



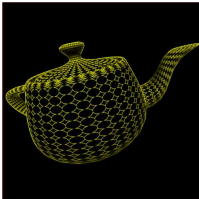

Rendering to a Texture:
A Good Way to Get a Texture for Use in a Shader Second Render Pass

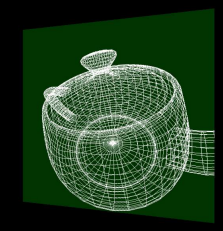


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Hardcopy and Display
Y Resolution 1024

Create Hardcopy File

Display the Hardcopy File [F10]

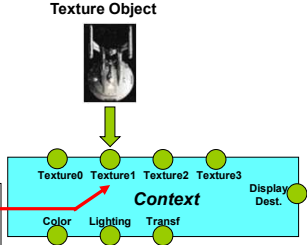
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Background -- "Binding" to the Context

The OpenGL term "binding" refers to "docking" (a Star Trek-ish metaphor which I find to be more visually pleasing) an OpenGL object to the Context. You can then assign characteristics, and they will "flow" through the Context into the object.

```
glActiveTexture( GL_TEXTURE1 );
glBindTexture( GL_TEXTURE_2D, texA );
glTexParameterf( GL_TEXTURE_2D, GL_TEXTURE_WRAP_S, GL_REPEAT );
glTexParameterf( GL_TEXTURE_2D, GL_TEXTURE_WRAP_T, GL_REPEAT );
glTexParameterf( GL_TEXTURE_2D, GL_TEXTURE_MAG_FILTER, GL_LINEAR );
glTexParameterf( GL_TEXTURE_2D, GL_TEXTURE_MIN_FILTER, GL_LINEAR );
glTexImage2D( GL_TEXTURE_2D, 0, GL_RGBA, dimS, dimT, 0, GL_RGBA,
              GL_UNSIGNED_BYTE, image );
```





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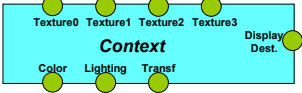
Background -- "Binding" to the Context

When you want to use that same Texture Object, just bind it again. All of the characteristics will then be active, just as if you had specified them again.


Texture Object



↓



```
glActiveTexture( GL_TEXTURE1 );
glBindTexture( GL_TEXTURE_2D, texA );
```




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The Overall Render-to-Texture Process

- 1 Generate a handle for a Framebuffer Object.
- 2 Generate handles for one Color Texture Object and for one Depth Texture Object.
- 3 Bind the Color Texture Object to the Context (glBindTexture). Act as if you are downloading texels to it but set that array to NULL. Just give the texture size. Assign texture parameters to it. Attach it to the Framebuffer Object (glFramebufferTexture2D) as the GL_COLOR_ATTACHMENT0.
- 4 Bind the Depth Texture Object to the Context (glBindTexture). Act as if you are downloading texels to it but set that array to NULL. Just give the texture size. Assign texture parameters to it. Attach it to the Framebuffer Object (glFramebufferTexture2D) as the GL_DEPTH_ATTACHMENT.
- 5 Bind the Framebuffer Object to the Context (glBindFramebuffer), thus un-binding the display monitor.
- 6 Render as normal. Be sure the size of the viewport matches the size of the textures you created.
- 7 Un-bind the Framebuffer Object from the Context, glBindFramebuffer(0), thus re-binding the display monitor.



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Code for the Render-to-Texture Process

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In `InitGraphics()`, generate a `Framebuffer` handle, a `ColorBuffer` handle, and a `DepthBuffer` handle:

```
GLuint FrameBuffer;
GLuint ColorTexture;
GLuint DepthBuffer;

glGenFramebuffers( 1, &FrameBuffer );
glGenTextures( 1, &ColorTexture );
glGenTextures( 1, &DepthBuffer );
```

Bind the offscreen framebuffer to be the current output display:

```
glBindFramebuffer( GL_FRAMEBUFFER, FrameBuffer );
```

Setup the size you want the texture rendering to be (this can be larger than the display window or even the display monitor):

```
int sizeS = 2048;
int sizeT = 2048;
```



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Code for the Render-to-Texture Process

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Bind the `Color Buffer` to the context, allocate its storage, and attach it to the current `Framebuffer`:

```
glBindTexture( GL_TEXTURE_2D, ColorBuffer );
glTexImage2D(GL_TEXTURE_2D, 0, GL_RGBA, sizeS, sizeT, 0, GL_RGBA, GL_UNSIGNED_BYTE, NULL);
glTexParameteri(GL_TEXTURE_2D, GL_TEXTURE_MIN_FILTER, GL_LINEAR);
glTexParameteri(GL_TEXTURE_2D, GL_TEXTURE_MAG_FILTER, GL_LINEAR);
glTexParameteri(GL_TEXTURE_2D, GL_TEXTURE_WRAP_S, GL_CLAMP_TO_EDGE);
glTexParameteri(GL_TEXTURE_2D, GL_TEXTURE_WRAP_T, GL_CLAMP_TO_EDGE);
```

```
glFramebufferTexture2D(GL_FRAMEBUFFER, GL_COLOR_ATTACHMENT0, GL_TEXTURE_2D, ColorBuffer, 0);
```

Bind the `Depth Buffer` to the context, allocate its storage, and attach it to the current `Framebuffer`:

```
glBindTexture( GL_TEXTURE_2D, DepthBuffer );
glTexImage2D(GL_TEXTURE_2D, 0, GL_DEPTH_COMPONENT, sizeS, sizeT, 0, GL_DEPTH_COMPONENT, GL_FLOAT, NULL);
glTexParameteri(GL_TEXTURE_2D, GL_TEXTURE_MIN_FILTER, GL_LINEAR);
glTexParameteri(GL_TEXTURE_2D, GL_TEXTURE_MAG_FILTER, GL_LINEAR);
glTexParameteri(GL_TEXTURE_2D, GL_TEXTURE_WRAP_S, GL_CLAMP_TO_EDGE);
glTexParameteri(GL_TEXTURE_2D, GL_TEXTURE_WRAP_T, GL_CLAMP_TO_EDGE);
```

```
glFramebufferTexture2D(GL_FRAMEBUFFER, GL_DEPTH_ATTACHMENT, GL_TEXTURE_2D, DepthBuffer, 0);
```

Check to see if `OpenGL` thinks the framebuffer is complete enough to use:

```
GLenum status = glCheckFramebufferStatus( GL_FRAMEBUFFER );
if( status != GL_FRAMEBUFFER_COMPLETE )
    fprintf( stderr, "Framebuffer is not complete.\n" );
```



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Code for the Render-to-Texture Process

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Now, render as you normally would. Be sure to set the viewport to match the size of the color and depth buffers:

```
glClear( GL_COLOR_BUFFER_BIT | GL_DEPTH_BUFFER_BIT );
glEnable( GL_DEPTH_TEST );
glShadeModel( GL_SMOOTH );
glViewport( 0, 0, sizeS, sizeT );

glMatrixMode( GL_PROJECTION );
glLoadIdentity();
gluPerspective( 90., 1., 0.1, 1000. );

glMatrixMode( GL_MODELVIEW );
glLoadIdentity();
gluLookAt( 0., 0., 3., 0., 0., 0., 0., 1., 0. );

glRotatef( RotY, 0., 1., 0. );
glRotatef( RotX, 1., 0., 0. );
glScalef( Scale, Scale, Scale );
glColor3f( 1., 1., 1. );

glutWireTeapot( 1. );
```

Tell `OpenGL` to go back to rendering to the display monitor:

```
glBindFramebuffer( GL_FRAMEBUFFER, 0 );
```



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Code for the Render-to-Texture Process

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Now, render the second pass of the scene as normal, mapping the `Texture` onto a quadrilateral:

```
glClear( GL_COLOR_BUFFER_BIT | GL_DEPTH_BUFFER_BIT );
glEnable( GL_DEPTH_TEST );
glShadeModel( GL_FLAT );
glViewport( 0, 0, v, v );

glMatrixMode( GL_PROJECTION );
glLoadIdentity();
gluOrtho2D( -1., 1., -1., 1. );

glMatrixMode( GL_MODELVIEW );
glLoadIdentity();

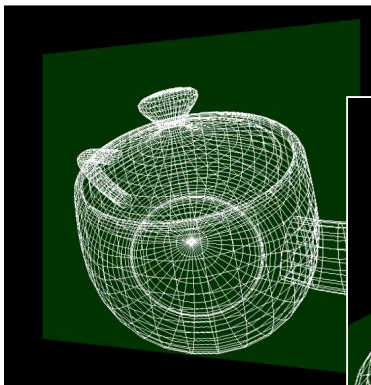
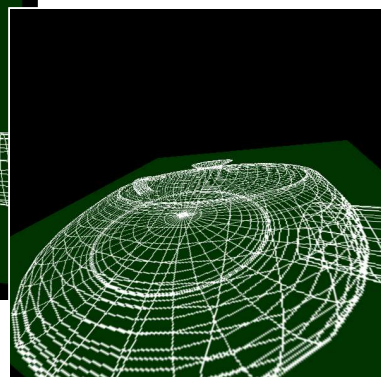
glEnable( GL_TEXTURE_2D );
glActiveTexture( GL_TEXTURE1 );
glBindTexture( GL_TEXTURE_2D, ColorBuffer );
Pattern.Use();
Pattern.SetUniformVariable( "uTexunit", 1 );
glBegin( GL_QUADS );
    glVertex2f( 0., 0. );
    glVertex2f( -1., -1. );
    glVertex2f( 1., 0. );
    glVertex2f( 1., -1. );
    glVertex2f( 1., 1. );
    glVertex2f( 1., 1. );
    glVertex2f( 0., 1. );
    glVertex2f( -1., 1. );
glEnd();
Pattern.UnUse();
glDisable( GL_TEXTURE_2D );
```


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Render-to-Texture A Rotating 3D Teapot Displayed on a Rotating Plane



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Render-to-Texture : An Image-filtered 3D Noisy-Oval Teapot using Glim

```

twopass.glsl
##OpenGL GLSL
Perspective 90

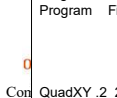
Texture2D 6 1024 1024 # a 1024x1024 NULL texture
RenderToTexture 6 # render to texture unit 6
Background 0. 0. 0.
Clear
LookAt 0. 0. 3. 0. 0. 0. 0. 1. 0.

Vertex ovals.vert
Fragment ovals.frag
Program Ovals
        uAd <.01 .2.5> uBd <.01 .2.5>
        uNoiseAmp <0. 0. 1.> uNoiseFreq <0. 1. 2.>
        uTol <0. 0. 1.>

Teapot

RenderToTexture # render to the display monitor
Background 0. 0. 0.
Clear
LookAt 0. 0. 3. 0. 0. 0. 0. 1. 0.



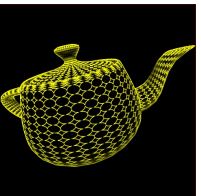



Vertex image.vert
Fragment image.frag
Program Filter
        uTexUnit 6
        uEdgeDetect <true>
        uTedge <0. 0. 1.>
        uTSharp <-3. 1. 10.>
    
```




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Multipass Algorithm to Render and then Image Process

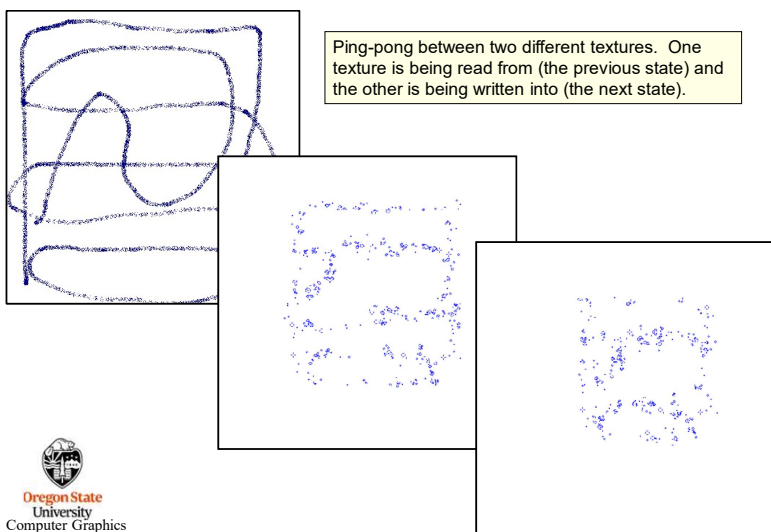
	Original	Sharpened	Edge Detected
No Noise			
Noise			




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Multipass Algorithm to Implement Conway's Game of Life



Ping-pong between two different textures. One texture is being read from (the previous state) and the other is being written into (the next state).



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```

life.glib

##OpenGL GLIB
Perspective 70

# setup the 2 textures:
Texture2D 5 paint0.bmp
Texture2D 6 512 512

# execute the first iteration:
RenderToTexture 6
Background 0. 0. 0.
Clear
Vertex life.vert
Fragment life.frag
Program GameOfLife1 uTexUnit 5
TextureMatrix
Translate 0. 0. -3.08
QuadXY .2.2.

# render it so we can see it:
RenderToTexture
Background 0. 2 0.
Clear
Vertex texture.vert
Fragment texture.frag
Program Texture1 uTexUnit 6
ModelViewMatrix
Translate 0. 0. -3.08
QuadXY .2.2.
SwapBuffers

# execute the second iteration:
RenderToTexture 5
Background 0. 0. 0.
Clear
Vertex life.vert
Fragment life.frag
Program GameOfLife2 uTexUnit 6
QuadXY .2.2.

# render it so we can see it:
RenderToTexture
Background .2 0. 0.
Clear
Vertex texture.vert
Fragment texture.frag
Program Texture uTexUnit 5
QuadXY .2.2.

# repeat:
animate

```

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```

life.frag, I

uniform sampler2D uTexUnit;
in vec2 vST;

const vec3 DEAD = vec3(1., 1., 1.);
const vec3 ALIVE = vec3(0., 0., 1.);

const float TB = 0.20; // color threshold
const float TR = 0.20; // color threshold
const int T1 = 1; // critical # of neighbors
const int T3 = 3; // critical # of neighbors
const int T4 = 4; // critical # of neighbors

void main()
{
    ivec2 isize = textureSize( uTexUnit, 0 );
    vec2 st = vST;
    ivec2 ist = ivec2( st.s*float(isize.s-1) , st.t*float(isize.t-1) ); // 0 -> dimension-1
    ivec2 istp0 = ivec2( 1, 0 );
    ivec2 istop = ivec2( 0, 1 );
    ivec2 istpp = ivec2( 1, 1 );
    ivec2 istpm = ivec2( 1, -1 );

    vec3 i00 = texelFetch( uTexUnit, ist, 0 );rgb; // index using integer indices
    vec3 im10 = texelFetch( uTexUnit, ist-istp0, 0 );rgb;
    vec3 i0m1 = texelFetch( uTexUnit, ist-ist0p, 0 );rgb;
    vec3 ip10 = texelFetch( uTexUnit, ist+istp0, 0 );rgb;
    vec3 i0p1 = texelFetch( uTexUnit, ist+ist0p, 0 );rgb;
    vec3 im1m1 = texelFetch( uTexUnit, ist-istpp, 0 );rgb;
    vec3 ip1p1 = texelFetch( uTexUnit, ist+istpp, 0 );rgb;
    vec3 im1p1 = texelFetch( uTexUnit, ist-istpm, 0 );rgb;
    vec3 ip1m1 = texelFetch( uTexUnit, ist+istpm, 0 );rgb;
}

```

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```

life.frag, II

int sum = 0;
if( im10.b > TB && im10.r < TR ) sum++;
if( i0m1.b > TB && i0m1.r < TR ) sum++;
if( ip10.b > TB && ip10.r < TR ) sum++;
if( i0p1.b > TB && i0p1.r < TR ) sum++;
if( im1m1.b > TB && im1m1.r < TR ) sum++;
if( ip1p1.b > TB && ip1p1.r < TR ) sum++;
if( im1p1.b > TB && im1p1.r < TR ) sum++;
if( ip1m1.b > TB && ip1m1.r < TR ) sum++;

vec3 newcolor = i00;
if( sum == T3 )
{
    newcolor = ALIVE;
}
else if( sum <= T1 || sum >= T4 )
{
    newcolor = DEAD;
}

gl_FragColor = vec4( newcolor, 1.);
}

```

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Code for Reading Pixels Back

Read the pixels back and do something with them (such as writing an image file):

```

glBindFramebuffer( GL_FRAMEBUFFER, FrameBuffer );
unsigned char *image = new unsigned char[ 3*sizeS*sizeT ];
glPixelStorei( GL_PACK_ALIGNMENT, 1 );
glReadPixels( 0, 0, sizeS, sizeT, GL_RGB, GL_UNSIGNED_BYTE, image );
...

```

Tell OpenGL to go back to rendering to the display monitor:

```

glBindFramebuffer( GL_FRAMEBUFFER, 0 );

```

Render-to-Framebuffer is great for creating arbitrary-resolution hardcopy.

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