

Editorial

Point-based Computer graphics

With Moore's law unquestioned, computer graphics researchers are witnessing ever more powerful computers deal with increasingly complex and detailed geometric objects. However, the challenges of managing, processing, and manipulating very large polygonal-mesh connectivity information have led many leading researchers to question the future utility of polygons as the fundamental primitive. Recently, point primitives have emerged as an alternative that reduce the cost of managing geometric shape descriptions to a minimum. Points are essentially samples of a 3D object, and point-based representations merely consist of unstructured sets of such samples. Points constitute discrete building blocks of object geometry and appearance—much as pixels are the digital elements for images. Points also naturally arise as the raw data produced by modern 3D digital photography and 3D scanning systems, which acquire both geometry and appearance of complex, real-world objects.

The simplicity of the point-based approach has inspired a wealth of research in recent years. Point-based methods have been introduced into a variety of areas in computer graphics, including point-based surface analysis, reconstruction, processing, modeling, and rendering. In June 2004, researchers came together at the first Symposium on Point-Based Graphics to discuss their work on point-based techniques. This was the first event in the computer graphics community that was entirely dedicated to points, and the research contributions covered all aspects of computer graphics. For this issue of *Computers & Graphics*, we invited a number of authors to publish extended versions of their submissions to the symposium. Our selection of papers is intended to reflect the variety of ongoing research in point-based methods and their success for solving a wide range of problems.

Kobbelt and Botsch provide an extensive overview of recent research efforts in the field of point-based computer graphics, focusing on shape representations, geometric algorithms, and rendering methods. Their paper makes a strong argument for point- and splat-based shape models, illustrating their advantages over mesh-based surfaces in terms of modeling flexibility, approximation error, and memory requirements.

Gobetti and Marton present a point-based multi-resolution data structure that allows the interactive visualization of very large objects. Their method improves upon previous approaches in terms of rendering speed and the ability to seamlessly handle out-of-core data. They demonstrate their system with data sets containing several hundred million points, which proves its practicability for interactive visualization of large data sets. This work highlights the suitability of points for constructing efficient hierarchical representations that can be streamed and rendered interactively.

The contribution by Guennebaud, Barthe and Paulin presents a method for real-time point cloud refinement. It is inspired by subdivision schemes similar to those popular for meshes. This technique allows interactive up-sampling of point-based surfaces for high quality rendering. It illustrates the flexibility of point-based representations to efficiently interpolate new points on a smooth surface, but it also shows the challenges posed by unstructured points to analyze surface properties.

Klein and Zachmann introduce a new point set surface model based on geometric proximity graphs. Their method adapts the local reconstruction kernels to include geodesic distance information derived from the point cloud. This reduces artifacts common in implicit models that only take the Euclidean distance between point samples into account. Their paper provides an extensive analysis of different proximity graphs and the relation of the proposed surface model to existing techniques.

Clarenz, Rumpf and Telea present a framework for processing point-based surfaces using finite element discretization, which allows to solve partial differential equations directly on the point cloud. The paper gives an impressive selection of surface processing examples, ranging from surface segmentation, reconstruction and fairing, to texture synthesis and inpainting.

As one of the first applications of points, Levoy and Whitted proposed to use points as a display primitive already in 1985. Their work identified the main issues in point-based rendering, which have been addressed by more than a dozen publications ever since. Pajarola's and Sainz's survey compares and analyzes a number of state-of-the-art rendering techniques. It illustrates

performance-quality trade-offs and points out important implementation details that are often neglected in other research publications.

An interesting new perspective on shape analysis of point cloud data is given in the paper by Collins, Zomorodian, Carlsson and Guibas. They apply techniques from differential geometry and algebraic topology, combining the differentiating power of the former with the classifying power of the latter. Using persistent homology on the tangent complex, they define a robust barcode shape descriptor that allows efficient classification and characterization of point-sampled curves.



Mark Pauly received his M.S. degree in Computer Science (with honors) from the University of Kaiserslautern, Germany, and his Ph.D. from the Computer Graphics Laboratory at ETH Zurich, Switzerland. Dr. Pauly has served on various program committees including ACM SIGGRAPH, Eurographics and Pacific Graphics conferences and been involved in the

organization of the first ACM/Eurographics Symposium on Point-Based Graphics 2004. His research focuses on multi-scale and spectral methods for geometry processing, 3D shape and appearance modeling, physics-based animation, and statistical shape analysis. Dr. Pauly is currently a postdoctoral scholar at the Computer Science Department at Stanford University.



Matthias Zwicker obtained his Ph.D. from the Computer Graphics Lab at ETH Zurich, Switzerland. His thesis focused on reconstruction, rendering, and editing of point-sampled objects. He has also extended this work towards high quality volume rendering. Dr. Zwicker has served as a reviewer for various international journals and conferences and he has been a member of the program committee of Eurographics 2004. He also was a co-organizer of the Eurographics Symposium on Point-Based Graphics 2004. Currently, Dr. Zwicker is a postdoctoral associate with the Computer Graphics Group at the Massachusetts Institute of Technology.

Guest Editors
Matthias Zwicker
CSAIL

*Massachusetts Institute of Technology
The stata Center, 32 Vassar street
02139 Cambridge, MA, USA*

E-mail address: matthias@graphics.csail.mit.edu

MarkPauly
Computer Science Department
Stanford University
Gates Building 375
Stanfordf CA 94305, USA

E-mail address: mapauly@graphics.stanford.edu