Among the many cool things he's done:

If you're interested

Summer job available in civil engineering

Some people still haven't demoed P2
If you don't demo you get a 0!
- Come see me after class
- Sign up with cyang@cs ASAP
  - 74832049
  - 40112005
  - 84323013
  - 79325999
  - 81163990

News

Guest lecture Friday
- Prof. Robert Bridson, on animation
  - Among the many cool things he's done: cloth simulation used for Yoda fight scene

News

Summer job available in civil engineering

News

Summer job available in civil engineering
- Today is last day to express interest!
- Position must be filled by Friday
- Come see me after class
  - If you're interested
  - Even if you already sent mail, so that I can match faces to names

News

Summer job opportunity
- Student needed to integrate UBC Earthquake Engineering Research Facility with Network for Earthquake Engineering Simulation (www.nesrc.org)
- Required:
  - Graphics background
  - Linux familiarity
  - NSERC USRA eligible (http://www.nesrc.ca/)
- Contact Ken Elwood (k.elwood@civil.ubc.ca) and CC me
- Contact k.elwood@cs.ubc.ca by 2pm
- Decision will be made by Friday!
Review: Particle Systems
- changeable/fluid stuff
  - fire, steam, smoke, water, grass, hair, dust, waterfalls, fireworks, explosions, flocks
- life cycle
  - generation, dynamics, death
- rendering tricks
  - avoid hidden surface computations

Review: Simple Ray Tracing
- view dependent method
- cast a ray from viewer’s eye through each pixel
- compute intersection of ray with first object in scene
- cast ray from intersection point on object to light sources

Review: Recursive Ray Tracing
- ray tracing can handle
  - reflection (chrome)
  - refraction (glass)
  - shadows
- spawn secondary rays
  - reflection, refraction
    - if another object is hit, recurse to find its color
  - shadow
    - cast ray from intersection point to light source, check if intersects another object

Review: Subsurface Scattering
- light enters surface, bounces around inside, leaves at different location on the surface

Advanced Rendering II

Radiosity
- radiosity definition
  - rate at which energy emitted or reflected by a surface
- radiosity methods
  - capture diffuse-diffuse bouncing of light
    - indirect effects difficult to handle with raytracing
Radiosity
- recall radiative heat transfer
- conserve light energy in a volume
- model light transport until convergence
- solution captures diffuse-diffuse bouncing of light
- view independent technique
  - calculate solution for entire scene offline
  - browse from any viewpoint in realtime

Raytracing vs. Radiosity Comparison
- ray-tracing: great specular, approx. diffuse
  - view dependent
- radiosity: great diffuse, specular ignored
  - view independent, mostly-enclosed volumes
- advanced hybrids: combine them

Image-Based Rendering
- store and access only pixels
  - no geometry, no light simulation, ...
- input: set of images
- output: image from new viewpoint
  - surprisingly large set of possible new viewpoints

IBR Characteristics
- display time not tied to scene complexity
- expensive rendering or real photographs
- massive compression possible (120:1)
  - can point camera in or out
    - QuickTimeVR: camera rotates, no translation

Characterizing Light
- 7D plenoptic function: $P(x, y, z, \theta, \phi, \lambda, t)$
  - (x,y,z): every position in space
  - (\theta, \phi): every angle
  - $\lambda$: every wavelength of light
  - $t$: every time
- can simplify to 4D function
  - fix time: static scene
  - fix wavelength: static lighting
  - partially fix position: empty space between camera and object
4D Light Field / Lumigraph
- $P(u,v,s,t)$
- images: just one kind of 2D slice

Non-Photorealistic Rendering
- look of hand-drawn sketches or paintings
- www.red3d.com/cwr/npr/

NPRQuake
- www.cs.wisc.edu/graphics/Gallery/NPRQuake

Advanced Rendering
- so many more algorithms, so little class time!
- Renderman REYES
- photon mapping
- and lots more...

Sampling
- most things in the real world are continuous
- everything in a computer is discrete
- the process of mapping a continuous function to a discrete one is called sampling
- the process of mapping a discrete function to a continuous one is called reconstruction
- the process of mapping a continuous variable to a discrete one is called quantization
- rendering an image requires sampling and quantization
- displaying an image involves reconstruction
Line Segments
- we tried to sample a line segment so it would map to a 2D raster display
- we quantized the pixel values to 0 or 1
- we saw stair steps, or jaggies

Unweighted Area Sampling
- shade pixels wrt area covered by thickened line
- equal areas cause equal intensity, regardless of distance from pixel center to area
  - rough approximation formulated by dividing each pixel into a finer grid of pixels
- primitive cannot affect intensity of pixel if it does not intersect the pixel

Weighted Area Sampling
- intuitively, pixel cut through the center should be more heavily weighted than one cut along corner
- weighting function, \( W(x,y) \)
  - specifies the contribution of primitive passing through the point \((x, y)\) from pixel center

Images
- an image is a 2D function \( I(x, y) \) that specifies intensity for each point \((x, y)\)

Image Sampling and Reconstruction
- convert continuous image to discrete set of samples
- display hardware reconstructs samples into continuous image
- finite sized source of light for each pixel
Point Sampling an Image
- simplest sampling is on a grid
- sample depends solely on value at grid points

Point Sampling
- multiply sample grid by image intensity to obtain a discrete set of points, or samples.

Sampling Errors
- some objects missed entirely, others poorly sampled
- could try unweighted or weighted area sampling
- but how can we be sure we show everything?
- need to think about entire class of solutions!

Image As Signal
- image as spatial signal
- 2D raster image
  - discrete sampling of 2D spatial signal
- 1D slice of raster image
  - discrete sampling of 1D spatial signal

Sampling Theory
- how would we generate a signal like this out of simple building blocks?
- theorem
  - any signal can be represented as an (infinite) sum of sine waves at different frequencies

Sampling Theory in a Nutshell
- terminology
  - bandwidth – length of repeated sequence on infinite signal
  - frequency – 1/bandwidth (number of repeated sequences in unit length)
- example – sine wave
  - bandwidth = 2\pi
  - frequency = 1/2\pi
  - \( \sin(t) \)
Summing Waves I

represent spatial signal as sum of sine waves (varying frequency and phase shift)

very commonly used to represent sound “spectrum”

1D Sampling and Reconstruction

1D Sampling and Reconstruction

1D Sampling and Reconstruction

1D Sampling and Reconstruction

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1D Sampling and Reconstruction

- problems
  - jaggies – abrupt changes

Sampling Theorem

Continuous signal can be completely recovered from its samples iff
sampling rate greater than twice maximum frequency present in signal

- Claude Shannon

Falling Below Nyquist Rate

- when sampling below Nyquist Rate, resulting signal looks like a lower-frequency one
  - this is aliasing!

Nyquist Rate

- lower bound on sampling rate
  - twice the highest frequency component in the image’s spectrum
Aliasing
- incorrect appearance of high frequencies as low frequencies
- to avoid: antialiasing
  - supersample
    - sample at higher frequency
  - low pass filtering
    - remove high frequency function parts
    - aka prefiltering, band-limiting

Supersampling
None
3x3
5x5

Low-Pass Filtering

Filtering
- low pass
  - blur
- high pass
  - edge finding

Previous Antialiasing Example
- texture mipmaping: low pass filter