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COURSE NOTES

C25

TOPICS IN THE CONSTRUCTION, MANIPULATION, AND ASSESSMENT OF SPLINE SURFACES

Chair
Richard Bartels
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Lecturers
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Topics in the Construction, Manipulation, and Assessment of Spline Surfaces

Course Abstract

The course will review basics for geometry, splines, and linear algebra. Rational and nonrational splines will be compared Main surfaces categories – patches, tensor products, and hierarchies – will be introduced. Generation by sweeping, extrusion, rotation, curve-net filling, and data fitting will be reviewed. Surface manipulation will focus on direct control of features Hierarchical surfaces will be described with their manipulation for design and animation The construction of patches of special form and their smooth joining to surfaces will be detailed The course will conclude with surface quality – continuity and curvature distribution – and its assessment and visualization.

Speaker Biographies

Richard Bartels is a Professor in the Department of Computer Science at the University of Waterloo and a member of Waterloo's Computer Graphics Laboratory He received his Ph D from Stanford in 1968 and has been on the faculty of the University of Texas at Austin and The Johns Hopkins University before coming to Waterloo His research interests are in the Computer Aided Geometric Design of surfaces He is co-author, with John Beatty and Brian Barsky, of the book *An Introduction to Splines for Use in Computer Graphics and Geometric Modeling*

Tony D. DeRose is currently an associate professor of computer science at the University of Washington He received his B S in physics from the University of California, Davis in 1981 and his Ph D in computer science from the University of California, Berkeley in 1985 He received a Presidential Young Investigator award from the National Science Foundation in 1989 His research interests include the mathematical aspects of computer graphics and geometric modeling, and high level methods of shape representation DeRose is an associate editor for ACM Transactions on Graphics, and is a member of SIGGRAPH, SIAM, and the IEEE Computer Society

David Forsey is an Assistant Professor in the Department of Computer Science at the University of British Columbia and a director of Imager, UBC's Computer Graphics Laboratory He received his Ph D from Waterloo in 1990 and has a BSc in Zoology from the University of Guelph His research interests are in free-form surface design, user interfaces, and animation

David Warn is a Senior Staff Research Scientist in the Computer Science Department at the General Motors Research Laboratories He holds a B S in Mathematics from Carnegie-Mellon University and joined GM in 1968 after receiving a M S in Computer Science from Purdue University His current research interests are in interactive surface design and evaluation, computer graphics, interactive techniques, and databases for computer aided design

Schedule

3/4 hour, Tony DeRose (Pages 1-0 to 1-60 and following Appendix)

The course will begin with a review of the elementary concepts of geometry, specifically affine geometry and geometric frames of reference

1/2 hour, Richard Bartels (Pages 2-0 to 2-24)

The basics of splines will be reviewed using the multiaffine polar form (blossom) The elements of rational splines will be introduced along with their connection to conic sections

1/2 hour, Richard Bartels (Pages 3-0 to 3-12)

Basic computational linear algebra will be covered linear equations, least squares, constrained least squares, and appropriate matrix transformations

1/2 hour Richard Bartels (Pages 4-0 to 4-16)

The direct manipulation of position, tangent, and curvature will be introduced as an example of applying the above material

1 hour, David Forsey (Pages 5-0 to 5-56)

Editing is aided by the ability to add features at any level of detail in any order Small features should respond reasonably to modification of large, surrounding features The hierarchical spline surface will be introduced and described, detailing the definition and use of overlays, offsets, and offset mapping functions Examples of non-rational and rational hierarchical B-splines will be shown using examples in applications from animation and human figure modeling

1 hour, Richard Bartels (Pages 6-0 to 6-34 and Pages 7-0 to 7-14)

It is convenient to generate basic surface templates by intuitive operations There is frequently a need to model existing surfaces Standard generation techniques will be covered sweeping, revolution, and extrusion The fitting of curve nets to data and the filling nets with patches will follow This section will end with the fitting of gridded data by tensor-product surfaces and the adaptive refinement of this fitting process to produce a hierarchical surface

3/4 hour, Tony DeRose (Pages 8-0 to 8-9 and following Appendix)

For complicated geometry, four-sided patches are not enough This section will cover generalized B-splines and multi-sided patches Surface construction methods that generalize bi-quadratic and bi-cubic tensor product B-splines will be introduced As these methods are based on a class of multi-sided patches known as S-patches, the section will begin with a survey of basic S-patch theory Algorithms for smoothly filling curve networks using S-patches will be emphasized

1 hour, David Warn (Pages 9-0 to 9-14 and Pages 10-0 to 10-9)

In an industrial design setting, there is a practical need for surface quality This section will present indicators of surface quality and methods for their visualization The section will include various surface evaluation techniques including shaded images, color coded surface curvature displays, line curvature plots, surface normals, and section cuts The discussion will focus on identifying problem areas and verification of quality in mathematical surfaces with some practical suggestions for methods of correction

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