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Editorial

Multi-Resolution Modeling and 3D Geometry Compression

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This special issue addresses some of the problems involved in manipulating multi-resolution three-dimensional polygonal models and sharing and delivering polygonal models across networked environments.

Techniques for compressing meshes of arbitrary connectivity and topology and for developing multi-resolution representations have matured considerably in recent years, justifying their inclusion in international standards such as MPEG-4, as well as in commercial software and hardware. The papers presented here illustrate some of the most recent approaches and results, and show how multi-resolution modeling and compression are intimately related.

Three-dimensional (3D) computer graphics exert a powerful attraction, that has revolutionized the computer gaming industry. Until recently, 3D graphics have met limited success on the Internet, partly because bandwith limitations have impeded the transmission of three-dimensional models. Exploiting the results presented here, or equivalent 3D compression and progressive transmission technologies, 3D graphics may play a more important role in the future of the Internet.

1. Contents of the issue

The first four papers center on methods for generating and editing multi-resolution mesh representations, while the last four papers focus on mesh compression issues.

Kobbelt et al. develop a framework for multi-resolution modeling exploiting general edge collapse operations, generalizing previous work using subdivision-surface hierarchies.

Gioia extends methods for applying wavelet techniques to arbitrary surfaces by introducing a new mesh partitioning technique that allows to define a higher quality base mesh.

Mesh simplification techniques have been used to generate multi-resolution models. Heckbert and Garland study the theoretical behavior of their mesh simplification method and provide results on triangle aspect ratios.

Gopi and Manocha address the issue of simplifying curved surface meshes consisting of triangular Bezier patches. Their approach may also be used for representing polygonal models using triangular Bezier patches.

King and Rossignac's paper studies the appropriate combination between mesh simplification and vertex quantization level when encoding a shape. It is thus an appropriate transition paper between

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decimation and encoding papers, and illustrates the intricate relationship between multi-resolution and compression.

Rossignac and Szymczak's paper describes a linear-time decompression scheme for Rossignac's EdgeBreaker algorithm, and illustrates the linear-storage-space behavior of EdgeBreaker.

The last two papers broaden the domain of representations for which efficient encoding algorithms are developed.

A method for compressing meshes containing degeneracies (non-manifold meshes) without perturbing the connectivity is presented by Guéziec et al. [1] This paper shows how non-manifold connections can be encoded as an additional layer to manifold-mesh compression methods. The paper provides some details on the MPEG-4 bit-stream standard and implementation.

Bajaj et al. present another general method for compressing meshes with manifold or non-manifold connectivity, using the "DAG of rings" approach for the connectivity, and vector quantization for the geometry and properties.

2. Background information

The call for papers for this issue was published on 15 November 1998, with a submission deadline of 15 January 1999. This issue would not have been produced without the help of excellent and dedicated peer reviewers, who accepted to work with our aggressive publication schedule and helped evaluate and improve the original submissions.

Several of the papers presented here were first given or previewed during the Workshop on Multi-Resolution Representation of 3D Geometry for Progressive Transmission that was held on 17 October 1998 together with the IEEE Visualization'98 conference in Research Triangle Park, NC. Our special issue was instigated by this workshop. Further information on the workshop, including some of the talks and a summary of the workshop debate are currently available online at the address http://www.research.ibm.com/people/g/gueziec.

André Guéziec is a Senior Software Architect at Multigen-Paradigm, Inc. He holds a PhD in Computer Science from University Paris 11 Orsay that was obtained with honors in 1993. In 1993–1994 he was a post-doc and adjunct faculty at the Courant Institute of Mathematical Sciences of New York University and at New York University Medical Center. From 1994–1999, he was a Research Staff Member at the IBM T.J. Watson Research Center. His main contributions are in the fields of Medical Imaging, for co-registering Computed Tomography and X-ray image data, in Scientific Visualization (iso-surfaces) and Computer Graphics (model simplification, 3-D compression and progressive transmission). He has authored fifteen patents and has published about thirty papers in related areas. He is currently interested in various topics in geometric modeling, including non-manifold models and multi-resolution representations.

[1] The paper by Guéziec et al. on "Efficient compression of non-manifold polygonal meshes" was handled by the Editor-in-Chief J.-R. Sack.

Gabriel Taubin is a Research Staff Member and Manager of the Visual and Geometric Computing Group at the IBM T.J. Watson Research Center, in Yorktown Heights, New York. He holds a Ph.D. degree in Electrical Engineering from Brown University, and a Licenciado en Ciencias Matemáticas degree from the University of Buenos Aires, Argentina. Gabriel is known for his work on 3D geometry compression and progressive transmission of polygonal models, the signal processing approach for polygonal mesh smoothing, algebraic curve and surface rasterization, and algebraic curves and surfaces in Computer Vision. Gabriel has published 35 book chapters, refereed journal or conference papers, 25 other conference papers and technical reports, and 15 patents (6 issued). He has presented the Eurographics'99 State of the Art Report on 3D Geometry Compression and Progressive Transmission, and organized and taught two courses on 3D Geometry Compression at Siggraph'98 and Siggraph'99. Gabriel was granted an IBM Research 1998 Computer Science Best Paper Award for his paper Geometry Compression through Topological Surgery. He has lead the effort to incorporate the 3D geometry compression technology developed by his group during the last four years was incorporated in the MPEG-4 standard. He is currently interested in 3D Graphics in a networked environment, including 3D modeling, 3D scanning, surface reconstruction, surface simplification, geometry compression, progressive transmission, geometric algorithms and computation, and rendering; as well as in new image-based representation and rendering schemes.

Computational Geometry 14 (1999) 13. Editorial. Multi-Resolution Modeling and 3D Geometry Compression. Andr Guziec, Gabriel Taubin.Â Techniques for compressing meshes of arbitrary connectivity and topology and for developing multi-resolution representations have matured considerably in recent years, justifying their inclusion ininternational standards such as MPEG-4, as well as in commercial software and hardware. The paperspresented here illustrate some of the most recent approaches and results, and show how multi-resolutionmodeling and compression are intimately related. Three-dimensional (3D) computer graphics exert a powerful attraction, that has revolutionized thecomputer gaming industry. 3D reconstruction from multiple images is the creation of three-dimensional models from a set of images. It is the reverse process of obtaining 2D images from 3D scenes. The essence of an image is a projection from a 3D scene onto a 2D plane, during which process the depth is lost. The 3D point corresponding to a specific image point is constrained to be on the line of sight. From a single image, it is impossible to determine which point on this line corresponds to the image point. If two images are