UTAH

Luiz Velho
IMPA

The Graphics Pantheon

- College of Science at the University of Utah

The “Camelot Era”

They were a group of young, scrappy, but brilliant University of Utah computer science students and professors who changed the world.

A handful of luminaries in the late 1960s and 1970s who revolutionized computer graphics by inventing technologies that have shaped countless industries today.

- Ph.D. Program in Computer Graphics

- Created by Ivan Sutherland and David Evans

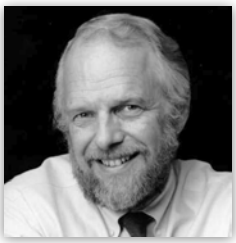
The Dream Team

- IEEE Milestone ceremony at the University of Utah in Salt Lake City (March 2023)

[back, left] Nolan Bushnell, Bob Sproull, Martin Newell, John Warnock, Fred Parke, Gary Watkins, Alvy Ray Smith, Henri Gouraud, Ed Catmull, [front, left] Robert Schumacker, Ivan Sutherland, Jim Blinn, and Henry Fuchs.

Luminaires

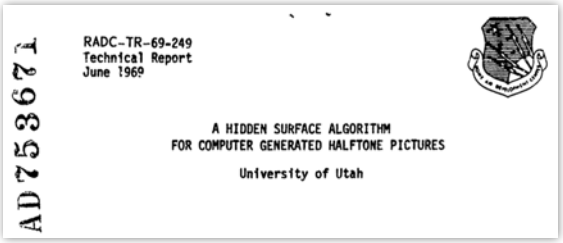
John Warnock



- Ph.D. (1969)
  - "A *Hidden Surface Algorithm for Computer Generated Halftone Pictures*"
- Contribution
  - Developed the Warnock algorithm for hidden surface determination.

Adobe's founder

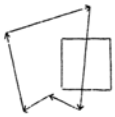
Hidden Surface Algorithm

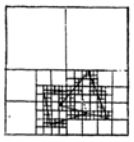

AD753671

RADC-TR-69-249
Technical Report
June 1969

A HIDDEN SURFACE ALGORITHM
FOR COMPUTER GENERATED HALFTONE PICTURES

University of Utah


Subdivision Criteria

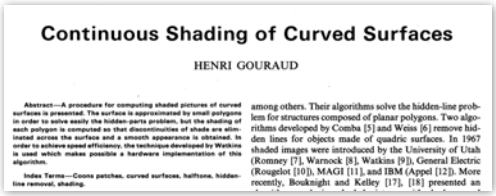

Quad-Tree Structure

- Introduced Recursive Visible Surface Computation

Henry Gouraud

- Ph.D. (1971)
  - "*Computer Display of Curved Surfaces*"
- Contribution
  - Introduced Gouraud shading for smooth shading of surfaces.

Gouraud Shading



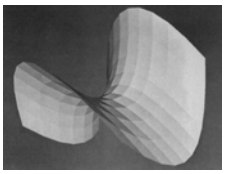
Continuous Shading of Curved Surfaces

HENRI GOURAUD

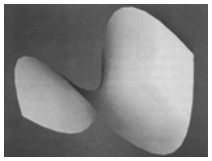
Abstract—A procedure for computing shaded pictures of curved surfaces is presented. The surface is approximated by small polygons in order to solve easily the hidden-parts problem, but the shading of each polygon is computed so that discontinuities of shade are eliminated across the surface and a smooth appearance is obtained. In order to achieve speed efficiency, the technique developed by Watkins is used which makes possible a hardware implementation of this algorithm.

Index Terms—Coons patches, curved surfaces, halftone, hidden-line removal, shading.

among others. Their algorithms solve the hidden-line problem for structures composed of planar polygons. Two algorithms developed by Comba [5] and Weiss [6] remove hidden lines for objects made of quadric surfaces. In 1967 shaded images were introduced by the University of Utah (Romney [7], Warnock [8], Watkins [9]), General Electric (Rougelot [10]), MAGI [11], and IBM (Appel [12]). More recently, Bouknight and Kelley [17], [18] presented an



Flat Shading



Gouraud shading

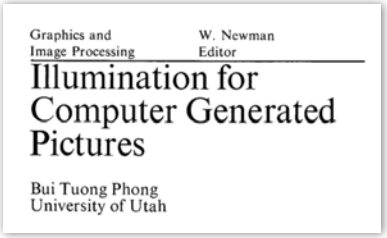
- Smooth Shading Interpolation

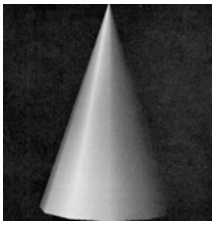
Bui Tuong Phong

- Ph.D., (1973)
  - "*Illumination for Computer Generated Pictures*"
- Contribution
  - Developed Phong shading and the Phong reflection model.

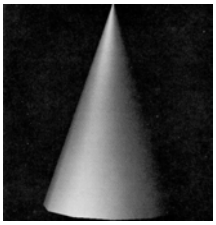
Stanford University

Phong Shading





Gouraud shading



Phong Shading

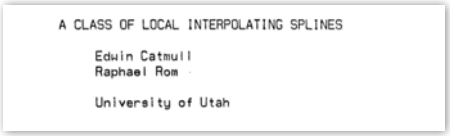
- Improved Gouraud shading

Edwin Catmull

- Ph.D., (1974)
  - "*A Subdivision Algorithm for Computer Display of Curved Surfaces*"
- Contribution
  - Co-created the Catmull-Clark surface and contributed to texture mapping

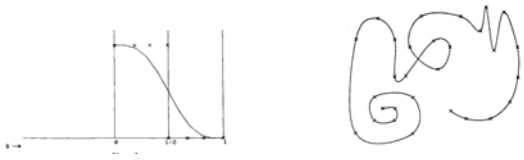
Pixar's President

Spline Interpolation


A CLASS OF LOCAL INTERPOLATING SPLINES

Edwin Catmull
Raphael Rom

University of Utah



Parameter Space Curve Space

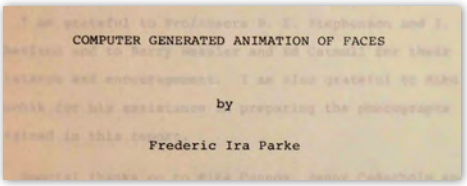
- Developed Splines and Subdivision Methods for Modeling and Animation

Fred Parke

- Ph.D., (1974)
  - "*Computer Generated Animation of Faces*"
- Contribution
  - Pioneered techniques in facial animation

Texas A&M

Facial Animation


COMPUTER GENERATED ANIMATION OF FACES

by

Frederic Ira Parke

Sylvie Gouraud


Modeling


Rendering

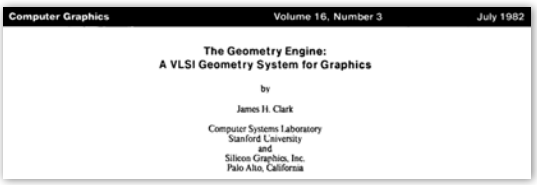
- Pioneered Computer Animation of Faces

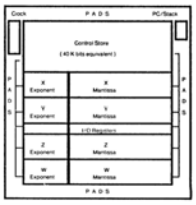
Jim Clark

- Ph.D., (1974)
  - "*Hierarchical Geometric Models for Visible Surface Algorithms*"
- Contribution
  - Developed algorithms for efficient hidden surface determination using hierarchies

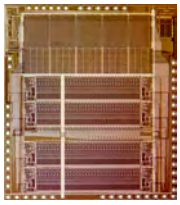
Silicon Graphics - Netscape CTO

Geometry Engine





Block Diagram



VLSI Chip

- Created the First Graphics Processor Unity (GPU)

Martin Newell

- Ph.D., (1975)
  - "*The Utilization of Procedure Models in Digital Image Synthesis*"
- Contribution
  - Known for the development of the Newell teapot

The Utah Teapot

- Melitta-Brand Teapot
  - designed by Lieselotte Kantner
  - Modeled by Martin Newell (1975)

the real Melitta teapot

wireframe

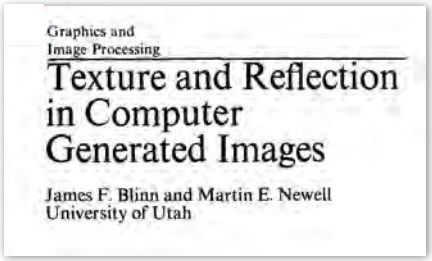
shaded

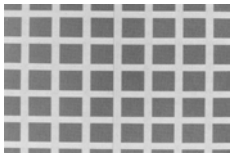
Jim Blinn

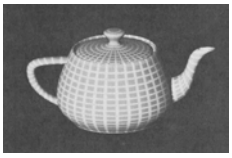
- Ph.D., (1978)
  - "*Models of Light Reflection for Computer Synthesized Pictures*"
- Contribution
  - Introduced the Blinn-Phong reflection model and bump mapping.

JPL - NASA

Texture and Reflection




Texture Image


Textured Surface

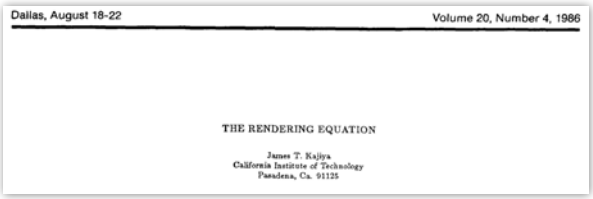
- Established Texture Mapping for Rendering

Jim Kajiya

- Ph.D., (1979)
  - "*The Rendering Equation*"
- Contribution
  - Formulated the rendering equation, foundational in global illumination

Caltech / Microsoft

The Rendering Equation


Dallas, August 18-22 Volume 20, Number 4, 1986

THE RENDERING EQUATION

James T. Kajiya
California Institute of Technology
Pasadena, Ca. 91125

The rendering equation is

$$I(x,x') = g(x,x')\left[\epsilon(x,x') + \int_S \rho(x,x',x'')I(x',x'')dx''\right]. \quad (1)$$

where:

$I(x,x')$	is the related to the intensity of light passing from point x' to point x
$g(x,x')$	is a "geometry" term
$\epsilon(x,x')$	is related to the intensity of emitted light from x' to x
$\rho(x,x'x'')$	is related to the intensity of light scattered from x'' toz by a patch of surface at x'

Mathematical Formulation

Path Traced Image

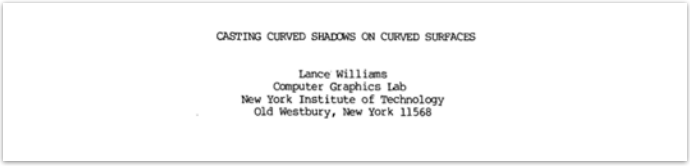
- Introduced the Foundation Model of Global Illumination

Lance Williams

- Ph.D. (-)
  - "Casting Shadows on Curved Surfaces"
  - "*Brute Force in Image Space*"
- Contribution
  - Introduced shadow mapping. Made significant contributions to texture synthesis
- Lance left Utah (without completing his degree) in 1974 to join NYIT.
- He was later awarded his doctorate from Utah based on a rule allowing someone who published three seminal papers in his field to bind them together as his thesis.

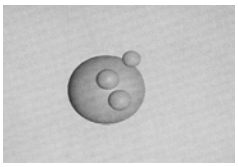
Apple / Google

Shadow Mapping

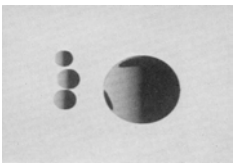


CASTING CURVED SHADOWS ON CURVED SURFACES

Lance Williams
Computer Graphics Lab
New York Institute of Technology
Old Westbury, New York 11568



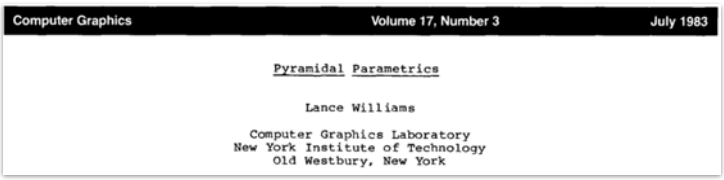
Light View



Camera View

- Established Image-Space Photorealistic Lighting

MIP Mapping

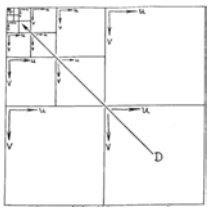


Computer Graphics Volume 17, Number 3 July 1983

Pyramidal Parametrics

Lance Williams

Computer Graphics Laboratory
New York Institute of Technology
Old Westbury, New York



Multiresolution Map

RGB Image Pyramid

- Introduced Multiresolution Analysis to Graphics

Watch @ Home

- NY Siggraph1986 part 1 - NYIT

Ed Kramer - CGI History Channel

Alan Kay, Ph.D., 1969 — Envisioned the windowing graphical user interface at Xerox PARC, which led to the design of Apple MacIntosh and Windows computers.

Henri Gouraud, Ph.D., 1971 — Created the Gouraud shading method for polygon smoothing—a simple rendering method that dramatically improved the appearance of 3-D objects.

Ed Catmull, Ph.D., 1974 — Pioneer in computer animation who co-developed RenderMan rendering software. Co-founder of Pixar Animation Studios and winner of five Academy Awards.

Jim Clark, Ph.D., 1974 — Rebuilt the head-mounted display and 3-D wand to see and interact with 3-D graphic spaces. Founder of Netscape and Silicon Graphics.

Martin Newell, Ph.D., 1975 — Developed procedural modeling for 3-D object rendering.
Co-developed the Painter's algorithm for surface rendering.

Henry Fuchs, Ph.D., 1975 — Innovator in high-performance graphics hardware, 3-D medical imaging and head-mounted display and virtual environments.

James Blinn, Ph.D., 1978 — Created specular lighting models, bump mapping and environment mapping for surface textures in graphical images.

Rodney Rougelot — Former president and chief executive officer of Salt Lake City-based Evans & Sutherland, which then developed military and aviation simulators with 3-D graphics.
Robert A. Schumaker — An engineer with Evans & Sutherland who conceived a new architecture for rendering complex, high-quality 3-D images for its flight simulators.

Alvy Ray Smith — Co-founder of Pixar Animation Studios. First Director of Computer Graphics for George Lucas' Lucasfilm.

Ivan Sutherland, U Computer Science. Co-founded Evans & Sutherland with David Evans.
Professor, 1968-1974