

Computer Graphics in Games: present & Future



MIT EECS 6.837

Frédo Durand

<http://www.pong-story.com/>

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Course evaluation

- HKN underground guide survey
- <https://sixweb.mit.edu/evaluate/6.837-f2006>
- until 11:59pm Friday, December 22nd

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Final exam

- Wednesday December 20 1:30-3:30
- 4 pages (2 double-sided sheets) of notes
- Everything we saw this semester
 - With emphasis on 2nd part
- Similar to quiz 1, maybe time will be tighter

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A5 Hall of fame

- <http://courses.csail.mit.edu/6.837/assn/fivearts.shtml>

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6.839: Advanced Computer Graphics

- Convex hull, mesh representation
- Optimization & mesh deformation
- Motion correspondence
- Forward & inverse kinematics
- Constrained Optimization
- Subdivision surfaces
- More particles, implicit integration
- Radiosity, finite elements
- Monte Carlo Integration
- Fourier analysis for graphics
- Generative models & machine learning for graphics

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6.088/6.882 Computational Photography

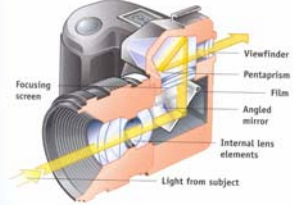
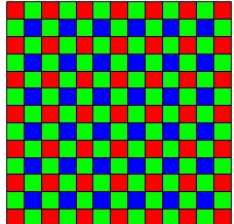

- Convergence of image processing, computer vision, computer graphics and photography
- Digital photography:
 - Simply replaces traditional sensors and recording by digital technology
 - Involves only simple image processing
- Computational photography
 - More elaborate image manipulation, more computation
 - New types of media (panorama, 3D, etc.)
 - Camera design that take computation into account

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Syllabus

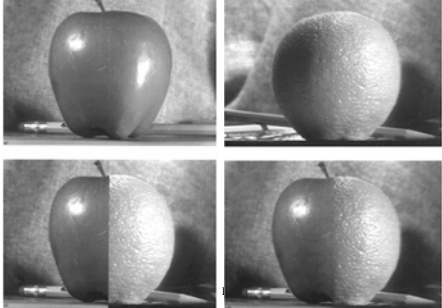
- Image formation
- Color and color perception

EECS

Syllabus

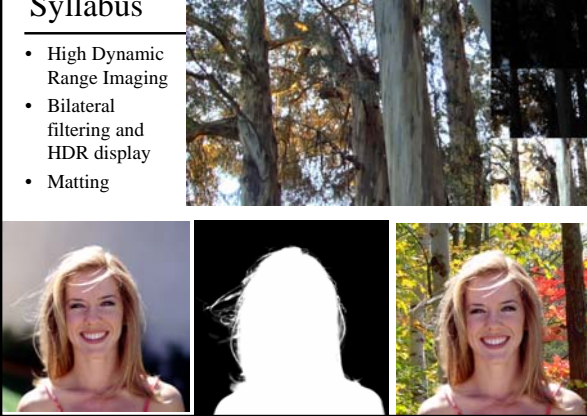
- Image processing and wavelets
- Applications of wavelets: pyramid texture synthesis



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Syllabus

- High Dynamic Range Imaging
- Bilateral filtering and HDR display
- Matting



Syllabus

- Gradient image manipulation




sources/destinations cloning seamless cloning

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Syllabus

- Taking great pictures



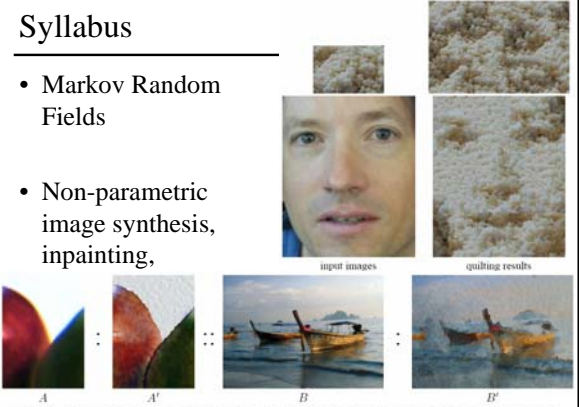
Art Wolfe

ANSEL ADAMS

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Syllabus

- Markov Random Fields
- Non-parametric image synthesis, inpainting,



input images quitting results

A A' B B'

Figure 1: An image analogy. Our problem is to compute a new "analogous" image B' that relates to B in "the same way" as A' relates to A . Here, A , A' , and B are inputs to our algorithm, and B' is the output. The full-size images are shown in Figures 10 and 11.

Syllabus

- Tampering detection and higher-order statistics

original

probability map (p)

forgery

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Syllabus

- Panoramic imaging

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Syllabus

- Motion analysis

Syllabus

- Active flash method
- Lens technology
- Depth and defocus

Flash

No-flash

our result

Aspherical lens

Syllabus

- Non-photorealistic rendering

Syllabus

- Future cameras
- Plenoptic function and light fields

Games & Graphics

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Valve source engine

- Slides from Jason Mitchell
- <http://www.pixelmaven.com/jason/>

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What visually impresses you in games?

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What frustrates you in game CG?

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Valve's graphics challenges

Compiled for you by Jason Mitchell

- Dynamic global illumination effects This could include in-between steps such as dynamic ambient occlusion
- Omnidirectional soft shadows with contact hardening
- Surface detailing (solutions include displacement mapping, wrinkle mapping etc)
- Motion Blur
- Procedural modeling to increase productivity (foliage etc)
- Character animation Proper foot placement during walking/turning/running (while still having immediate response from player input) Walking/running animation on uneven surfaces (stairs, hills, etc)
- Volume preserving deformations, particularly during object-object interactions
- Cloth animation (physics is more challenging than rendering)
- Hair rendering
- Fluid rendering
- Local adaptation for tone mapping.
- Large scale dynamically modifiable/destructable environments

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Nick Porcino, LucasArt

- Big issues: Low memory budget, multiprocessing
- Local information, no access to the scene → Recast problems as local
- Deferred rendering/shading
 - multiple passes, decompose the problem according to components, polynomial approximation, each coefficient in a pass and accumulate them
- Parallelism
 - Load balance, teapot in football field (moving forward) PS3 (G80 similar to Cell, extrapolate forward, hypercube bus)
 - Plan to not using HLSL in the future, move to something like Cuda, UPC, Peakstream, accelerator to do the rendering and more (compositing layers), physics
 - Lucas Art is unusual (most companies don't do water/physics on GPU) cloth, water, ductile fracture. in announced star wars, indiana jones, hair cloth, water, FEM for soft body, ductile fracture (a couple ms/frame at 60hz)
 - Question: PPU: window of opportunity has closed, purpose too limited, optional
 - Rigid physics, collision, etc one ms of CPU time
 - Next gen GPU will be so much more powerful, not planning to use PPU

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Nick Porcino, LucasArt

- mocap: happy with it. Black sheep of animation. "devil's rotoscope" because data is dirty, they spend more time cleaning.
 - no longer true. Mathematics make it reliable. Second pirate caribbean, mocap. Very clean, little extra work. Google imocap.
 - Same technique for games, but need to reuse
 - Lots of interesting problem: smoothing, interpolation, matching
 - create motion not occur in mocap. Z. Popovic's stuff. Karen Liu. Synthesis from first principles, conservation of energy/momentum. 2002 stuff.
- Q: combine mocap & physics;
 - they do it, difficult. hierarchical rigs. He's disappointed by state of the art. kinematic skeleton only, needs balance skeleton, vertex cluster. Kineamtic drives balance skeleton. Create a direction controller, drives kineamtic, center of gravity, constrained cloth, dense hierarchy. Only able to afford kinematic skeleton 12 bones, have to map on deformation skeleton: 90 bones. Plausible mapping? Synthesize data for other 90 bones. e.g. spine is easy (from 2 to 5 bones). Shoulder joint can have 9 bones but only arm+scapula in kinematic skeleton. interpolate??? Only dealt with partially. Forced them to standardize.
 - Use natural motion technoly + Havock.
 - Challenge: getting up. Easy to collapse, but unpredictable. Then how do you stand up? Try to get standard collapsed poses.

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Nick Porcino, LucasArt

- Q: procedural modeling & amplification.
 - Mixed feeling. Keen on the technique. Has had to back off and not use. Xbox, 360 can do it. Problem: structure of current pipeline, cannot be blind, tessellator becomes the bottleneck. Need access to 1-ring
 - Particle systems, trees, L system. Suffer greatly from lack of global information. L systems look too procedural. Real tree needs knowledge of accessibility to light, etc.
 - Fractal terrain easier. But same problem with recursion, needs filtering, needs smooth normals. Needs adjacency.
 - Pascal Mueller, city engine project. Can be enforced locally.
- Material appearance
 - 3 components: mechanical application of algorithms: BRDF shading. Capture of data, reduction of model to be tractable. Interesting: polynomial texture maps, surface transfer, did attempt, but not applicable (e.g. FTM too big data).
 - Some techniques: enough memory but data is too scattered. (bad cache performance)
- More and more global illumination? Yes, it is required. ambient occlusion is the current solution. Does not hold under deformation. Search for techniques that encode 1st and second bounce into maps.
 - Geometric algebra. hemcube, attempt to solve initial transfer on hemcube, then remap. Geometrics. Alternative to linear interpolation & sleeps.
 - want it, find more and more sophisticated ways to approximate it.
 - Bake more and more static stuff, hope to get more dynamic.
 - Photorealism? Bemused by Photorealism. On the one hand, drives mathematics and advances, but on the other hand, he does not believe it's a useful goal. Starts with bad assumption (name is an oxymoron) realism is what you perceive, photo is mechanical/chemical, it ignores our perception. Realism is about what our perception does. Computer graphics should go there. TV & movies work because they are not photorealistic, they have an interpretive mechanism (director, director of photo). Rules such as continuity editing are designed to skew perception, so that you understand. Example, camera pans over group of people. Position is adjusted depending on camera viewpoint.
 - Glad graphics is spending so much time because they provide toolbox
 - The expressive lighting engine nasr el feief

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Frédo's complaints

- Aliasing
- Motion blur, depth of field
- Shadows
- LoD pooping (but much better now)
- Character Animation
 - Foot contact
 - Stiffness, dynamics
- Physics simulation
 - Water, cloth, rigid body, deformable
 - coupling with characyer
- Shader level of detail
- Multithreading
- Collision detection
- Material appearance
- Hair
- Open worlds
- Open scripts
- Detail amplification
- Humans
- NPR, different styles

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Wanna be a game programmer?

- Take 6.034, 6.170, 6.837
- Practice C++
- Make a game to show off
- Learn multithreading & parallel programming
 - Take the Cell programming course

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Resources

- <http://www.gamasutra.com/>
- <http://www.pixelmaven.com/jason/>
- <http://delivery.acm.org/10.1145/1180000/1177637/cs26.pdf?key1=1177637&key2=6572994611&coll=GUIDE&dl=&CFID=4383172&CFTOKEN=78290111>
- http://www.acmqueue.com/modules.php?name=Content&pa=printer_friendly&pid=139&page=1

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