

前沿计算研究实践II

Study and Practice on Topics of Frontier Computing (II)

计算机图形理论与应用

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视觉计算 (Visual Computing)

专业：计算机图形、计算机视觉、可视化、人机交互、机器学习

应用：机器人、3D打印、虚拟现实、无人驾驶

Traditional Graphics



Sunday Afternoon on La Grande Jatte, by Seurat

Computer Graphics



Applications...

- • Entertainment
- Computer-aided design
- Scientific visualization
- Training
- Education
- E-commerce
- Computer art



King Kong

(Universal Pictures)



Flower

Baoquan Chen 2019 (Sony)



The Incredibles

(Pixar)

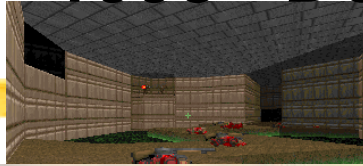


Crysis

(Crytek)



1993 - Doom 1996 - Doom II



Simulation



Battlefield Simulation

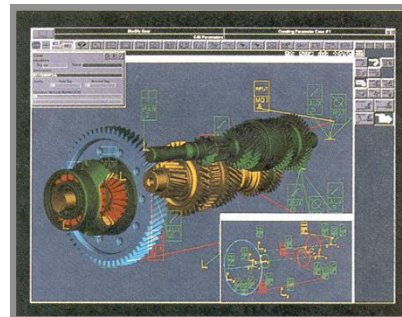


Applications

- Entertainment
- • Computer-aided design
- Scientific visualization
- Training
- Education
- E-commerce
- Computer art



Los Angeles Airport
(Bill Jepsen, UCLA)

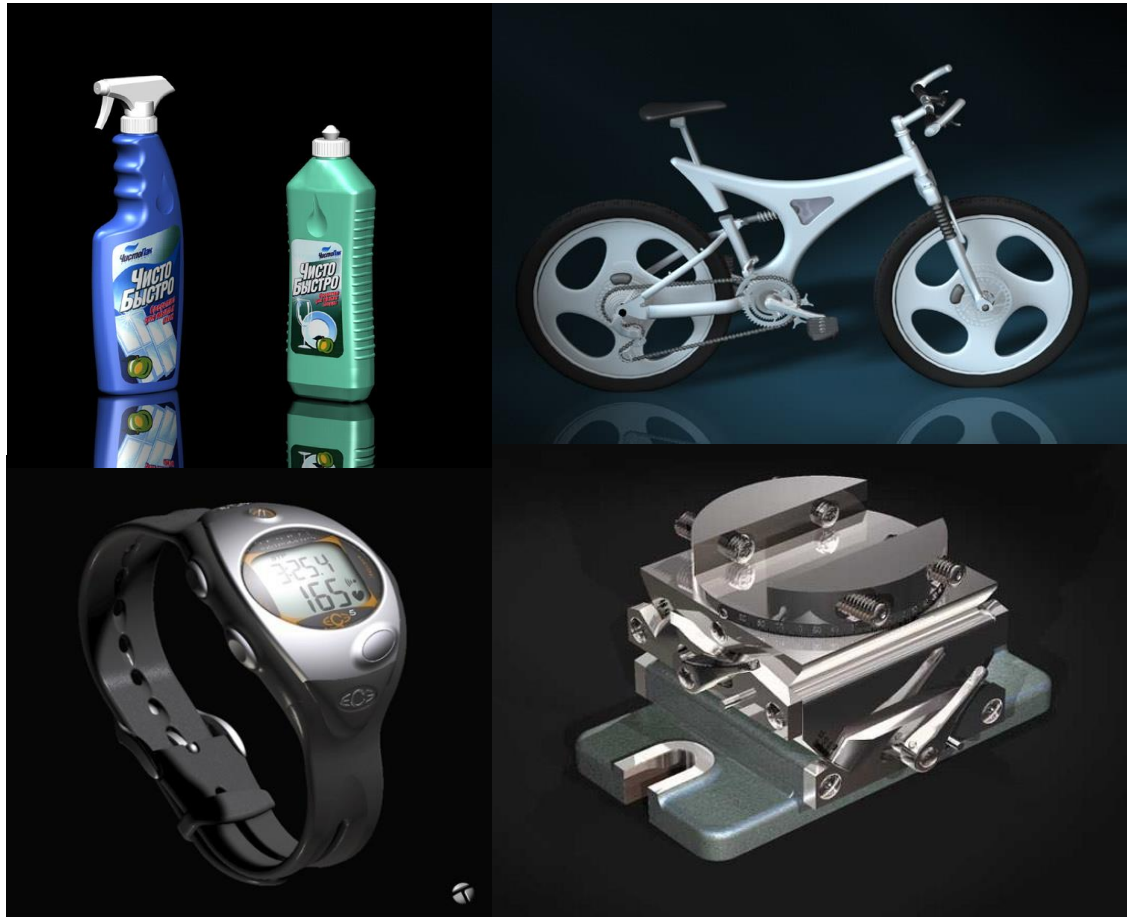


Gear Shaft Design
(Intergraph Corporation)



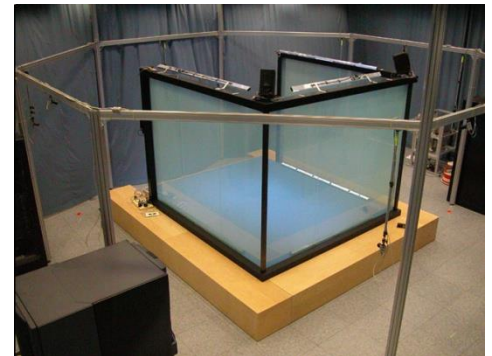
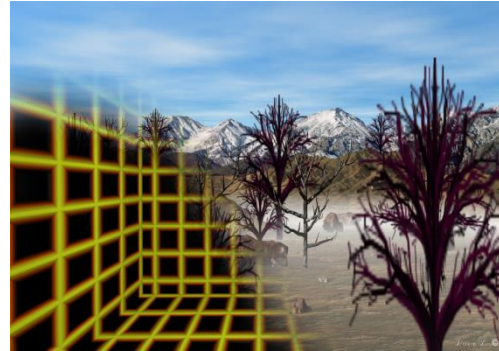
Boeing 777 Airplane
(Boeing Corporation)

CAD-CAM & design



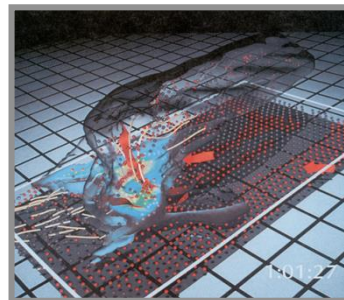
Virtual reality

- Virtual Reality
 - C. A. V. E
- Augmented Reality
- Augmented Virtuality
- Human-Machine Interfaces
 - Jeeves
 - Photogeist
- Virtual Worlds

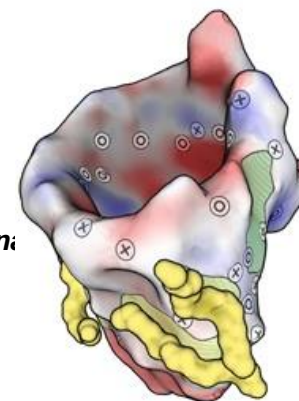


Applications

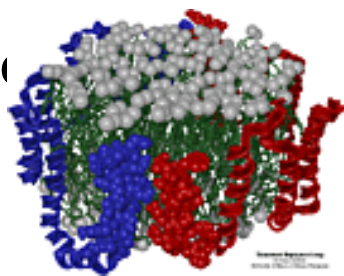
- Entertainment
- Computer-aided design
- • Scientific visualization
- Training
- Education
- E-commerce
- Comput



Airflow Inside a Thunderstorm
(Bob Wilhelmson, University of Illinois at Urbana-Champaign)



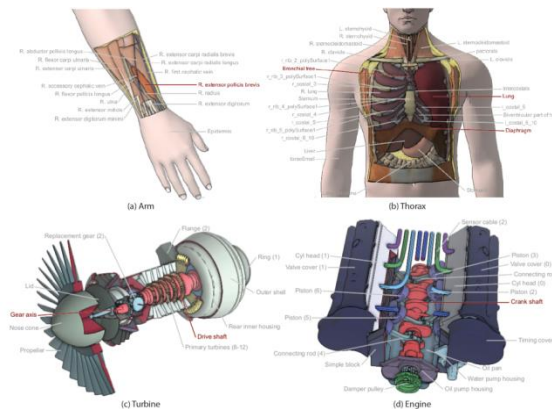
Molecular Surface Abstraction
(Cipriano et al)



Apo A-1

(Theoretical Biophysics Group,

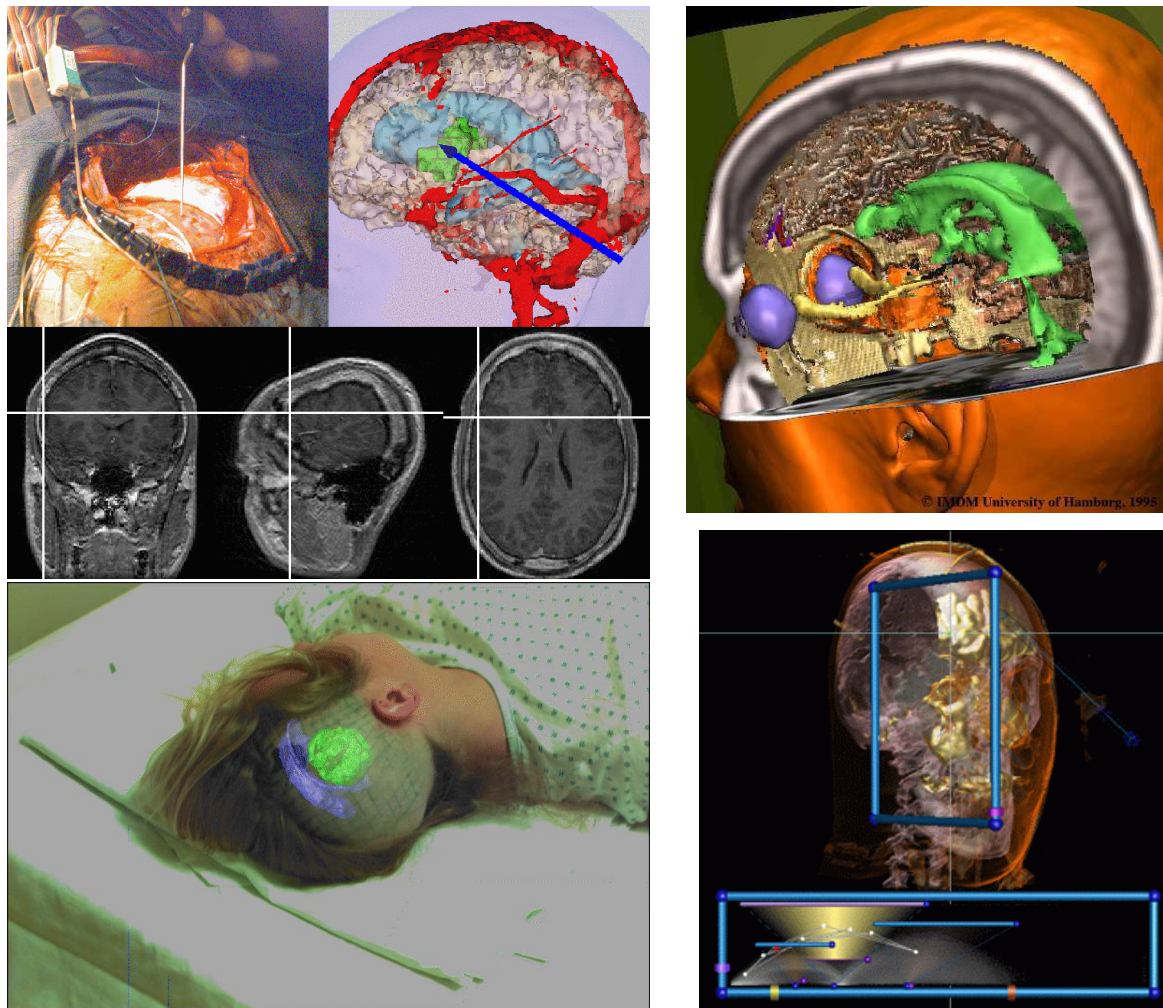
University of Illinois at Urbana-Champaign, 2019



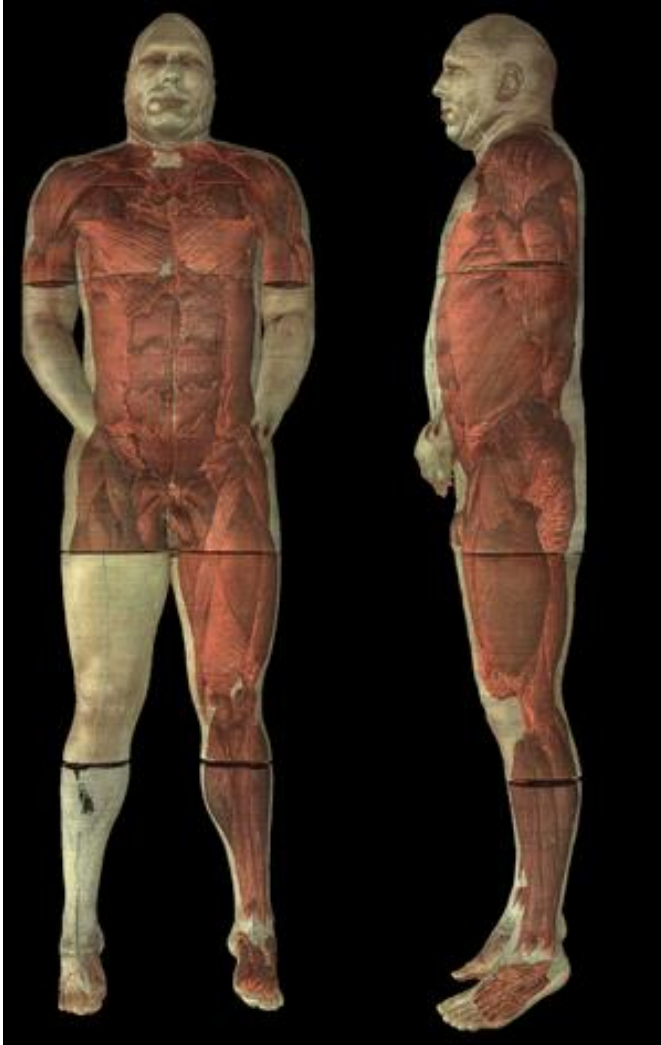
Interactive Cutaway Illustrations
(Microsoft Research)



Medical imaging



Medical Visualization



Medical Visualization

The screenshot displays a medical visualization application with several panels:

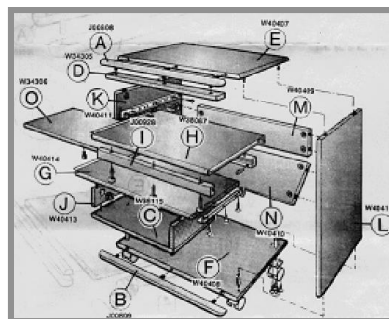
- Current Slices:** A vertical stack of three CT scan slices. The top slice is labeled "Sagittal slice: 340" and shows a sagittal view of the colon with a green line and a yellow dot. The middle slice is labeled "Coronal slice: 184" and shows a coronal view with a green line and a yellow dot. The bottom slice is labeled "Transverse slice: 217" and shows a transverse view with a green line and a yellow dot.
- Virtual Colonoscopy:** A large central window showing a 3D rendered view of the colon in orange, with a green line tracing the path through the lumen.
- Colon Cross Section:** A window showing a cross-section of the colon with a red crosshair in the center.
- Coronal Projection:** A window showing a 3D projection of the colon with a cyan line tracing the path. It includes the text "Distance from rectum is 1134.17 mm." and three colored markers: a red marker (A), a green marker (B), and a yellow marker (C).
- Navigation and Control Panel:** A panel at the bottom center containing:
 - Navigation:** to rectum, to appendix, skeleton, volume render
 - Camera control:** still, leveling, compass
 - Potential fields:** force , speed , bounce
 - Others:** light , field-of-view
 - Buttons:** Red Marker, Green Marker, Yellow Marker, Load Markers, Save Markers, Markers Info, and Quit.

Applications

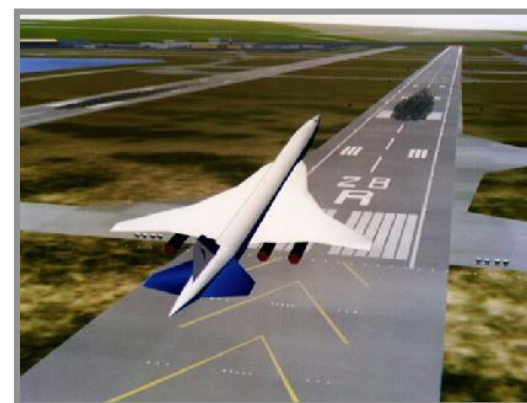
- Entertainment
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- Computer art



Driving Simulation
(Evans & Sutherland)



Desk Assembly
(Silicon Graphics, Inc.)



Flight Simulation
(NASA)

Applications

- Entertainment
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Forum of Trajan
(Bill Jepson, UCLA)



Human Skeleton
(SGI)

Applications

- Entertainment
- Computer-aided design
- Scientific visualization
- Training
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- • E-commerce
- Computer art



Second Life



Virtual Phone Store
(Lucent Technologies)

Applications

- Entertainment
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- E-commerce
- • Computer art



Blair Arch

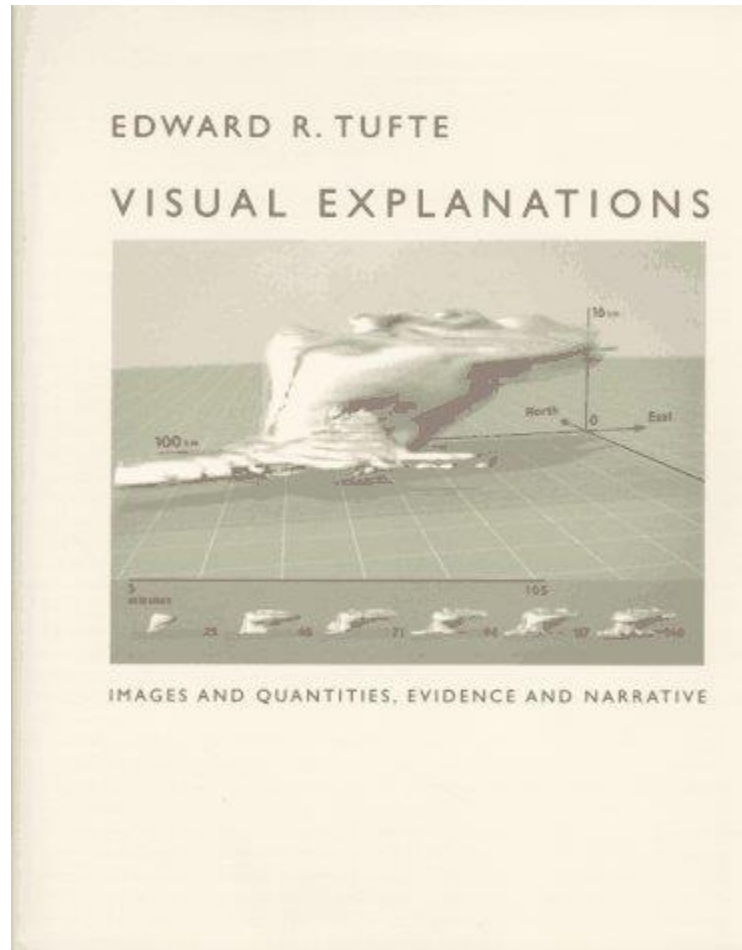
<https://www.youtube.com/watch?v=gDToHwHNf5E#t=66> (Marissa Range & Adam Finkelstein,

Princeton University)



Applications

Visual reasoning, explanation, and communication!



What Is Computer Graphics About?

It is about:

- 1. realistic and/or pretty pictures.*
movies, games, ...
- 2. scientifically informative (not necessary pretty) pictures.*
scientific visualization, CAD, ...



Three big topics *form, behavior, appearance*

- **Modeling**: how to represent objects; how to *build* those representations.
- **Animation**: representing/controlling the way things move.
- **Rendering**: how to simulate the image-forming process.



Rendering

- 3D Rendering Pipeline
 - Modeling transformations
 - Viewing transformations
 - Hidden surface removal
 - Illumination, shading, and textures
 - Scan conversion, clipping
 - Hierarchical scene graphics
 - OpenGL
- Global illumination
 - Ray tracing
 - Radiosity



OpenGL

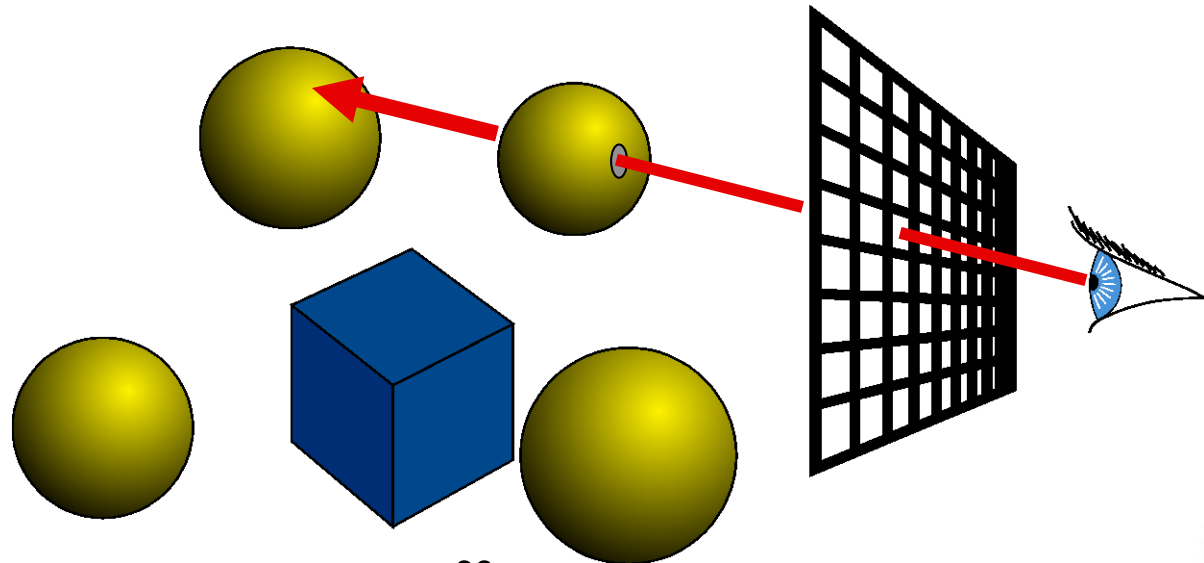


Ray Tracing



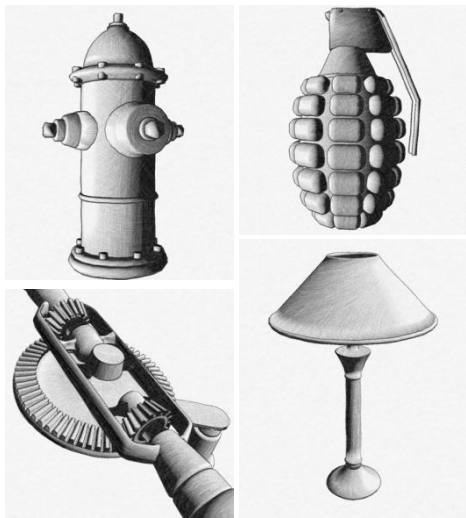
Ray Casting

- For every pixel
construct a ray from the eye
 - For every object in the scene
 - » Find intersection with the ray
 - » Keep if closest

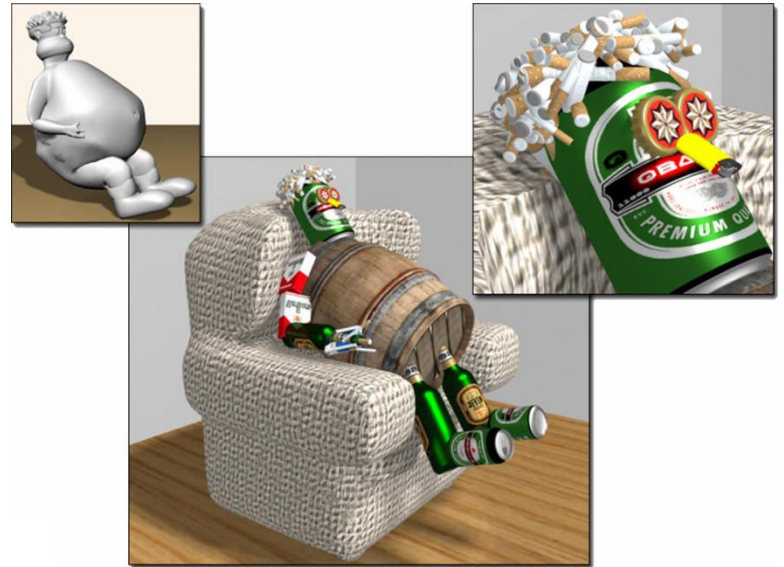


Rendering - NPR

- Non Photorealistic Rendering



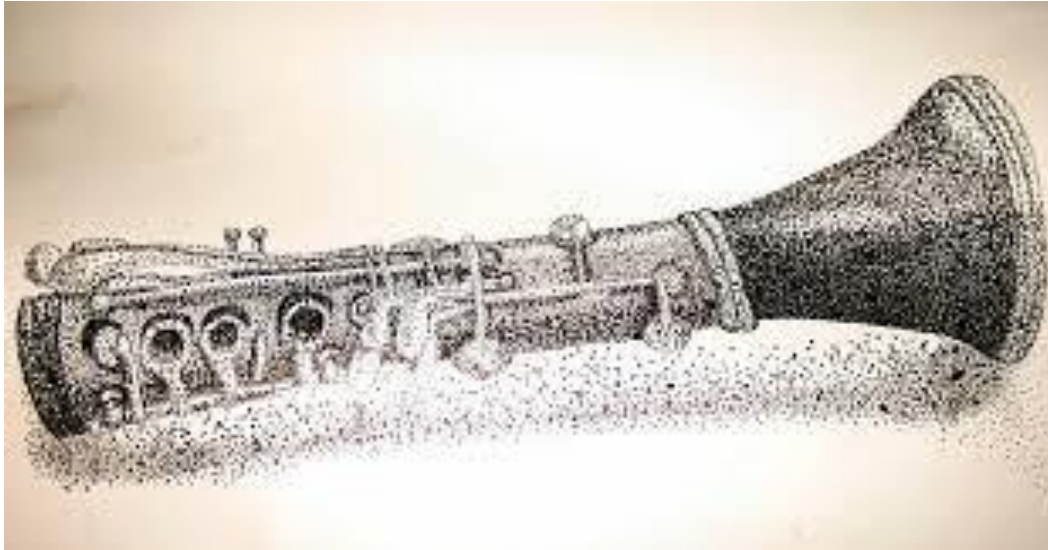
Real-time Pencil Rendering (Lee et al)



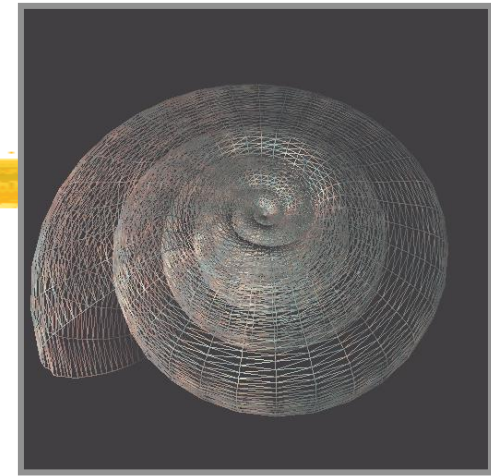
3D Collage (Gal et al)



Zelda the Windwalker (Nintendo)



Modeling



Shell

- Representations of geometry
 - Curves: splines
 - Surfaces: meshes, splines, subdivision
 - Solids: Voxels, CSG, BSP
- Procedural modeling
 - Sweeps
 - Fractals
 - Grammars

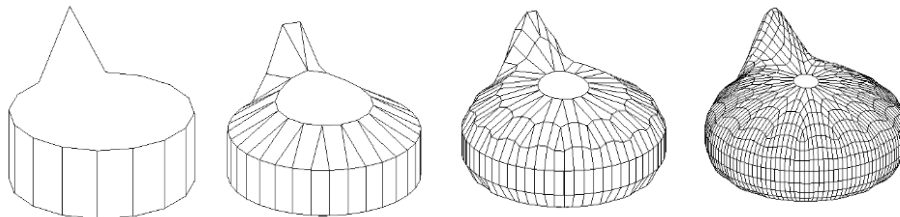
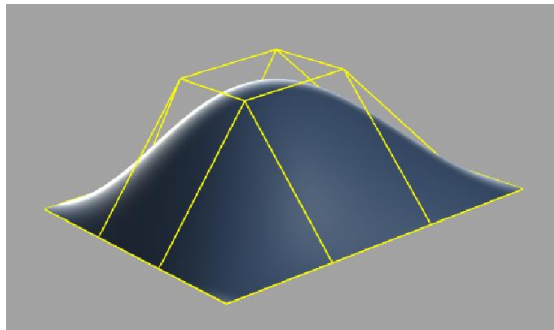


Scenery Designer

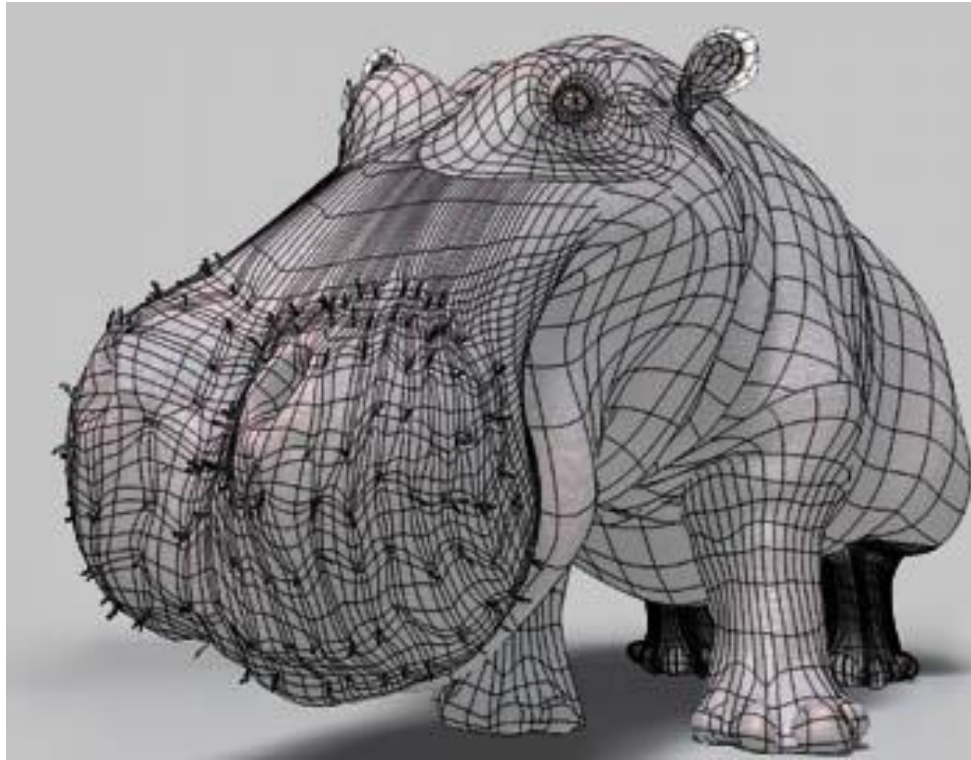


Modeling

- Curved surfaces
- Subdivision surfaces
- Bump Mapping



Textures and Shading



Just the model

<http://www.3drender.com/jbirn/hippo/hairyhipponose.html>

Textures and Shading



Add a little shading

<http://www.3drender.com/jbirn/hippo/hairyhipponose.html>

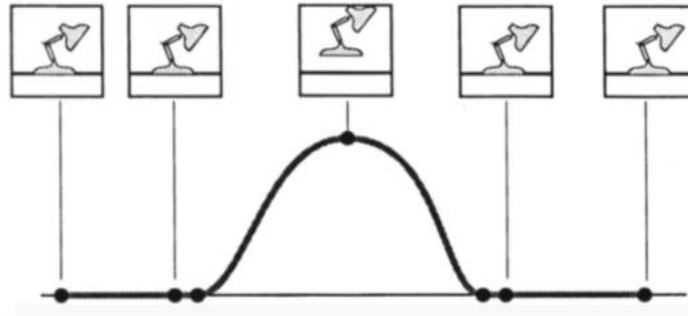
Textures and Shading



And sprinkle some textures and shadows

<http://www.3drender.com/jbirn/hippo/hairyhipponose.html>

Animation: Keyframing



ACM © 1987 "Principles of traditional animation applied to 3D computer animation"

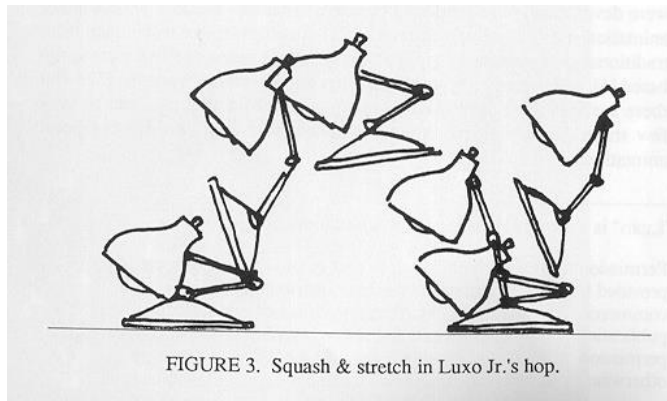


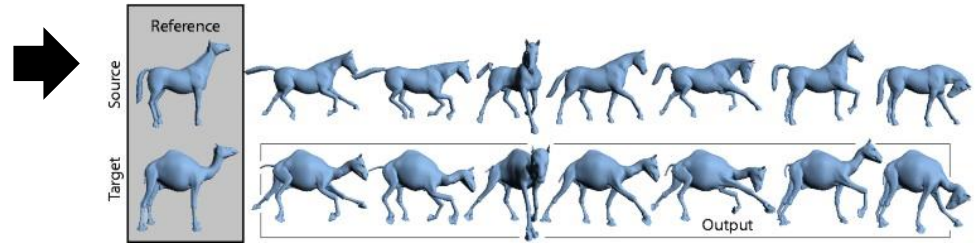
FIGURE 3. Squash & stretch in Luxo Jr.'s hop.

Animation

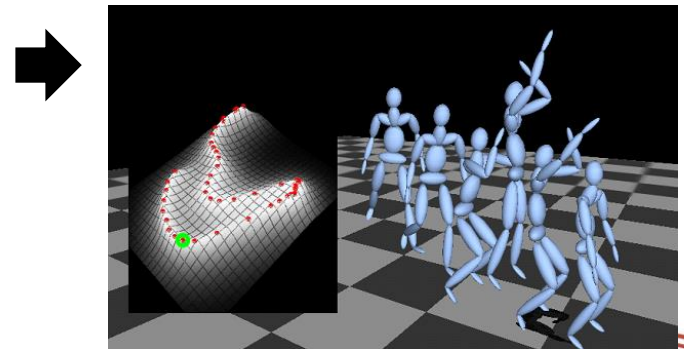


Flocking Behaviour 1978 (Reynolds)

- Keyframing
 - Kinematics
 - Articulated figures
- Motion capture
 - Capture
 - Warping
- Dynamics
 - Physically-based simulations
 - Particle systems
- Behaviors
 - Planning, learning, etc.



Deformation Transfer (Sumner et al)



*Style Based Inverse Kinematics
(Grochow et al)*





“The screen is a window through which one sees a virtual world. The challenge is to make that world look real, act real, sound real, feel real.” – Sutherland, 1965



Computer Vision



Building Rome in a day, ICCV 09 ([youtube](#), [project](#))



Human Detection Using Partial Least Squares Analysis, ICCV 09

Introduction to computer vision

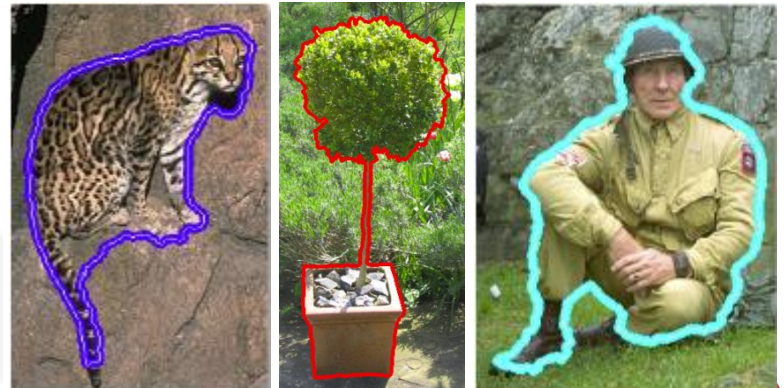
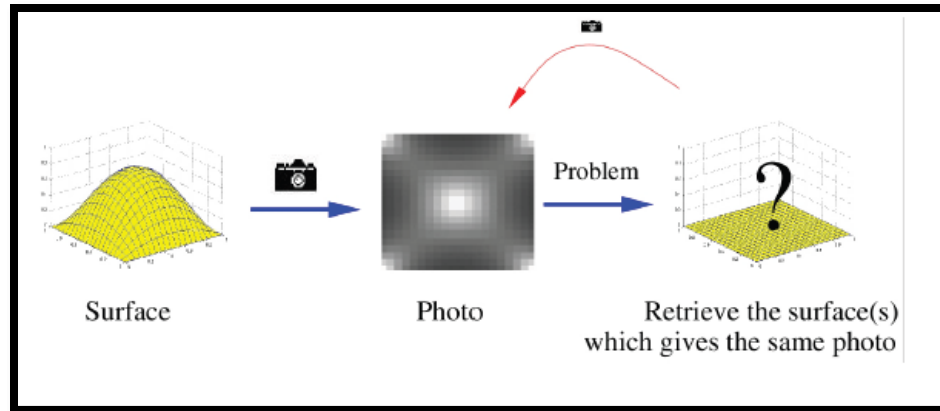


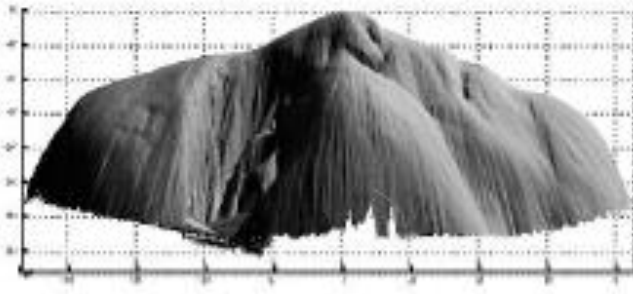
Image segmentation with a Bounding Box Prior, ICC 09



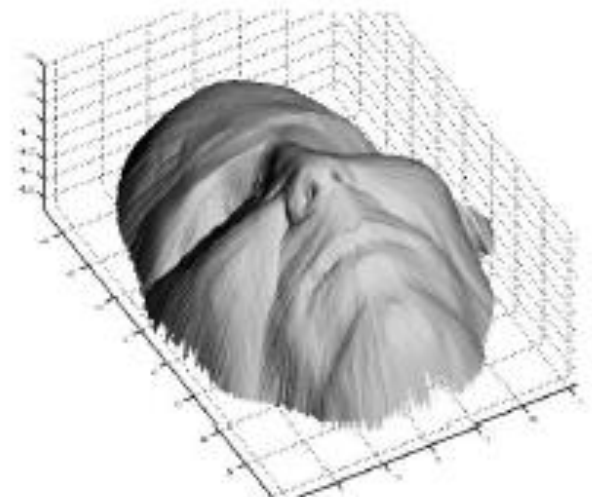
Shape from Shading



a)



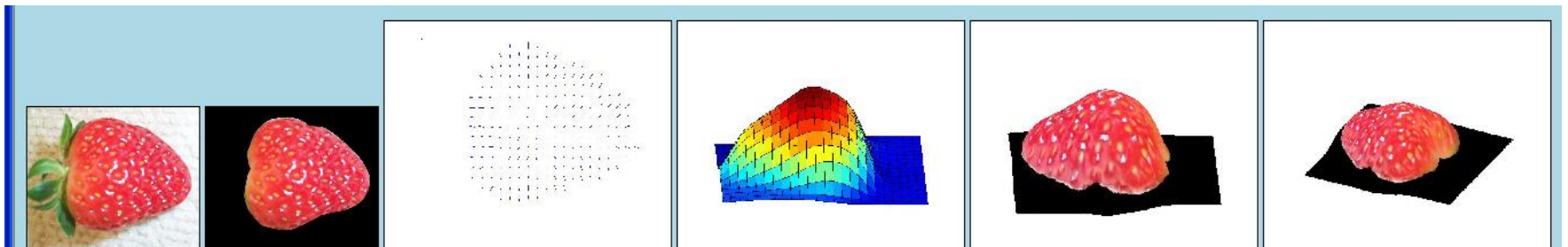
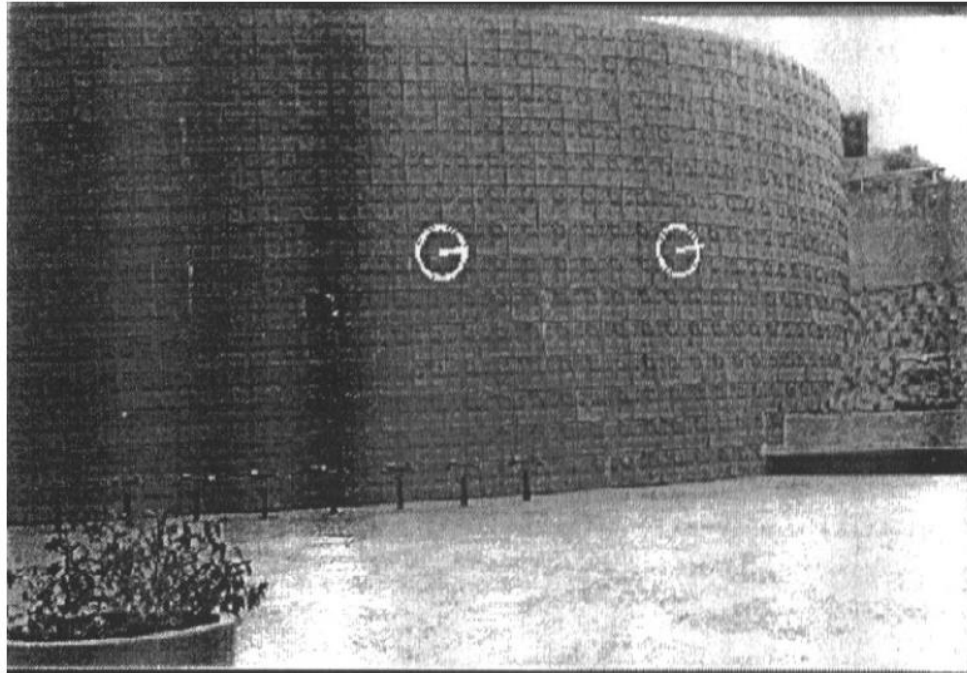
b)



c)

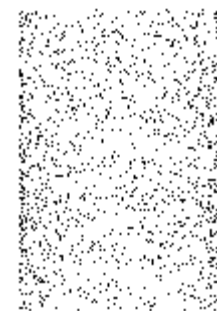
[Figure from Prados & Faugeras 2006]

Shape from Texture



[From A.M. Loh. The recovery of 3-D structure using visual texture patterns. PhD thesis]

Shape from Motion



Figures from L. Zhang

<http://www.brainconnection.com/teasers/?main=illusion/motion-shape>

Image-based Rendering

- Use images as inputs and representation
 - E. g. Image-based modeling and photo editing
Boh, Chen, Dorsey and Durand 2001



Input image



Relighting



New viewpoint