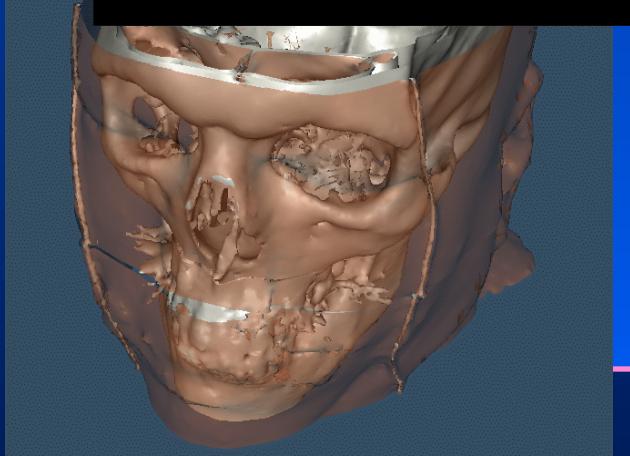
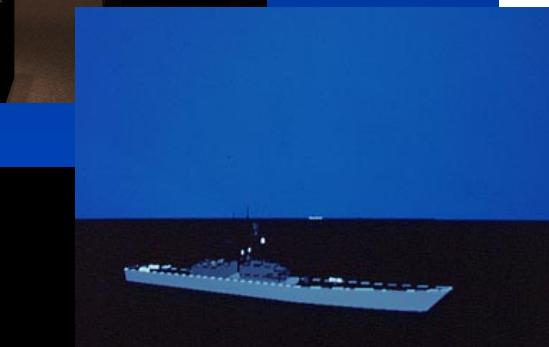
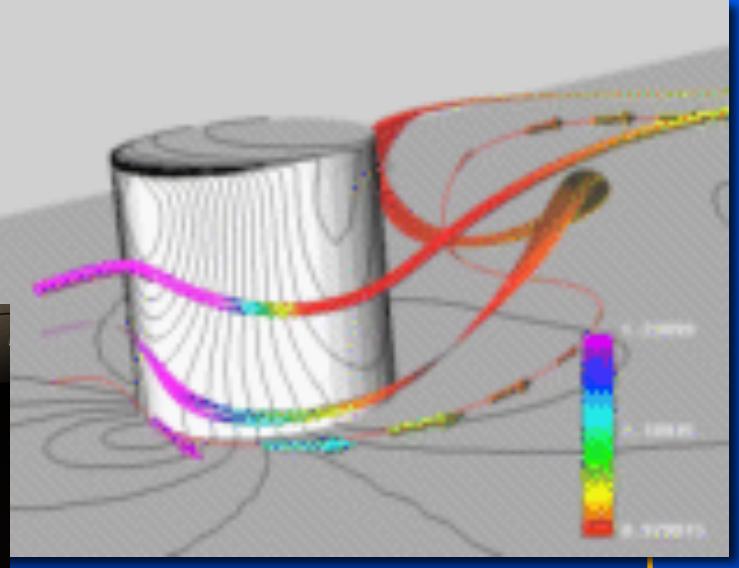
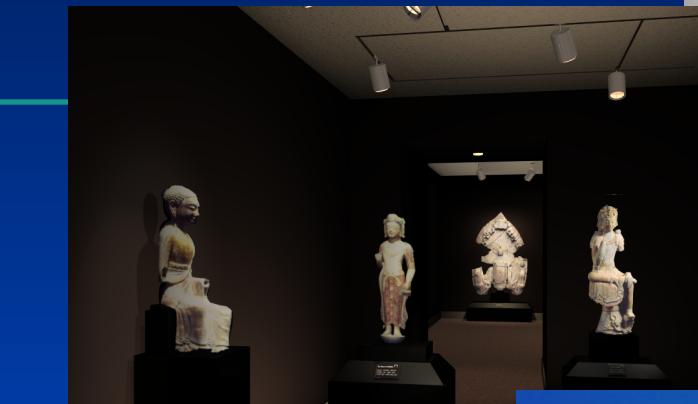
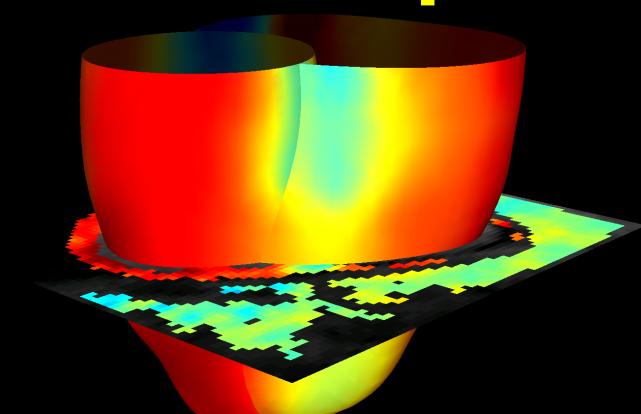


Computer Graphics



JAMES K. HAHN

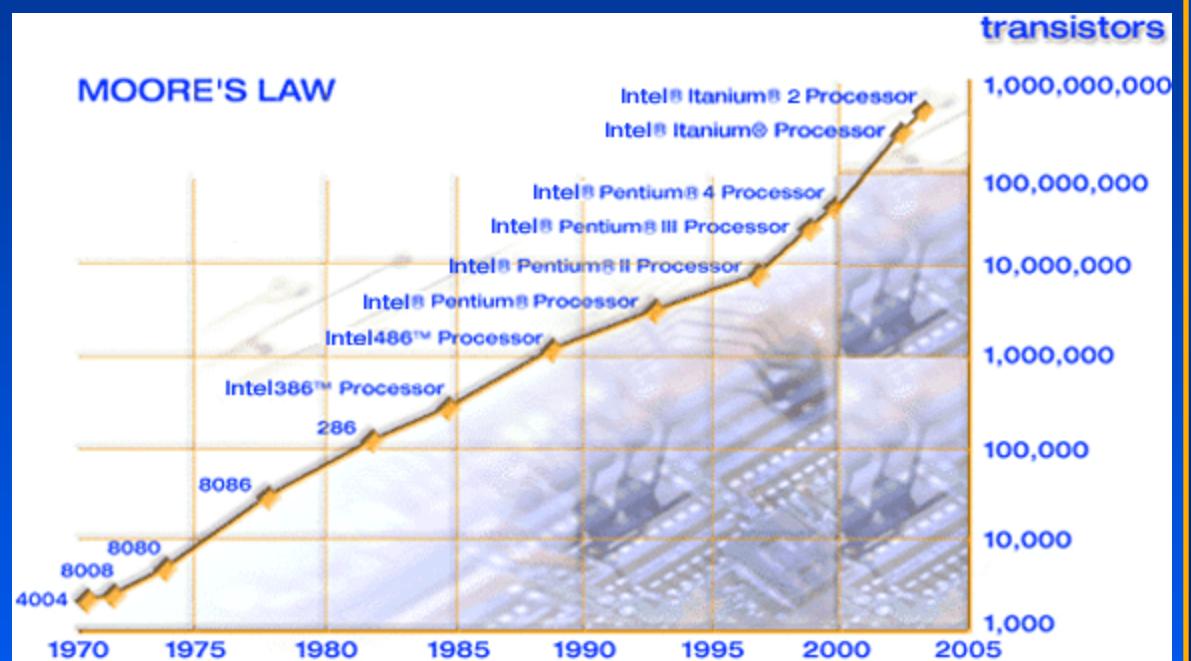
- Director Institute for Computer Graphics
Director Institute for Biomedical Engineering
- Professor of Computer Science
Professor of Computer Medicine
- Academic Center 720C
- 202-994-5920
- hahn@gwu.edu
<http://www.icg.gwu.edu>
<http://www.ibe.gwu.edu>

Computer Graphics

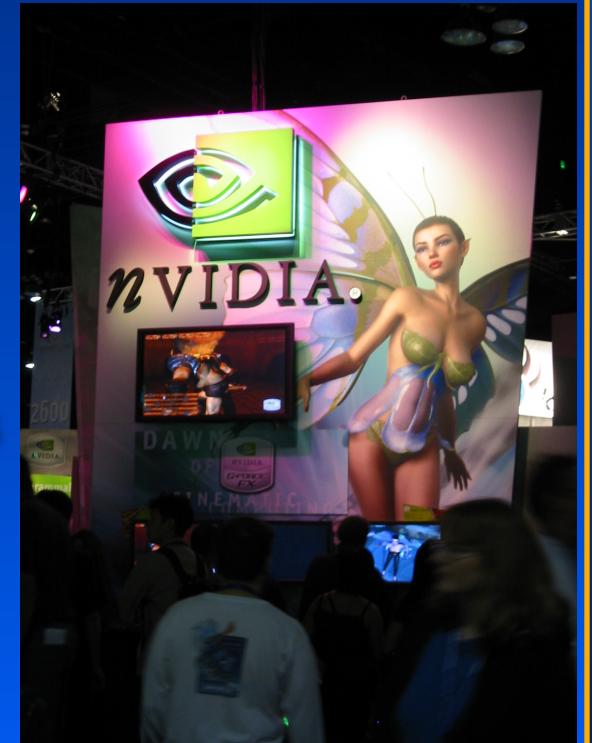
- Relatively short history of ~30 years
- Established itself as one of the most active disciplines within computer science
 - SIGGRAPH-largest SIG in ACM draws approximately 30-40 thousand participants each year
- Interdisciplinary (science, art, design, medicine, engineering, dance, archeology, ...)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



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

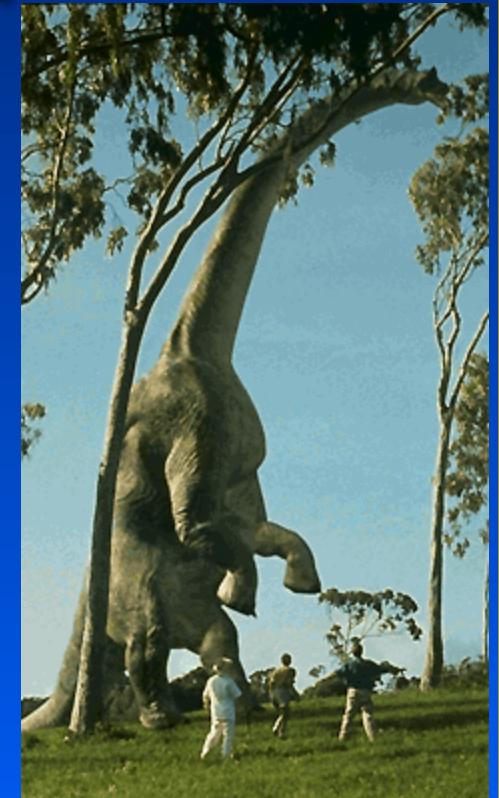


- Driven by economics
 - Worldwide revenue from games
\$22 Billion
 - Bigger than movies, less than music
 - Explosive growth predicted to overtake music: 20% next 4 years as opposed to 2% music
- Ubiquitous



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!



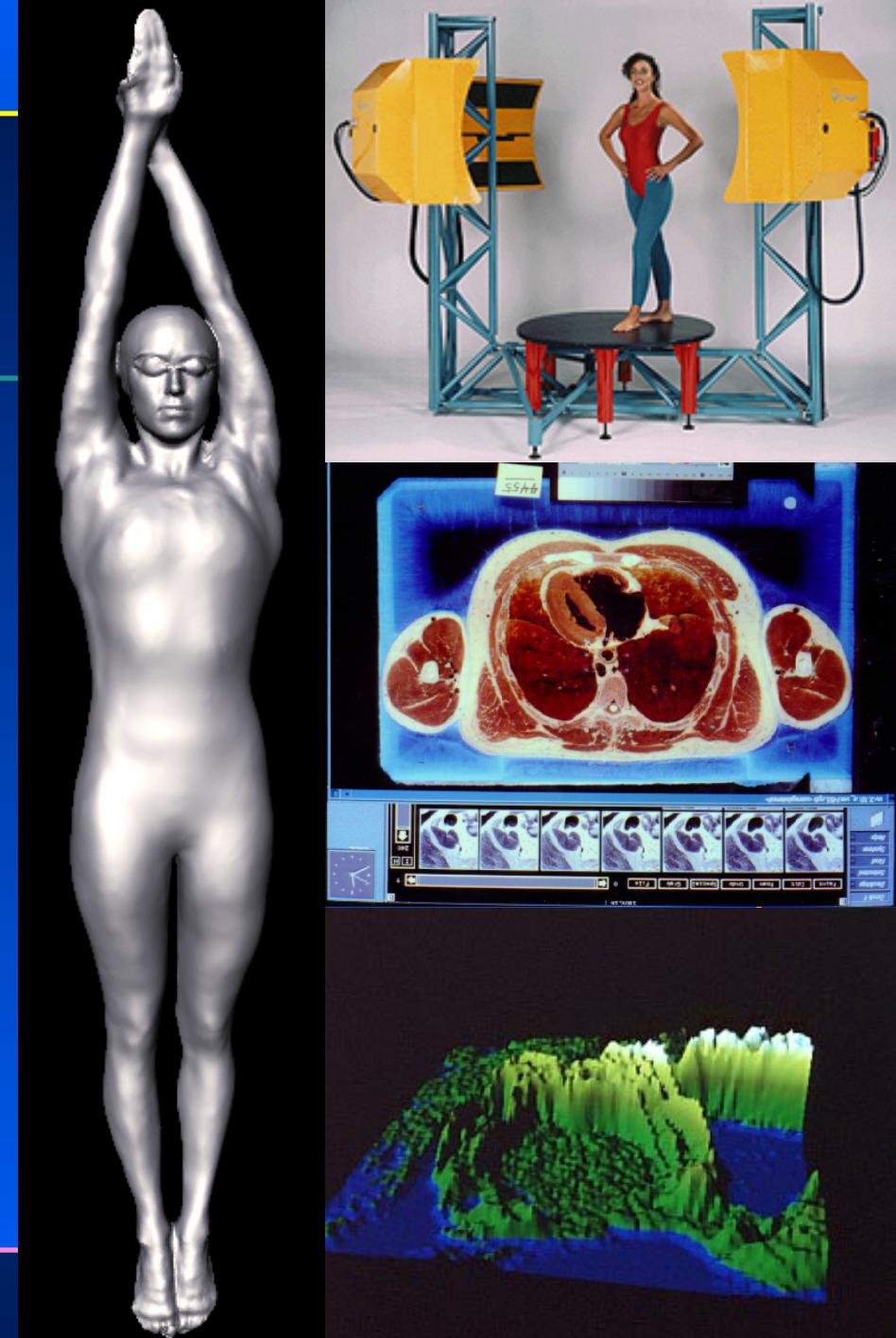
What is Computer Graphics?

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

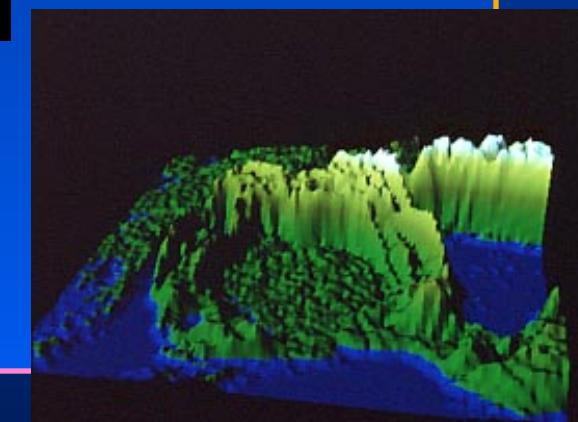
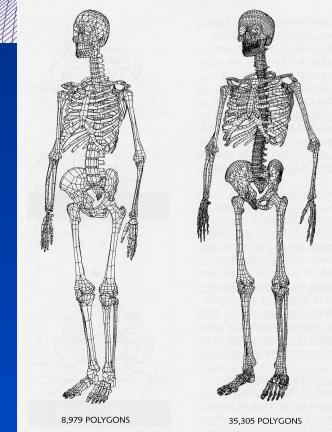
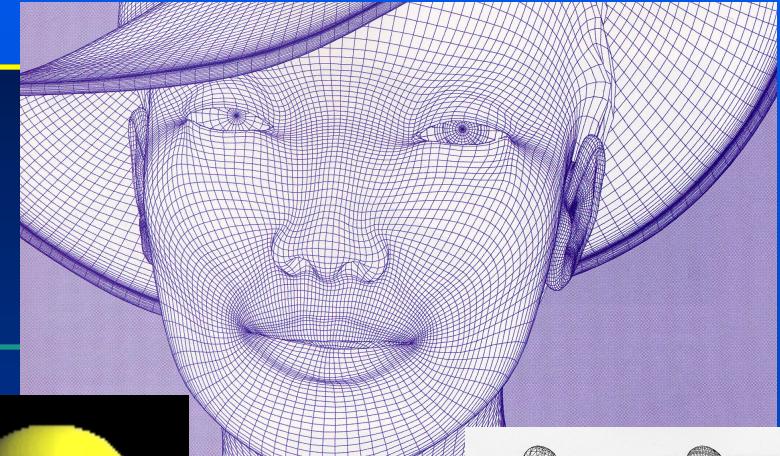
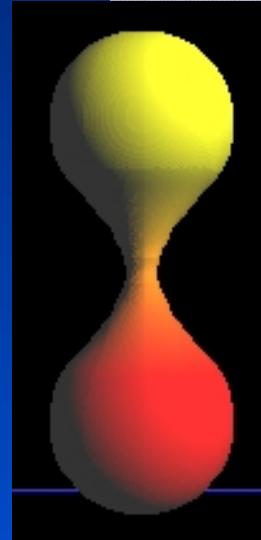


Modeling

- 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)

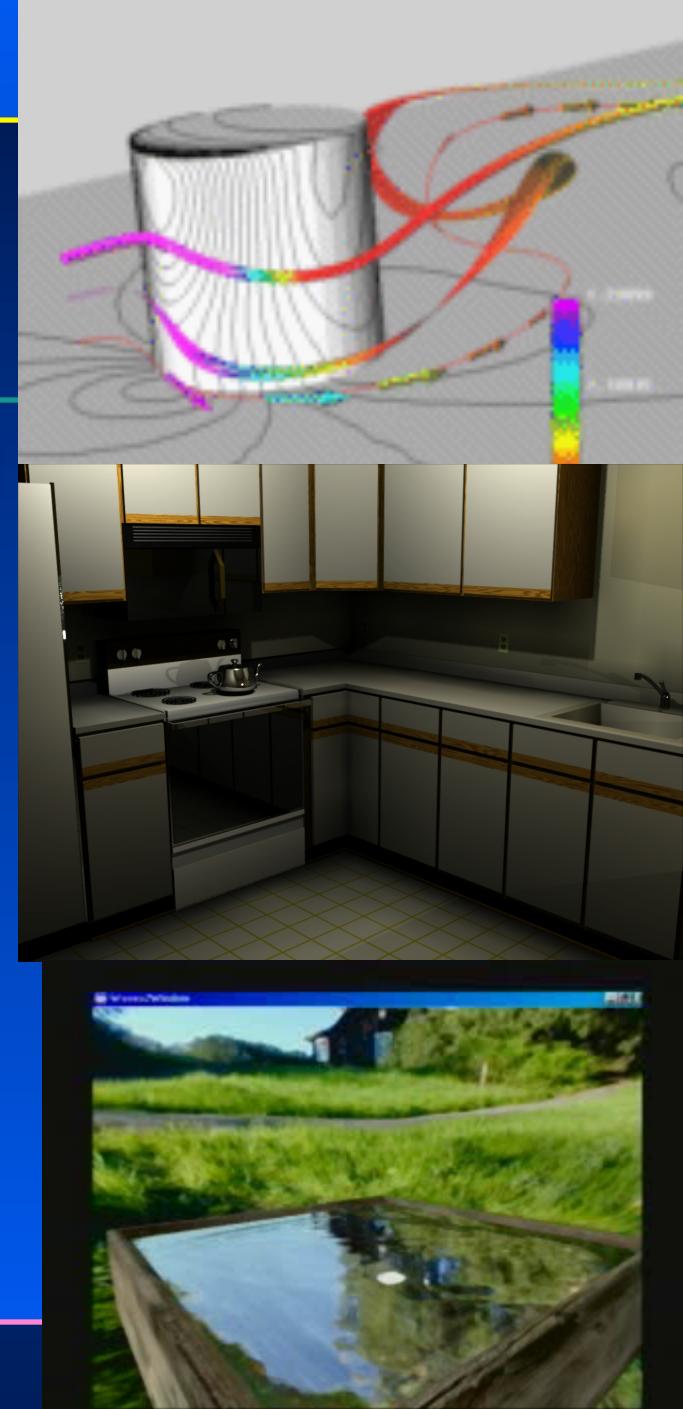


- Representation
 - Polygons
 - Surface patches
 - Point clouds
 - Volumes
 - Implicit surfaces
 - CSG
 - Levels of detail
- Algorithmic models
 - Fractals



Rendering images

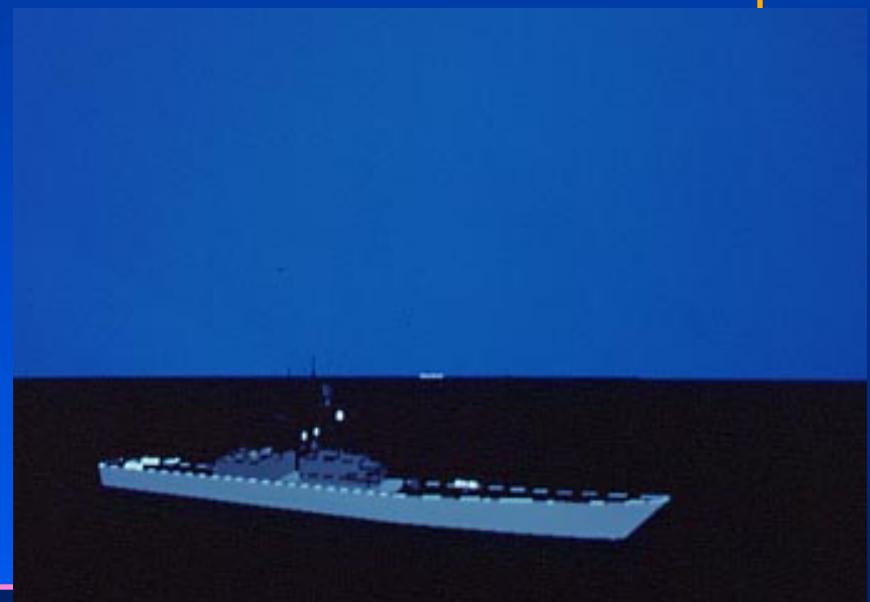
- Creating computer images of the virtual world
- Photo-realism
 - Virtual camera models
 - Illumination models simulate physics of light
- Information visualization
- Realtime performance for games using GPU
 - Approaching realism of film



Rendering

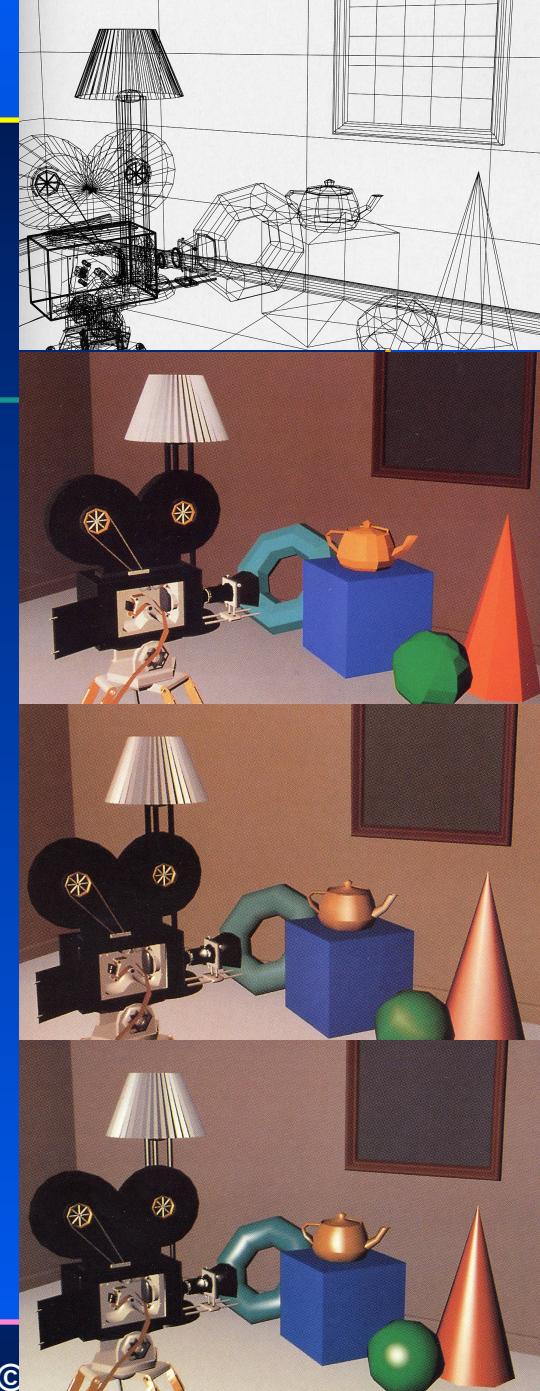
- Per-polygon processing
 - Viewing transformation
 - Hidden surfaces
- Per-pixel processing
 - Scan conversion, hidden surfaces
 - Shading and illumination

- Shading
- Illumination models



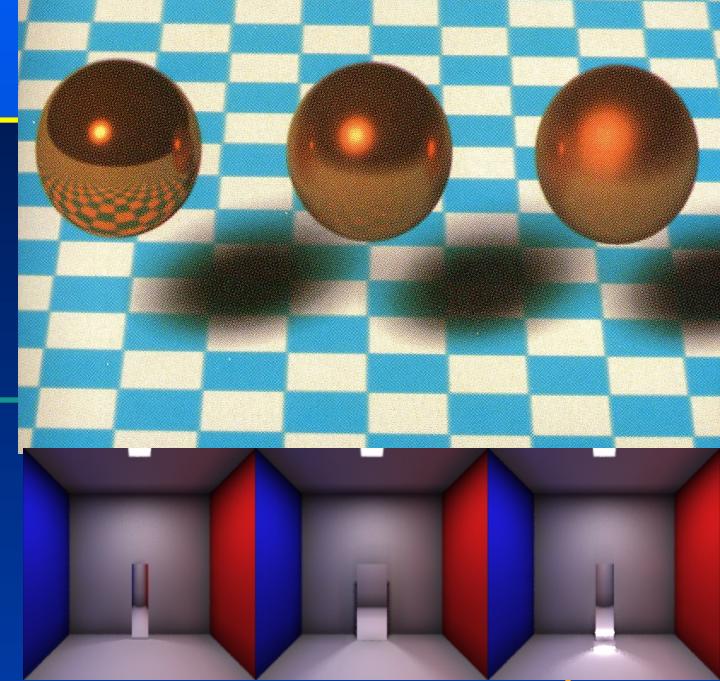
Shading

- 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

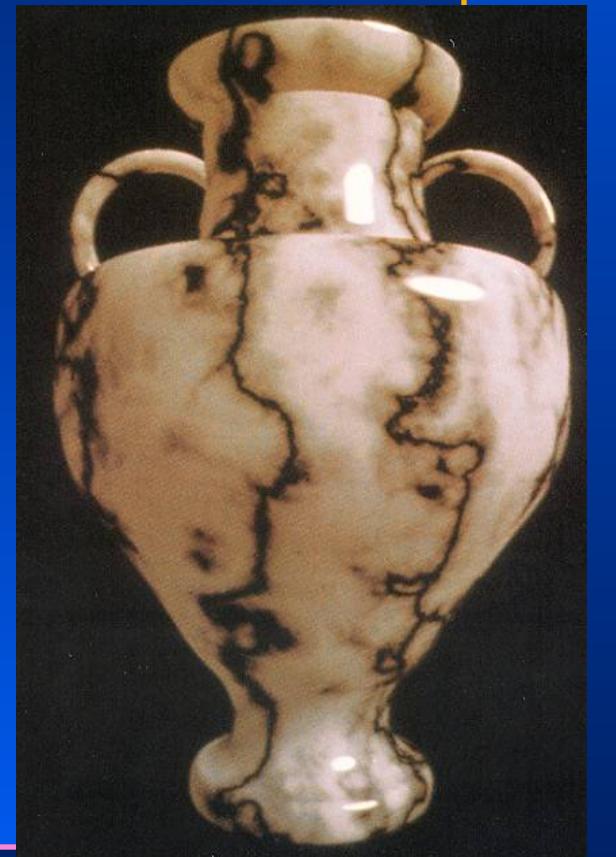
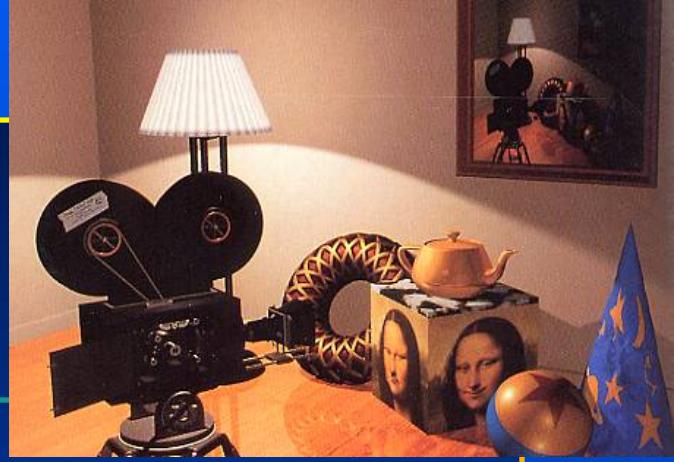


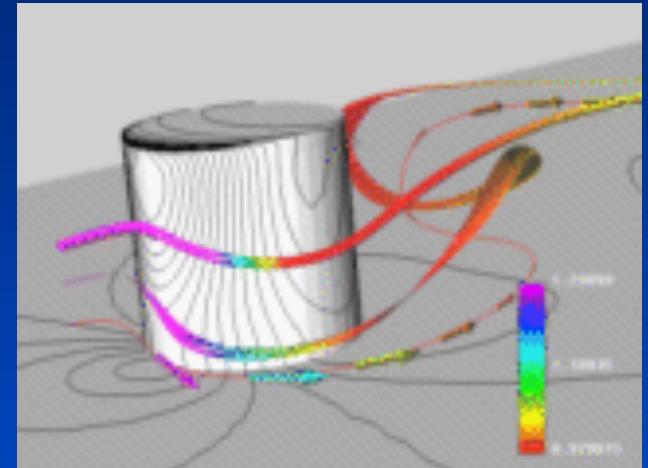
Image-based rendering

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



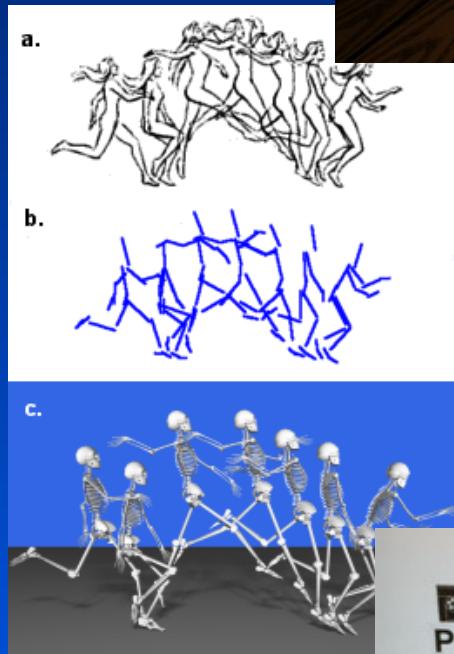
Volume Rendering

- 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)



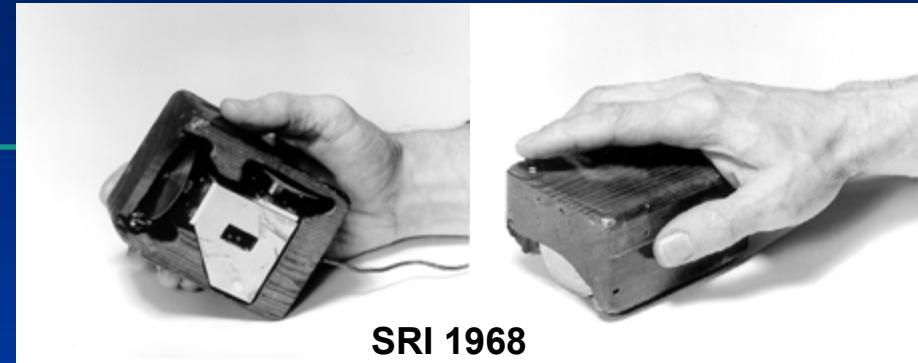
Animation: Motion Control

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



Human Computer Interaction

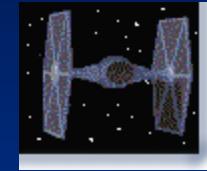
- Historically, I/O lag behind computation
 - Anthropologist in the future conclusion about us based on I/O devices?
- Windows Icons Mouse Pointer (WIMP) metaphor... alternatives?
- Haptic and tactile senses
- Immersion



SRI 1968



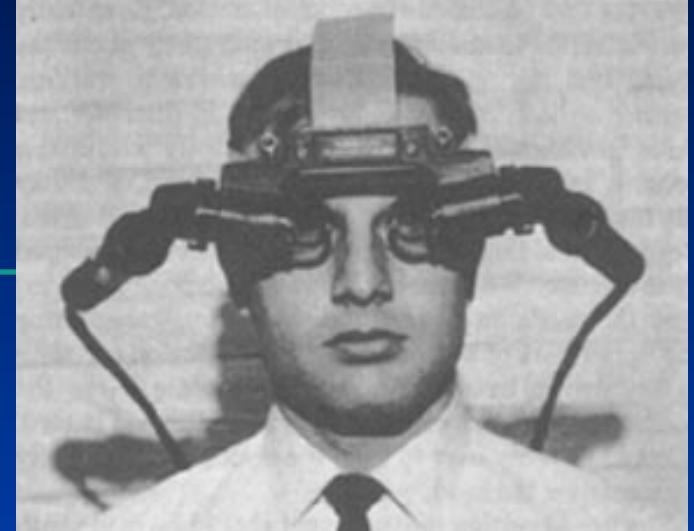
Sound



- 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”

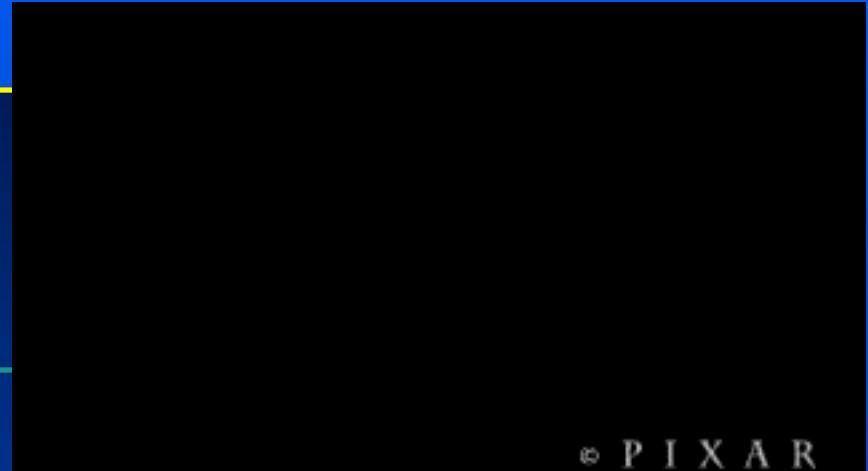


Sutherland, HMD, 1967



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.

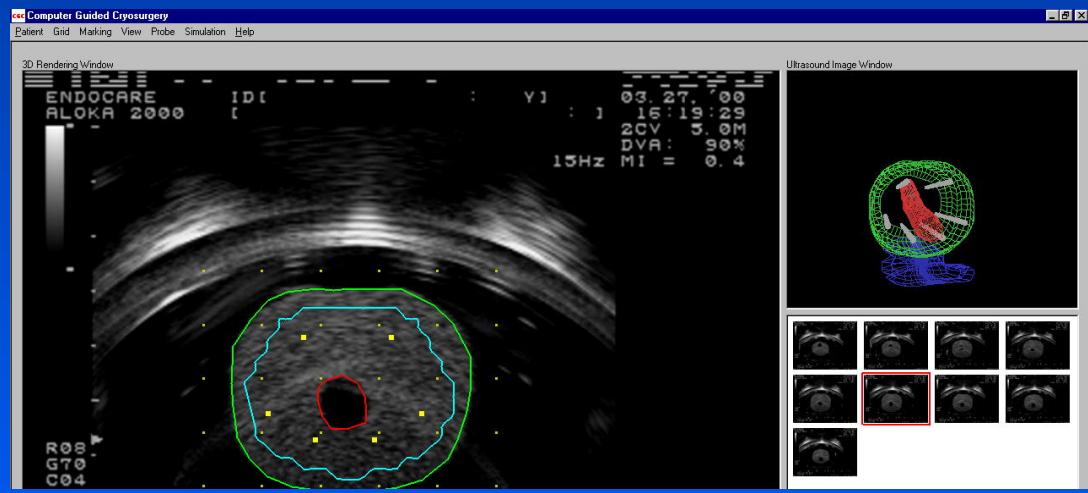


- Virtual actors replace real?



Medicine

- Visualization
- Training
- Image-guided procedures



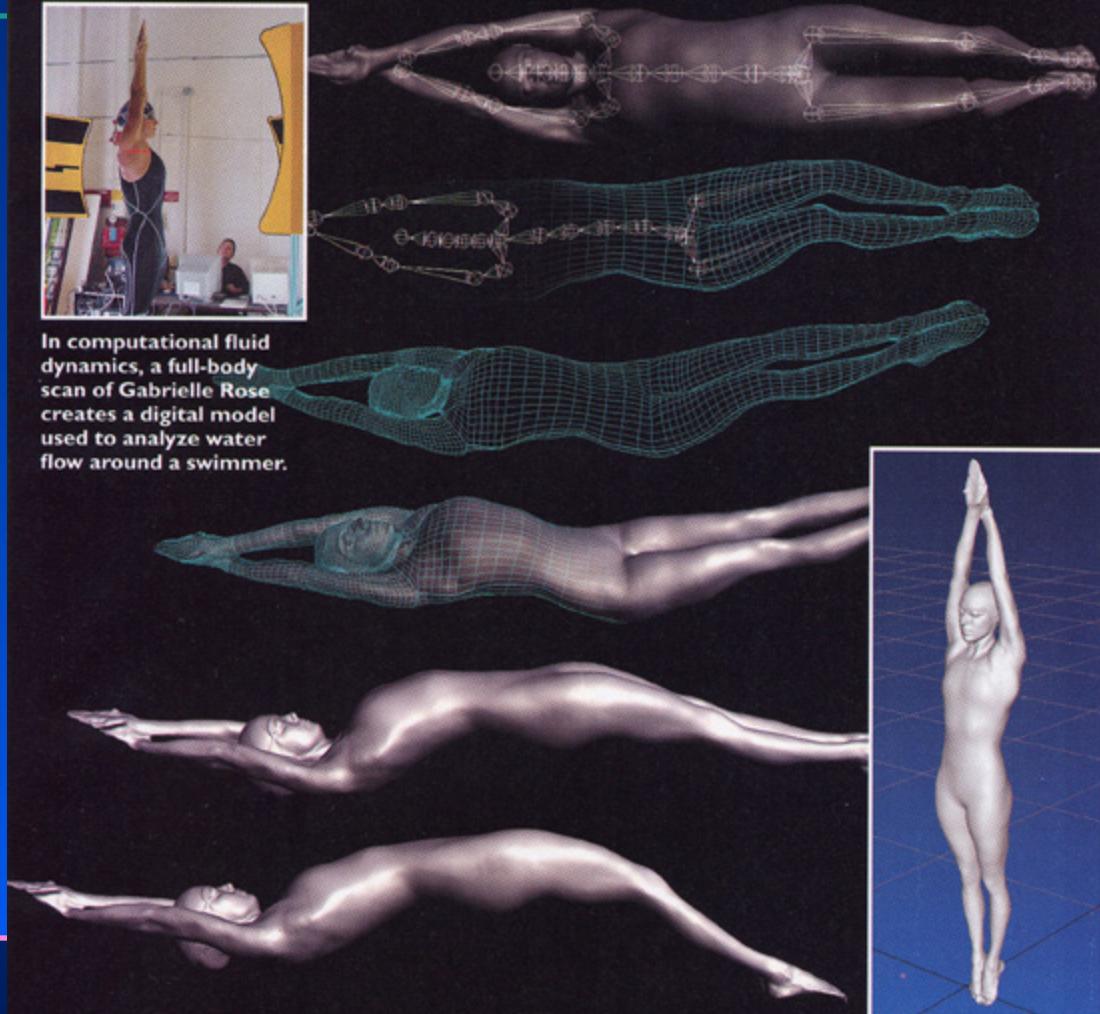
- Olympic project

Stroke Science

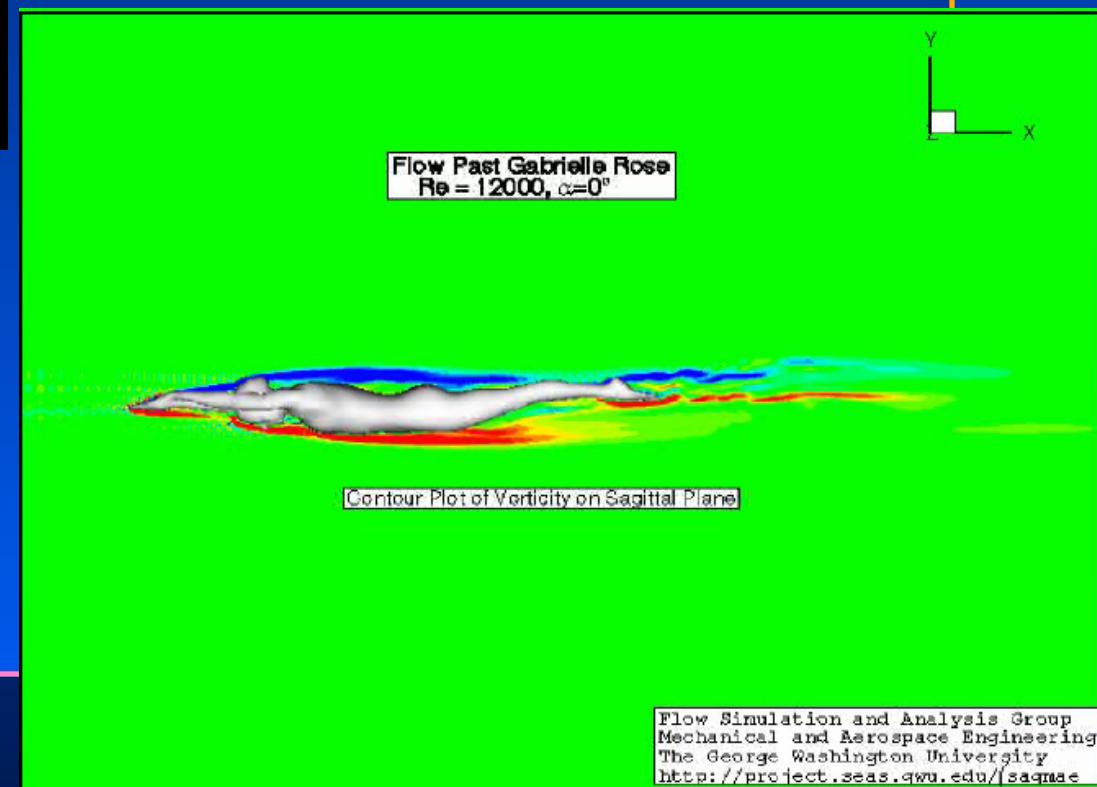
Talent + tech = gold for the U.S. swim team, which is wiring its way to success in Athens and beyond



In computational fluid dynamics, a full-body scan of Gabrielle Rose creates a digital model used to analyze water flow around a swimmer.



Full Body Analysis of Swimming Techniques



Manufacturing CAD/CAM

- Designing, prototyping



Product development marketing

- Building walkthrough
- Interior design



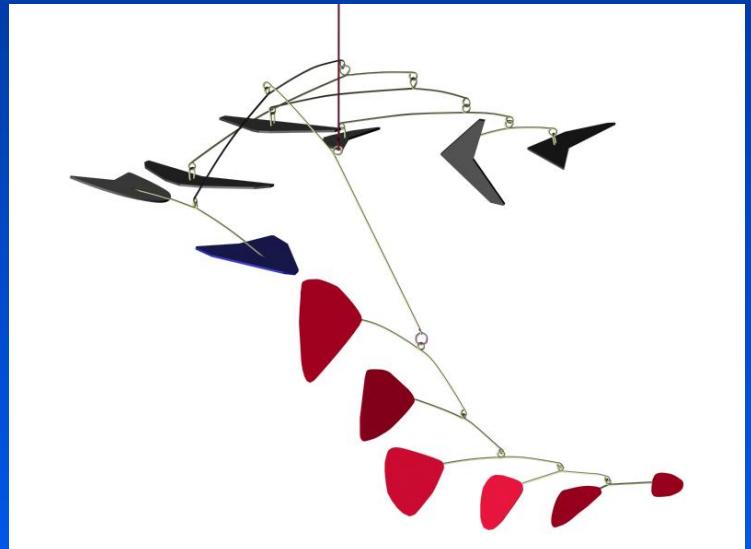
RETURN OF THE BUDDHA

The Arthur M. Sackler Gallery is the only museum in the United States to show these recently unearthed Chinese sculptures. Found during excavation for a et lorem ipsum. Ipsume et lorem e lorem in fortuna.

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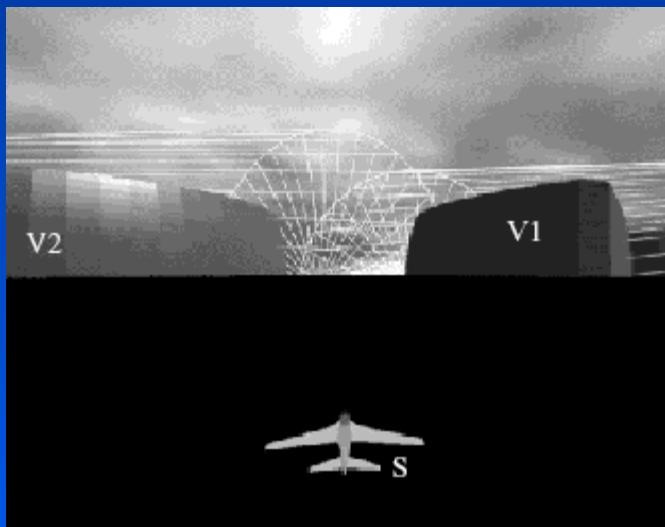


Games

- Console, PC, Location-based
- Rise of networked/internet-based games
- Game from GW alum

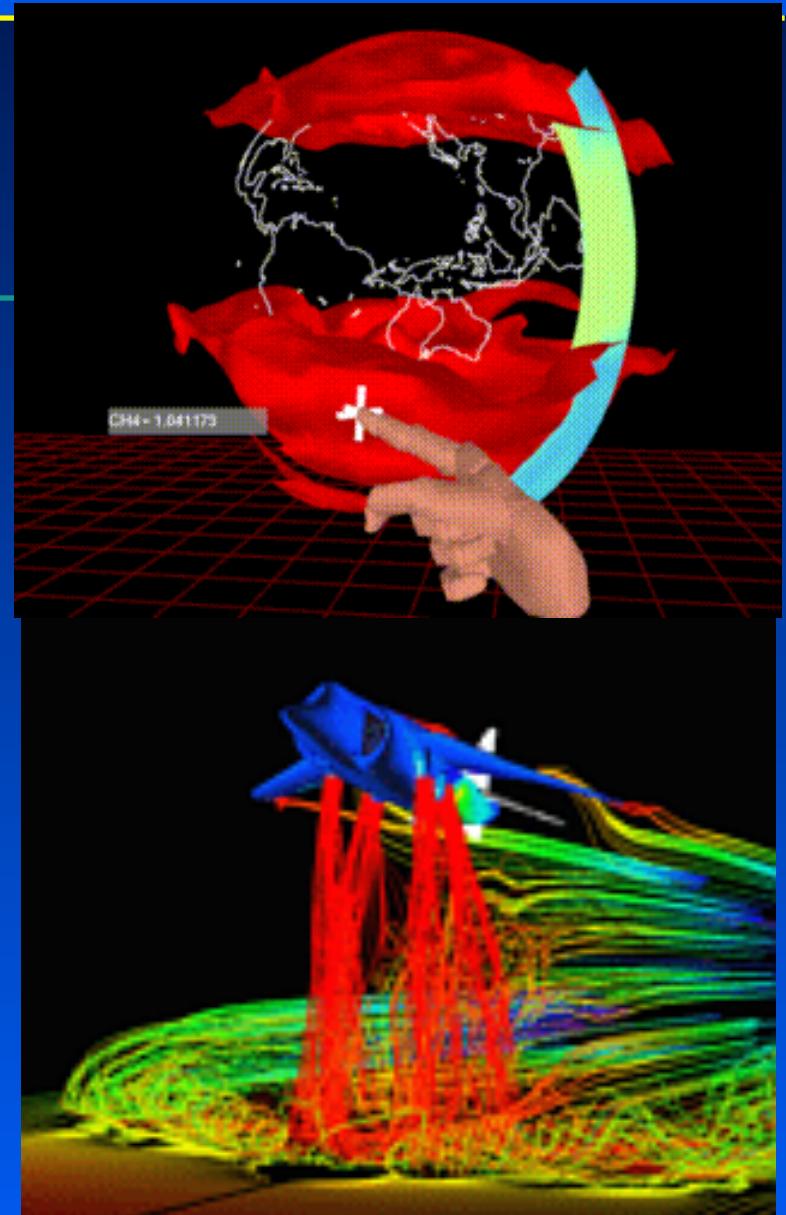
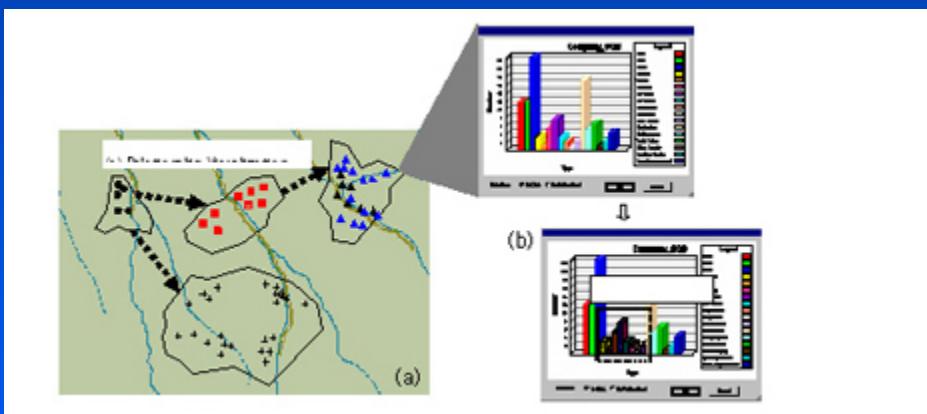


Military training mission rehearsal



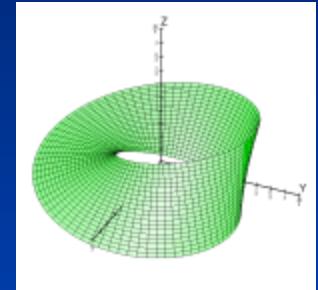
Information Visualization

- Exploration of data
- Process of discovery



Education

- Teaching math, physics, history, etc.



Forensic Animation



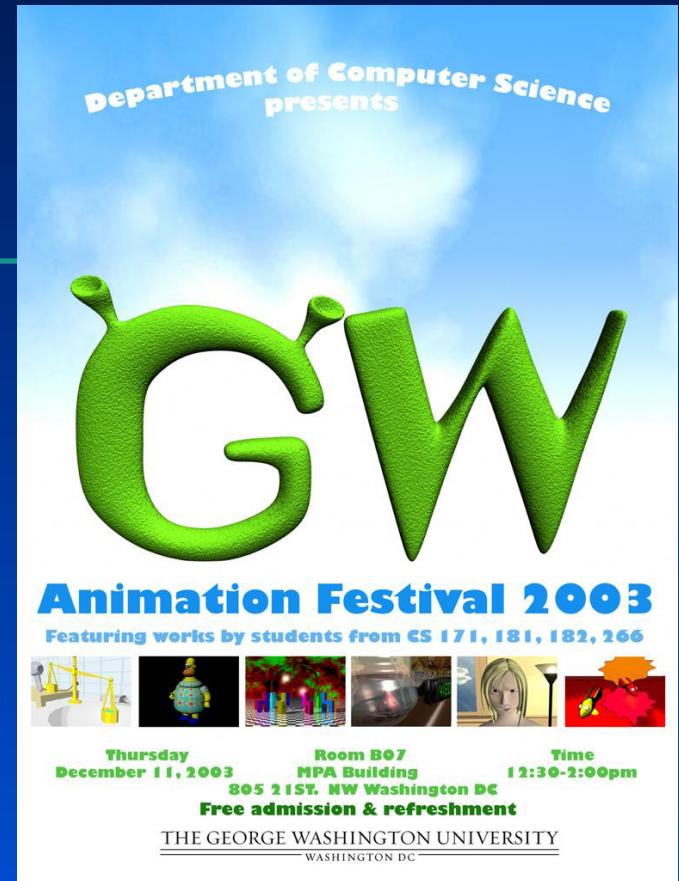
Alumni

- 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