<< RETURN

Procedural Shaders: A Feature Animation Perspective

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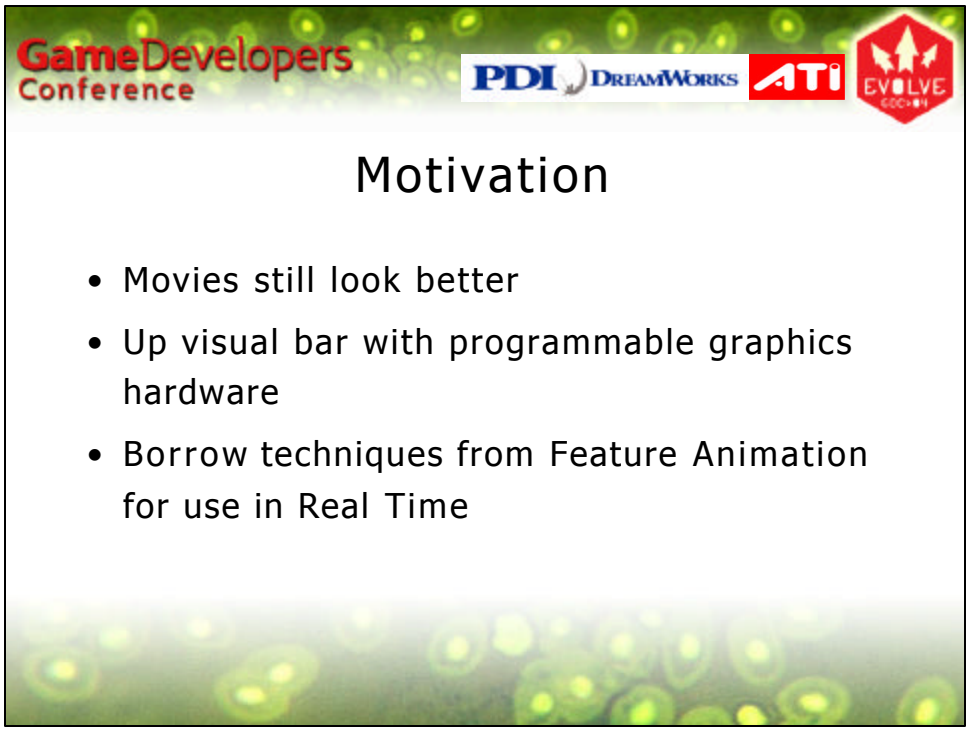

Motivation

- Movies still look better
- Up visual bar with programmable graphics hardware
- Borrow techniques from Feature Animation for use in Real Time

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Motivation – get from here

Jak 2

(2003)

PS 2

Naughty Dog

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… to here

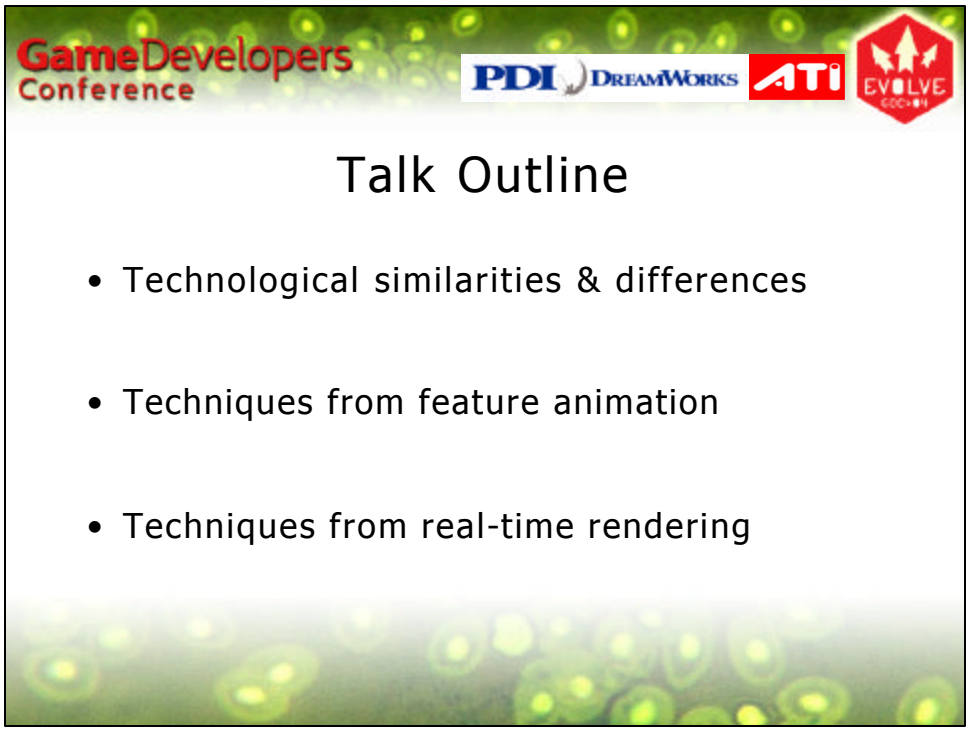
Shrek 4D

(2003)

Film

PDI/

DreamWorks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Talk Outline
• Technological similarities & differences
• Techniques from feature animation
• Techniques from real-time rendering


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Where we are
• Typical values for Shrek
– Typical frame
– Pentium 4 @ 2.8 GHz
• Typical values for DX 9 part
– Assuming 30 FPS
– Based on Radeon 9800
– Some values based on theoretical max

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"Typical" Shrek frame

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Similarities

Technology	Feature Animation	Realtime Rendering
Resolution	720 x 486 (NTSC) 1828 x 1102 (Academy 1.66)	640 x 480 1024 x 768 1280 x 1024
Anti-Aliasing	8 x 8	4 x 4
Bits per channel	32 (internal float) 4-8 (YUV 4:2:2)	32 (internal float) 8 (RGB 8:8:8)

Differences (Geometry)

Technology	Feature Animation	Realtime Rendering	Order of Magnitude
Time per frame	8000 secs	0.015 secs	6
Polys / frame	100 M	0.1M - 1M	2
Bones & Skinning	350 CPU proc.	32 4 mat/bone	1

Geometric Resolution

- Feature Animation
  - Mostly procedural geometry
  - NURBS, NUBS or subdivision surfaces
- Realtime
  - Usually triangles and quads
  - Recently N-patches or RT-patches

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Differences (Rendering)

Technology	Feature Animation	Realtime Rendering	Order of Magnitude
Time per frame	7000 secs	0.015 secs	6
Number of Lights	100	5 - 10	2
Shadow samples	1000 (soft shadows)	1 (depth map)	3

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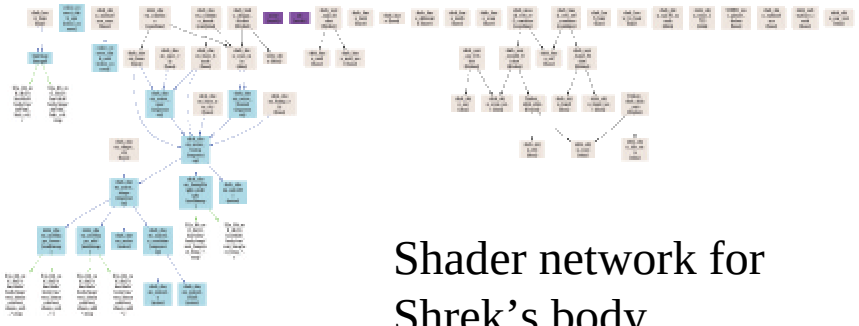
Differences (Shading)



Shader network for Shrek's body

Differences (Shading)

Technology	Feature Animation	Realtime Rendering	Order of Magnitude
Shader ops per pixel	1 M	100	4
Shader Parameters	~100 (chained)	~10	2
Texture RAM	1545 MB	64 MB	1.5

Other Differences

- Texture Filtering
  - Analytic vs Trilinear Mipmap (Dave)
- Shader Environment
  - P, dPdUV, N vs streams (Dave)
- Shading Language
  - C/C++ vs Cg/HLSL/GLSL (Preetham)
- Color Calibration

Color Calibration

- Consistent view for
  - Artists, content provider, consumers
- Feature Animation
  - Artists calibrate, Theatres calibrate
- Realtime Rendering
  - Artists calibrate (sometimes)
  - Gamers turn up the gamma!

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Shader Environment

By *shader* I mean *plugin*

Compiled .dso (.dll) written in C

Materials, maps, lights, geometry, etc..

Shaders are (ideally) stream filters / DG nodes

Look at inputs and outputs only

But we (PDI) always cheat

Traversing scene, loading files, ray tracing, etc..

Full access to all app. libraries

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Shader Environment

P, N, Ng, UV, dPd[UV], ref[PN], etc...

These data come in both singles & *tuples*

- Singles = data at the poly center
- Tuples = data at poly vertices
  - (e.g. vertex normals, vertex UVs, etc...)

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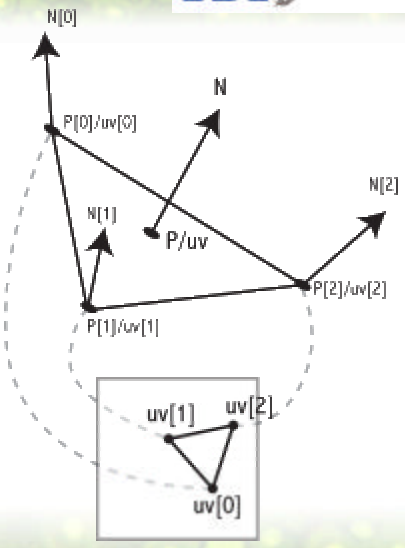
Polygon

Texture



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Anti-aliasing

No-one *wants* aliasing, but in reality…

- Hardware support
- Performance
  - features / quality / speed

no aliasing allowed (noise is not OK)

Fortunately, we (FA) have lots of time

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Image mapping for RT

Input UV is a single

Tri-linear MIPMAP interpolation

MIPMAP is point-sampled using single (face) UV

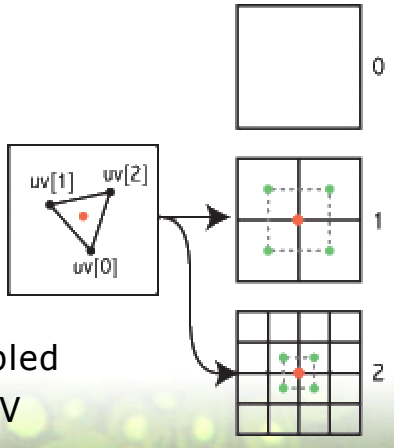
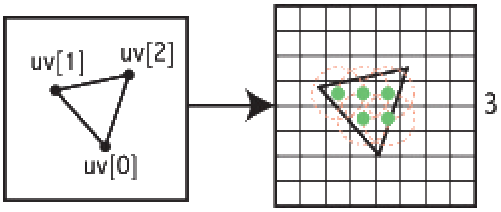


Image mapping for FA

Input UV is tuple

Integrate filtered texels in tuple



Quality knob chooses MIPMAP level

(e.g. GL_TEXTURE_LOD_BIAS_EXT in openGL)

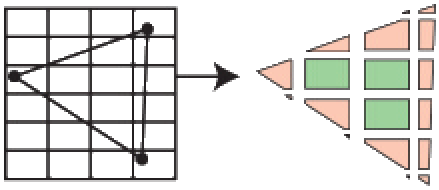
Brick Shader

Use uv tuple polygon

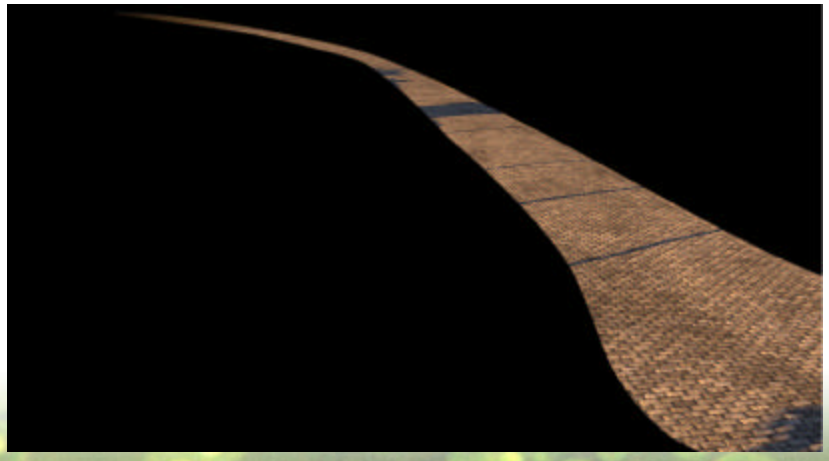
Find fully & partly enclosed bricks

Fully enclosed = average color

Partly enclosed = clip & evaluate

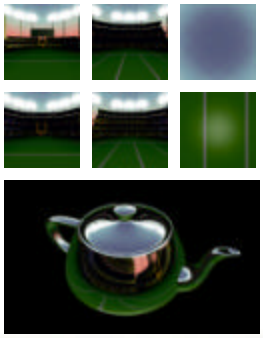


Brick Shader



Env mapping

- Function maps (I,N) to UV
  - Using reflection vector R
- Builds on Image mapping
- Tuple UVs computed with tuple N & P
- UV tuple is passed on to image map



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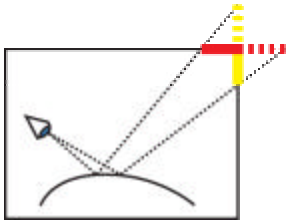
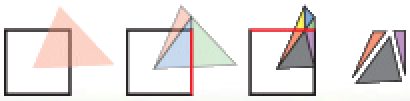
Env mapping

Tuple UVs might cross seams, so subdivide tuple UV polygon

Each tuple polygon is evaluated by image map shader.





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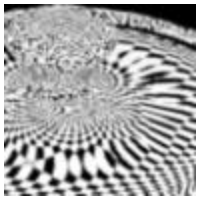
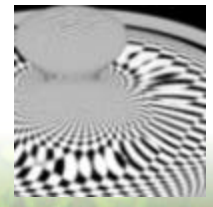
Env mapping

Singles eval

Tuples eval





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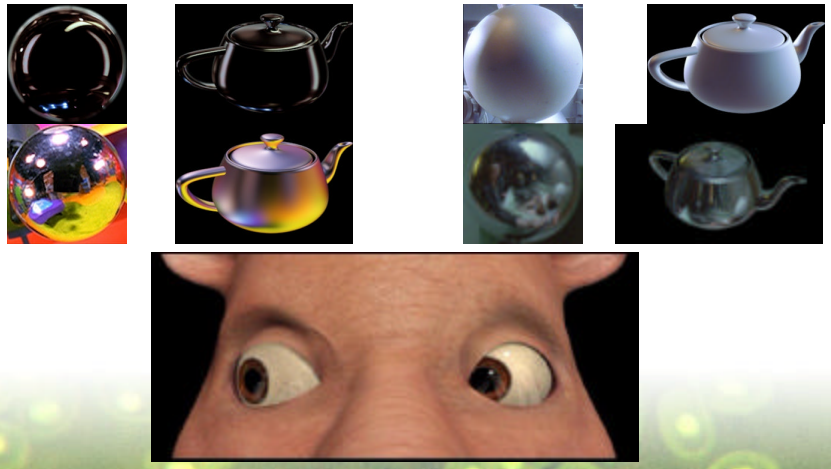
Env mapping



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Procedural noise

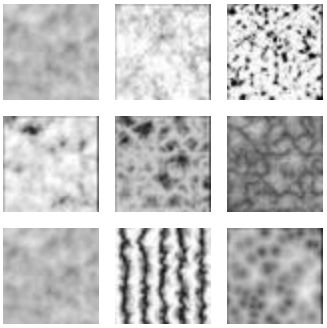
We use noise heavily

Many different types

- gradient, cell, convolution, turbulence, marble, worley
- 1d,2d,3d,4d…

Fractal noise anti-aliasing

- Evaluate frequency in 'octaves'
- Only evaluate the frequencies that are below Nyquist limit



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Shading Models

- Wide range of complex models
  - Default material has standard terms:
    - Ambient, Diffuse, Specular
  - And some non-standard terms:
    - Shadowing, Directional ambient, Directional diffuse, Retro-reflection, Fresnel reflectivity, transparency…
- Not just surface materials:
  - Maps, Fabric, Fur, Particles, Volumes,

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Fur Shader

Shading model for curves [Kajiya ’89]

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Shrek 4D

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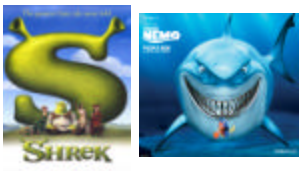
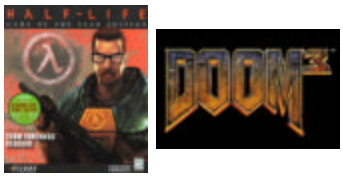
Shading Languages

CPU



- RenderMan®
- C Libraries

GPU



- HLSL, GLSL, Cg.
- Assembly.

Shading Blocks

- On CPU
  - Light, Surface, Volume shaders.
- On GPU
  - Vertex & Pixel shaders.

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Shading on graphics hardware

- Instruction set
  - Limited Control Flow
  - No Bitwise operators
- Resources
  - Limited Registers (Temp, Interpolators, Constants)
- No Global Memory

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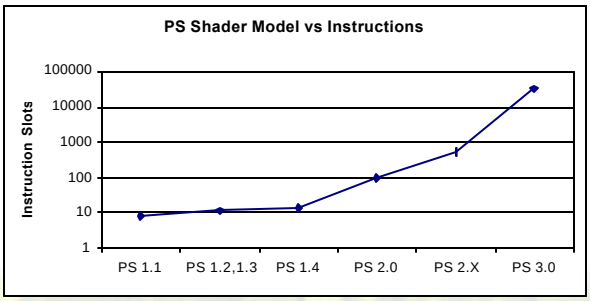
Shading on graphics hardware (cont'd)

- Finite number of instructions



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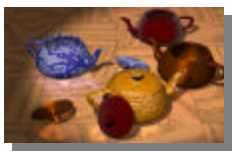
Multipassing

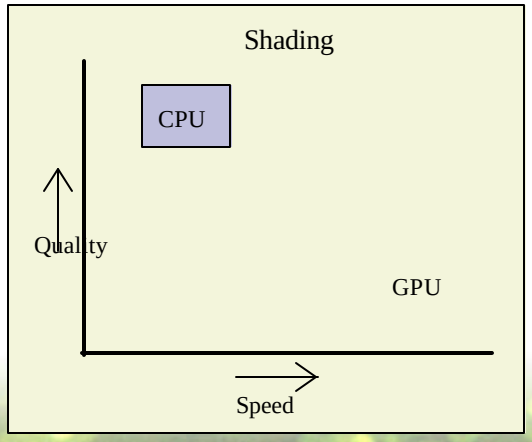
- Interactive multi-pass programmable shading, *Siggraph 2000 - Peercy et al*
- Efficient partitioning of fragment shaders for multi-pass rendering on programmable graphics hardware, *Siggraph 2002 – Chan et al.*



Peercy et al, 2000.

Chan et al, 2002.

CPU vs GPU Shading



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CPU Quality & GPU speed

- Use GPU for offline shaders.
  - Procedural Lights.
  - Complex Surfaces.
  - Noise.

Lights

- Fixed Function
  - 8 lights
  - Dir, Point, Spot
- Programmable
  - Any number of lights
  - Custom light shaders
  - Eg. Windowlight

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Windowlight

- Light through a window.
- Parameters:
  - # horiz panes, vert panes
  - from, to, up
  - frame width & height
  - fuzz.

Surface Models

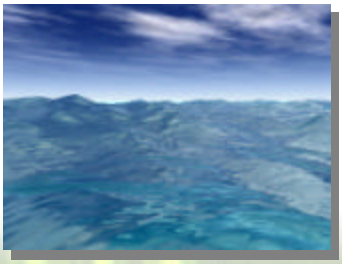
- Fixed Function
  - Diffuse, Phone, Multi-texture
- Programmable
  - Custom surface models.
  - Eg. OrenNayar, Anisotropic, Fur.

Fur

- Fur geometry rendered as triangles.
- Shading uses fur tangent direction

Noise

- Widely used in studios.
- GLSL & HLSL shading languages have noise functions.
- Popular implementation
  - Perlin noise
- Eg: Ocean waves



Texture Noise

- Noise based demos used textures.
- Advantages: Fast.
- Disadvantages: Repeat, memory expensive, linear filtering

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Procedural Noise

- Advantages: No filtering artifacts.
- Disadvantages: Computationally expensive.
- Perlin noise implementation on GPU.
  - float noise3d(): 56 alu, 16 tex.
  - float3 noise3d(): 172 alu, 48 tex.

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Conclusion

Cinematic quality in real time ?

Still a long way to go.


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