GPU Shading and Rendering: OpenGL Shading Language

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Outline

OpenGL

- Derived from SGI GL in 1992
- Cross-platform, Cross-vendor
- Architecture Review Board
  - Apple, ATI, Dell, IBM, Intel, NVIDIA, SGI, Sun, 3Dlabs
- Core, Extensions

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- Originally proposed by 3DLabs
- ARB extension in OpenGL 1.5
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- High-level language
- Inspired by C & RenderMan
- Float & vector types & operations
- RenderMan-inspired shading & math functions

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Interesting features

- Compiler built-into driver
  - Enables vendor optimizations
- Virtualization
  - Compiler handles long shaders
- Direct access to built-in state
  - OpenGL state
  - vertex & fragment input & output
- New arbitrary parameters
  - vertex input
  - vertex/fragment communication

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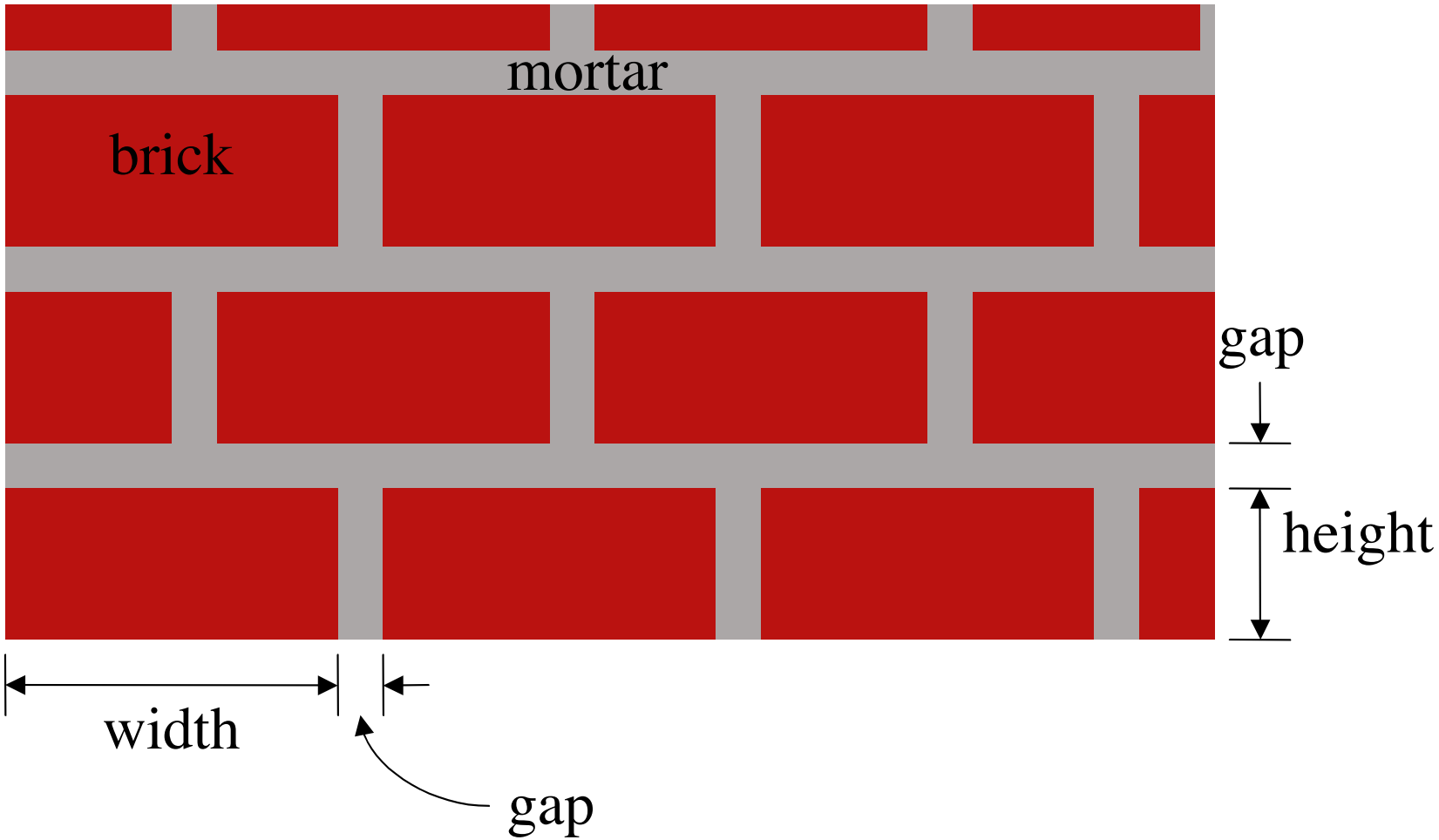
Simple Brick



OpenGL Vertex Shader

- Transform & Light

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void main(void) {
    vec4 P = gl_ModelViewMatrix * gl_Vertex;
    vec4 E = gl_ProjectionMatrixInverse * vec4(0,0,1,0);
    vec3 I = P.xyz*E.w - E.xyz*P.w;
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OpenGL spaces

vec4 E = gl_ProjectionMatrixInverse * vec4(0,0,1,0);

- Model space: object vertices
- View space: common space for lighting
  - gl_ModelViewMatrix * gl_Vertex
- Clip/Projection space: parallel; view down -z

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Homogeneous Subtraction

vec3 I = P.xyz*E.w - E.xyz*P.w;

- Common to see P.xyz/P.w - E.xyz/E.w
- Same as (P.xyz-E.xyz)/(P.w*E.w)
- Homogeneous result vector: vec4(P.xyz-E.xyz,P.w*E.w)
  - Works even if P.w or E.w = 0!
- Only care about direction
  - So ignore w vector scale factor
  - Also safe to ignore if normalizing

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OpenGL Vertex Shader (II)

- Accumulate light contribution

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gl_FrontColor = vec4(0,0,0,1);
for (int i=0; i < gl_MaxLights; i++) {
    vec3 L = normalize(
        gl_LightSource[i].position.xyz*P.w -
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    gl_FrontColor.xyz +=
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OpenGL Fragment Shader

- Compute per-fragment brick color

```
uniform float width, height, gap;
uniform vec3 brick, mortar;

void main(void) {
    vec3 bc;
    float s = gl_TexCoord[0].s;
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    /* [compute brick color] */
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OpenGL Fragment Shader (II)

- Compute brick color
- Where am I in my brick (Brick Coordinates)

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float bs, bt;
/* [compute brick coordinates] */
if (bs < width && bt < height)
    bc = brick;
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OpenGL Fragment Shader (III)

- Compute brick coordinates

```
bt = mod(t, height+gap);
bs = s;
if (mod((t-bt)/(height+gap), 2.) < 1.5)
    bs += (width+gap)/2.;
bs = mod(bs, width+gap);
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- Compute brick coordinates

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3D Noise

- Recall

$$hash(x) = x^2 \bmod M$$

$$\begin{aligned} noise(\vec{p}) = flerp(z, &zconst(\vec{p}^x, \vec{p}^y + hash(Z_0)) \\ &+ zgrad(\vec{p}^x, \vec{p}^y\, hash(Z_0)) * z, \\ &zconst(\vec{p}^x, \vec{p}^y\, hash(Z_1)) \\ &+ zgrad(\vec{p}^x, \vec{p}^y + hash(Z_1)) * (z-1)) \end{aligned}$$

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3D Noise Fragment Shader (I)

```
varying vec3 Nin;
const float modulus = 61;
uniform sampler2D ntex;

void main() {
    /* noise computation */
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```
varying vec3 Nin;
const float modulus = 61;
uniform sampler2D ntex;

void main() {
    /* noise computation */
}
```

3D Noise Fragment Shader (II)

```
float fracArg = fract(modulus*Nin.z);
float intArg = floor(modulus*Nin.z);

vec2 hash = mod(intArg,modulus);
hash.y = hash.y+1;
hash = mod(hash*hash,modulus);
hash = hash/modulus;
```

3D Noise Fragment Shader (II)

```
float fracArg = fract(modulus*Nin.z);
float intArg = floor(modulus*Nin.z);

vec2 hash = mod(intArg,modulus);
hash.y = hash.y+1;
hash = mod(hash*hash,modulus);
hash = hash/modulus;
```

3D Noise Fragment Shader (III)

```
vec2 g0, g1;
g0 = texture2D(ntex, Nin.xy+vec2(0,hash.x)).xy*2-1;
g1 = texture2D(ntex, Nin.xy+vec2(0,hash.y)).xy*2-1;
float noise = mix(g0.r+g0.a*fracArg,
                  g1.r+g1.a*(fracArg-1),
                  smoothstep(0,1,fracArg));
```

3D Noise Fragment Shader (III)

```
vec2 g0, g1;
g0 = texture2D(ntex, Nin.xy+vec2(0,hash.x)).xy*2-1;
g1 = texture2D(ntex, Nin.xy+vec2(0,hash.y)).xy*2-1;
float noise = mix(g0.r+g0.a*fracArg,
                  g1.r+g1.a*(fracArg-1),
                  smoothstep(0,1,fracArg));
```

Outline

Resources


Kessenich, J., Baldwin, D., and Rost, R. (2004).
The OpenGL Shading Language.
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OpenGL(R) Shading Language.
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