Hugues Hoppe

Geometry Images: Sampling Surfaces on Regular Grids

Surfaces in graphics are commonly represented using irregular meshes, since these approximate many shapes using fewer vertices. However, their flexible connectivity comes at a price, since most mesh operations require random memory accesses and filter kernels must handle arbitrary neighborhoods. In contrast, media like audio and images are represented using regular samplings - 1D and 2D grids. Such grids allow efficient traversal, random access, convolution, composition, downsampling, compression, and synthesis. Many surface signals have now migrated into texture images. As the cost of 3D transformations becomes negligible, one should re-evaluate whether geometry itself could not also be represented using ordinary grids.

This talk will present several recent projects involving geometry images. These are constructed by parametrizing the surface over a planar domain, and resampling the surface geometry on a regular domain grid. One exciting possibility is to then exploit the highly parallel GPU rasterizer to directly process geometry.

Hugues Hoppe is a senior researcher in the Computer Graphics Group at Microsoft Research. His primary interests lie in the acquisition, representation, and rendering of geometric models. For his PhD work on surface reconstruction from 3D scans, he was selected as a finalist in the 1995 Discover Awards for Technological Innovation. He subsequently developed multiresolution representations for geometry, including wavelet-based multiresolution analysis [Eck et al 1995] for semi-regular meshing, progressive meshes [Hoppe 1996] for irregular meshing, and geometry images [Gu et al 2002] for completely regular meshing. Recent efforts have focused on surface parametrization to exploit the highly parallel GPU rasterizer. Contributions include lapped textures, normal-shooting parametrization, geometric-stretch metrics, hierarchical solvers, and signal-specialized parametrization. His most recent passion is the regular sampling of surfaces using geometry images, to exploit the forthcoming unification of vertex and image buffers. His publications include 17 papers at ACM SIGGRAPH, and he is associate editor for ACM Transactions on Graphics. He received a BS summa cum laude in electrical engineering in 1989 and a PhD in computer science in 1994 from the University of Washington.

Joe Warren

Applications of Commutative Relations for Subdivision Surfaces

While spectral methods for determining the smoothness of subdivision surfaces at extraordinary vertices are relatively well-known, a pervasive view in the geometric modeling community is that operations with subdivision surfaces are much more complex than similar operations for polynomial surfaces. A powerful, but little-known tool for manipulating subdivision schemes based on applying linear algebra to associated subdivision matrices makes it possible to perform a variety of operations involving complex subdivison schemes in an efficient way. Given a subdivision matrix S, the crux of this technique is to form a commutative relation of the form D S = T D where the matrix D annihilates some subset of the eigenvectors of S. This talk will consider three applications of commutative relations of this type to:

- analyze the smoothness of mixed element meshes such as triangle-quad meshes,
- compute exact inner products such as enclosed volume over subdivision surfaces,
- build smooth subdivision surfaces that loft (interpolate) curve networks.

Joe Warren, a Professor of Computer Science at Rice University, is one of the world's leading experts on subdivision. He has published a book "Subdivision Methods for Geometric Design" and numerous papers of this topic and its applications to computer graphics. These publications have appeared in such forums as SIGGRAPH, Transactions on Graphics, Computer-Aided Geometric Design and The Visual Computer. He has also organized and participated in a number of international workshops, short courses and minisymposia on the theory and practice of subdivision. Professor Warren's related areas of expertise include computer graphics, geometric modeling and visualization.

Alexander Bobenko

Surfaces made from Circles

Many important notions of surface theory such as curvature lines, conformal parametrization, and Willmore energy (the integral of the squared mean curvature) are invariant with respect to conformal transformations of space. This suggests to use conformally invariant building blocks such as circles for the corresponding discretizations. We will report on several recent projects dealing with the description of discrete surfaces in terms of circles:

- discrete Willmore energy and its applications for fairing and restoration of surfaces and optimization of triangulations,
- discrete conformal surfaces (as well as their special classes) in relation to the theory of circle patterns.

Alexander Bobenko is a professor of mathematics at the Technical University Berlin. His interests lie in differential geometry, dynamical systems and mathematical visualization. His publications include books and numerous papers in geometry and mathematical physics. During the last years his main interest has moved to discrete differential geometry, a mathematical area which aims to develop and apply discrete analogs of the notions and methods of differential geometry. He has organized and participated in a number of conferences in geometry, mathematical physics and visualization. He received his PhD in mathematical physics in 1985 from the Steklov Mathematical Institut, St. Petersburg.