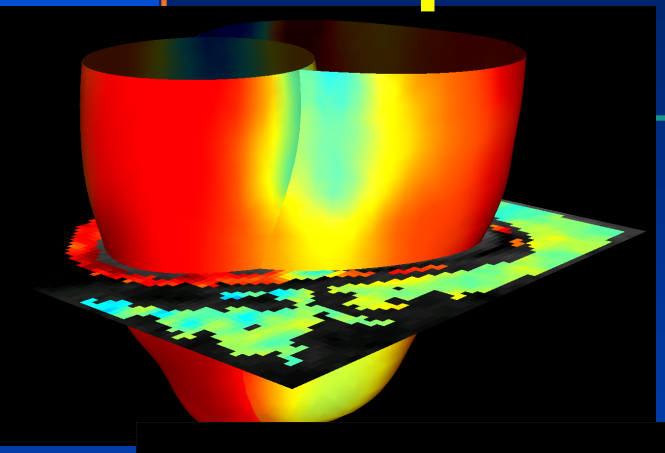
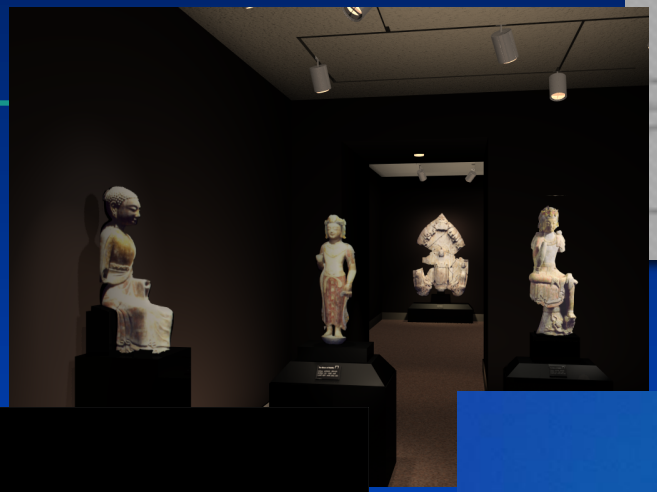
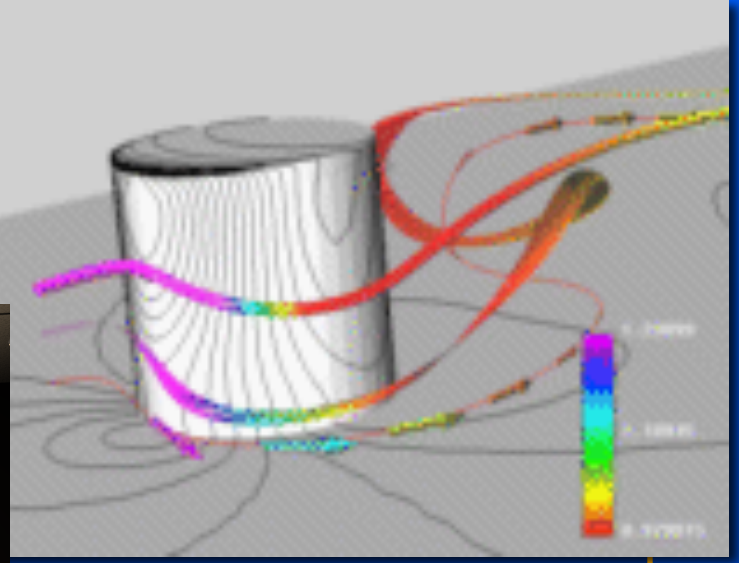
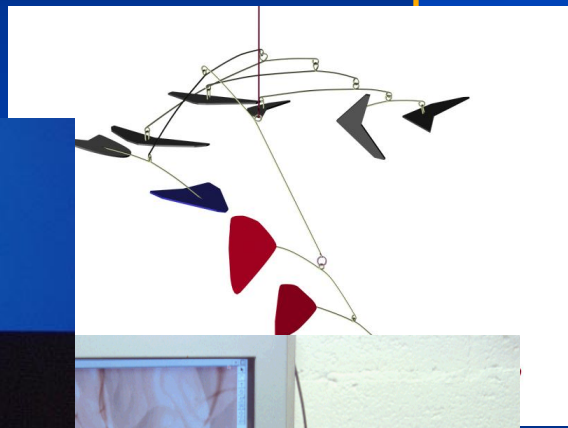
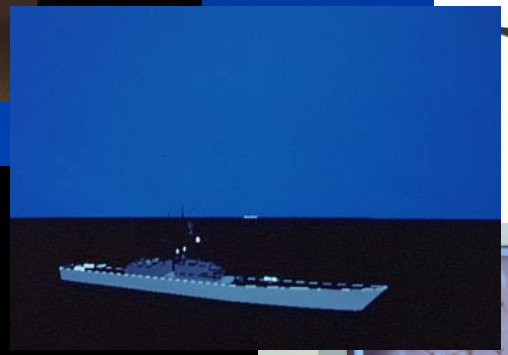
Computer Graphics

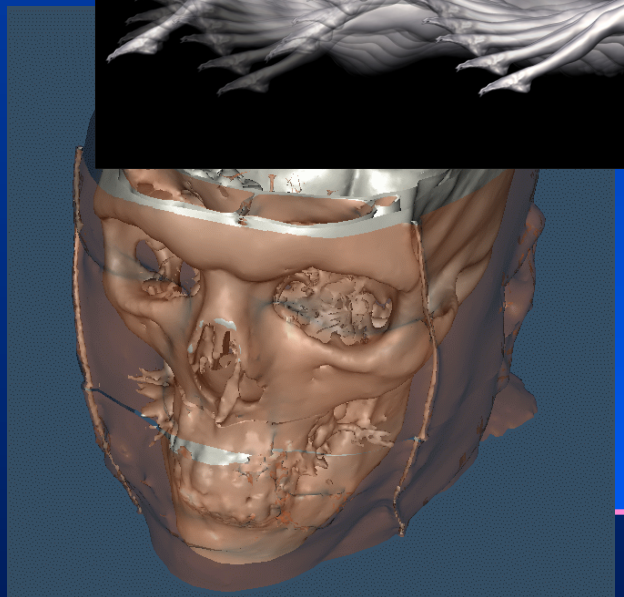












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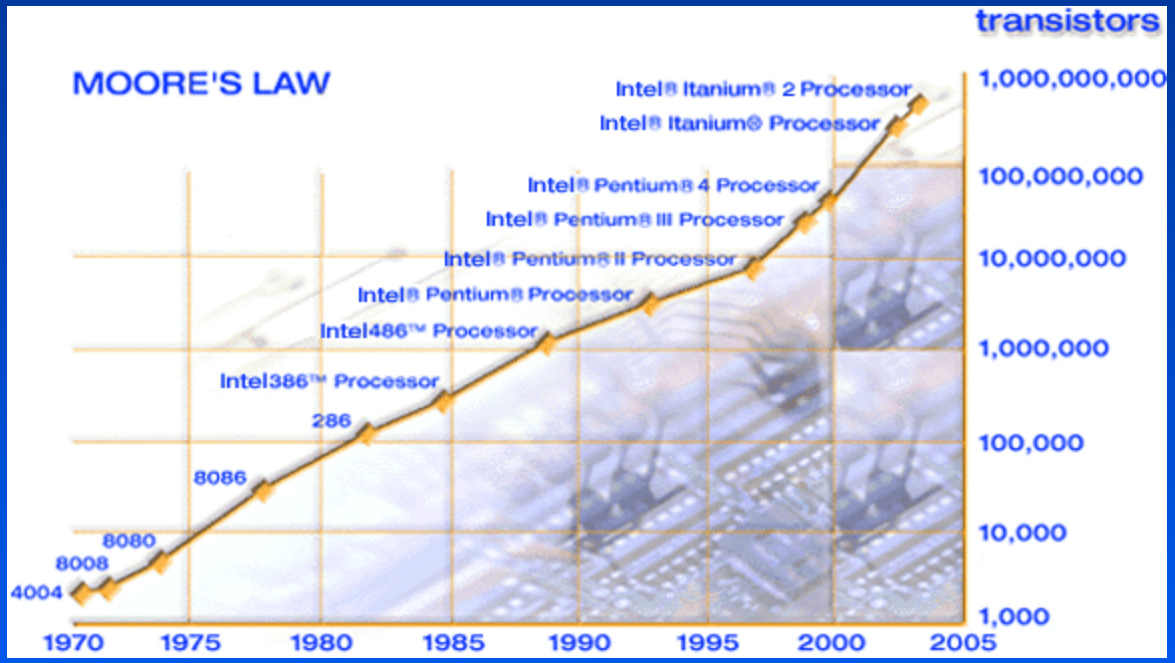
Computer Graphics

- Relatively short history of ~30 years
- Established itself as one of the most active disciplines within computer science
  - SIGGRAPH-largest SIG in ACM draws approximately 30-40 thousand participants each year
- Interdisciplinary (science, art, design, medicine, engineering, dance, archeology, …)
- Found everywhere

- Hardware enabled
  - Moore's Law: Every 18-24 months, double density of CPU
  - For GPU, double every 6 months!



Intel.com

- Driven by economics
  - Worldwide revenue from games $22 Billion
  - Bigger than movies, less than music
  - Explosive growth predicted to overtake music: 20% next 4 years as opposed to 2% music
- Ubiquitous

Why learn computer graphics?

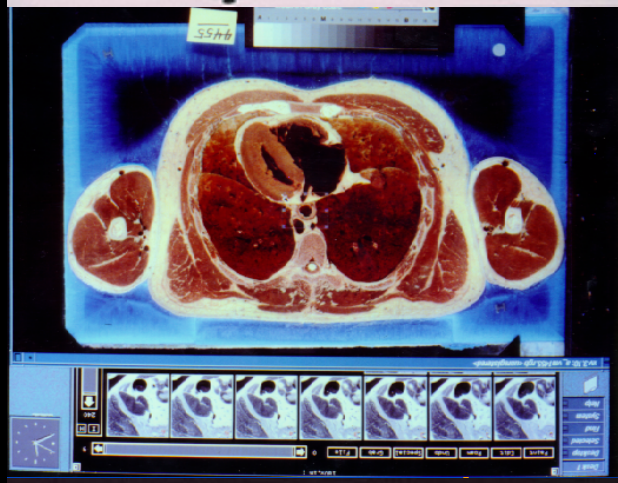
- Get ready for jobs in games, production, visualization, medicine, etc.
- They are everywhere… how did they do that?
- Computer graphics is about communicating information visually important in all fields
- It is fun!

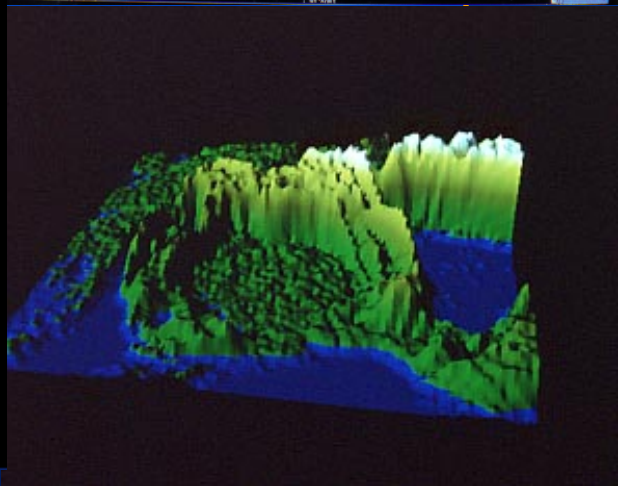
What is Computer Graphics?

- Computer Graphics
  - Modeling (create virtual worlds)
  - Rendering (create image)
  - Animation (create motion)
- Human Computer Interaction
- Multimedia
- Applications
  - Games, Movies
  - Visualization, Simulation
  - Medicine, Business, Engineering

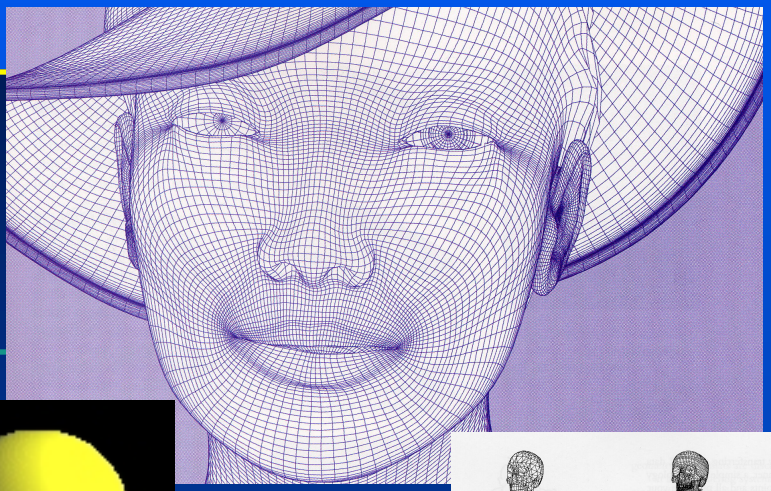
Modeling

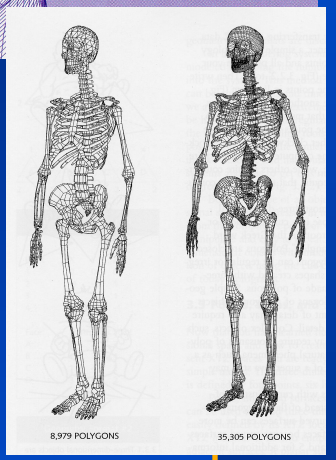
- Reproduce (in virtual world) the real world
  - 3D printers: Real world reproducing virtual world
- Digitized from real models
- Construct using modeling package
  - E.g. Maya, Max, etc.
- Algorithmic (e.g. fractals)

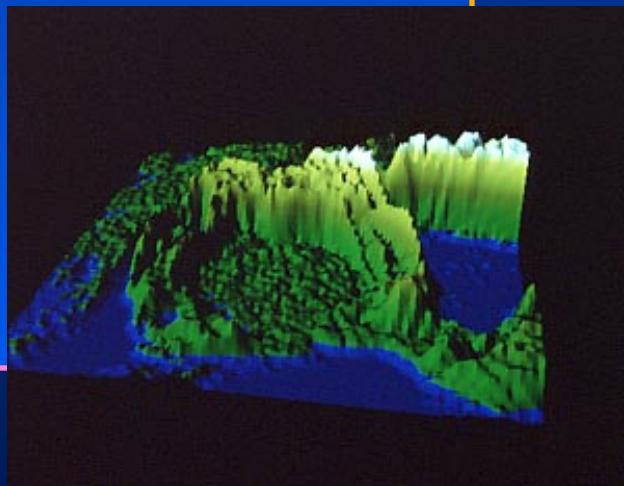




- Representation
  - Polygons
  - Surface patches
  - Point clouds
  - Volumes
  - Implicit surfaces
  - CSG
  - Levels of detail
- Algorithmic models
  - Fractals

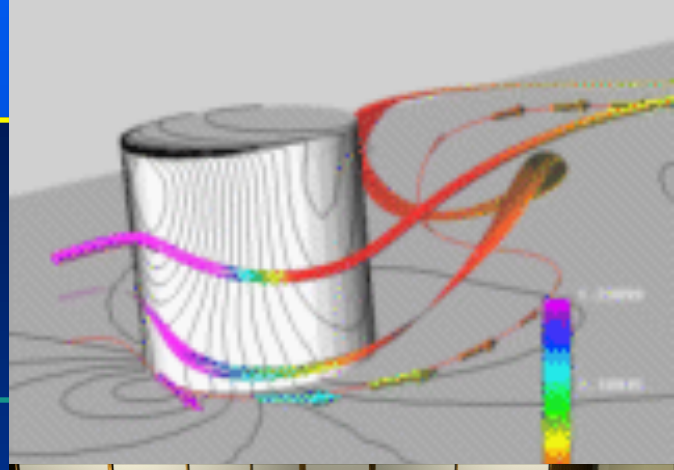


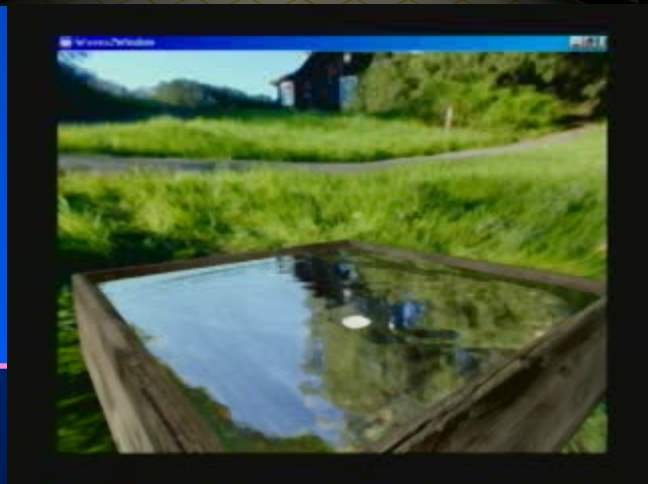




Rendering images

- Creating computer images of the virtual world
- Photo-realism
  - Virtual camera models
  - Illumination models simulate physics of light
- Information visualization
- Realtime performance for games using GPU
  - Approaching realism of film

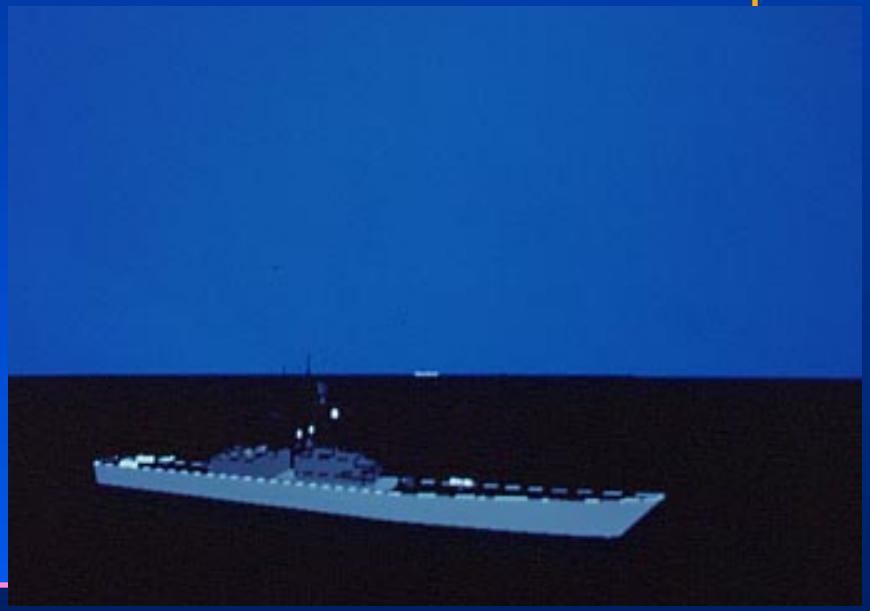




Rendering

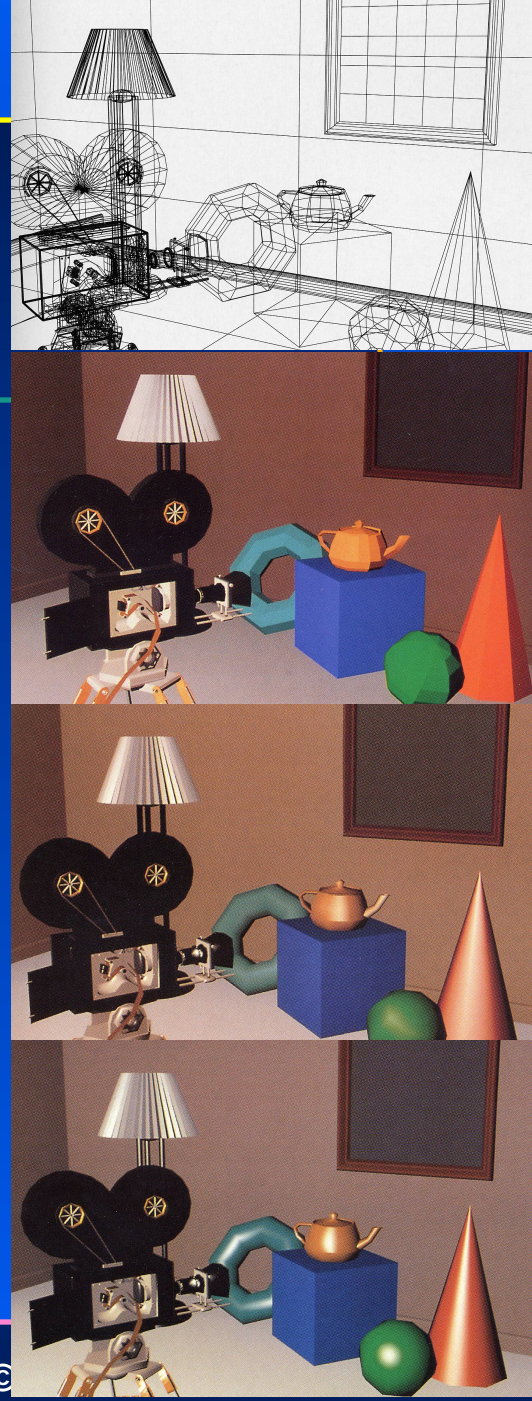
- Per-polygon processing
  - Viewing transformation
  - Hidden surfaces
- Per-pixel processing
  - Scan conversion, hidden surfaces
  - Shading and illumination

- Shading
- Illumination models

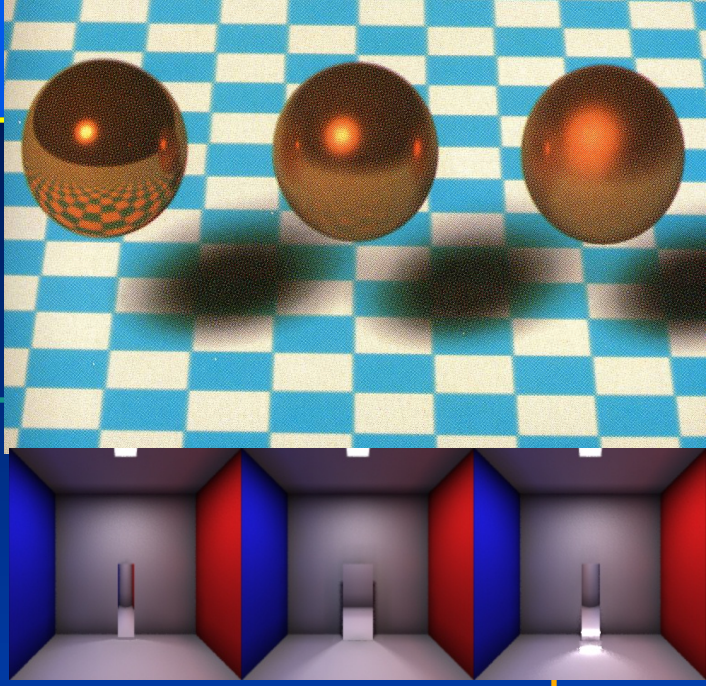


Shading

- Determination of pixel values
  - Shading models tell you when to invoke the illumination model
  - Illumination models tell you how to calculate light intensity
- Wireframe, Constant, Gouraud, Phong
- Anti-aliasing, Shadows
- Ray-tracing is both a shading and illumination model



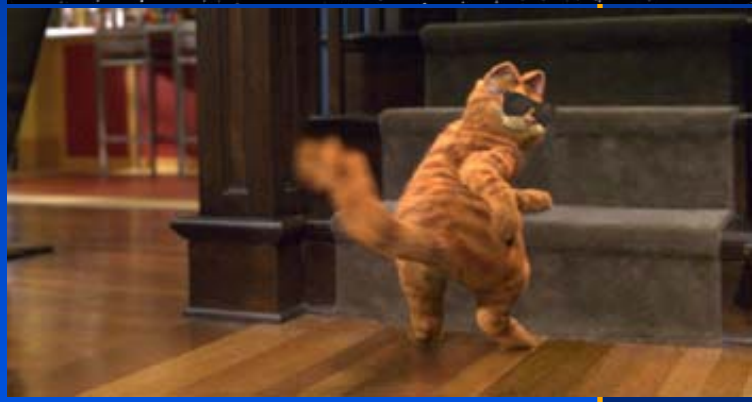
Illumination models



- Local
  - Model light transport from source to surface to camera
- Global
  - Model light transport via multiple bounces
  - Ray-tracing, Radiosity
- Need to model interaction of light with surface and participating media
  - Surface characteristics: BRDF

Compositing

- Combine a number of images
- Create illusion that images happened at same time and same place
- Blue screen to create mattes
- Matchmoving
  - Drop a virtual creature in a real scene with moving camera



Texture Mapping

- Add detail without complexity
- Color, reflection (environment map), surface normal (bump map), specularity, transparency, displacement
- 2D, 3D
- Transformation from texture space to surface
- Procedural texture maps
  - 1/f noise, Perlin noise
- Anti-aliasing

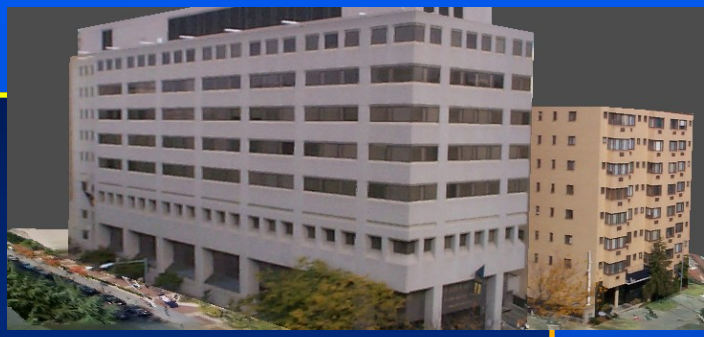
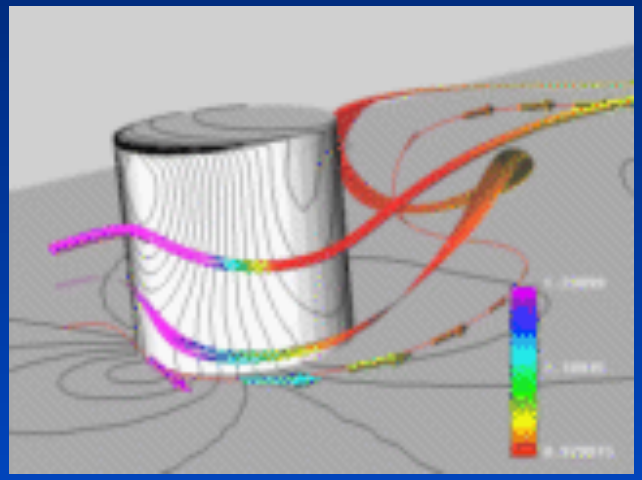


Image-based rendering

- Use real photographs
- No 3D models of objects
- Fast, realistic
- Where computer graphics meets computer vision and image processing

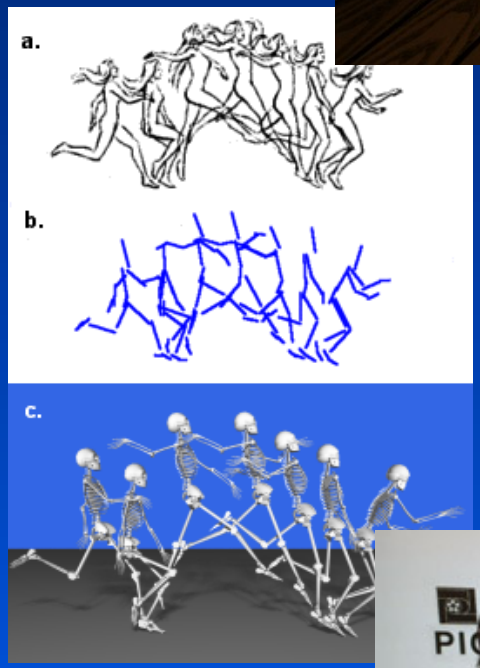
Volume Rendering

- Mathematical model
  - CFD (Computational Fluid Dynamics)
  - FEM (Finite Element Models)
- Medical Digitization
  - CT (Computed Tomography)
  - MRI (Magnetic Resonance Imaging)
- Extraction of surfaces (Marching Cubes)
- Direct volume rendering (Ray-tracing)



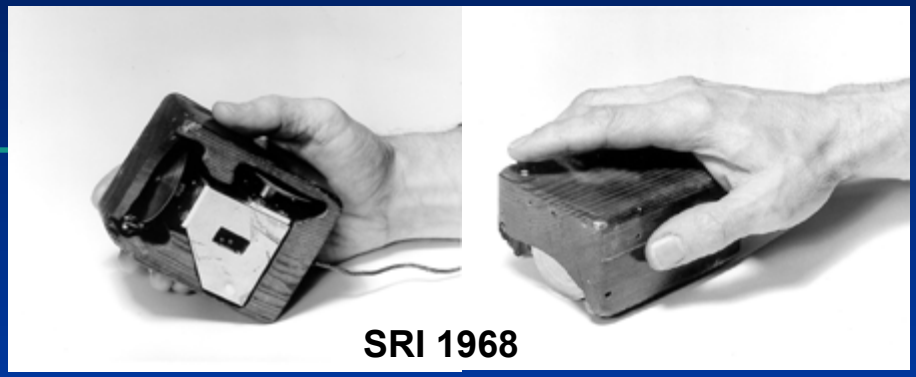
Animation: Motion Control

- Motion of actors (objects) in virtual environment
- Key-framing
- Behavioral
- Algorithmic
- Physics-based
- Motion capture
- 6555 Computer Animation



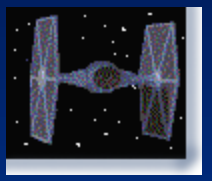
Human Computer Interaction

- Historically, I/O lag behind computation
  - Anthropologist in the future conclusion about us based on I/O devices?
- Windows Icons Mouse Pointer (WIMP) metaphor… alternatives?
- Haptic and tactile senses
- Immersion



SRI 1968

Sound



- Sounds are more subconscious than visuals
  - “Back door” vs “Front door”
- Sounds are “impressionistic”
  - Can of dog food and Terminator II?
- Sounds are cheaper to produce than visuals
- Sounds reinforce each other (we see actor shout, we hear shouting)
- Sounds could counterpoint each other (we see actor shout, music tells us that he is happy)

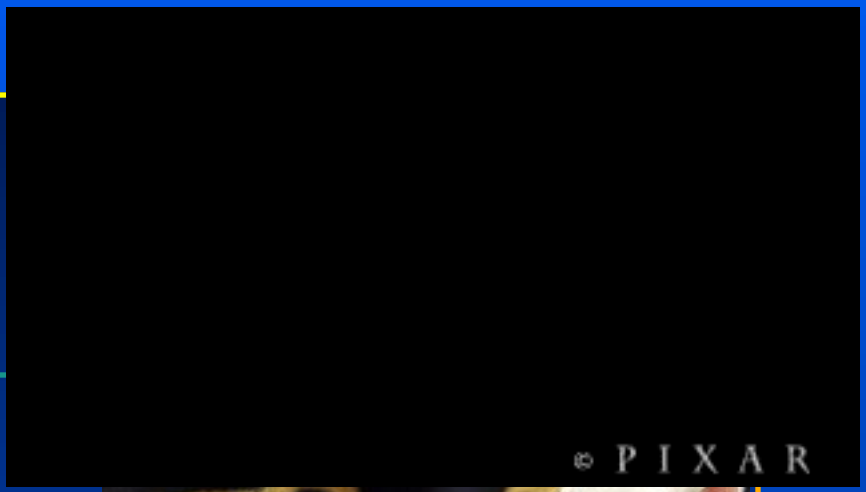
Virtual Reality

- More bandwidth between user and virtual world
- Interfaces exploit skills user already has
- Increased realism
- More flexible, cheaper, risk-free than “real world”

Sutherland, HMD, 1967

Applications: Movies

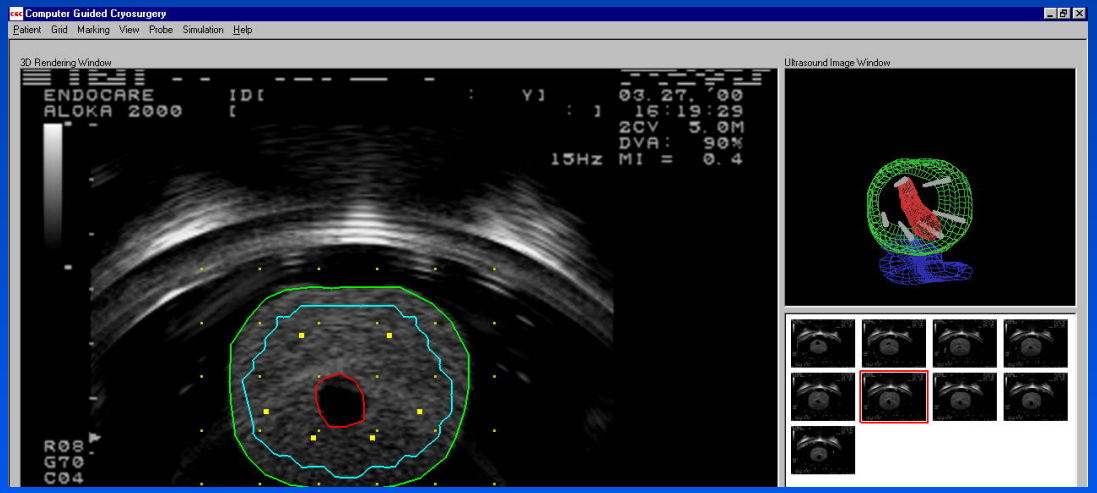
- Toy Story lead the way to a series of computer animated full-feature movies
- GW Alum:
  - Visual effects supervisor for Golden Compass (Academy Award), Life of Pi (Academy Award), Stuart Little I and II, Elf, MIB, etc.
  - Technical director for Toy Story I and II, etc.

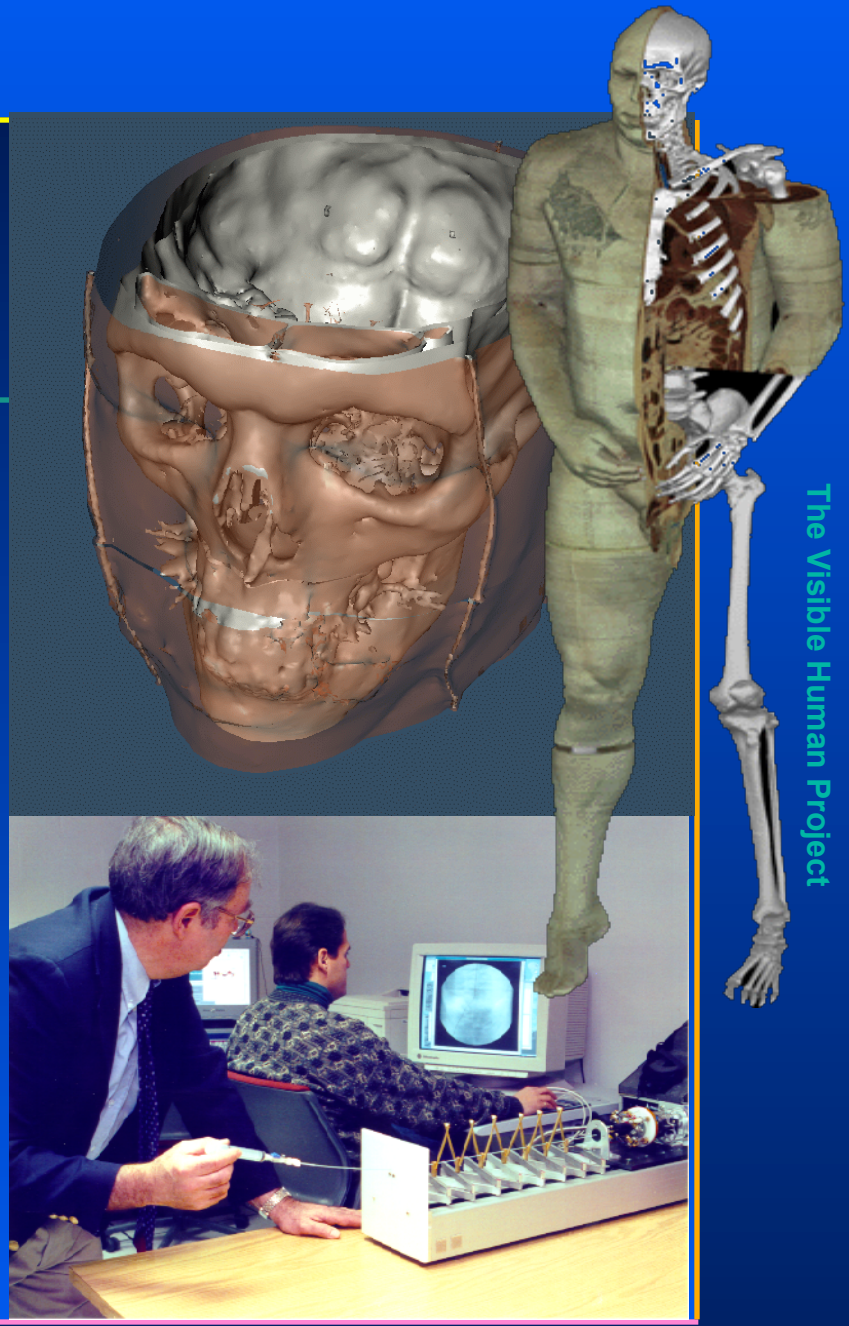


- Virtual actors replace real?

Medicine

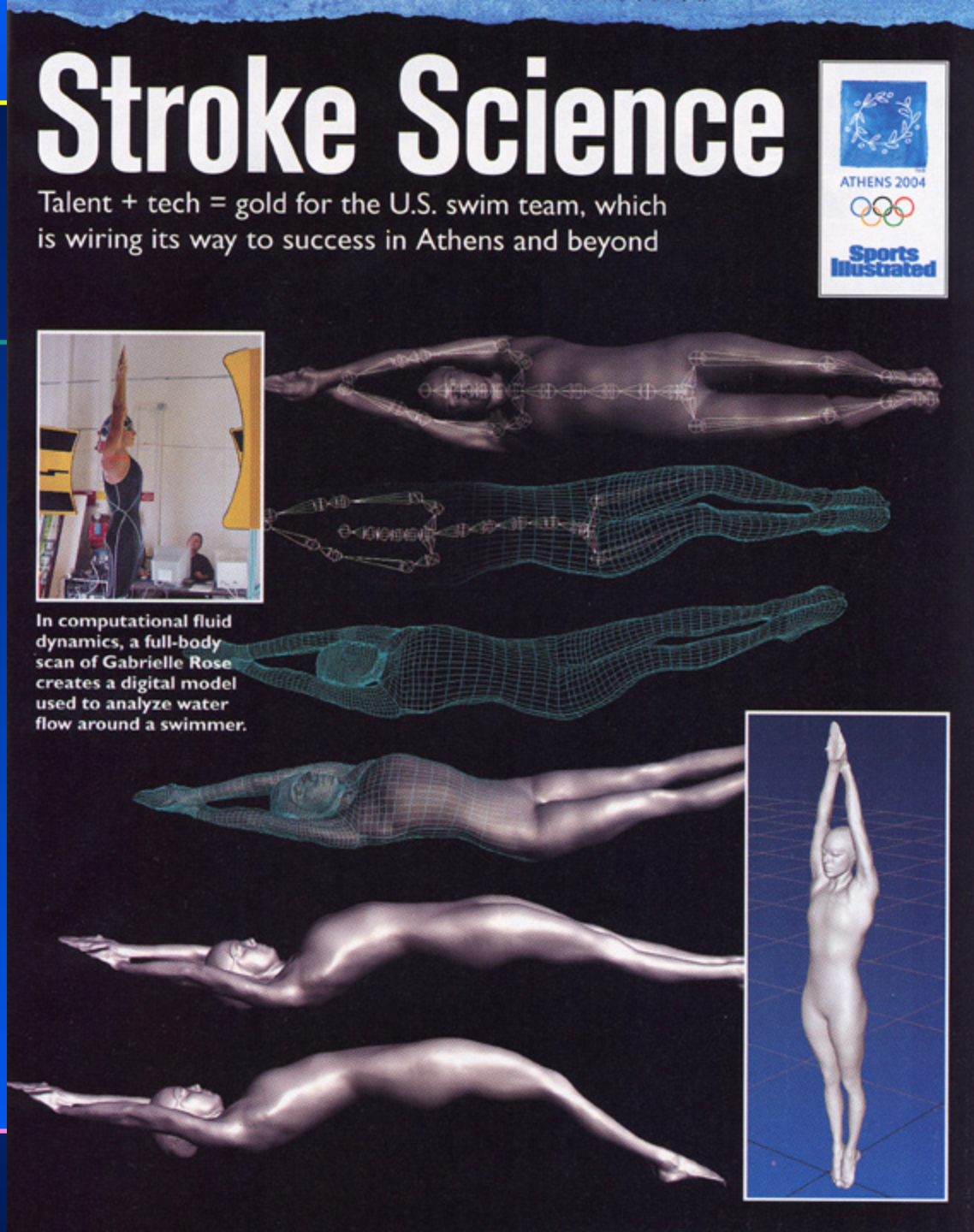
- Visualization
- Training
- Image-guided procedures



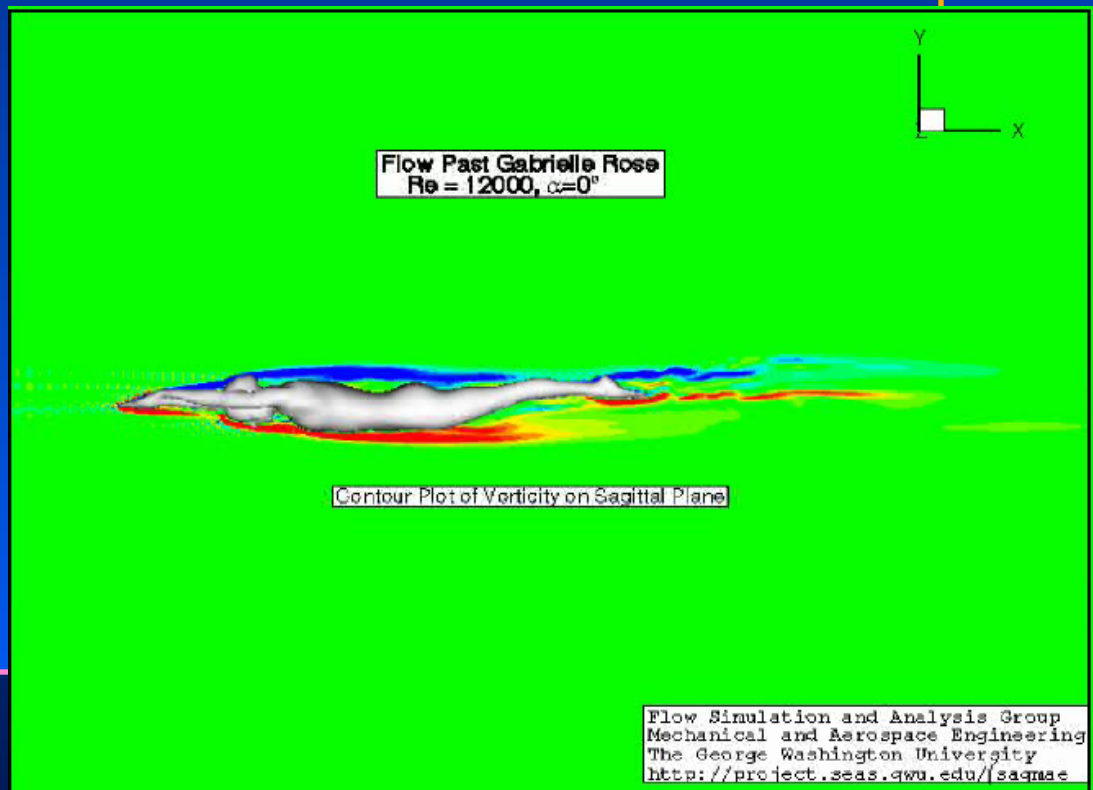


The Visible Human Project

- Olympic project

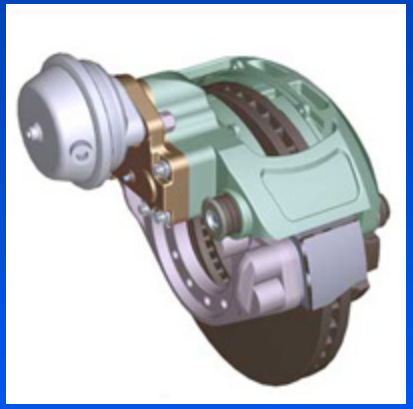


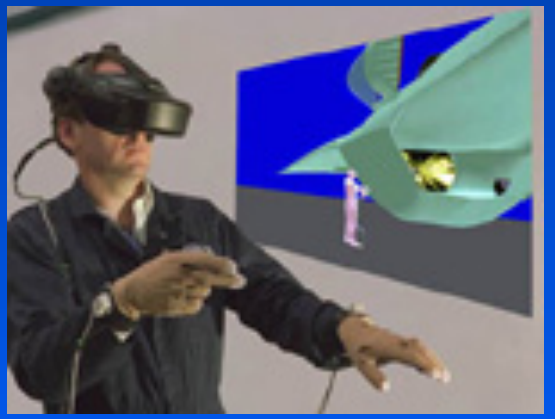
Full Body Analysis of Swimming Techniques



Manufacturing
CAD/CAM

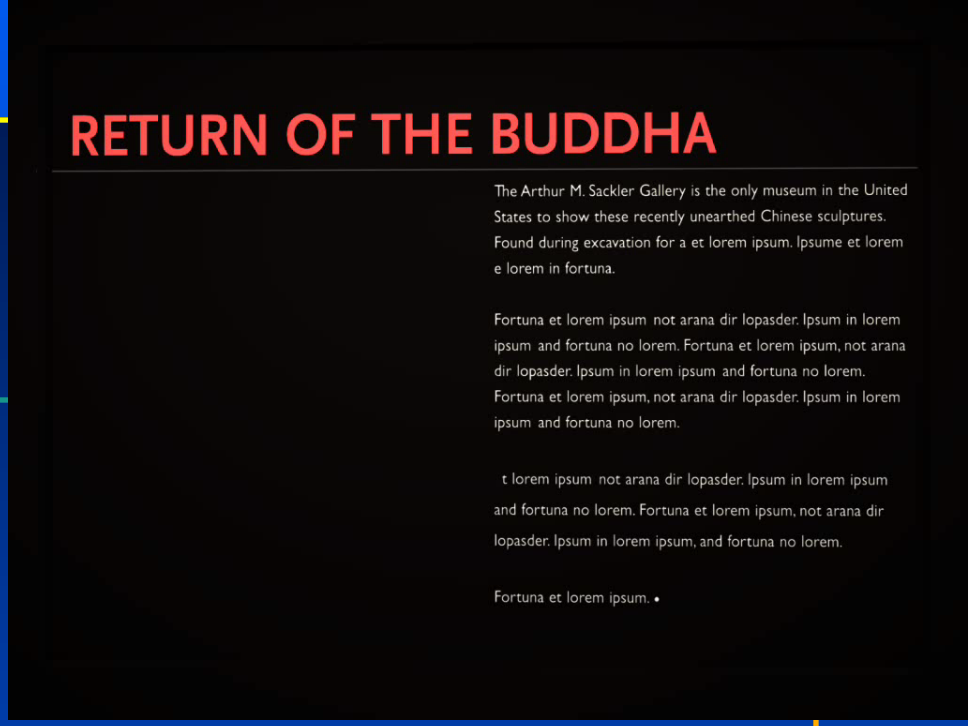
- Designing, prototyping

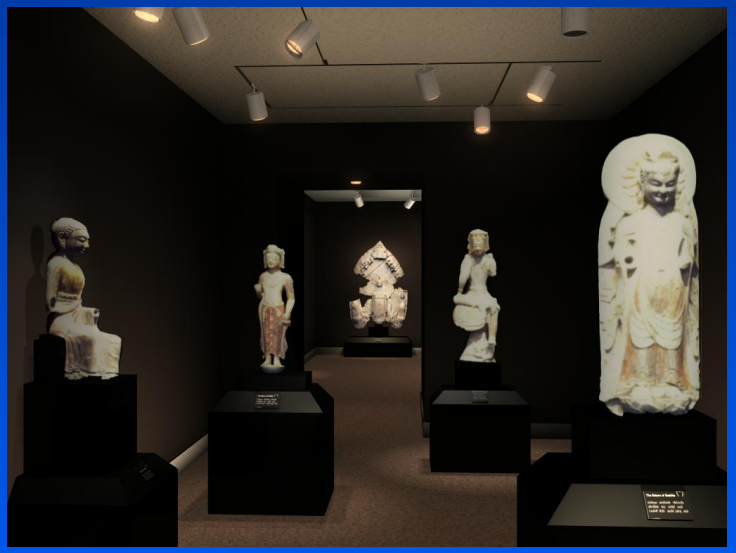


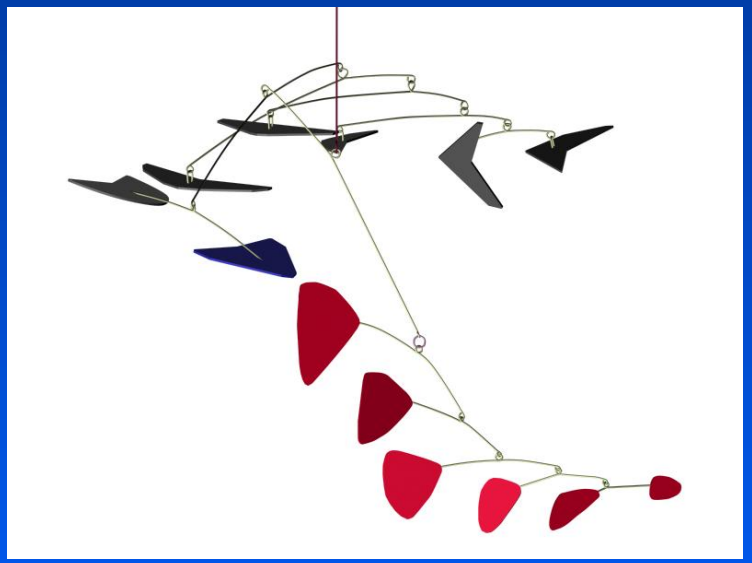


Product development marketing

- Building walkthrough
- Interior design





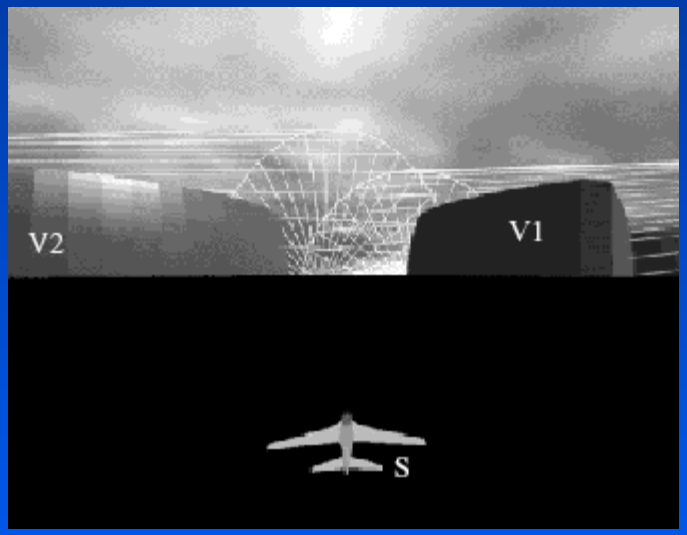


Games

- Console, PC, Location-based
- Rise of networked/internet-based games

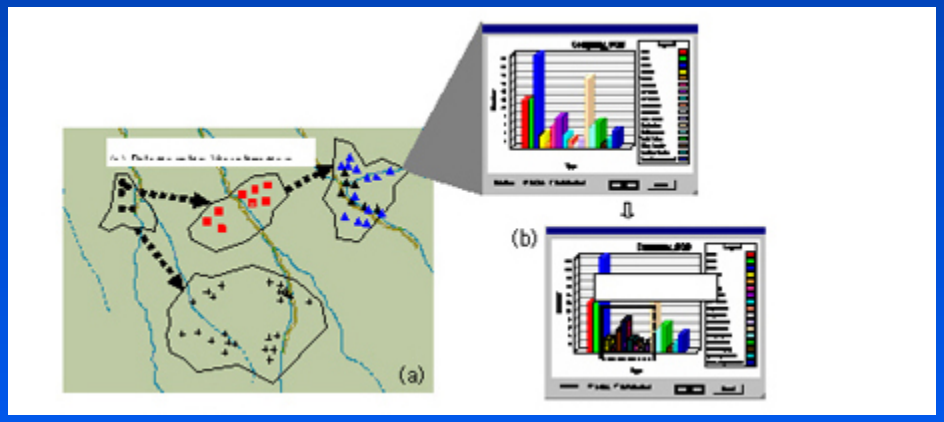
- Game from GW alum

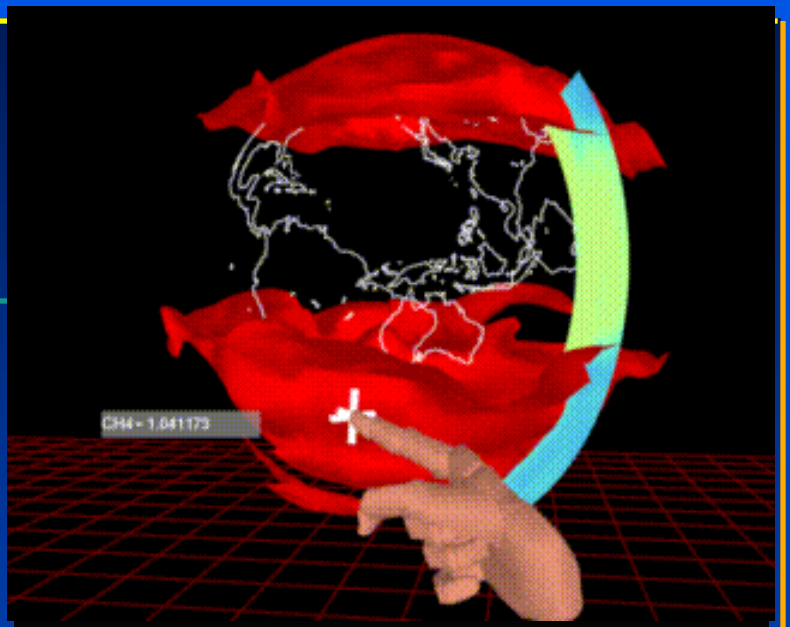
Military training mission rehearsal

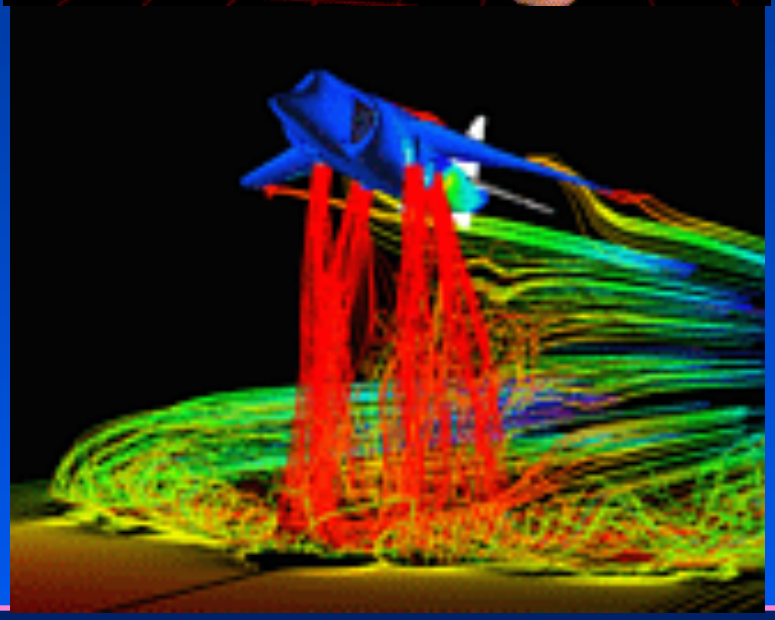


Information Visualization

- Exploration of data
- Process of discovery

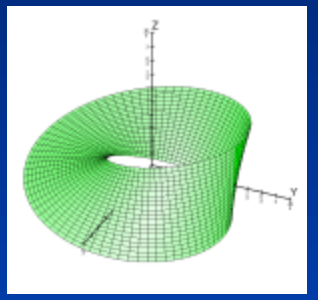






Education

- Teaching math, physics, history, etc.

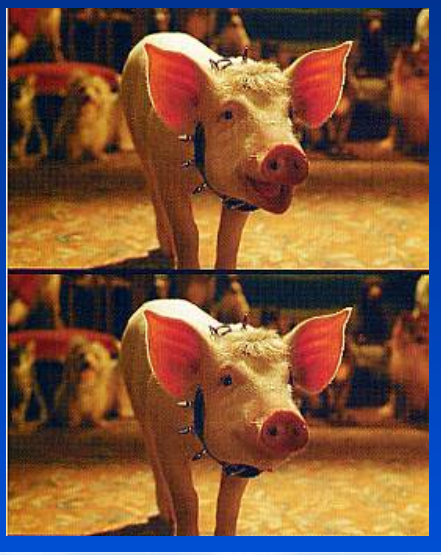


Sunrisevr.com

Forensic Animation

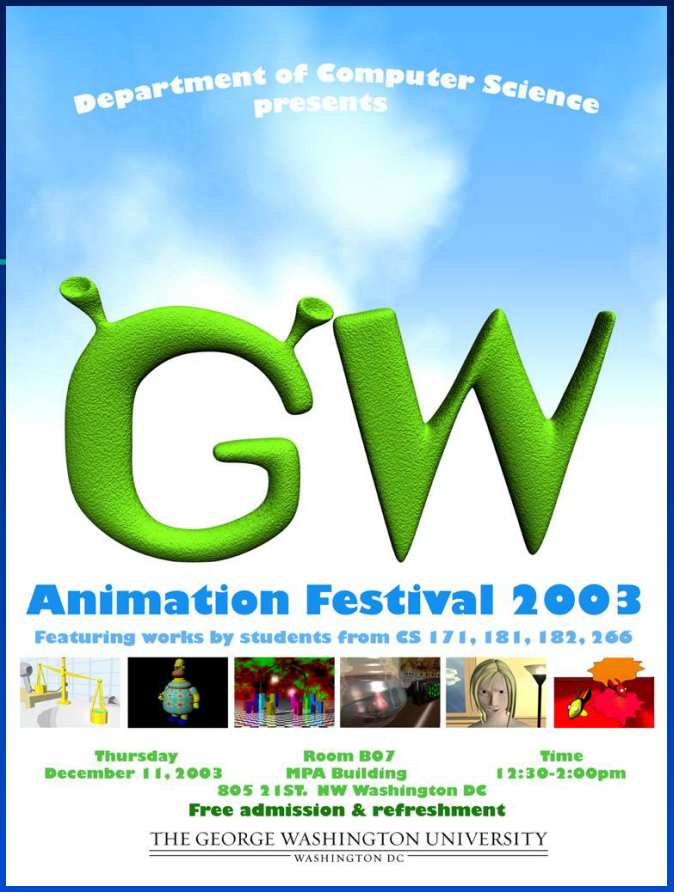
Alumni

- PIXAR:
  Technical Director
  (Toy Story, Monster's Inc, etc.)
- Rhythm & Hues:
  Visual effects supervisor
  (Academy Award for "Golden Compass" and "Life of Pi"
  Nomination for "The Chronicles of Narnia: The Lion, the Witch and the Wardrobe"
- Computer Games:
  CEO, Designer, Management, Sound producer
- Engineering, Medical, Business, Academia



Courses

- Computer Graphics (non programming)
  CSCI 4551
- Computer Animation (non programming)
  CSCI 4552, 4553
- Game Design
  CSCI 4455
- Computer Graphics
  CSCI 4554, 6554
- Computer Animation
  CSCI 6555
- Advanced Topics
  CSCI 8554



What to expect from the course?

- Learn fundamentals of computer graphics
- Solid foundation in computer graphics
- Will not learn to use packages
- Will implement a complete renderer from scratch
- 5 assignments (each building on the previous)
- Midterm and Final
- Upload assignments on Blackboard