CMSC 435/634

Shading

Based on SIGGRAPH 97 education slide set
Rosalee Wolfe, DePaul University
Procedural Shading

So many options for shading, how to represent?

Write a procedure!

- Simple function
- Specialized high-level shading language
Shading Languages

Shade Trees [Cook 84]
- Simple expressions: surface, light, atmosphere
- Built-in vector math & common shading functions

Image Synthesizer [Perlin 86]
- Full language with branch & loop
- Band-limited noise function (more on this in a minute)

RenderMan [Hanrahan & Lawson 90/Pixar]
- C-like language
- Designed to work with many rendering algorithms
- Surface, light, displacement, volume/atmosphere
Shading Example

```
if (mod(trunc(zcomp(P)),2)==0)
    Ci = color(1,0,0);
else
    Ci = color(1,1,1);
```
RenderMan Surface Shaders

Input

- Cs, Os
- u, v, du, dv, s, t
- time, dtime
- P, N, Ng, dPdu, dPdv, dPdtime
- E, I
- L, Cl, Ol (In illuminance)

Output

- Ci, Oi
More Complex Example

float d = sqrt(
    xcomp(P)*xcomp(P) + ycomp(P)*ycomp(P));
if (mod(trunc(d),2)==0)
    Ci = color(1,0,0);
else
    Ci = color(1,1,1);
float r1 = mod(x, 2)/2; float r2 = sin(x);  
Ci = mix(yellow, magenta, r1); Ci = mix(yellow, magenta, r2);
Color Tables
Perturbed Color Tables

\[ C_i = \text{texture} \left( \text{“rainbow“}, x + \text{noise}(P) \right) ; \]
Noise

What is this *noise*?

- “it provides seasoning to help you make things irregular enough so that you can make them look more interesting” – Ken Perlin

- Random but repeatable
  - Different arguments give different random values
  - Same argument gives the same value every time
  - Consistency in animation!

- Frequency band-limited (approximately one octave)
  - Control: can choose frequency range by combining several octaves of noise
RenderMan noise

Biased to give values centered at .5 rather than 0 float, color or vector output

• inferred, but can force: \( C_i = \text{float noise}(P) \);

1D, 2D, 3D or 4D

• \( \text{noise}(x) \)
• \( \text{noise}(x, y) \)
• \( \text{float}(P) \)
• \( \text{noise}(P, t) \)

Periodic version

• \( \text{pnoise}(x, y, x\_\text{period}, y\_\text{period}) \)
Simple RenderMan Example

C Code

```c
#include "ri.h"

RtPoint Square[4] = {
    {1.4, 1, 1}, {1.4, -1, 1}, {-1.4, 1, 1}, {-1.4, -1, 1}};

int main() {
    float noisescale = 4;
    RiBegin("square.rib");
    RiDeclare("sc", "uniform float");
    RiWorldBegin();
    RiSurface("noisetest", "sc", &noisescale, RI_NULL);
    RiPatch(RI_BILINEAR, RI_P, (RtPointer) Square, RI_NULL);
    RiWorldEnd();
    RiEnd();
    return 0;
}
```
Simple RenderMan Example

SL Code

surface noisetest(float sc=1) {
    Ci = float noise(floor(1/t)*sc*P);
}


Fractional Brownian Motion (fBm)

Combine octaves, scaled by $1/f$

```plaintext
for(f=1; f<=floor(1/t); f*=2)
    Ci += (float noise(f*sc*P)-.5)/f;
Ci += .5;
```

Image: Fractional Brownian Motion simulation.
Turbulence

fBm using abs(noise)

for (f=1; f<=floor(1/t); f*=2)
    Ci += abs(float noise(f*sc*P)-.5)/f;
Ci += .5;
Marble

texture(xcomp(P) + turbulence(P))
Wood

Concentric rings of dark & light wood
Perturbed by noise
Volume/Cloud

Solid ellipse
Noise modifies density
More Atmospheric Effects

Getting Into Art – David Ebert