this paper derives from experience gained during the design of a prototype B-spline surface editor intended for the construction of jointed bodies to be used in a realistic animation system [7] with which one of the authors has become involved. The two issues that influenced the design of the editor in this context were: the need to mix broad-scale surface manipulations with manipulations of a finer nature and the need to superimpose fine-scale details upon broad-scale surface movements and distortions. This has led to a hierarchy of surface refinements, which we refer to as *overlays*, to a representation of control vertices in terms of *offsets* relative to a hierarchy of local reference frames, and to the investigation of mechanisms for the *direct manipulation* of points on surfaces

rather than manipulation indirectly through the movement of control vertices.

The techniques we employ are suitable for any tensor-product, parametric surface, defined in terms of control vertices and basis functions, provided that the surface supports a refinement algorithm; i.e. a re-representation process that replaces each basis function by an equivalent linear combination of one or more new basis functions. This includes, but is not restricted to, surfaces constructed from B-splines, Beta-splines, Bezier patches, and NURBS. This paper will develop the underlying ideas in the notation of B-splines, and assume that refinement is provided by the Oslo Algorithm [4].

Occasional discussions will be specific to the uniform, bicubic B-spline case, to streamline the presentation. The ideas have been implemented and tested using uniform cubic B-splines on a Silicon Graphics 4-D workstation. This simplification was made for reasons of the ease and speed with which such surfaces are supported on the hardware and in the graphics library of this workstation, not out of a limitation of the approach.

In Section 2 we will give a brief background for spline refinement. Section 3 follows with a description of overlays and their construction through the use of refinement. The representation of an overlay through the use of a local reference frame and offsets is covered in Section 4. Mechanisms for achieving direct manipulation of surface features are mentioned in Section 5. In Section 6 we touch upon some obvious ways to join our proposals with techniques introduced by Barr, Cobb, and Sederberg and Parry. Section 7 closes with some examples taken from our prototype editor.

2. Terminology and Notation

The material that we will be presenting, in its broadest formulation, relates to surfaces $S(u,v)$ which are defined by control vertices $V_{i,j}$ and basis functions $B_{i,k}(u)$, $B_{j,\ell}(v)$ of some polynomial order k and ℓ, respectively.

$$S(u,v) = \sum_i \sum_j V_{i,j} B_{i,k}(u) B_{j,\ell}(v) \ .$$

The basis functions, furthermore, should be *refinably* in the sense that each one can be re-expressed as a linear combination of one or more "smaller" basis functions

$$B_{i,k}(u) = \sum_r \alpha_{i,k}(r) N_{r,k}(u)$$

$$B_{j,\ell}(v) = \sum_s \alpha_{j,\ell}(s) N_{s,\ell}(v) \ .$$

Reflected in this property is a corresponding re-representation of the surface in terms of the smaller basis functions and a larger number of control vertices

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Photorealism in Computer Graphics Kadi Bouatouch,Christian Bouville,2013-03-09 The goal of this book is to present the most advanced research works in realistic computer generated images It is made up of the papers presented during a Eurographics workshop that has been held in Rennes France on June 1990 Although realism in computer graphics has existed for many years we have considered that two research directions can now clearly be identified One makes use of empirical methods to efficiently create images that look real As opposed to this approach the other orientation makes use of physics to produce images that are exact representations of the real world at the expense of additional processing time hence the term photosimulation which indeed was the subject of this book The objectives of this workshop were to assemble experts from physics and computer graphics in order to contribute to the introduction of physics based approaches in the field of computer generated images The fact that this workshop was the first entirely devoted to this topic was a bet and fortunately it turned out that it was a success The contents of this book is organized in five chapters Efficient Ray Tracing Meth ods Theory of Global Illumination Models Photometric Algorithms Form Factor Cal culations and Physics Based Methods

Computergenerierte Pflanzen Oliver Deussen,2013-07-01 Die Sch nheit der Natur mit dem Rechner nachzubilden fasziniert die Computergraphik seit jeher Im vorliegenden Buch werden Verfahren zur Erzeugung k nstlicher Pflanzenmodelle beschrieben und deren Anwendung in Bereichen wie Simulation Virtual Reality Botanik Landschaftsplanung und Architektur Die Modelle werden zu G rten Parks und ganzen Landschaften kombiniert Die Palette der Darstellungsformen reicht von t uschend echt wirkenden Bildern bis zu abstrakten Repr sentationen Mit hnlichen Algorithmen k nnen organische K rper hergestellt ver ndert und animiert werden Die beigef gten Programme Windows erlauben dies auch dem Leser   *Rendering Techniques '99* Dani Lischinski,Greg W. Larson,2012-12-06 This book contains the proceedings of the 10th Eurographics Workshop on Rendering which took place from the 21st to the 23rd of June 1999 in Granada Spain Origi nally an outgrowth of the annual Eurographics meeting the workshop was organized by a dedicated group of researchers who felt there was insufficient opportunity at Eu rographics and Siggraph to exchange ideas specifically on rendering Over the past 9 years the workshop has become renown as an international watershed for top quality work in this field attracting between 50 and 100 attendees each year to share their latest research This year we received a total of 63 submissions Each paper was carefully reviewed by two of the 25 international programme committee members as well as two

external reviewers selected by the co chairs from a pool of 71 individuals The programme committee and external reviewers are listed following the contents pages In this new review process all submissions and reviews were handledelectronically with the ex ception of videos submitted with a few of the papers This streamlined the review process considerably while reducing the costs and confusion associated with courier delivery of hundreds of papers **Creating and Animating the Virtual World** Nadia Magnenat Thalmann,Daniel Thalmann,2012-12-06 This book contains invited papers and a selection of research papers submitted to Computer Animation 92 the fourth international workshop on computer animation held in Genova on May 20 22 1992 This workshop now an annual event is organized by the Computer Graphics Society the University of Genova and the Swiss Federal Institute of Technology in Lausanne Original research results and applications experience to the various areas of computer animation are represented in the book This year most contributions are related to physics based animation human animation and geometric modelling for animation Rendering Techniques 2001 S.J. Gortler,K. Myzskowski,2001-07-31 This book contains the proceedings of the lih Eurographics Workshop on Rendering th which took place from the 25 to the 27th of June 2001 in London United Kingdom Over the past 11 years the workshop has become the premier forum dedicated to research in rendering Much of the work in rendering now appearing in other conferences and journals builds on ideas originally presented at the workshop This year we received a total of 74 submissions Each paper was carefully reviewed by two of the 28 international programme committee members as well as external reviewers selected by the co chairs from a pool of 125 individuals In this review process all submissions and reviews were handled electronically with the exception of videos submitted with a few of the papers The overall quality of the submissions was exceptionally high Space and time constraints forced the committee to make some difficult decisions In the end 29 by papers were accepted and they appear here Almost all papers are accompanied color images which appear at the end of the book The papers treat the following varied topics methods for local and global illumination techniques for acquisition and modeling from images image based rendering new image representations hardware assisted methods shadow algorithms visibility perception texturing and filtering Each year in addition to the reviewed contributions the workshop includes invited presentations from internationally recognized experts Computer Animation Rick Parent,2012-08-29 Updated to include the most current techniques of computer animation along with the theory and high level computation that makes this book the best technically oriented animation resource **UIST** ,1993 **Proceedings** ,2001 *I3D ... ACM SIGGRAPH Symposium on Interactive 3D Graphics and Games* ,2001 SIGGRAPH '88 conference proceedings ,1988 *Comptes Rendus - Interface Graphique* ,2005 **Proceedings of the ACM Symposium on User Interface Software and Technology** ,1992 **Proceedings of the ... Annual ACM-SIAM Symposium on Discrete Algorithms** ,1999 *Proceedings of the ... Annual Conference and Exposition of the National Computer Graphics Association, Inc* National Computer Graphics Association (U.S.). Conference and Exposition,1989 SIGGRAPH '88 Conference Proceedings ,1988

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