Procedural Texturing and Shading

Paradigm for programmability in the graphics pipeline

Allows for a wide variety of surface materials and embellishments

May be facilitated by a custom shading language

• e.g. Pixar’s RenderMan
### Potential Advantages of Procedural Textures

- Compact representation
- No fixed resolution
- No fixed area
- Parameterized - generates class of related textures

### Disadvantages of Procedural Textures

- Difficult to build and debug
- Surprising results
- Slow evaluation
- Antialiasing handled manually
Procedural Texture Conventions

Avoid conditionals

- Convert to mathematical functions when possible
- Makes anti-aliasing easier

Parameterize rather than building in constants

- Assign reasonable defaults which may be overridden

Simple Building Blocks

- Mix (lerp)
- Step, smoothstep, pulse
- Min, max, clamp, abs
- Sin, cos
- Mod, floor, ceil
Mix

\[ \text{mix}(a,b,x) \]

Step
**Smoothstep**

\[ \text{smoothstep}(a, b, x) \]

**Pulse**

\[ \text{pulse}(a, b, x) = \text{step}(a, x) - \text{step}(b, x) \]
Clamp

\[ \text{clamp}(x, a, b) = \min(\max(x, a), b) \]

Mod

\[ \text{mod}(x, a) / a \]
### Periodic Pulse

\[ \text{pulse}(0.4, 0.6, \text{mod}(x,a)/a) \]

### Example 1 - brick (see handout)

Brick is primarily a 2D pulse

Input parameters may include:

- color of brick and mortar
- size of brick
- thickness of mortar
- mortar bump size
- frequency of brick color variation
- etc.
Example 2 - star (see handout)

Exploit symmetry of star geometry

Input parameters may include:

- Inner and outer star radii
- Number of points
- Star and background colors
- Star bump parameters
- Parameters for star distribution
Star

Rendering Techniques Handout – Brick and Star Shaders

#include "proctext.h"

#define BRICKWIDTH 0.25
#define BRICKHEIGHT 0.08
#define MORTARTHICKNESS 0.01

#define BMWIDTH (BRICKWIDTH+MORTARTHICKNESS)
#define BMHEIGHT (BRICKHEIGHT+MORTARTHICKNESS)
#define MWF (MORTARTHICKNESS*0.5/BMWIDTH)
#define MHF (MORTARTHICKNESS*0.5/BMHEIGHT)

surface brick(
    uniform float Ka = 1;
    uniform float Kd = 1;
    uniform color Cbrick = color (0.5, 0.15, 0.14);
    uniform color Cmortar = color (0.5, 0.5, 0.5);
)
{
    color Ct;
    point Nf;
    float ss, tt, sbrick, tbrick, w, h;
    float scoord = s;
    float tcoord = t;

    Nf = normalize(faceforward(N, I));

    ss = scoord / BMWIDTH;
    tt = tcoord / BMHEIGHT;

    if (mod(tt*0.5,1) > 0.5)
        ss += 0.5;  /* shift alternate rows */
    sbrick = floor(ss); /* which brick? */
    tbrick = floor(tt); /* which brick? */
    ss -= sbrick;
    tt -= tbrick;
    w = step(MWF,ss) - step(1-MWF,ss);
    h = step(MHF,tt) - step(1-MHF,tt);

    Ct = mix(Cmortar, Cbrick, w*h);

    /* diffuse reflection model */
    Oi = Os;
    Ci = Os * Ct * (Ka * ambient() + Kd * diffuse(Nf));
}

#include "proctext.h"

surface star(
    uniform float Ka = 1;
    uniform float Kd = 1;
    uniform color starcolor = color (1.0000,0.5161,0.0000);
uniform float npoints = 5;
uniform float sctr = 0.5;
uniform float tctr = 0.5;
}
{
point Nf = normalize(faceforward(N, I));
color Ct;
float ss, tt, angle, r, a, in_out;
uniform float rmin = 0.07, rmax = 0.2;
uniform float starangle = 2*PI/npoints;
uniform point p0 = rmax*(cos(0),sin(0),0);
uniform point p1 = rmin*
(cos(starangle/2),sin(starangle/2),0);
uniform point d0 = p1 - p0;
point d1;
ss = s - sctr; tt = t - tctr;
angle = atan(ss, tt) + PI;
r = sqrt(ss*ss + tt*tt);
a = mod(angle, starangle)/starangle;
if (a >= 0.5)
a = 1 - a;
d1 = r*(cos(a), sin(a),0) - p0;
in_out = step(0, zcomp(d0^d1));
Ct = mix(Cs, starcolor, in_out);
/* diffuse ("matte") shading model */
Oi = Os;
Ci = Os * Ct * (Ka * ambient() + Kd * diffuse(Nf));
}