

# 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



**Flower**  
Baoquan Chen 2019 (Sony)



**The Incredibles**  
(Pixar)



**King Kong**  
(Universal Pictures)



**Crysis**  
(Crytek)



*1993 - Doom 1996 – Doom II*



# Simulation

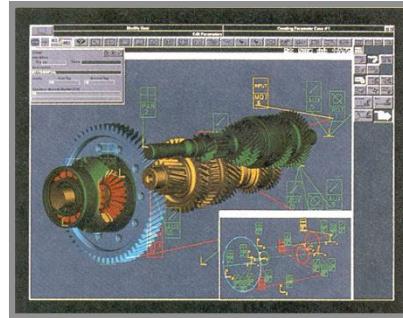


# Battlefield Simulation



# Applications

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- • Computer-aided design
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**Gear Shaft Design**  
(Intergraph Corporation)

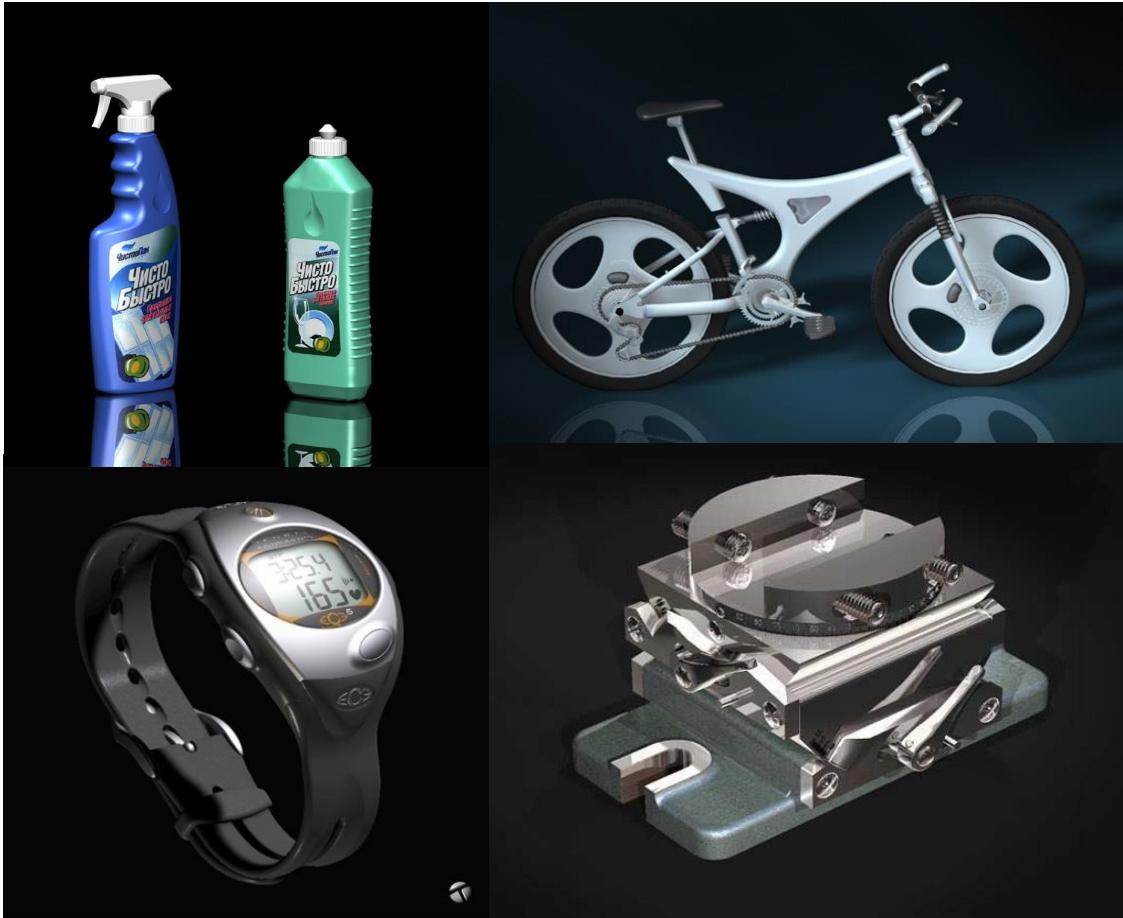


**Los Angeles Airport**  
(Bill Jepson, UCLA)



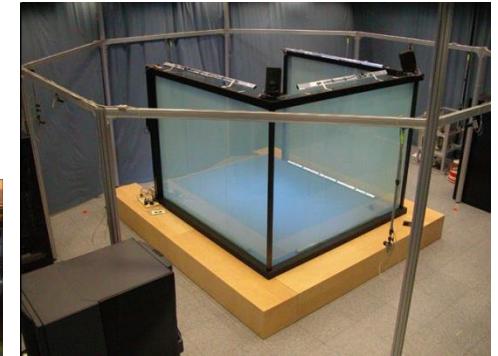
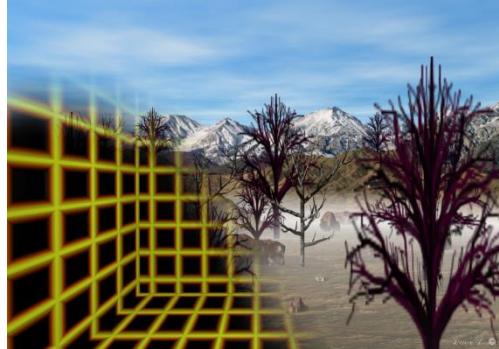
**Boeing 777 Airplane**  
(Boeing Corporation)

# CAD-CAM & design



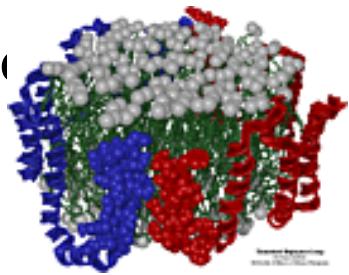
# Virtual reality

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



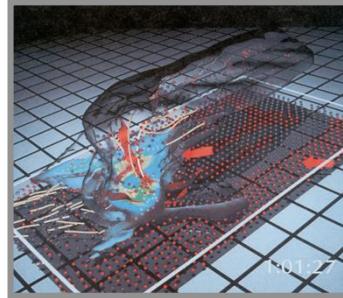
# Applications

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

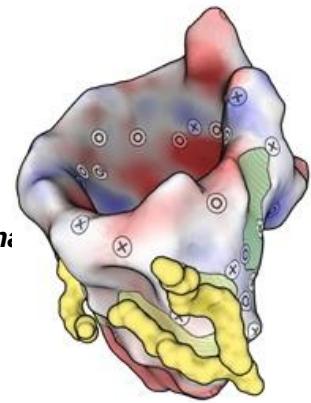


**Apo A-1**

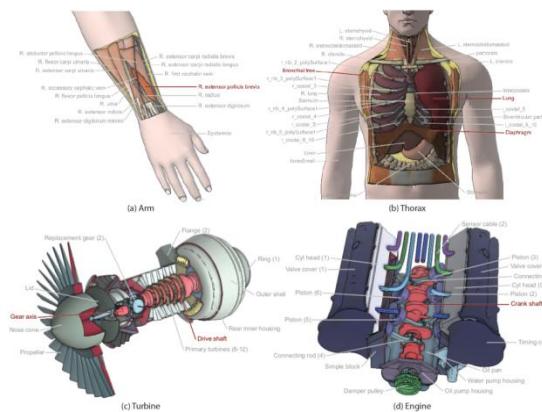
Baoquan Chen, University of Illinois at Urbana-Champaign, *Theoretical Biophysics Group*, *Interactive Cutaway Illustrations* (Microsoft Research)



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



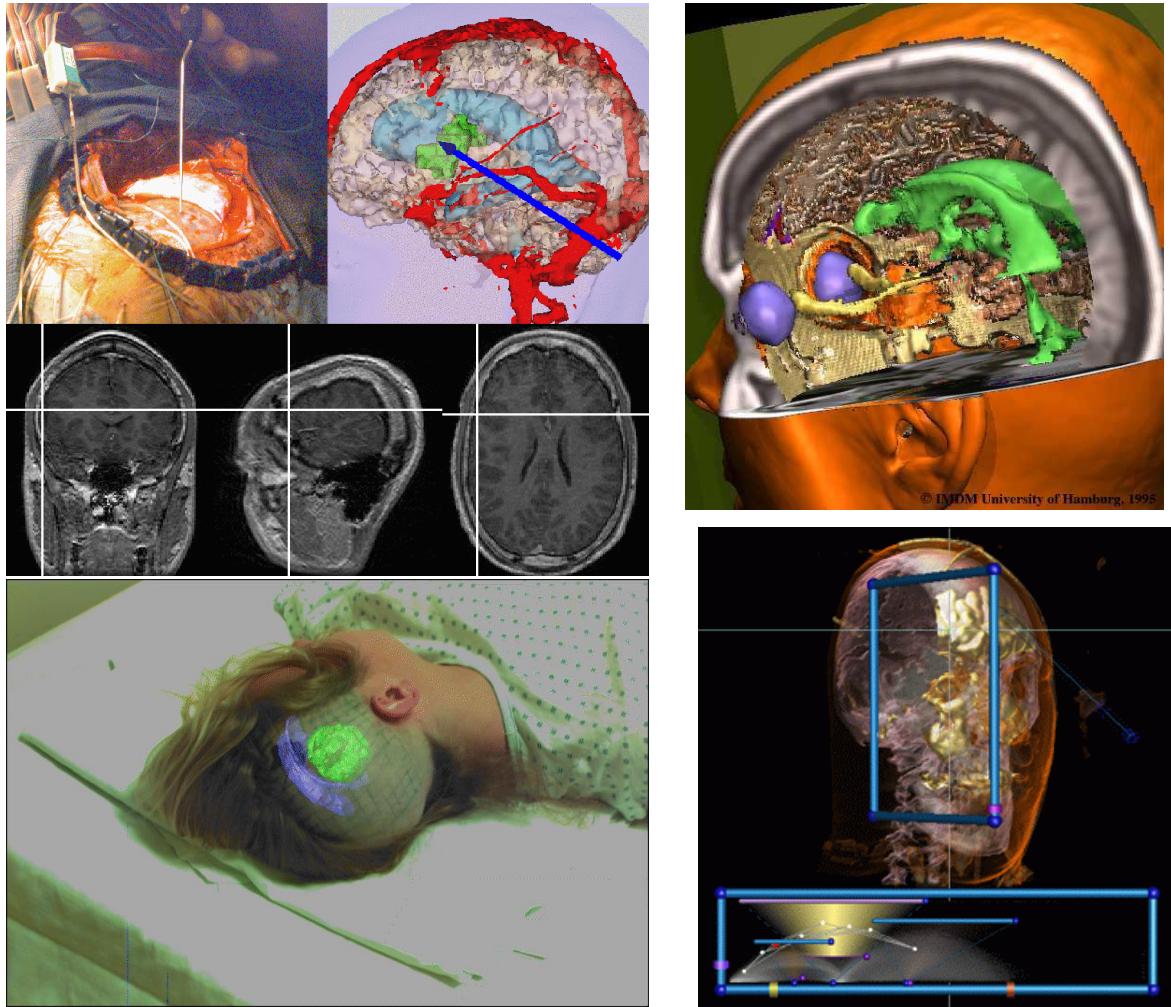
**Molecular Surface Abstraction**  
(Cipriano et al)



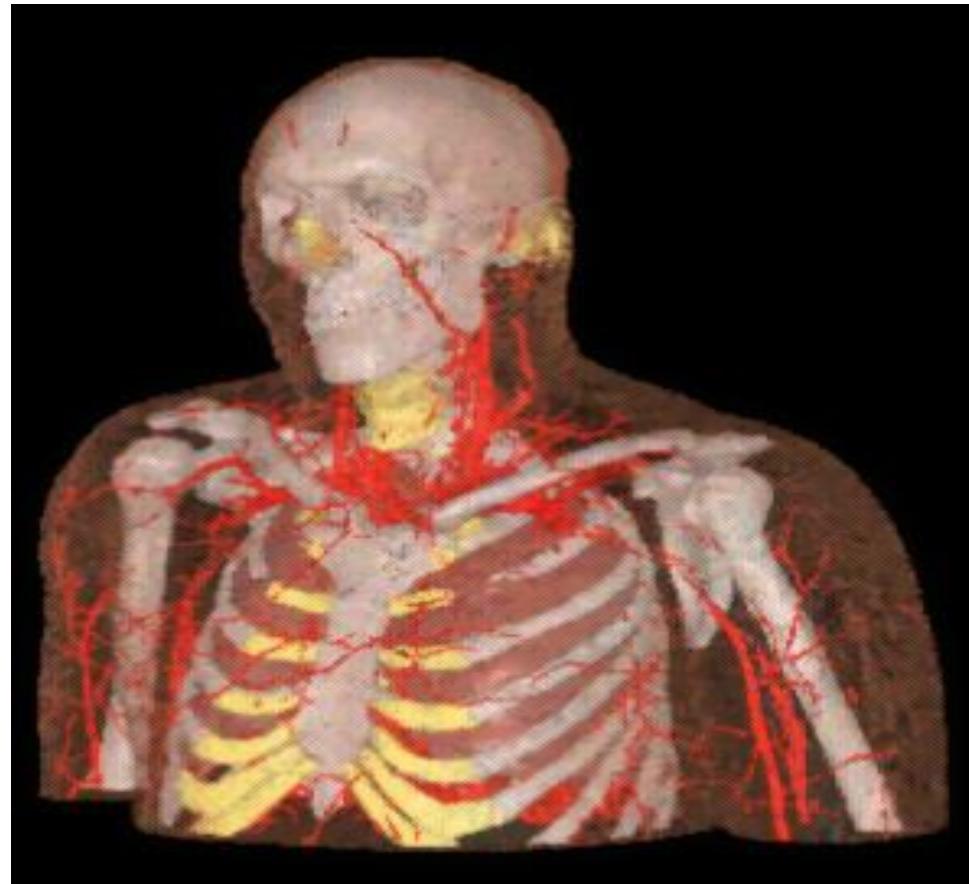
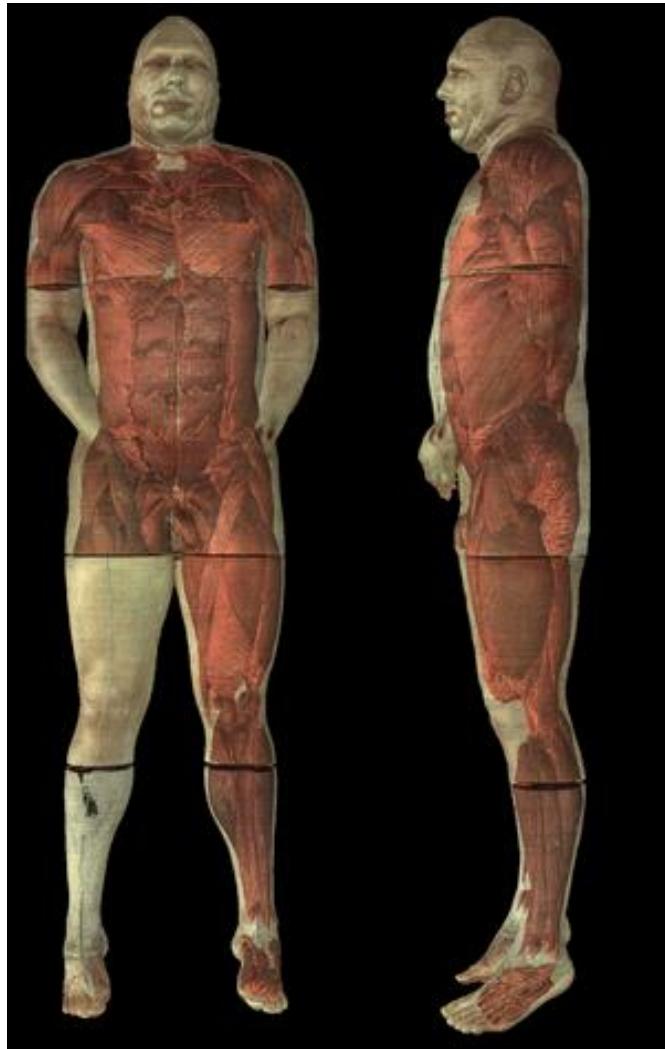
(Microsoft Research)



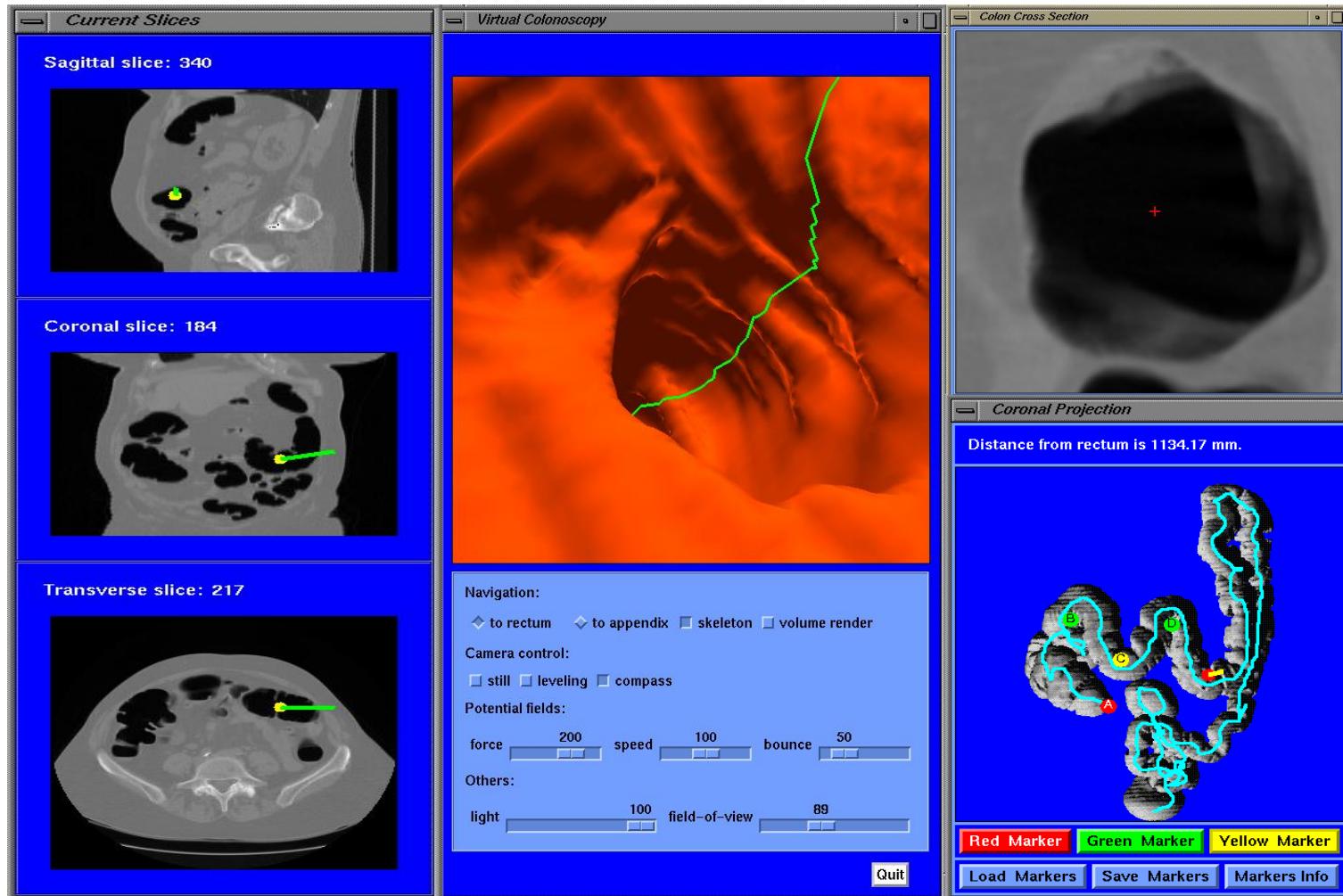
# Medical imaging



# Medical Visualization

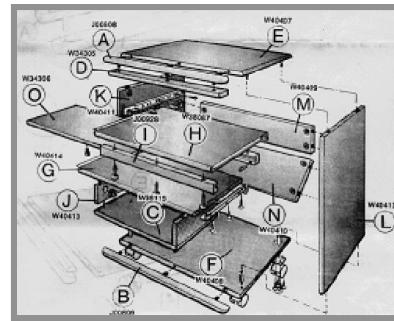


# Medical Visualization

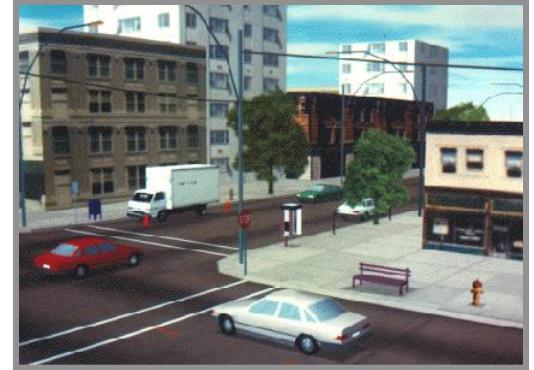


# Applications

- Entertainment
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- E-commerce
- Computer art



**Desk Assembly**  
(Silicon Graphics, Inc.)



**Driving Simulation**  
(Evans & Sutherland)



**Flight Simulation**  
(NASA)

# Applications

- Entertainment
- Computer-aided design
- Scientific visualization
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- Computer art



***Forum of Trajan***  
*(Bill Jepson, UCLA)*



***Human Skeleton***  
*(SGI)*

# Applications

- Entertainment
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***Second Life***



***Virtual Phone Store***  
*(Lucent Technologies)*

# Applications

- Entertainment
- Computer-aided design
- Scientific visualization
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- • Computer art

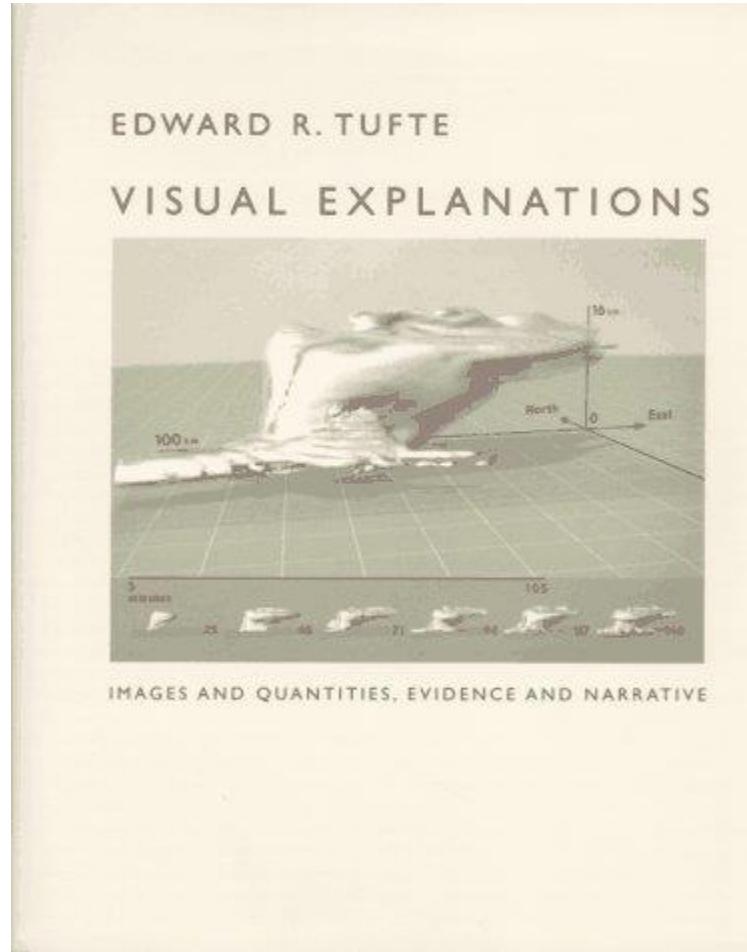


*Blair Arch*

<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



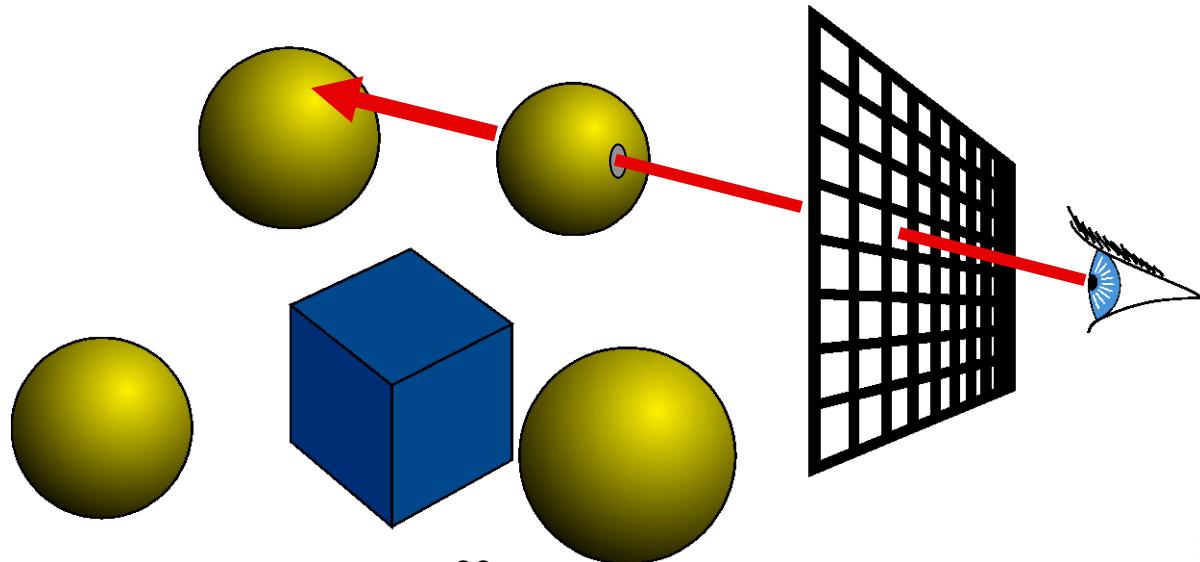
***OpenGL***



***Ray Tracing***

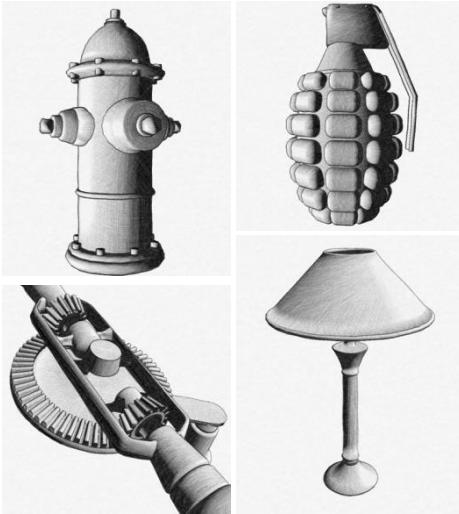
# Ray Casting

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

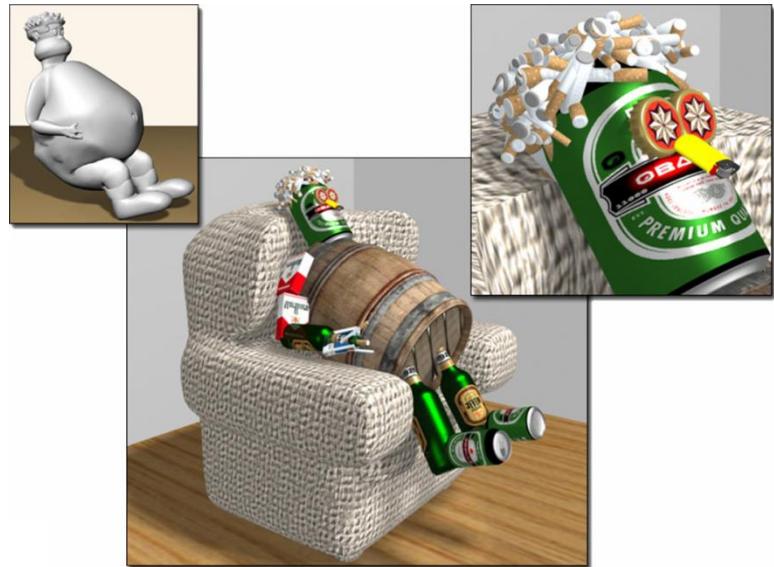


# Rendering - NPR

- Non Photorealistic Rendering



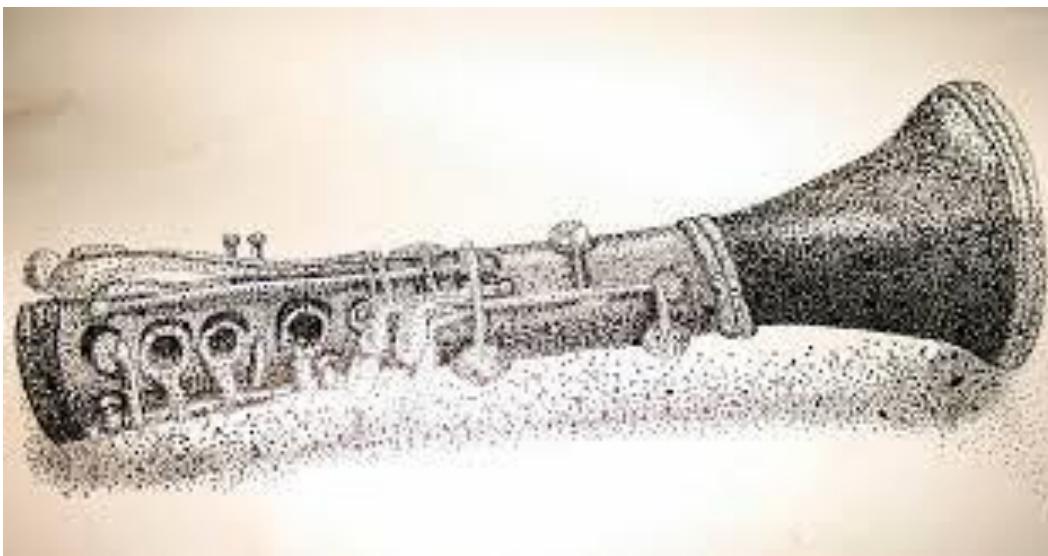
*Real-time Pencil Rendering (Lee et al)*



*3D Collage (Gal et al)*



*Zelda the Windwalker  
(Nintendo)*



# Modeling

- Representations of geometry

- Curves: splines
  - Surfaces: meshes, splines, subdivision
  - Solids: Voxels, CSG, BSP

- Procedural modeling

- Sweeps
  - Fractals
  - Grammars



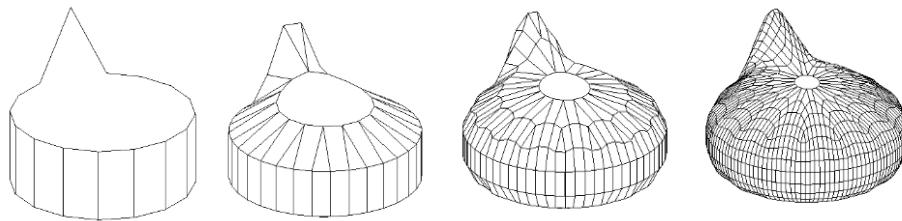
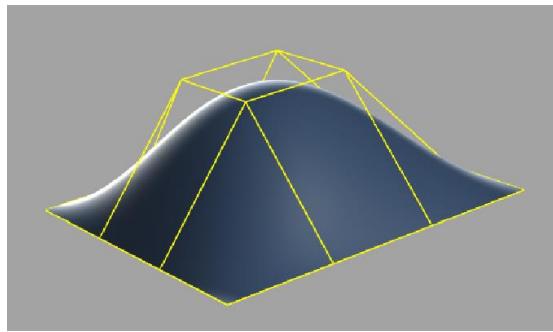
*Shell*



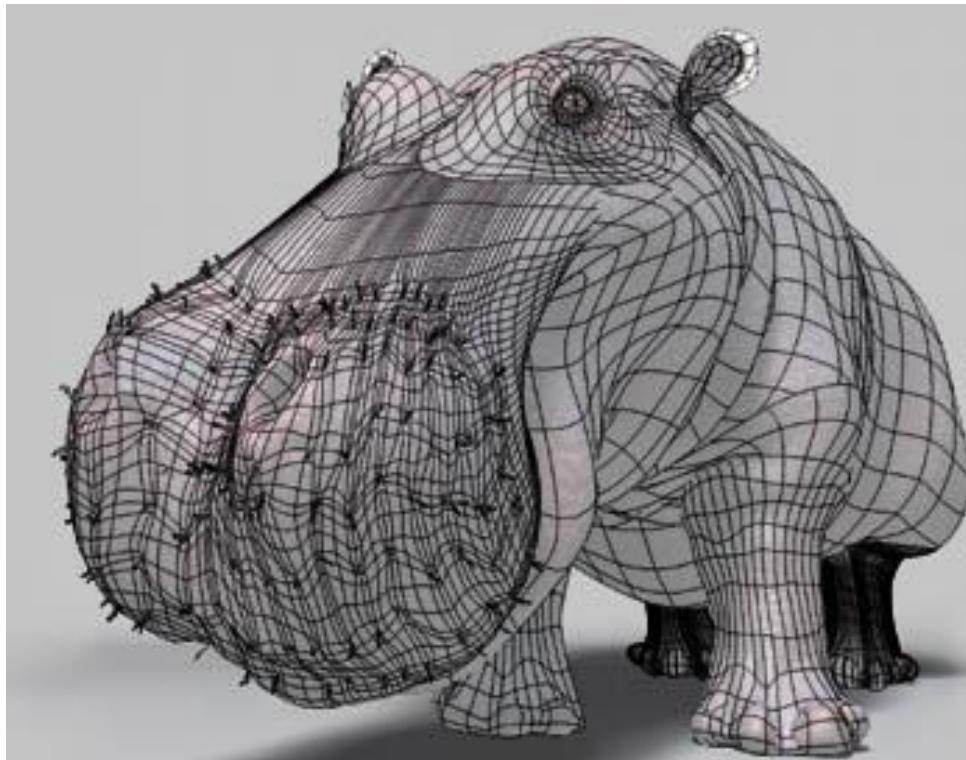
*Scenery Designer*

# 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>



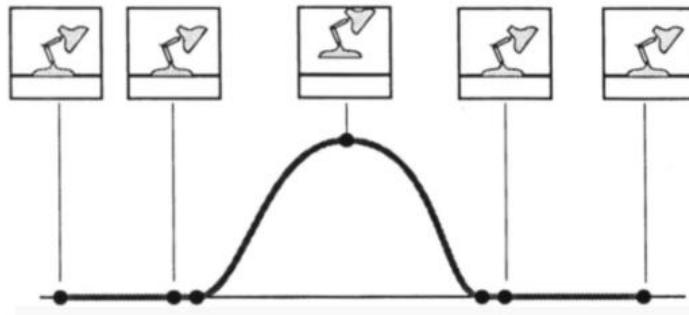
# Textures and Shading



*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"*

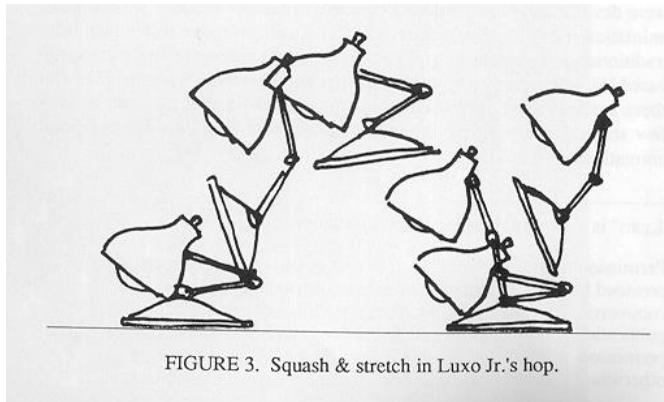


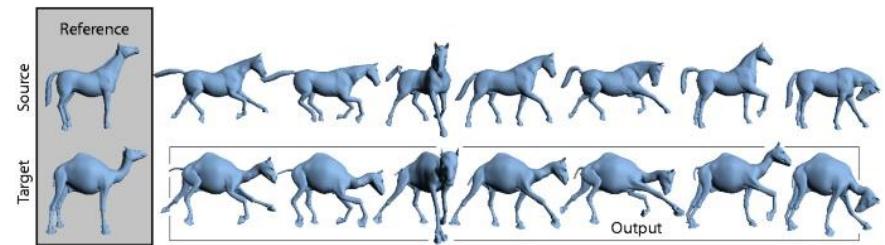
FIGURE 3. Squash & stretch in Luxo Jr.'s hop.

# Animation

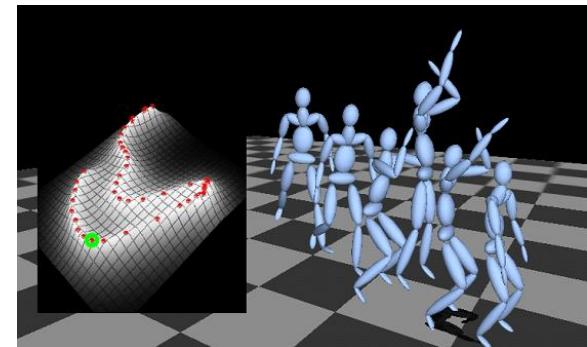


*Flocking Behaviour 1978 ( Reynolds)*

- 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)*



CGSociety.org

Copyright (C) Raphael Lacoste, submitted 02 January 2008

***"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)*

*Introduction to computer vision*



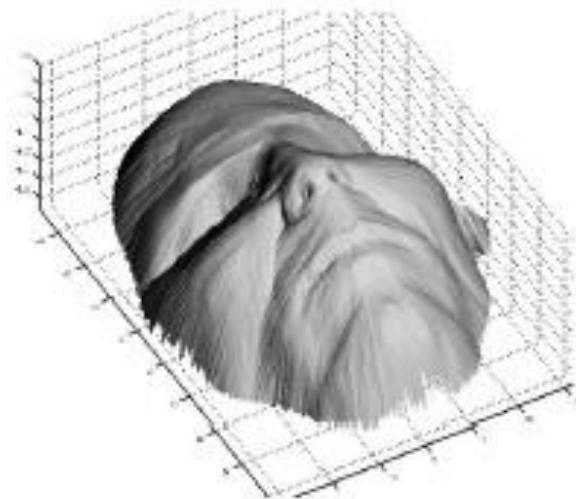
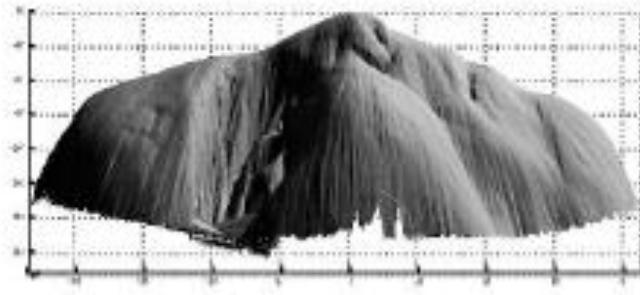
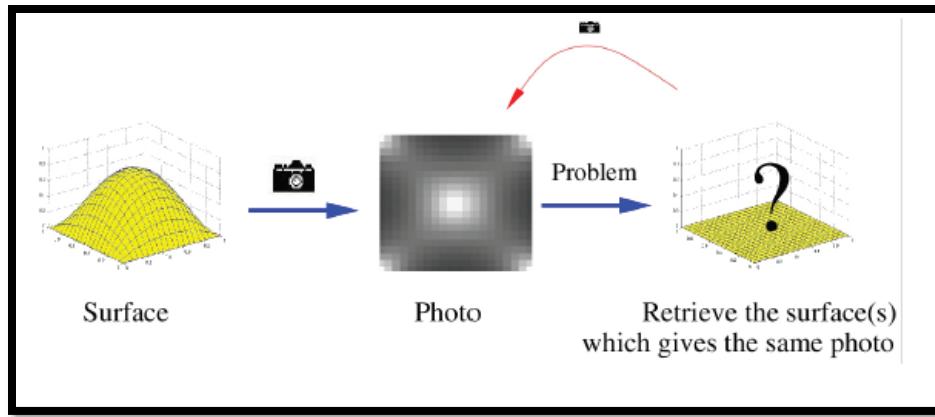
*Human Detection Using Partial Least Squares Analysis, ICCV 09*



*Image segmentation with a Bounding Box Prior, ICC 09*

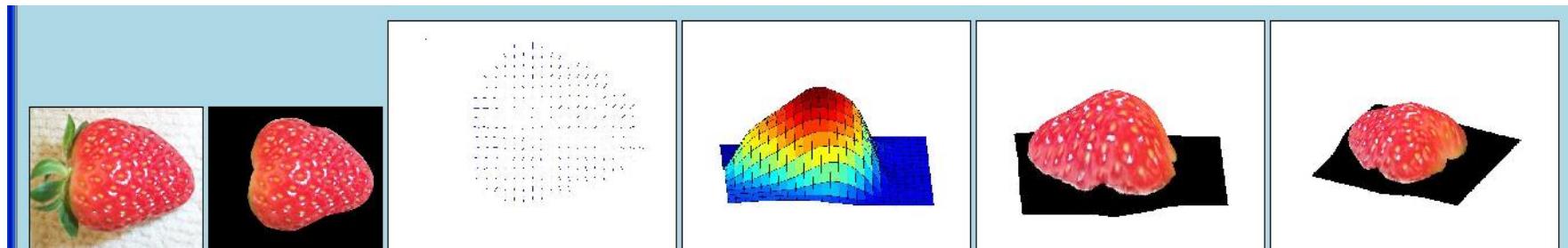
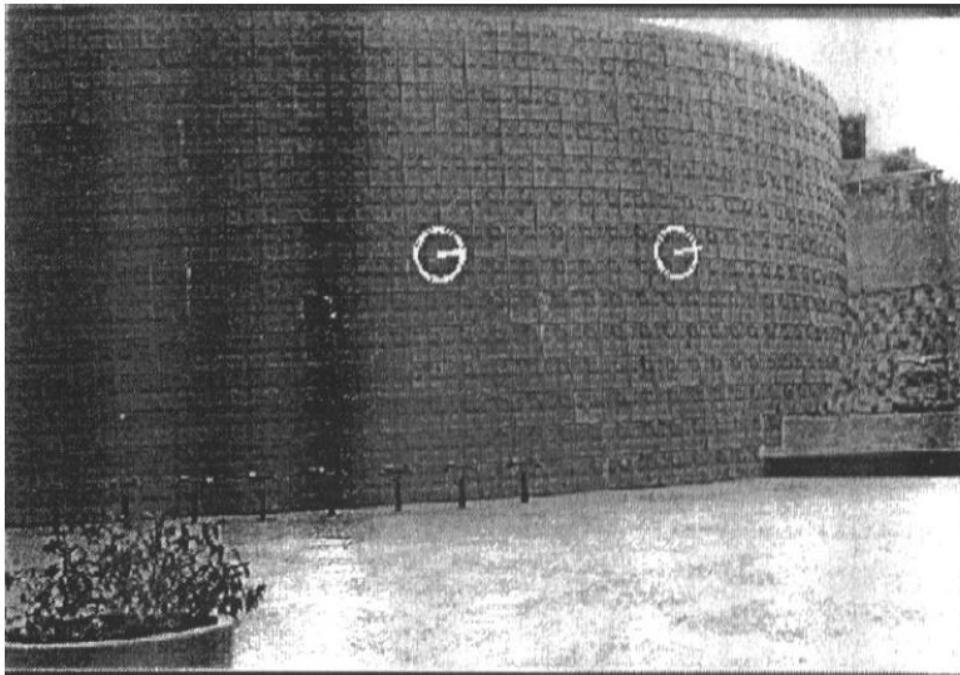


# Shape from Shading



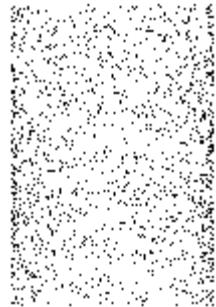
[Figure from Prados & Faugeras 2006]

# 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

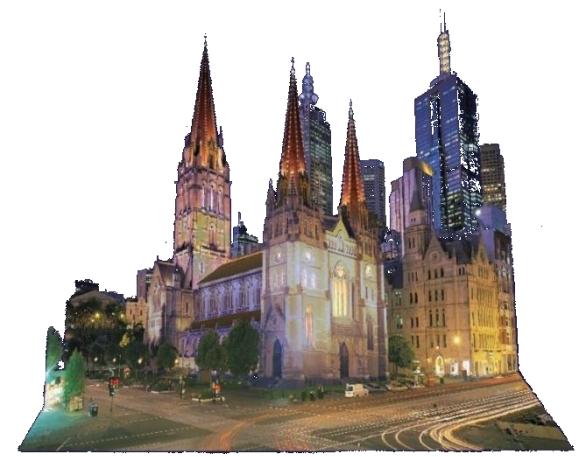
- Use images as inputs and representation
  - E. g. Image-based modeling and photo editing  
Boh, Chen, Dorsey and Durand 2001



*Input image*



*Relighting*



*New viewpoint*