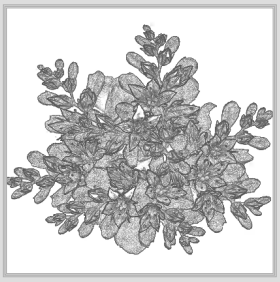
Adaptively Sampled Distance Fields

Representing Shape for Computer Graphics



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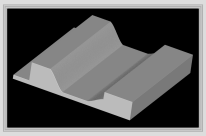
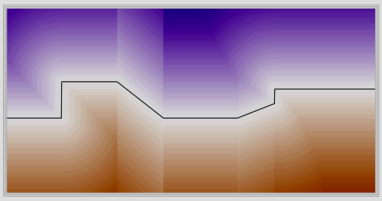
2-14-2002

Adaptively Sampled Distance Fields - ADFs

- ADFs are a new digital representation of shape with several advantages over existing approaches



3D shape

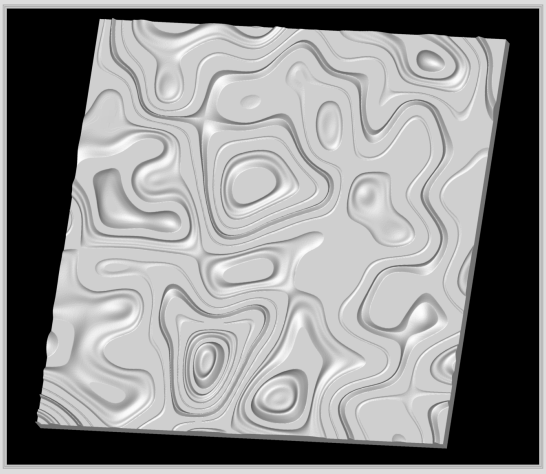


Cross section of the shape's distance field

Adaptively Sampled Distance Fields - ADFs

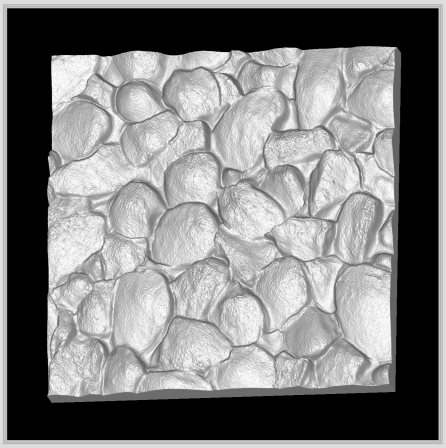
- Advantages
  - ADFs provide a compact representation of sharp features and curved surfaces
  - Sculpting is direct, intuitive, and fast
  - ADFs do not require control point manipulation or trimming
  - The distance field enables an enhanced user interface for sculpting
  - ADFs facilitate robust and efficient reconstruction of detailed geometry and geometric texture from range data and photographs
  - ADFs unify the representation of surfaces and volumes
  - ADFs provide a computational substrate that facilitates numerous operations such as collision detection, proximity tests, geometric queries, level-of-detail management, visualization, sculpting, surface offsetting, blending and filleting, etc.

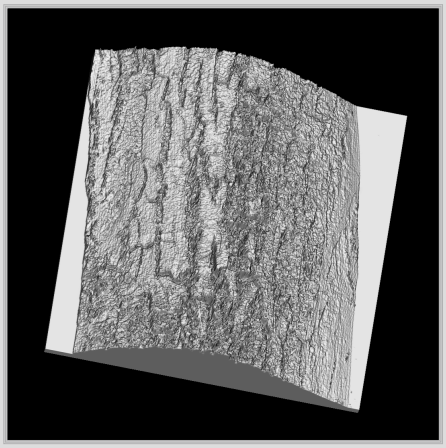
Gallery



Organic shape with razor sharp edges

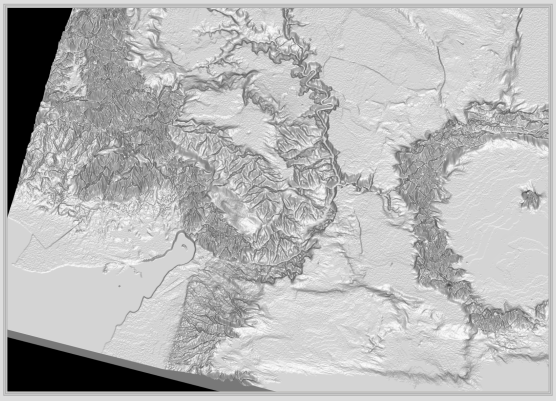
Gallery





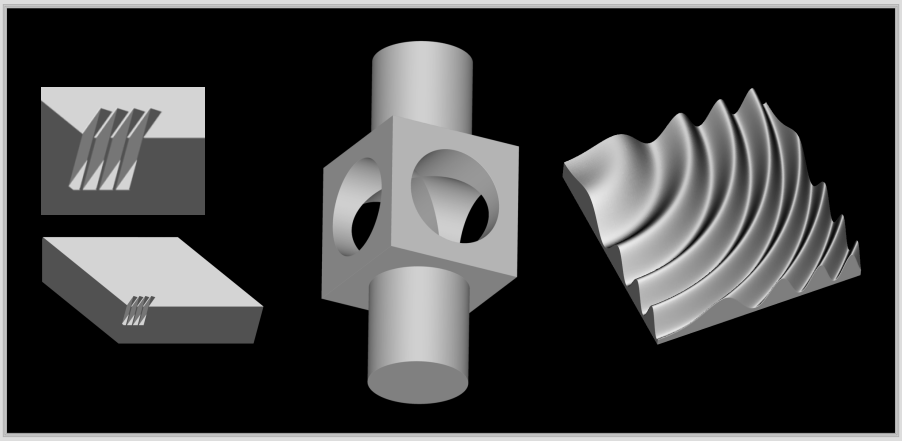
Exquisitely detailed concept models for "The Lord of the Rings"
(simple Phong illumination – all detail is geometric)

Gallery



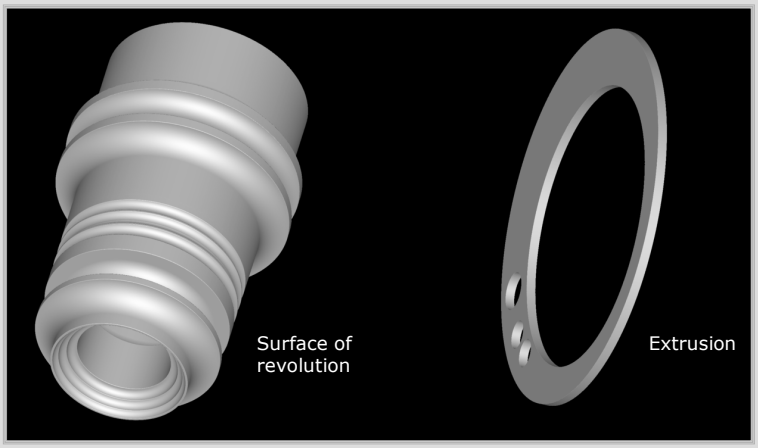
Concept model of Middle-earth for "The Lord of the Rings"
(simple Phong illumination – all detail is geometric)

Gallery



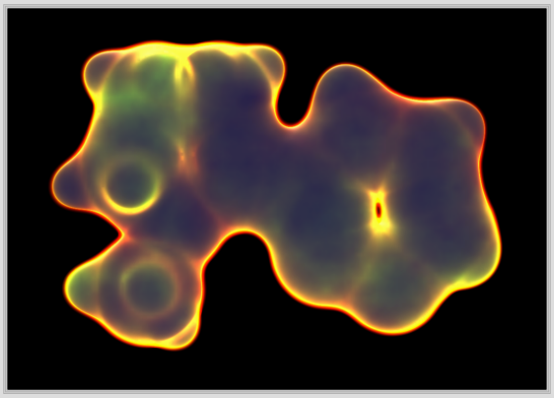
Machined parts showing sharp corners and smooth surfaces

Gallery



ADFs enable classic industrial design with an emphasis on simplicity, direct interaction, and precise, fine control

Gallery



Volume rendered ADF with semi-transparent thick surfaces and distance-based turbulence
(A single frame from an animation used in a NOVA documentary)

Adaptively Sampled Distance Fields - ADFs

- To achieve these results, our approach includes
  - Fundamental research
  - Incorporation of this research into a product-worthy C library ready for commercialization
  - Development of a comprehensive patent portfolio
  - Collaboration with key industrial players to refine and expand the vision for ADFs

Research Papers

- "A New Interaction Method for Creating and Editing 3D Geometry and Geometric Texture", SIGGRAPH 2002 Submission
- "Kizamu: A System For Sculpting Digital Characters", SIGGRAPH 2001 Conference Proceedings
- "Computing 3D Geometry Directly from Range Images", SIGGRAPH 2001 Conference Abstracts and Applications
- "A Computationally Efficient Framework for Modeling Soft Body Impact", SIGGRAPH 2001 Conference Abstracts and Applications
- "Dynamic Meshing Using Adaptively Sampled Distance Fields", SIGGRAPH 2001 Conference Abstracts and Applications
- "New Directions in Shape Representations", SIGGRAPH 2001 (full day) Course
- "Adaptively Sampled Distance Fields: A General Representation of Shape for Computer Graphics", SIGGRAPH 2000 Conference Proceedings
- "Using Distance Maps for Accurate Surface Representation in Sampled Volumes", IEEE VolVis Symposium 1998
- "A New Representation for Device Color Gamuts", MERL TR2001-09
- "A New Framework For Non-Photorealistic Rendering", MERL TR2001-12

Patents

- A comprehensive patent portfolio
  - 2 issued patents
  - 3 granted patents (but not yet issued)
  - 17 filed patent applications
  - 4 new patent disclosures

ADF Library

- A product-worthy C library
  - Features include: Stock distance functions for constructing and combining objects; Milling specific distance functions for extrusion, surface of revolution, and lathing; Tiled generation; Bounded-surface generation; Interactive CSG editing; Bezier tool paths; Surface and volume rendering; Procedural shading interface; Adaptive, asynchronous ray casting; ADF specific 2D antialiasing; Supersampling for standard 2D and 3D antialiasing; Simple camera and lighting model; Region rendering to support interactive CSG editing; Conversion of image and range data to ADFs; Idle time processing; Reconstruction functions; ADF read and write operations; Interactive generation of view-dependent and view-independent point models; Interactive generation of optimal triangle meshes; Generation of level-of-detail triangle meshes; Blending of ADFs; Input and output of Wavefront Object files; Amenable to parallel implementations; Developed with object-oriented ANSI C; Runs under Windows and Linux.

Business Opportunities

- ADFs provide digital clay and a fresh approach to design that incorporates
  - Organic shapes
  - Razor sharp edges
  - Highly detailed geometric texture
- Potential products
  - Freeform sculpting of digital characters for games and movies
  - Organic and textured sculpting for computer aided industrial design
  - Creating and sculpting volumetric characters for movies
  - Capturing 3D geometry from range data and photographs