Lecture 24: Tuesday, 9 November 1997

Today, Final lecture:
  Future directions in graphics
    Other contexts
    Academia
    R & D
    Industry
  Class Overview

Gaming / Entertainment

Interaction techniques
  Disambiguating 2D/3D motions
  Rendering acceleration
  Incorporating Sound/Haptics
Autonomous characters ("AIs")
Geometric indexing & algorithms
  E.g., for efficient collision detection

Rendering Algorithms

Realism vs. CPU, Storage Cost
Choice of scenario
  Static/Moving observer, scene, objects, etc.?
Use of parallelism, precomputation

Scientific Visualization & Analysis

Physical Phenomena
Visualizing Sensor Data
Simulation of Mechanical systems
Linked rigid body kinematics
Energy, momentum conservation
Efficient collision detection

Design Tools

Exploring design spaces
Evaluation of design alternatives

Performance/Entertainment

Synthesis of live and CG characters
Coupling visuals with audio streams

Medical Applications

Image-guided surgery
New modes of interacting with data

Modeling & Animation

Shape Definition
Human-mediated? Procedural? Automatic?
Texture Acquisition / Generation
Articulation & Kinematics
Lighting definition & preview
Key Framing Objects, Camera, etc.
Algorithmics:
 Computer Vision, Image Processing, Comp Geom, Numerical Optimization, Artificial Intelligence...

Academia (Alphabetical Order)

PhD (3-6 years)
PostDoc (Optional, 1-2 years)
From there, industry, "academic" lab, academia
UC Berkeley
- Brian Barsky
  - Splines, cornea modeling
- David Forsythe
  - Computer vision, global illumination
- (Raimund Seidel)
  - Computational geometry
- Carlo Séquin
  - Walkthroughs, fire-spreading simulation
  - Geometric modeling and interaction

British Columbia (UBC)
- Dave Forsey
  - Geometric modeling
- Alain Fournier
  - Global illumination, real/synthetic imagery
- Jack Snoeyink
  - Computational geometry

Brown
- Andy van Dam
  - Direct manipulation 3D UI's
- John Hughes
  - Ceiling head-trackers, VR
  - Gestural 3D user interfaces

Cal Tech
- Jim Arvo
  - Global illumination (theory)
- Al Barr (John Snyder)
  - Procedural modeling
- (Jim Blinn, Jim Kajiya)
- Peter Schröder
  - Global illumination, wavelets

Chapel Hill (UNC)
- Fred Brooks
  - Virtual design & simulation systems
- Henry Fuchs
  - Pixel-Planes, PixelFlow architectures

Carnegie Mellon (CMU)
- David Baraff
  - Physically-based simulation (e.g., collisions)
- Paul Heckbert
  - Rendering, modeling, sampling
- Andy Witkin
  - Procedural textures, image processing

Cornell
- Don Greenberg, Peter Shirley
  - Architecture, Global Illumination
- Dan Huttenlocher
  - Computational geometry, computer vision

UC Davis
- Ken Joy, complex CAD modeling/rendering

Georgia Tech
- Jessica Hodgins, human figure modeling
- Greg Turk, 3D scanning and editing

Harvard
- Steven Gortler, multiresolution methods, IBR

Illinois (Urbana)
- Herbert Edelsbrunner: Comp. Geom.

MIT:
- Steve Benton
  - Holography
- Leonard McMillan
  - Specialized rendering hardware
  - Plenoptic (image-based) rendering
- Julie Dorsey
  - Modeling and Simulation
- Olivier Faugeras, Berthold Horn
  - Mathematical Vision
- Eric Grimson
  - Image-guided surgery
- Ken Salisbury
  - Haptics
- Seth Teller
  - 3D Capture; Comp. Geom.; On-line Educ. s/w
- Paul Viola
  - Machine Vision, Formula understanding

Montreal
- Pierre Poulin
  - Rendering, reflection models, particle systems

UNC (North Carolina)
- Fred Brooks, Henry Fuchs, many others

NYU
- Ken Perlin
  - Rendering, multi-resolution desktop UIs

Princeton
- David Dobkin
  - Comp geom, spatial data structures, discrepancy
- Bernard Chazelle
  - Computational geometry, surface partitioning
- Adam Finkelstein
  - Image indexing, animation, multi-res techniques
- Tom Funkhouser
  - Interactivity, many-user environments

Academia

UC Santa Cruz
  Jane Wilhelms
    Volume rendering
Stanford
  Bill Dally
    Parallel, image-based rendering h/w
  Leo Guibas
    Comp geom, global illumination
  Pat Hanrahan
    Volume rendering, global illumination, workbench
  Marc Levoy
    3D scanning, volume rendering
Toronto
  Demetri Terzopoulos, solid modeling
UW (Seattle)
  David Salesin: Rendering, modeling

Industry

Development position (BSc, MSc, MEng, etc.)
R & D lab (usually requires advanced degree...)

R & D (mostly "R")

Lucent/Bell Labs
  Tom Duff: Rendering, digital imaging
  Ken Clarkson, Steve Fortune, Peter Shor
    Comp geom, randomized algs, quantum computing
Microsoft Research (Redmond)
  Michael Cohen, Jim Kajiya, Andy Glassner, Jim Blinn...
    Rendering, animation, agents
  Talisman architecture, Direct3D
MERL (Mitsubishi Electric Research Labs), Cambridge
  Perception, Haptics, Interaction, Vision
IBM Watson, Yorktown, Almaden
  Gabriel Taubin, Holly Rushmeier...
    Solid modeling, surface design, visualization
Xerox PARC
  Data browsing, direct-manipulation UIs, CG & vis
DEC SRC

INRIA (France, many centers)

Industry R & D (some "R", lots of "D")

LEGO Futura (Boston)
  LEGO design, "smart" bricks
Viewpoint DataLabs (Oregon)
  Acquisition, motion capture (new VC rounds)
BDI (Boston Dynamics Inc.; Marc Raibert)
  Motion capture & merging, Haptics, VR
SRI, SDRC, Mitre, TASC, Aberdeen
  Military pursuits
  Photogrammetry, radar, range-finding...
Schlumberger
  3D modeling, site exploration

Government Labs

Lawrence Berkeley Labs
Illumination engineering, goniometry
NIST
Illumination standards, goniometry
NIMA/DMA
Imagery & photogrammetry archives

Graphics Hardware

SGI GT, GTX, VGX, RE, REII, IR, 02, N64, Octane...
Cutting (bleeding) edge h/w development
  Near massively parallel, many $$ are OK
  Development: ASIC, off-shelf, μ-coding!
Workstation competition: IBM, Sun, HP, etc.
  6-18 month lag
Recently, low-end graphics, e..g, Indy, N64
PC-card makers (e.g., Cirrus) catching up fast
Microsoft Talisman (still a bad idea)

Graphics Toolkits

OpenGL, Inventor, Performer
  Template, etc.
Pixar RenderMan
IBM 3DIX, Brush
RenderWare, RenderMorphics
Direct3D

Graphics Application Development

Boeing
  Design/simulate jet with 10^{10} parts
AutoDesk
  AutoCAD modeler, on many/most designer desks
  Kinetix/3D Studio Max
InterGraph (CAD)
  Heavy use of scans, semi-automatic acquisition
Trumbull, Disney
  Interactive (sometimes autonomous) Vis Sim
  Autonomous ride development! (Raiders of Lost Ark)
NASA (including JPL)
  Large-scale scientific visualization

Creative Tool Users/Builders

Startup CAD/Visual Simulation hybrids
  LightScape (radiosity, illumination engineering)
  Virtus (rapid architectural prototyping, rendering)
  Other tools for fast house/room "sketching"

Interaction Devices

FakeSpace Boom (mechanical eye tracking)
Polhemus (6 DOF mouse; full-body motion capture)
SensAble devices Phantom (haptic device)
SpaceBall (6 DOF, torque + stick + push/pull)
Hi-Ball (6DOF LED-based head tracker from UNC)

Geometry Acquisition

CyberWare scanner (laser stripe with triangulation)
Satellite-imagery (side-looking + photogrammetry)
Range-scanners (AM; time-of-flight)
  Serious need for s/w people with a clue

Cinematic "production" houses

Old days: animator, TD, s/w producer all one
Now: strong division
  Animators (artistic types)
    Be animators
  Engineers
    Craft tools that let animators be animators
PDI, Pixar
  "Puppeteering" view of world
  Animator is given lots of abstract strings
  Bottleneck: instrumenting models with "avars"
SoftImage/Alias
  Hierarchical modeling, DAG nodes
  Animator must specify causes, effects

Job directions

If you want to be an animator
  requires "classical" art skills
How (much) involved in production?
  Make pictures, or...
  Make tools
    For example, at Pixar, many s/w
    engineers write per-surface "shaders"
What kind of coding?
  Infrastructure, steady tool development
  "Front lines", weird code for particular shot
    E.g,, stretching fabric on moving characters
    Often, front line stuff "migrates" to corpus

Examples

Pixar, modeling Mr. Potato Head
  There is no hierarchical (say, ascii) model
  All modeling is procedural, with "strings"
  MPH's mouth is a piece of code!
Toolmakers
  Fast
  Good high-level interface
  Not too many strings / DOFs!
  Support for subtle timing adjustments

Trends

Procedural modeling
  Stop-motion animation vs. bag of clay
Code, rather than object, toolkits
  Example: Prisms (SideEffects, Toronto)
  Pixar, RenderMan (C-like API + linear algebra)
  Also, Digital Domain
2D world
  Animo (2D system, bought by DreamWorks)
    Animator draws keyframes
    Animo: high-level control of spline shapes
  Near-intelligent systems for coloring, etc.

Tech Houses

Lyon-Lamb
WindLight
  Motion capture, R/T performance animation
Sony Picture, ImageWorks
Disney – hiring (Fantasia II, CGI Dinosaurs)

Decisions

S/W only? Production (tool use) only? Both?
Huge CGI production for CDrom games (market?)
  Little fancy animation
  Focus mostly on user-level s/w
  Metropolis, Origin Systems
  Electronic Arts, Broderbund
Commercial spots
  PDI, Editel, PostPerformance, TapeHouse
Tight-focus effects, synthetic/real blends

Decisions

Effects? Live action? Synth/ Integration? Or...
  Lots of compositing issues
Animation (fully synthetic)
PDI does mixture, e.g., 3D Simpsons
R&H does mixture, Coca-Cola Polar Bear
ILM does mostly effects (Jurassic Park, Casper)

Small Studios

Buzz (Montreal)
Animatics (LA)
CORE Digital Pictures (Toronto)
  Outer Limits, TekWar
Foundation Imaging (LA)
  Babylon 5, SeaQuest
Area 51 (Burbank)
  Space Above and Beyond
Tippet Studios (Berkeley)
  Stop-motion, moving to CGI
  Verhoeven's "Starship Troopers"
  "... a fun place, full of motor heads and other oddities..."
  "An MIT graphics jock who had his/her head screwed on right
  and was interested in film could have a lot of fun there..."

6.837 Overview

Rendering Fundamentals (Classical Pipeline)
Modeling Fundamentals (Coord. systems, Objects)
Illumination Methods
  Local
  Ray Tracing
  Radiosity
Hardware Acceleration (Graphics Arch.)
Advanced Topics
  Texture Synthesis
  Morphing
  Visibility Computations
  Miscellanea (Haeberli)

This Class

By now, we hope you
- have mastered CG abstractions, some techniques
- are familiar with state of art & practice
- feel confident deploying CG for visualization
  and communication in your discipline
- can confidently initiate R & D in CG
  in industrial or academic setting

Thank you.