Procedural Texturing and Shading

Procedural Texturing/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**

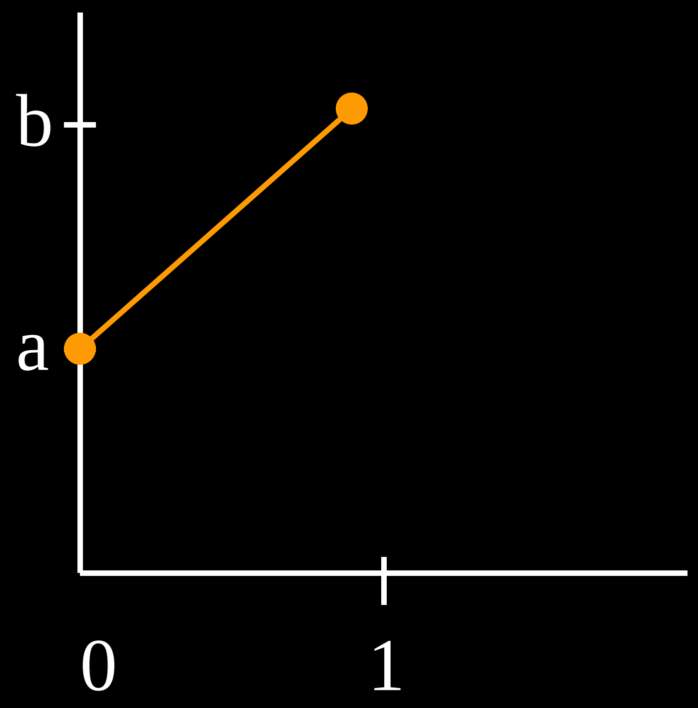
Parameterize rather than building in constants

- **Assign reasonable defaults which may be overridden**

Simple Building Blocks

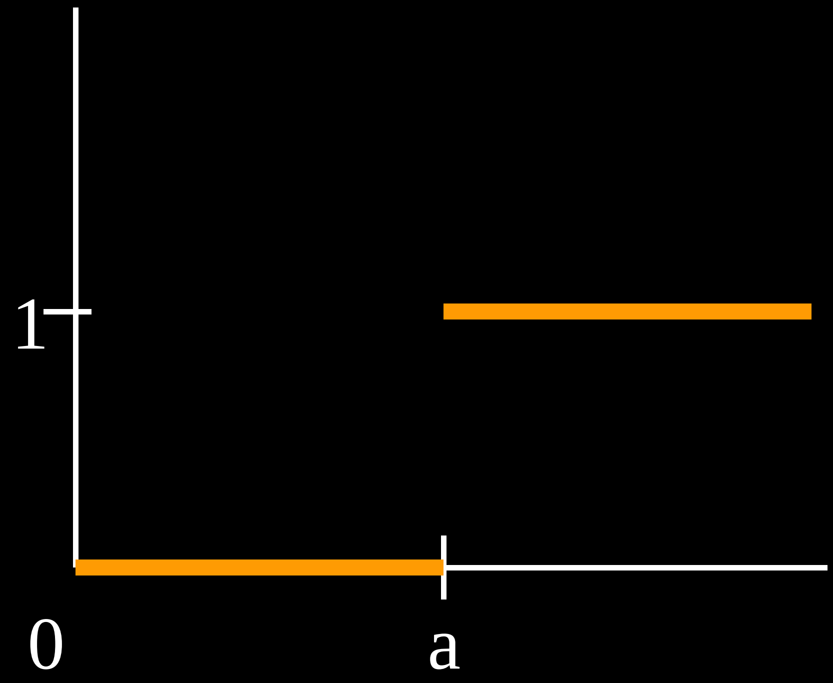
- Mix (lerp)
- Step, smoothstep, pulse
- Min, max, clamp, abs
- Sin, cos
- Mod, floor, ceil

Mix

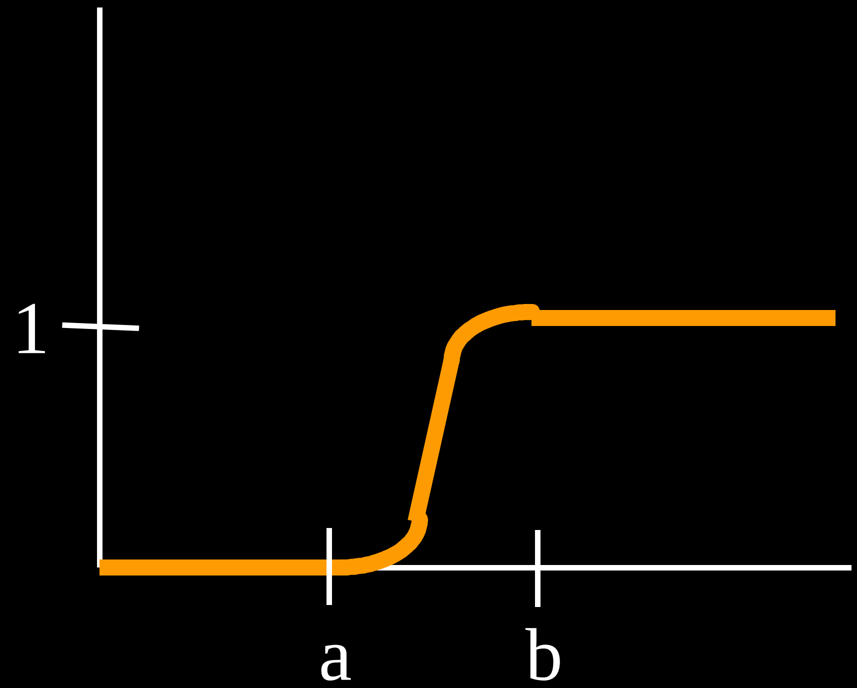


mix(a,b,x)

Step

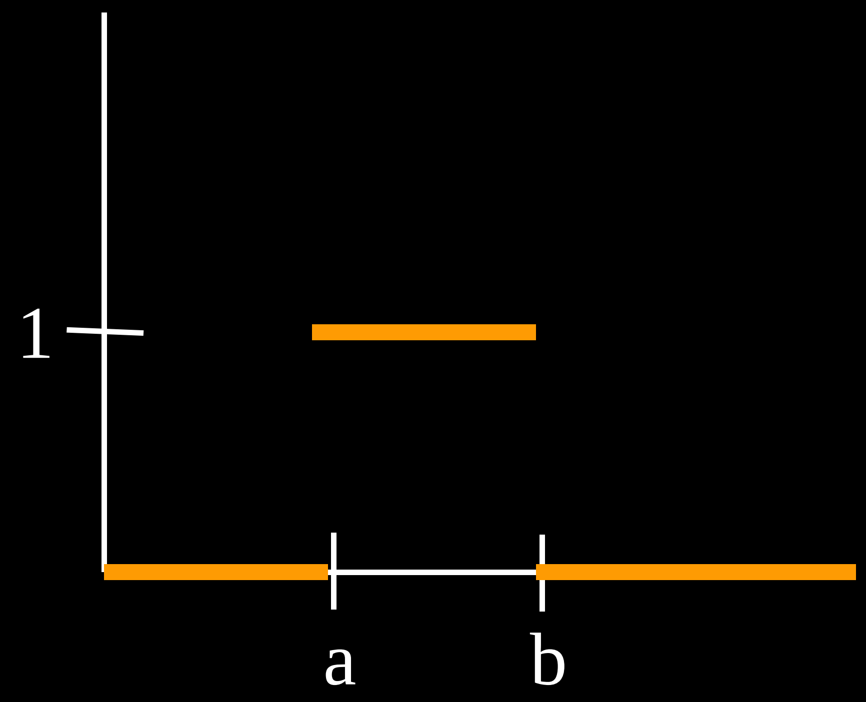


Smoothstep



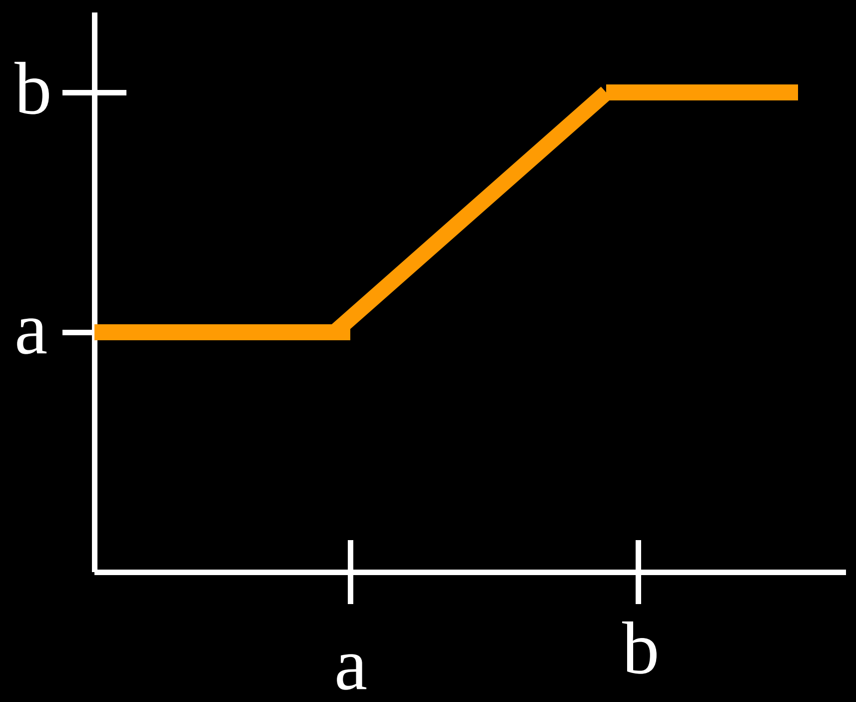
smoothstep(a,b,x)

Pulse



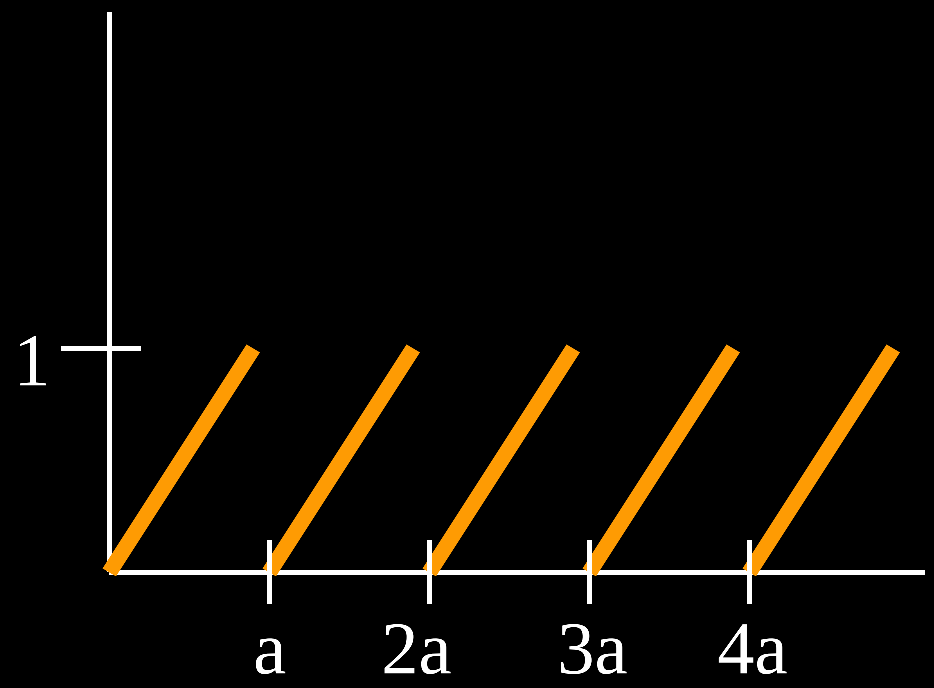
pulse(a,b,x) = step(a,x) - step(b,x)

Clamp



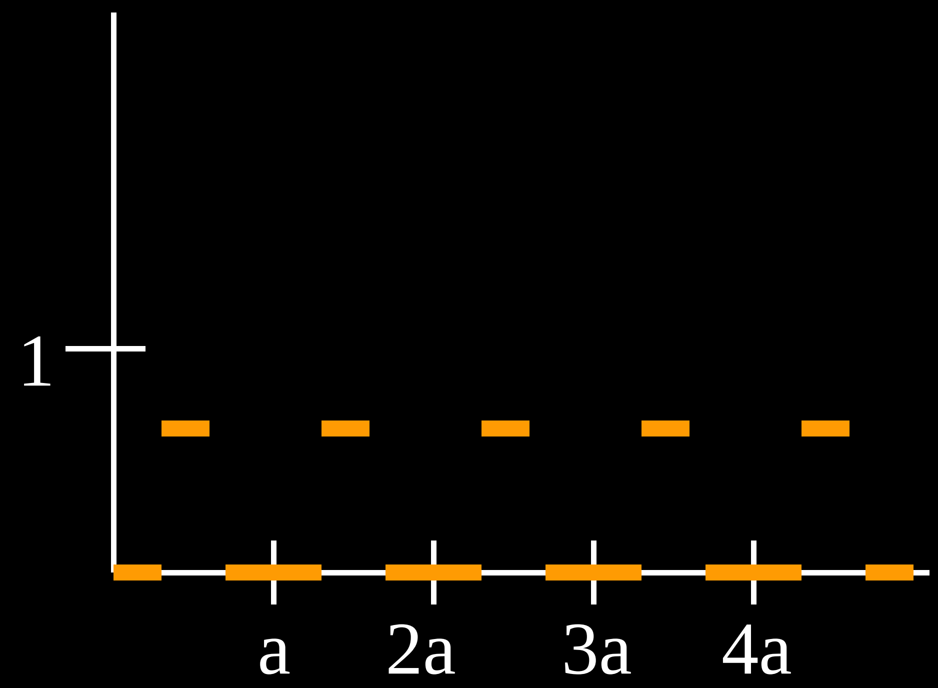
clamp(x,a,b) = min(max(x,a), b)

Mod



mod(x,a) / a

Periodic Pulse



pulse(0.4, 0.6, mod(x,a)/a)

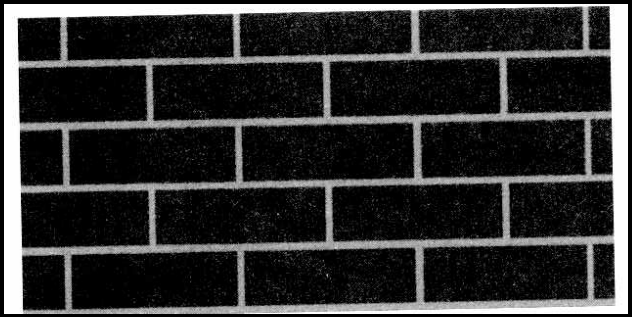
Example 1 - brick (see handout)

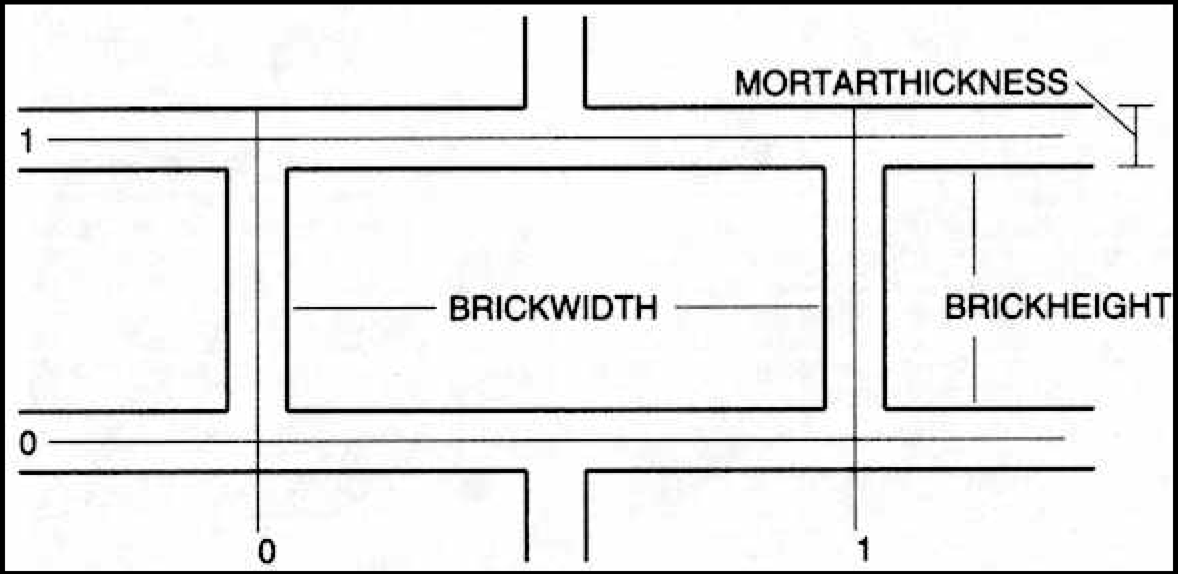
Brick is primarily a 2D pulse

Input parameters may include:

- **color of brick and mortar**
- **size of brick**
- **thickness of mortar**
- **mortar bump size**
- **frequency of brick color variation**
- **etc.**

Brick





from Ebert, ed., *Texturing and Modeling: a Procedural Approach, 1994, pages 37-38.*

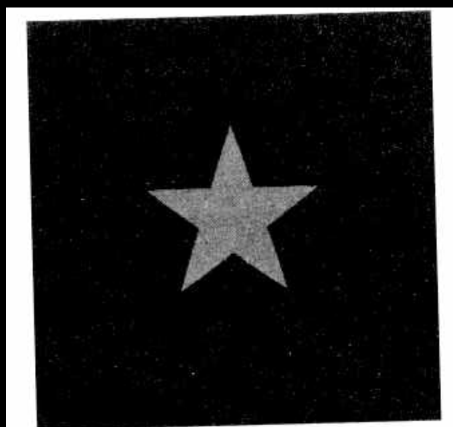
Example 2 - star (see handout)

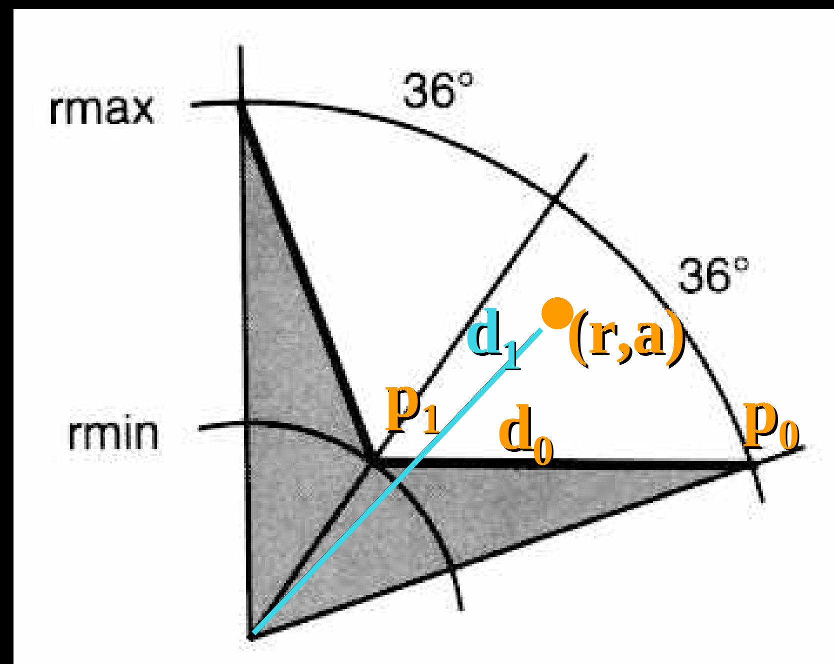
Exploit symmetry of star geometry

Input parameters may include:

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

Star





from Ebert, ed., ***Texturing and Modeling: a Procedural Approach, 1994, pages 44-46.***

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));
}
```