Effects Framework for OpenGL Testing

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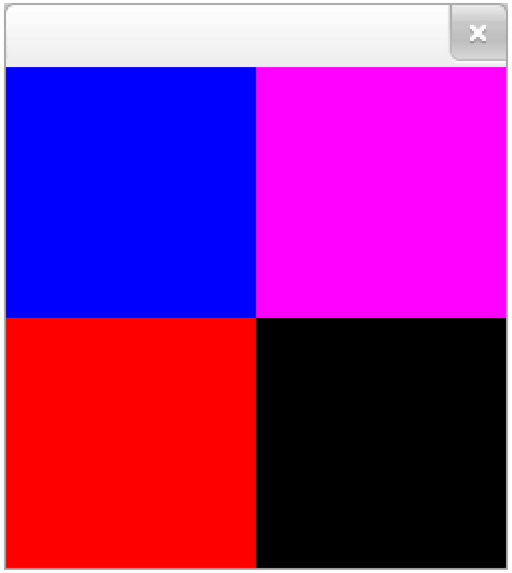
Agenda

- Why?
- What is an “effect” anyway?
- nvFX
- Is nvFS useful?

Why?



Why?

```
uniform mat4x2 arg0;
uniform mat4x2 arg1;
uniform float tolerance;
uniform mat4x2 expected;

void main()
{
  mat4x2 result = matrixCompMult(arg0, arg1);
  mat4x2 residual = result - expected;
  float error_sq = residual[0][0] * residual[0][0] + residual[0][1]
    * residual[0][1] + residual[1][0] * residual[1][0] + residual[1][1]
    * residual[1][1] + residual[2][0] * residual[2][0] + residual[2][1]
    * residual[2][1] + residual[3][0] * residual[3][0] + residual[3][1]
    * residual[3][1];
  gl_FragColor = error_sq <= tolerance * tolerance
    ? vec4(0.0, 1.0, 0.0, 1.0) : vec4(1.0, 0.0, 0.0, 1.0);
}
```

Why?

```
#version 130
in vec3 normal_es, position_es;
out vec4 color;
uniform vec3 light_es = vec3(0.0, 15.0, 4.0);
uniform float m = 0.2;
uniform float ri = 1.5;
uniform vec3 color_s = vec3(1.0);
uniform vec3 color_d = vec3(1.0, 0.0, 0.0);

float schlick(float ni, float cos_theta)
{
        float c = 1.0 - cos_theta;
        float r0 = (ni - 1.0) / (ni + 1.0);
        r0 = r0 * r0;
        return r0 + (1.0 - r0) * pow(c, 5.0);
}

float G(float n_dot_l, float n_dot_h,
        float n_dot_v, float v_dot_h)
{
        float c = 2.0 * n_dot_h / v_dot_h;
        return min(1.0, c * min(n_dot_v,
                                n_dot_l));
}
```

```
float beckmann(float m, float cos_theta)
{
        float c2 = cos_theta * cos_theta;
        m = max(m, 1e-6);
        float m_c2 = m * c2;
        return exp((c2 - 1.0) / (m * m_c2))
            / (4.0 * m_c2 * m_c2);
}

void main(void)
{
        vec3 l = normalize(light_es - position_es);
        vec3 v = -normalize(position_es);
        vec3 n = normalize(normal_es);
        vec3 h = normalize(l + v);
        float ndl = dot(n, l);
        float ndh = dot(n, h);
        float ndv = dot(n, v);

        float f = schlick(ri, ndv) * beckmann(m, ndh)
            * G(ndl, ndh, ndv, dot(v, h)) / ndv;

        vec3 spec = f * color_s;
        vec3 diff = color_d * max(ndl, 0.);

        color = vec4((spec + diff), 1.0);
}
```

Why?

- shader_runner is piglit's mechanism for testing shaders
  - Really hard to draw anything other than a rectangle
  - Really hard to get additional per-vertex data to the shader
  - Really hard to use a non-trival texture
    - You can use any texture you want, as long as you only want checkerboard or RGBW
  - Really hard to set other GL state
  - Difficult to extend
    - The parser... gives me nightmares.
  - etc.

Why?

- Holy grail: Easily import shaders from real apps
  - shader_runner doesn't really help here
    - There are a couple shader tests like this
  - apitrace could help
    - Trace files tend to be quite large
    - Trace files are difficult to tweak
      - Want to modify a GL 3.3 test to run on GL ES 3.0
    - Trace files are difficult to create from scratch
      - Write an application, then trace it

What is an effect?

- High-level encapsulation of a drawing method
  - Shader code
  - Uniform values
  - GL state settings
    - Samplers, textures, etc.
    - Rasterization settings
- An effect may contain multiple passes
  - Set one shader & parameters, draw, repeat...

What is nvFX?

- An effects file format created by Tristan Lorch (NVIDIA)
  - Inspired by cgFX, but not specific to cg
  - Open-source library
    - https://github.com/tlorach/nvFX
- See also:
  - https://developer.nvidia.com/sites/default/files/akamai/gamedev/docs/nvFX%20A%20New%20Shader-Effect%20Framework.pdf
    - Search “nvfx site:developer.nvidia.com”
  - https://www.khronos.org/assets/uploads/developers/library/2013-siggraph-opengl-bof/nvFX-effects-framework-OpenGL-BOF_SIGGRAPH-2013.pdf
    - Search “nvfx site:khronos.org”

nvFX Layout

```
GLSLShader {// Prepend to all shaders
    #version 130
    uniform mat4 mvp;
}
GLSShader ObjectVS {
    in vec4 position;
    in vec3 normal;
    out vec3 normal_eye_space;
    void main() {
        …
    }
}
GLSLShader ObjectFS {
    …
}
GLSLShader DiffuseFromTexture {
    uniform sampler2D tex;
    vec4 getDiffuse(vec3 tc) {
        return texture(tex, tc);
    }
}
```

```
SamplerState defaultSampState {
    TEXTURE_MIN_FILTER =
        LINEAR_MIPMAP_LINEAR;
    TEXTURE_MAG_FILTER = LINEAR;
}
TextureResource2D diffuseTexture <
    defaultFile = "image.ktx";
> {
    SamplerState = defaultSampState;
}

Technique TECH_Diffuse {
    Pass p0 {
        VertexProgram = ObjectVS;
        FragmentProgram = { ObjectFS,
            DiffuseFromTexture };
        SamplerResource(tex) =
            diffuseTexture;
    }
}
```

nvFX Layout

```
namespace floor {
    GLShader VS {
        …
    }
    …
}
```

```
Technique TECH_Floor {
    Pass p0 {
        VertexProgram = floor::VS;
        FragmentProgram = floor::FS;
    }
}
```

Mixed Versions

```
GLSLShader common_gl {
    #version 130
}
GLSLShader common_gles {
    #version 300 es
}

GLSLShader foo {
    …
}
```

```
// C++ code has to read the
// annotation and do something smart
// with it.
Technique TECH_gl <
    GLSL_min_version = 1.30
> {
    VertexProgram = { common_gl,
                      foo };
    …
}
Technique TECH_gles <
    GLSL_min_version = 3.00
> {
    VertexProgram = { common_gles,
                      foo };
    …
}
```

nvFX Advantages

- More robust language for combining shaders into programs
- More robust language for changing GL state
- Much better mechanism for associating data with vertex attributes
- Multiple passes
- Non-screen render targets
  - So that effects can render shadow maps, etc.
- Shaders targeting multiple shading languages can live in one place
  - Sharing shader text across versions is clunky
- Documentation :)

nvFX Disadvantages

- Still requires a lot of C++ code to use
- No direct integration with models
  - Model files would generally reference effects (by name) that are defined in the fx files
  - Sort of the opposite binding order from what we want
- No transform feedback support
- No direct way to verify results of rendered image
- No way to specify effect requirements
  - Like “`GLSL >= 1.30`” in `shader_runner`
  - Annotations may fill this gap
- No Linux or Mac build targets yet
  - It uses cmake, so it shouldn't be too hard to add...

Can piglit use nvFX?

- Probably not as-is
  - Not straightforward to replace tests that draw many quads & probe results
  - No obvious way to supply additional vertex data
    - Standard set of model files?
  - We'd probably have to extend their parser
- If apitrace could generate nvFX files...

Can shader_runner borrow ideas from nvFX?

- Nice file format
  - Decent parser, too
  - Clean syntax for textures and state information

```
[require]
GL >= 3.0

[fx]
…

[test]
technique foo
draw rect -1 -1 1 1
probe rgb 10 10 0 1 0
…
```

- May provide an eventual migration path to nvFX

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