News

- Project 3
  - due Thursday 6pm
  - grace days are 24 hours
  - teams average grace days, so can be fractional
  - README: do a good job with documenting your achievements and your sources
  - don’t forget to handin at least two images
  - or not eligible for Hall of Fame
  - signup for demo slots continues
  - Mon 10-1, Tue 12-5, Wed 3:30-6

Extra Sessions

- extra lab coverage for project 3 questions
  - Thursday 4/7 10-1 instead of 10-11
- pre-final Q&A session
  - day before the final: Mon Apr 18, 1-3pm
  - TA Dan Julius
  - in CICSR 911 lab
- reminder: my office hours Wed 3:45 in lab
  - today 4/6
- next week 4/13 no office hrs: grading P3

Review: Preattentive Visual Channels: Popout

- single channel processed in parallel for popout
  - visual attentional system not invoked
  - speed independent of distractor count
  - hue, shape, texture, length, width, size, orientation, curvature, intersection, intensity, flicker, direction of motion, stereoscopic depth, lighting direction,...
  - multiple channels not parallel
  - search linear in number of distractor objects

[Chris Healey, Preattentive Processing, www.csc.ncsu.edu/faculty/healey/IPP]

Review: Data Type Affects Channel Ranking

- spatial position best for all types
  - accuracy at judging magnitudes, from best to worst

[MacKinlay, Automating the Design of Graphical Presentations of Relational Information, ACM TOG 5:2, 1986]
Review: Coloring Categorical Data
- discrete small patches separated in space
- limited distinguishability: around 8-14
  - channel dynamic range: low
  - choose bins explicitly for maximum mileage
- maximally discriminable colors from Ware
  - maximal saturation for small areas
  - vs. minimal saturation for large areas

Review: Rainbow Colormap Disadvantages
- perceptually nonlinear segmentation, hue unordered

Review: Color Deficiency – vischeck.com
- 10% of males have red/green deficit
  - original
  - protanope
  - deuteranope
  - tritanope

Review: Space vs. Time: Showing Change
- literal
- abstract
  - time for time
  - space for time
- animation: show time using temporal change
  - good: show process
  - good: compare by flipping between two things
  - bad: compare between many things
  - interference from intermediate frames

Review: Space vs. Time: Showing Change
- small multiples: show time using space
  - overview: show each time step in array
  - compare: side-by-side easier than temporal
  - external cognition instead of internal memory
  - general technique, not just for temporal changes

Making Movies
**Stuart Little**

- 500 shots with digital character
- 6 main challenges
  - lip sync
  - matchmove (CG to live-action)
  - fur
  - clothes
  - animation tools
  - rendering, lighting, compositing

**Stuart Little**

- 100+ people worked on CG
  - 32 color/lighting/composite artists
  - 12 technical assistants
  - 30 animators
  - 40 artists
  - 12 R&D

**Concept**

- adapt book/comic/game/etc
  - Stuart Little: adopt-a-mouse
- original script
  - Toy Story: buddy movie

**Storyboarding**

- explicitly define
  - scenes
  - camera shots
  - special effects
  - lighting
  - scale
- used as guide by animators

**Sound**

- voice recording of talent completed before animation begins
- animations must match the voiceover
- quote from a puppeteer
  - voice makes or breaks a character

**Character Development**

- 300 drawings
Character Development

- 40 sculptures

Layout and Look

- build scenery
- match colors

Matchmoving

- CG camera must exactly match the real camera
  - position, rotation, focal length, aperture
- easy when camera is instrumented
  - film scanned
  - camera tracking data retrieved
- once shot is prepared, 2D images rendered and composited with live action
- still hard to place CG on moving objects on film

Merging CG and Live Action

*Although props that Stuart held, such as his toothbrush, were modeled, his vanity is a miniature physical model.*
Shooting Film For CG

- square patterns in live action allow easier matchmove tracking
  - furniture, wall paper
  - actors practice with maquettes
  - maquettes replaced with laser dots
  - lasers on when camera shutter is closed
- after each take, three extra shots
  - chrome ball for environment map for Stuart’s eyes
  - white and gray balls for lighting info

Water

Particle Sim and Indentation

Tools

Compositing

- lighting

Compositing
Facial Animation

Fur

Texture

Companies

- Pixar
- Disney
- Sony Imageworks
- Industrial Light and Magic (ILM)
- Rhythm and Hues
- Pacific Data Images (PDI)
- Meteor
- Dreamworks SKG
- Tippett Studios
- Angel Studios
- Blue Sky
- Robert Abel and Associates
- Giant Studios
- BUF
Toy Story (1995)
- 77 minutes long, 110,064 frames
- Frame render times: 45 min – 20 hours
- 800,000 machine hours of rendering
- Renderfarm
  - 110 Suns operating 24-7
  - 300 CPUs
- 1 terabyte of disk space
- 3.5 minutes of animation produced each week (maximum)

Toy Story
- Texture maps
  - Buzz: 189
  - Scuffs and dirt: 450
- Number of animation ‘knobs’
  - Buzz: 700
  - Woody: 712
  - Face: 212, mouth: 58
  - Sid’s backpack: 128
- Number of
  - Leaves on trees: 1.2 million
  - Shaders: 1300
  - Storyboards: 25,000

Toy Story 2
- 80 minutes long, 122,699 frames
- 1400 processor renderfarm
- Frame render time of 10 min to 3 days
- Software tools
  - Alias/Wavefront
  - Amazon Paint
  - RenderMan
  - Lots of custom in-house tools

Newman!
- Subdivision surfaces
- Polygonal hair (head)
  - Texture mapped on arms
- Sculpted clothes
- Complex shaders

Toy Store 2 Images

Toy Story 2 Images
- If you look closely, you can see yellowed printed material, little scratches, and paint worn off embossed surfaces that tell you this collection is old but well-maintained.

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Toy Story 2 Images

Lighting conditions in Toy Story 2 range from bright daylight to nighttime scenes such as this one in which Buzz and the toys race to Woody’s rescue in a Pizza Planet truck.

Final Fantasy

- main characters > 300,000 polys
- 1336 shots, 149,246 frames
- frame render time avg: 90 min
- 24,606 layers
  - avg 18 per shot, max 500
- 934,162 days of render time if one CPU
  - they used 1200 CPUs: 778 days of rendering
  - and that’s just final rendering!
  - lots of tests and tweaks before that

Final Fantasy

- Renderman (Pixar) used for rendering
  - direct illumination
  - many hacks to fake global illumination
- Maya used for modeling
- hair
  - modeled as splines
  - lighting and rendering complicated as well

Production Team

- director
- modeler
- lighting
- character animator
- technical director
- render wrangler
- tools developer
- shader writer
- effects animator
- looks team

Acknowledgements

- David Brogan, University of Virginia
  - CS 445/645, Fall 2002