CS6533/CS4533 Lecture 12 Slides/Notes

Shadow Blending in HW4 (b); Texture Mapping (Notes, Sample Program)

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*** Discussing how to modify the ``making decal'' process in HW3 to do shadow blending in HW4 part (b)** (a demo of HW4 is shown first).

* **Texture Mapping**

- Discussing the sample program ``Handout: checker-new.cpp" (complete sample program has been posted at https://cse.engineering.nyu.edu/cs653/Checker.tar.gz.
- Some screenshots of this sample program with annotations are then shown next.
- Showing a demo of this sample program, as well as a demo of HW4.

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Making Decal (from HW3) ⇒ HW4 (b) for semi-transparent shadow. (changes are shown in green)

(shadow is a decal on top of ground).

0. Always enable z-buffer testing.

1. (Draw ground only to frame buffer)
   Disable writing to z-buffer
   Draw ground (only to frame buffer)

2. ~~Enable writing to z-buffer~~ X
   Draw shadow (to Both buffers. z-buffer, frame buffer
   shadow is NOT blocked by ground. so is drawn on top of ground)
   (only to frame buffer)
   shadow : on top of ground.
   shadow Δ's are NOT in z-buffer ⇒ they are all drawn & blended. ok. ✓ to block each other

3. (Restore ground into z-buffer)
   Enable writing to z-buffer.
   Disable writing to frame buffer
   Draw ground (only to z-buffer)
   optional [Draw shadow (= = =)]

4. Enable writing to frame buffer.
   Resume normal operations.

T : critical section.

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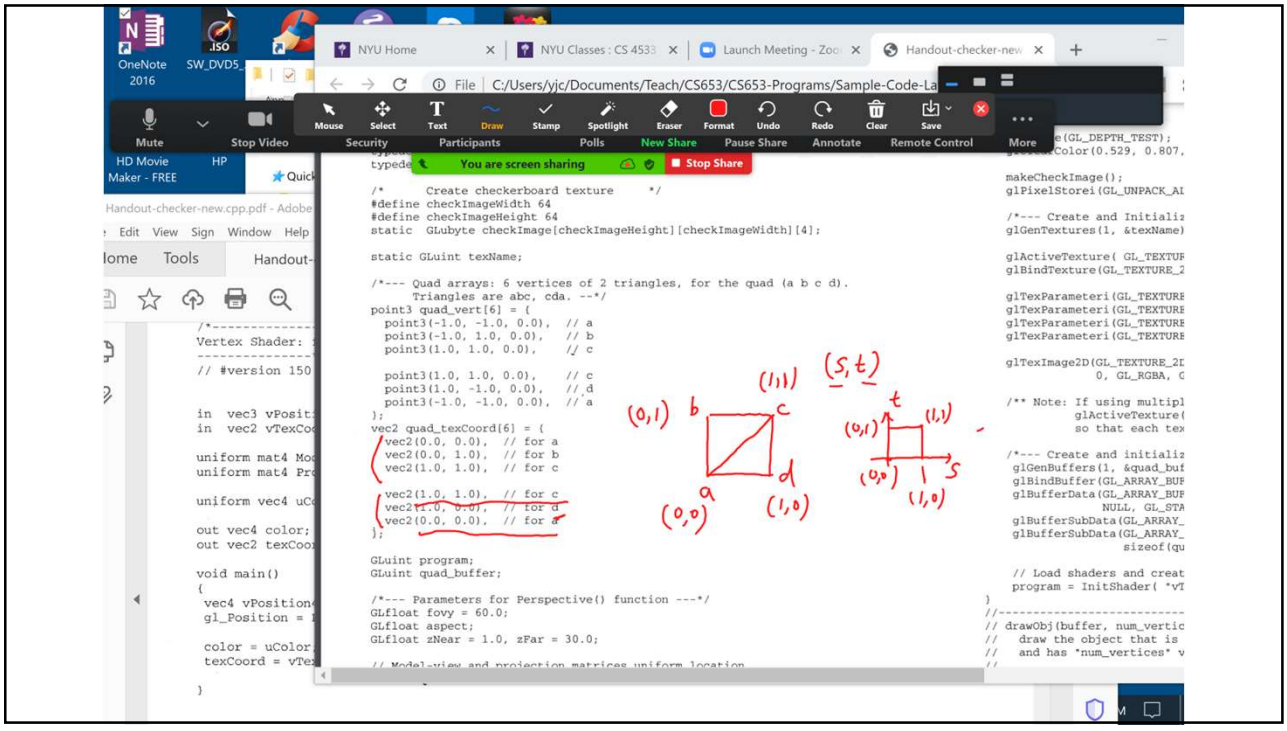
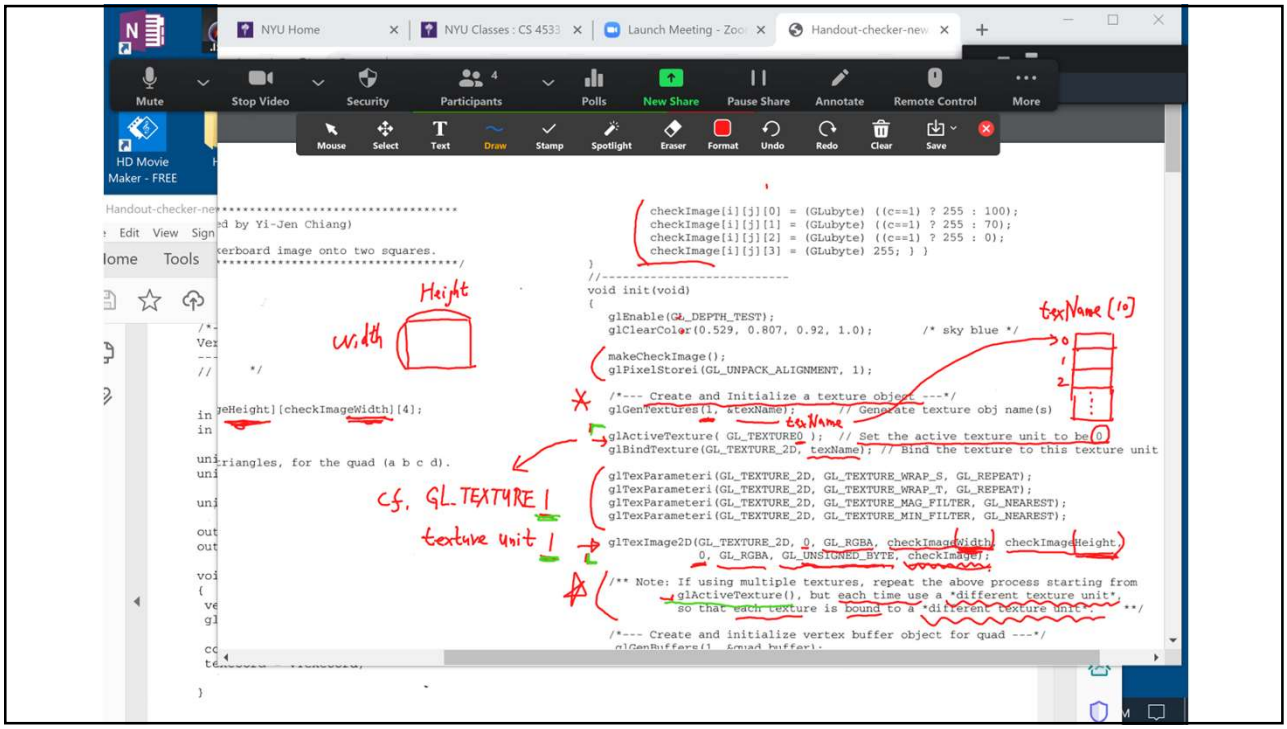


4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texName (10)
cf. GL_TEXTURE1
texture unit 1
checkImage[i][j][0] = (GLubyte) ((c==1) ? 255 : 100);
checkImage[i][j][1] = (GLubyte) ((c==1) ? 255 : 70);
checkImage[i][j][2] = (GLubyte) ((c==1) ? 255 : 0);
checkImage[i][j][3] = (GLubyte) 255; } }
void init(void)
glEnable(GL_DEPTH_TEST);
glClearColor(0.529, 0.807, 0.92, 1.0); /* sky blue */
makeCheckImage();
glPixelStorei(GL_UNPACK_ALIGNMENT, 1);
/*--- Create and Initialize a texture object ---*/
glGenTextures(1, &texName); // Generate texture obj name(s)
glActiveTexture(GL_TEXTURE0); // Set the active texture unit to be 0
glBindTexture(GL_TEXTURE_2D, texName); // Bind the texture to this texture unit
glTexParameteri(GL_TEXTURE_2D, GL_TEXTURE_WRAP_S, GL_REPEAT);
glTexParameteri(GL_TEXTURE_2D, GL_TEXTURE_WRAP_T, GL_REPEAT);
glTexParameteri(GL_TEXTURE_2D, GL_TEXTURE_MAG_FILTER, GL_NEAREST);
glTexParameteri(GL_TEXTURE_2D, GL_TEXTURE_MIN_FILTER, GL_NEAREST);
glTexImage2D(GL_TEXTURE_2D, 0, GL_RGBA, checkImageWidth, checkImageHeight,
0, GL_RGBA, GL_UNSIGNED_BYTE, checkImage);
/** Note: If using multiple textures, repeat the above process starting from
glActiveTexture(), but each time use a *different texture unit*,
so that each texture is bound to a *different texture unit*. **/
/*--- Create and initialize vertex buffer object for quad ---*/

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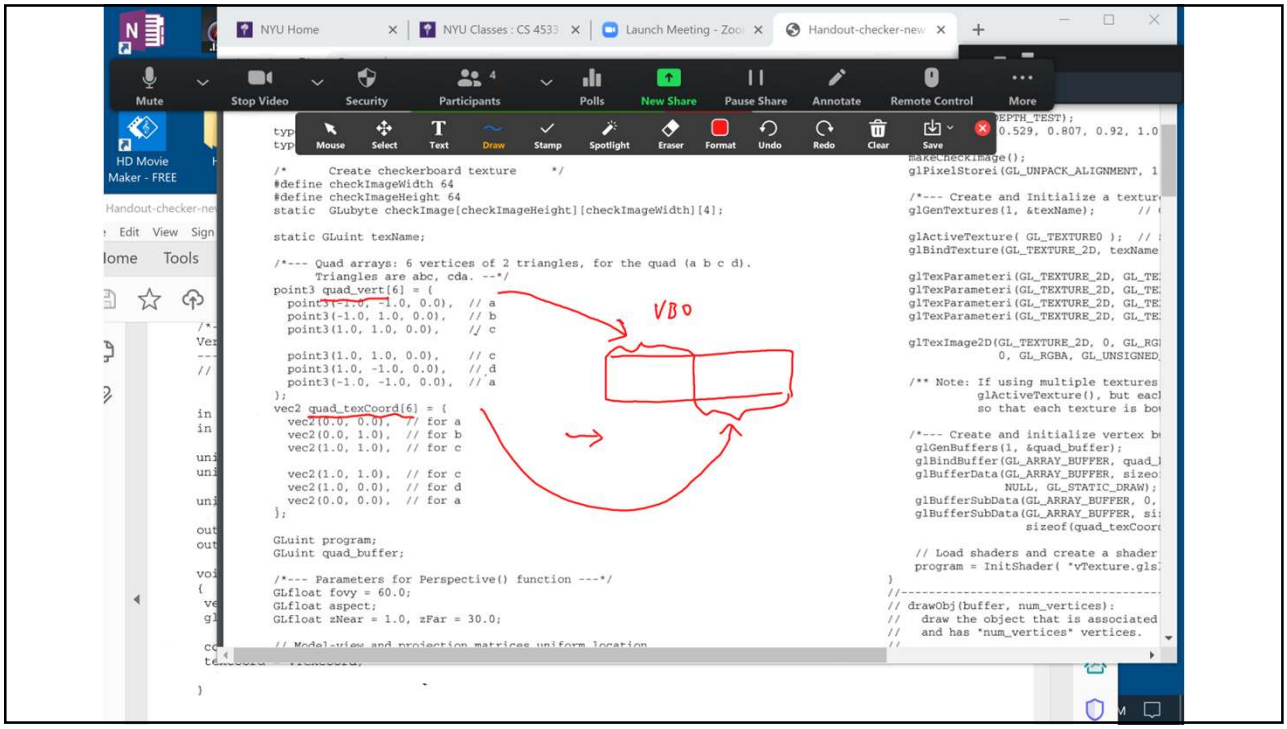
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/* Create checkerboard texture */
#define checkImageWidth 64
#define checkImageHeight 64
static GLubyte checkImage[checkImageHeight][checkImageWidth][4];
static GLuint texName;
/*--- Quad arrays: 6 vertices of 2 triangles, for the quad (a b c d).
Triangles are abc, cda. --*/
point3 quad_vert[6] = {
point3(-1.0, -1.0, 0.0), // a
point3(-1.0, 1.0, 0.0), // b
point3(1.0, 1.0, 0.0), // c
point3(1.0, 1.0, 0.0), // c
point3(1.0, -1.0, 0.0), // d
point3(-1.0, -1.0, 0.0), // a
};
vec2 quad_texCoord[6] = {
vec2(0.0, 0.0), // for a
vec2(0.0, 1.0), // for b
vec2(1.0, 1.0), // for c
vec2(1.0, 1.0), // for c
vec2(1.0, 0.0), // for d
vec2(0.0, 0.0), // for a
};
GLuint program;
GLuint quad_buffer;
/*--- Parameters for Perspective() function ---*/
GLfloat fovy = 60.0;
GLfloat aspect;
GLfloat zNear = 1.0, zFar = 30.0;
// drawObj(buffer, num_vertices):
// draw the object that is associated
// and has "num_vertices" vertices.

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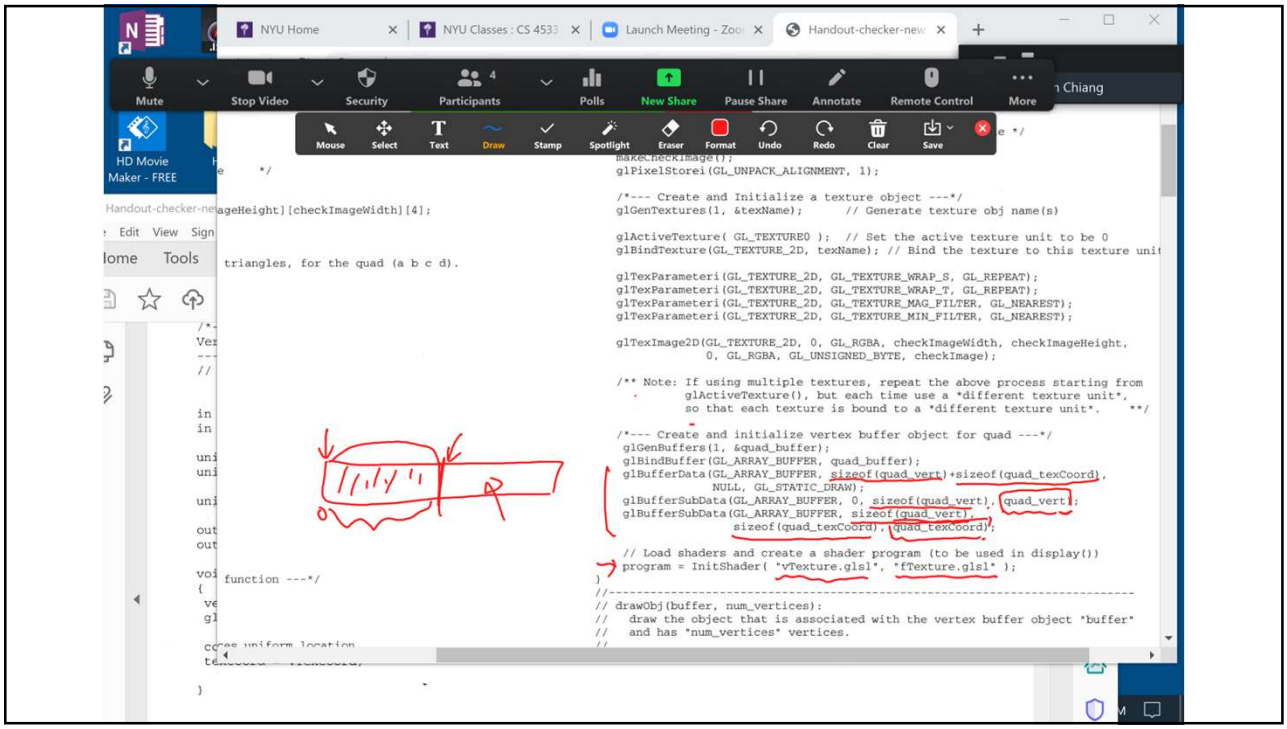
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HD Movie Maker - FREE
triangles, for the quad (a b c d).
function ---*/
glPixelStorei(GL_UNPACK_ALIGNMENT, 1);
/*--- Create and Initialize a texture object ---*/
glGenTextures(1, &texName); // Generate texture obj name(s)
glActiveTexture(GL_TEXTURE0); // Set the active texture unit to be 0
glBindTexture(GL_TEXTURE_2D, texName); // Bind the texture to this texture unit
glTexParameteri(GL_TEXTURE_2D, GL_TEXTURE_WRAP_S, GL_REPEAT);
glTexParameteri(GL_TEXTURE_2D, GL_TEXTURE_WRAP_T, GL_REPEAT);
glTexParameteri(GL_TEXTURE_2D, GL_TEXTURE_MAG_FILTER, GL_NEAREST);
glTexParameteri(GL_TEXTURE_2D, GL_TEXTURE_MIN_FILTER, GL_NEAREST);
glTexImage2D(GL_TEXTURE_2D, 0, GL_RGBA, checkImageWidth, checkImageHeight,
0, GL_RGBA, GL_UNSIGNED_BYTE, checkImage);
/** Note: If using multiple textures, repeat the above process starting from
glActiveTexture(), but each time use a *different texture unit*,
so that each texture is bound to a *different texture unit*. **/
/*--- Create and initialize vertex buffer object for quad ---*/
glGenBuffers(1, &quad_buffer);
glBindBuffer(GL_ARRAY_BUFFER, quad_buffer);
glBufferData(GL_ARRAY_BUFFER, sizeof(quad_vert)+sizeof(quad_texCoord),
NULL, GL_STATIC_DRAW);
glBufferSubData(GL_ARRAY_BUFFER, 0, sizeof(quad_vert), quad_vert);
glBufferSubData(GL_ARRAY_BUFFER, sizeof(quad_vert),
sizeof(quad_texCoord), quad_texCoord);
// Load shaders and create a shader program (to be used in display())
program = InitShader("vTexture.glsl", "fTexture.glsl");
}
//----------
// drawObj(buffer, num_vertices):
// draw the object that is associated with the vertex buffer object "buffer"
// and has "num_vertices" vertices.

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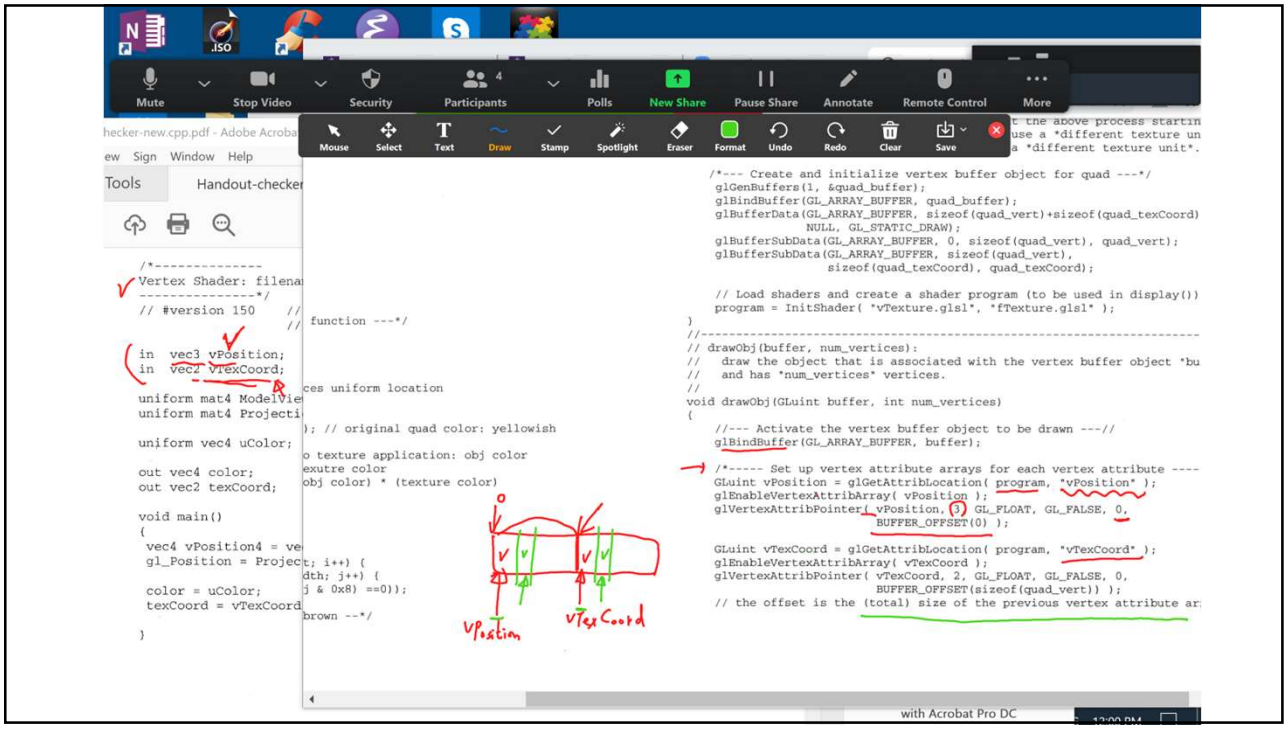
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Vertex Shader: filena
// #version 150
in vec3 vPosition;
in vec2 vTexCoord;
uniform mat4 ModelVie
uniform mat4 Projecti
uniform vec4 uColor;
out vec4 color;
out vec2 texCoord;
void main()
{
vec4 vPosition4 = ve
gl_Position = Project
color = uColor;
texCoord = vTexCoord
}
function ---*/
); // original quad color: yellowish
o texture application: obj color
exutre color
obj color) * (texture color)
brown --*/
/*--- Create and initialize vertex buffer object for quad ---*/
glGenBuffers(1, &quad_buffer);
glBindBuffer(GL_ARRAY_BUFFER, quad_buffer);
glBufferData(GL_ARRAY_BUFFER, sizeof(quad_vert)+sizeof(quad_texCoord)
NULL, GL_STATIC_DRAW);
glBufferSubData(GL_ARRAY_BUFFER, 0, sizeof(quad_vert), quad_vert);
glBufferSubData(GL_ARRAY_BUFFER, sizeof(quad_vert),
sizeof(quad_texCoord), quad_texCoord);
// Load shaders and create a shader program (to be used in display())
program = InitShader("vTexture.glsl", "fTexture.glsl");
}
//----------
// drawObj(buffer, num_vertices):
// draw the object that is associated with the vertex buffer object "bu
// and has "num_vertices" vertices.
void drawObj(GLuint buffer, int num_vertices)
{
//--- Activate the vertex buffer object to be drawn ---//
glBindBuffer(GL_ARRAY_BUFFER, buffer);
/*----- Set up vertex attribute arrays for each vertex attribute ----
GLuint vPosition = glGetAttribLocation(program, "vPosition");
glEnableVertexAttribArray(vPosition);
glVertexAttribPointer(vPosition, 3, GL_FLOAT, GL_FALSE, 0,
BUFFER_OFFSET(0));
GLuint vTexCoord = glGetAttribLocation(program, "vTexCoord");
glEnableVertexAttribArray(vTexCoord);
glVertexAttribPointer(vTexCoord, 2, GL_FLOAT, GL_FALSE, 0,
BUFFER_OFFSET(sizeof(quad_vert)));
// the offset is the (total) size of the previous vertex attribute ar
vPosition
vTexCoord
with Acrobat Pro DC

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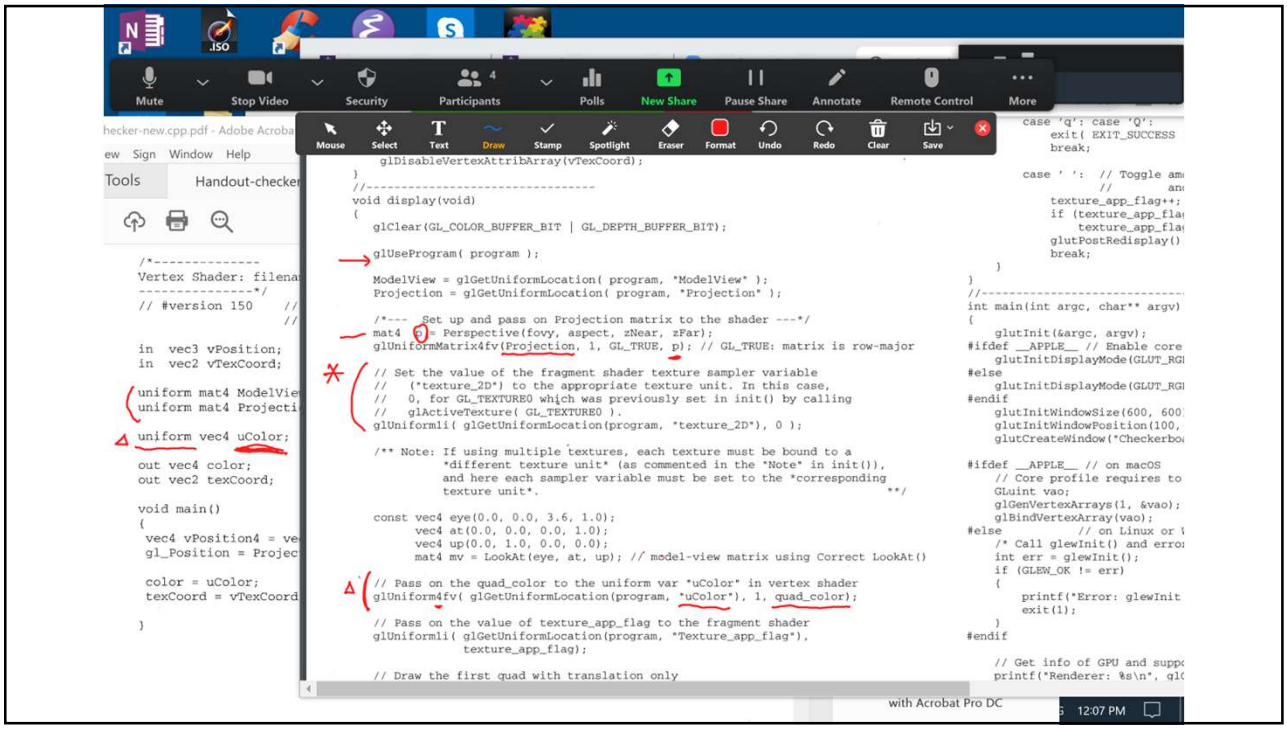
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/*---------------
Vertex Shader: filena
---------------*/
// #version 150
in vec3 vPosition;
in vec2 vTexCoord;
uniform mat4 ModelVie
uniform mat4 Projecti
uniform vec4 uColor;
out vec4 color;
out vec2 texCoord;
void main()
{
vec4 vPosition4 = ve
gl_Position = Projec
color = uColor;
texCoord = vTexCoord
}
glDisableVertexAttribArray(vTexCoord);
}
//---------------------------------
void display(void)
{
glClear(GL_COLOR_BUFFER_BIT | GL_DEPTH_BUFFER_BIT);
glUseProgram(program);
ModelView = glGetUniformLocation(program, "ModelView");
Projection = glGetUniformLocation(program, "Projection");
/*--- Set up and pass on Projection matrix to the shader ---*/
mat4 p = Perspective(fovy, aspect, zNear, zFar);
glUniformMatrix4fv(Projection, 1, GL_TRUE, p); // GL_TRUE: matrix is row-major
// Set the value of the fragment shader texture sampler variable
// ("texture_2D") to the appropriate texture unit. In this case,
// 0, for GL_TEXTURE0 which was previously set in init() by calling
// glActiveTexture(GL_TEXTURE0).
glUniform1i(glGetUniformLocation(program, "texture_2D"), 0);
/** Note: If using multiple textures, each texture must be bound to a
"different texture unit" (as commented in the "Note" in init()),
and here each sampler variable must be set to the "corresponding
texture unit". **/
const vec4 eye(0.0, 0.0, 3.6, 1.0);
vec4 at(0.0, 0.0, 0.0, 1.0);
vec4 up(0.0, 1.0, 0.0, 0.0);
mat4 mv = LookAt(eye, at, up); // model-view matrix using Correct LookAt()
// Pass on the quad_color to the uniform var "uColor" in vertex shader
glUniform4fv(glGetUniformLocation(program, "uColor"), 1, quad_color);
// Pass on the value of texture_app_flag to the fragment shader
glUniform1i(glGetUniformLocation(program, "Texture_app_flag"),
texture_app_flag);
// Draw the first quad with translation only
case 'q': case 'Q':
exit(EXIT_SUCCESS
break;
case ' ': // Toggle am
texture_app_flag++;
if (texture_app_fla
texture_app_fla
glutPostRedisplay()
break;
}
}
//---------------------------------
int main(int argc, char** argv)
{
glutInit(&argc, argv);
#ifdef __APPLE__ // Enable core
glutInitDisplayMode(GLUT_RGB
#else
glutInitDisplayMode(GLUT_RGB
#endif
glutInitWindowSize(600, 600
glutInitWindowPosition(100,
glutCreateWindow("Checkerboa
#ifdef __APPLE__ // on macOS
// Core profile requires to
GLuint vao;
glGenVertexArrays(1, &vao);
glBindVertexArray(vao);
#else // on Linux or
/* Call glewInit() and erro
int err = glewInit();
if (GLEW_OK != err)
{
printf("Error: glewInit
exit(1);
}
#endif
// Get info of GPU and suppo
printf("Renderer: %s\n", gl
with Acrobat Pro DC
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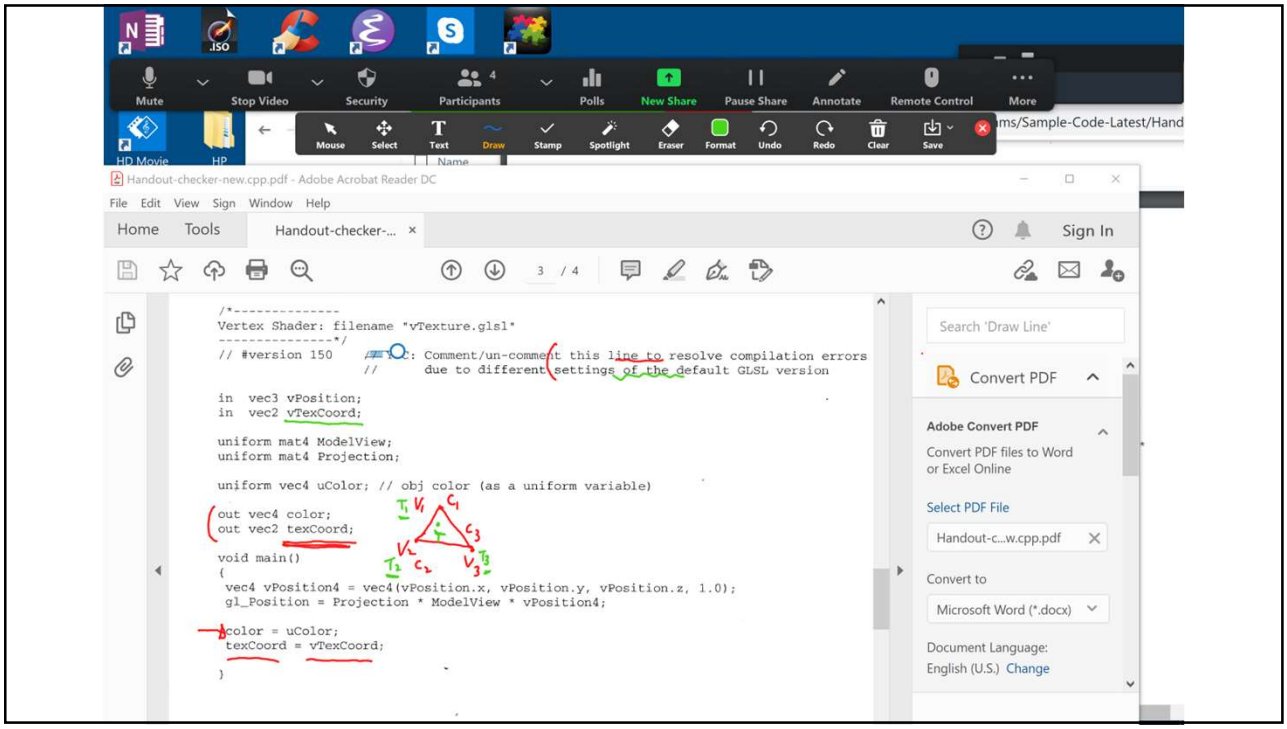
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File Edit View Sign Window Help
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Sign In
/*---------------
Vertex Shader: filename "vTexture.glsl"
---------------*/
// #version 150 // C: Comment/un-comment this line to resolve compilation errors
// due to different settings of the default GLSL version
in vec3 vPosition;
in vec2 vTexCoord;
uniform mat4 ModelView;
uniform mat4 Projection;
uniform vec4 uColor; // obj color (as a uniform variable)
out vec4 color;
out vec2 texCoord;
void main()
{
vec4 vPosition4 = vec4(vPosition.x, vPosition.y, vPosition.z, 1.0);
gl_Position = Projection * ModelView * vPosition4;
color = uColor;
texCoord = vTexCoord;
}
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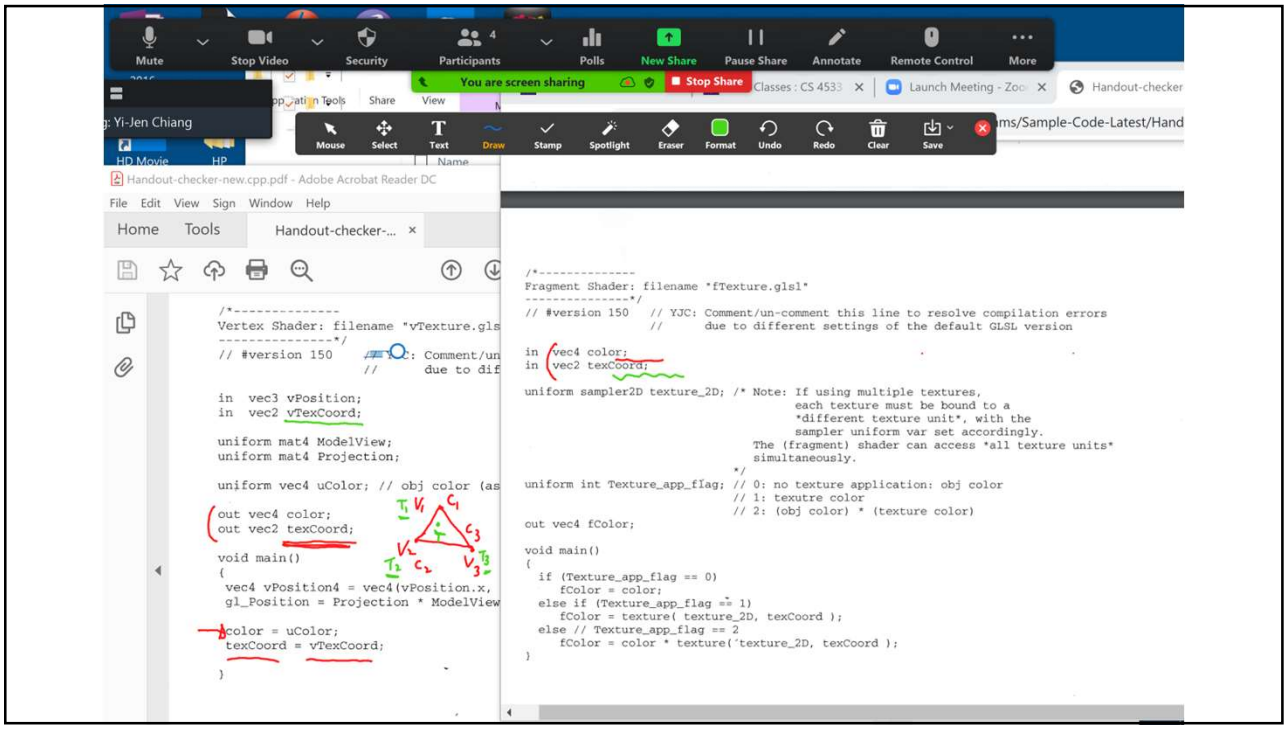
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/*--------------
Vertex Shader: filename "vTexture.gls
--------------*/
// #version 150
// YJC: Comment/un
due to dif
in vec3 vPosition;
in vec2 vTexCoord;
uniform mat4 ModelView;
uniform mat4 Projection;
uniform vec4 uColor; // obj color (as
out vec4 color;
out vec2 texCoord;
void main()
{
vec4 vPosition4 = vec4(vPosition.x,
gl_Position = Projection * ModelView
color = uColor;
texCoord = vTexCoord;
}
/*--------------
Fragment Shader: filename "fTexture.glsl"
--------------*/
// #version 150 // YJC: Comment/un-comment this line to resolve compilation errors
// due to different settings of the default GLSL version
in vec4 color;
in vec2 texCoord;
uniform sampler2D texture_2D; /* Note: If using multiple textures,
each texture must be bound to a
different texture unit, with the
sampler uniform var set accordingly.
The (fragment) shader can access *all texture units*
simultaneously.
*/
uniform int Texture_app_flag; // 0: no texture application: obj color
// 1: texutre color
// 2: (obj color) * (texture color)
out vec4 fColor;
void main()
{
if (Texture_app_flag == 0)
fColor = color;
else if (Texture_app_flag == 1)
fColor = texture(texture_2D, texCoord);
else // Texture_app_flag == 2
fColor = color * texture(texture_2D, texCoord);
}

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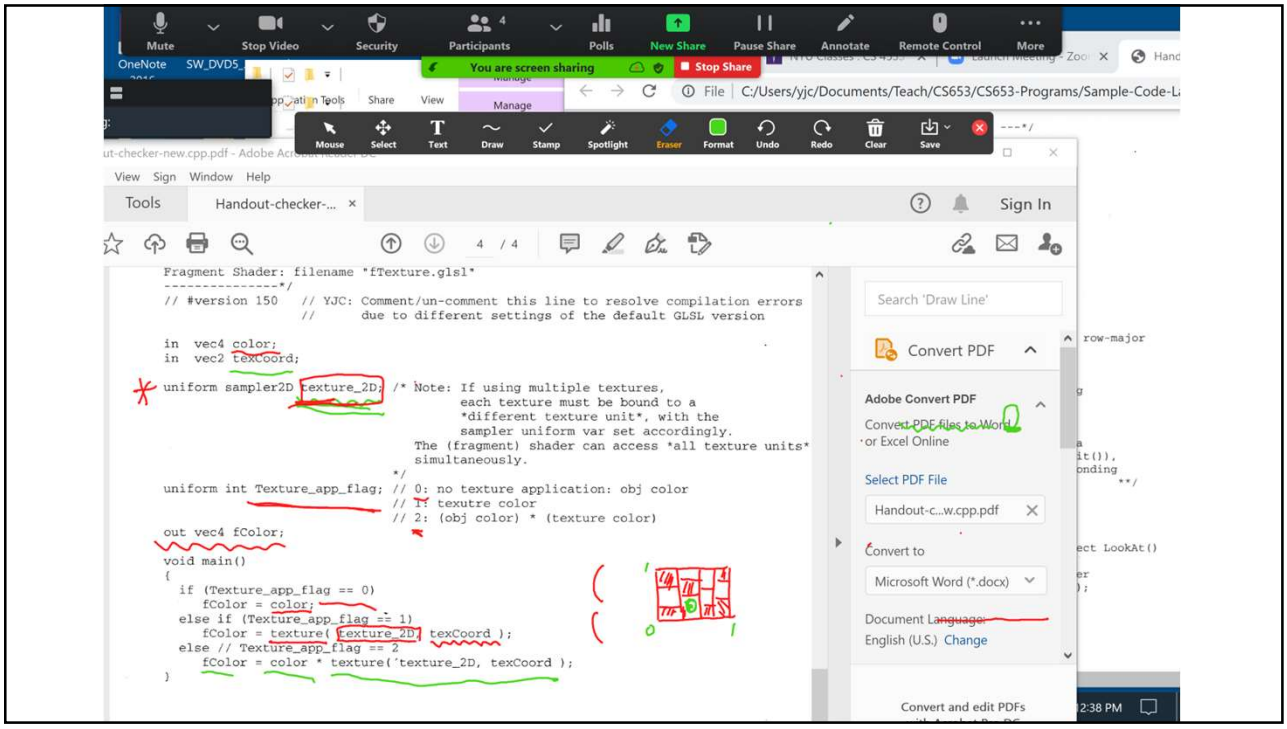
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Fragment Shader: filename "fTexture.glsl"
--------------*/
// #version 150 // YJC: Comment/un-comment this line to resolve compilation errors
// due to different settings of the default GLSL version
in vec4 color;
in vec2 texCoord;
uniform sampler2D texture_2D; /* Note: If using multiple textures,
each texture must be bound to a
different texture unit, with the
sampler uniform var set accordingly.
The (fragment) shader can access *all texture units*
simultaneously.
*/
uniform int Texture_app_flag; // 0: no texture application: obj color
// 1: texutre color
// 2: (obj color) * (texture color)
out vec4 fColor;
void main()
{
if (Texture_app_flag == 0)
fColor = color;
else if (Texture_app_flag == 1)
fColor = texture(texture_2D, texCoord);
else // Texture_app_flag == 2
fColor = color * texture(texture_2D, texCoord);
}
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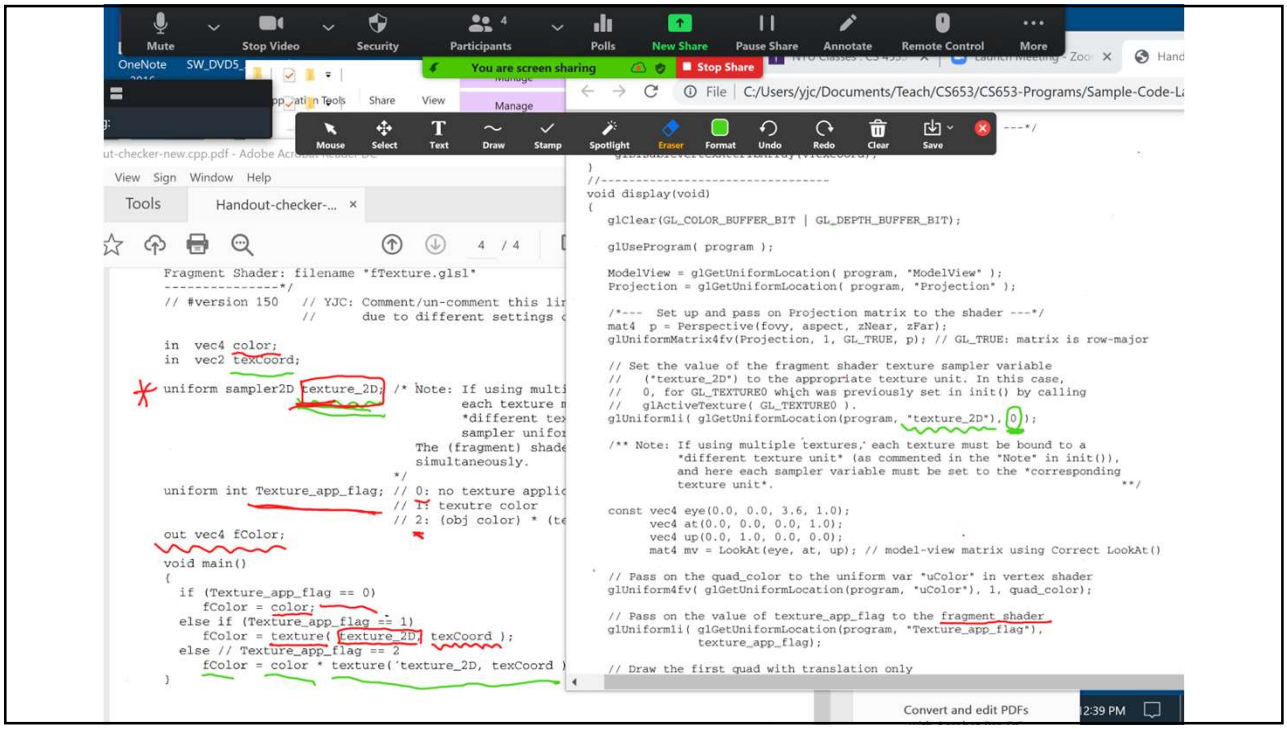
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4 / 4
Fragment Shader: filename "fTexture.gls1"
// #version 150
in vec4 color;
in vec2 texCoord;
uniform sampler2D texture_2D; /* Note: If using multi
each texture
*different tex
sampler unifo
The (fragment) shade
simultaneously.
*/
uniform int Texture_app_flag; // 0: no texture applic
// 1: texutre color
// 2: (obj color) * (te
out vec4 fColor;
void main()
{
if (Texture_app_flag == 0)
fColor = color;
else if (Texture_app_flag == 1)
fColor = texture(texture_2D, texCoord);
else // Texture_app_flag == 2
fColor = color * texture(texture_2D, texCoord
}
void display(void)
{
glClear(GL_COLOR_BUFFER_BIT | GL_DEPTH_BUFFER_BIT);
glUseProgram(program);
ModelView = glGetUniformLocation(program, "ModelView");
Projection = glGetUniformLocation(program, "Projection");
/*--- Set up and pass on Projection matrix to the shader ---*/
mat4 p = Perspective(fovy, aspect, zNear, zFar);
glUniformMatrix4fv(Projection, 1, GL_TRUE, p); // GL_TRUE: matrix is row-major
// Set the value of the fragment shader texture sampler variable
// ("texture_2D") to the appropriate texture unit. In this case,
// 0, for GL_TEXTURE0 which was previously set in init() by calling
// glActiveTexture(GL_TEXTURE0).
glUniform1i(glGetUniformLocation(program, "texture_2D"), 0);
/** Note: If using multiple textures, each texture must be bound to a
different texture unit (as commented in the "Note" in init()),
and here each sampler variable must be set to the *corresponding
texture unit*. **/
const vec4 eye(0.0, 0.0, 3.6, 1.0);
vec4 at(0.0, 0.0, 0.0, 1.0);
vec4 up(0.0, 1.0, 0.0, 0.0);
mat4 mv = LookAt(eye, at, up); // model-view matrix using Correct LookAt()
// Pass on the quad_color to the uniform var "uColor" in vertex shader
glUniform4fv(glGetUniformLocation(program, "uColor"), 1, quad_color);
// Pass on the value of texture_app_flag to the fragment shader
glUniform1i(glGetUniformLocation(program, "Texture_app_flag"),
texture_app_flag);
// Draw the first quad with translation only
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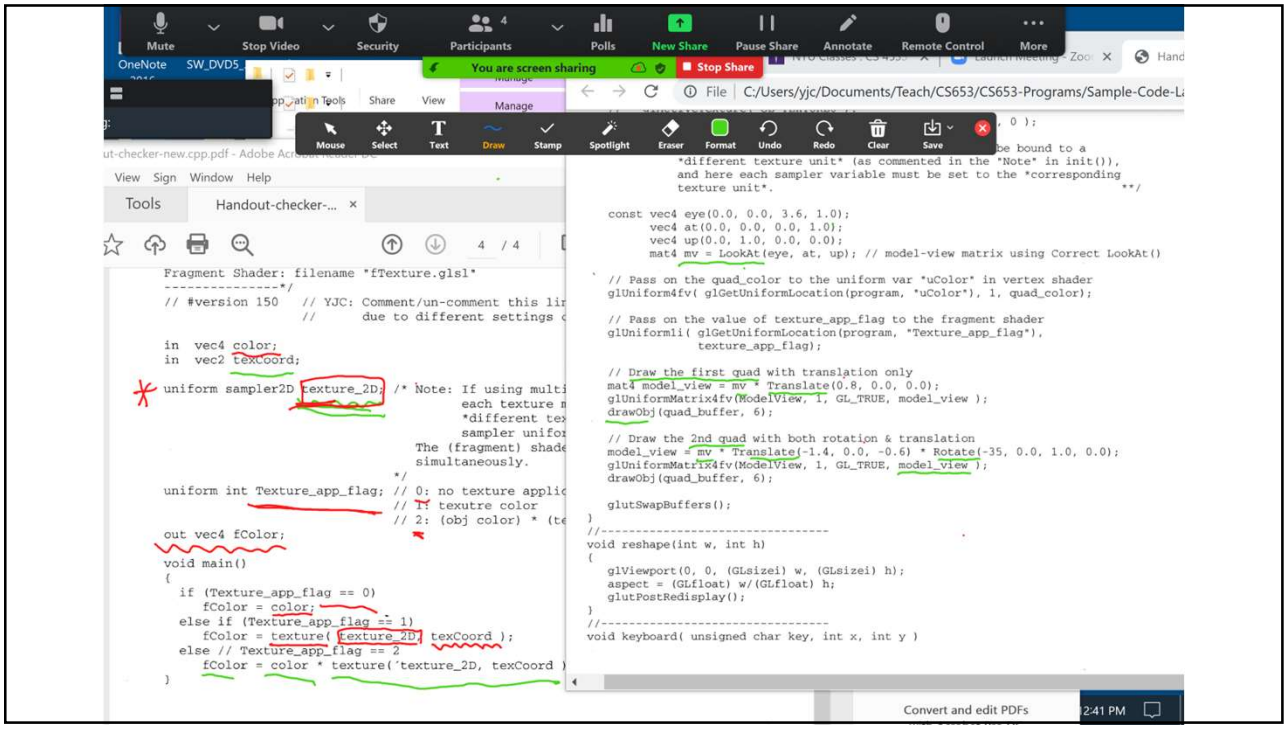
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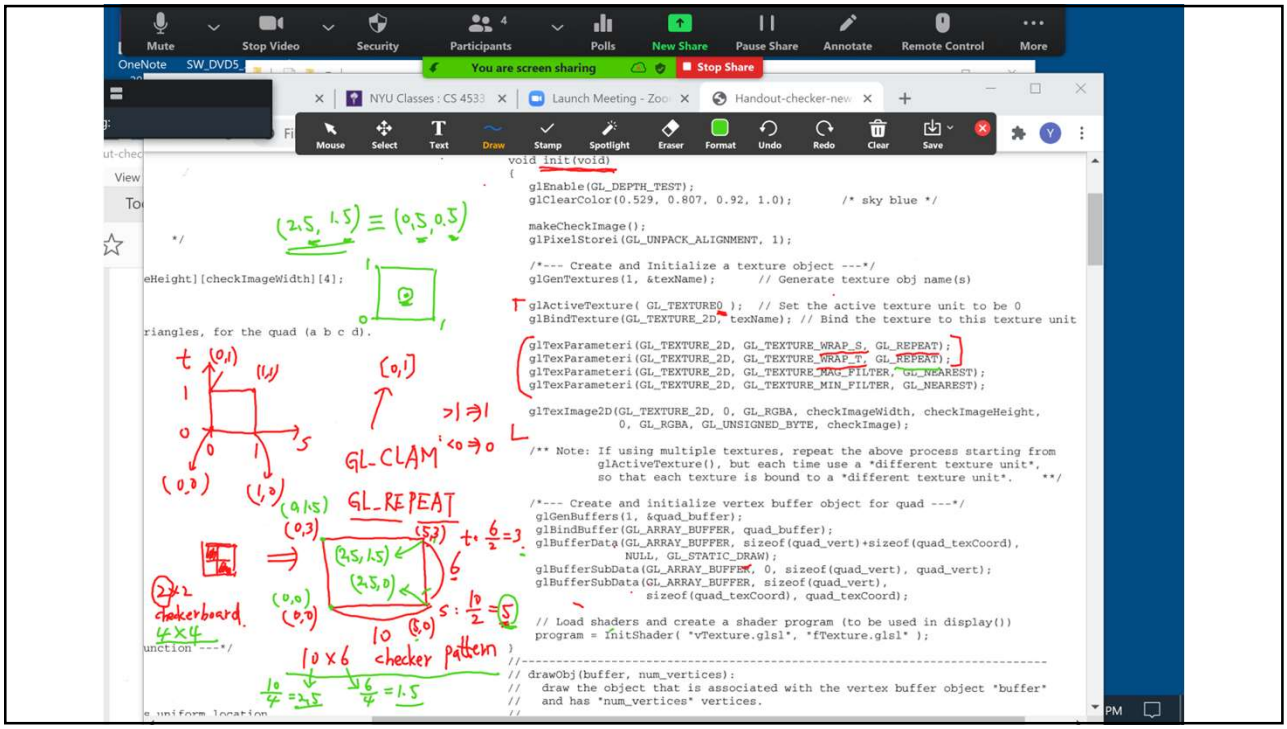
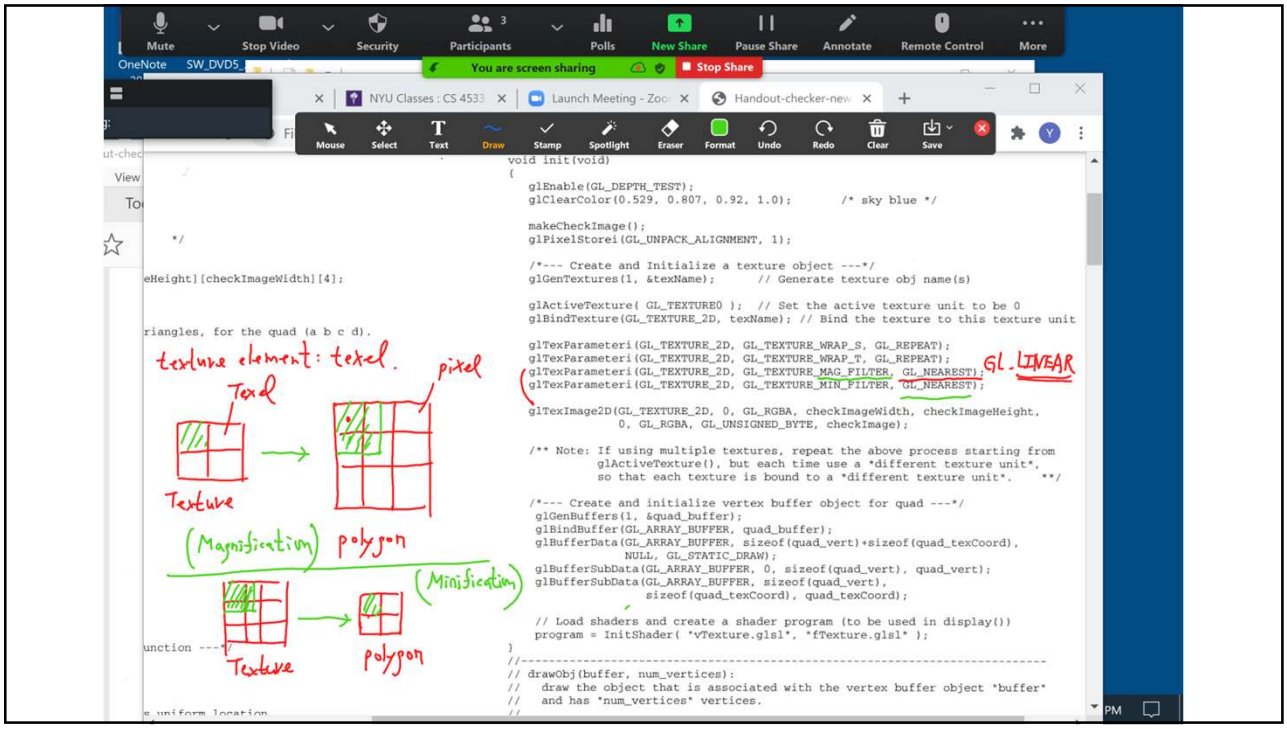
Fragment Shader: filename "fTexture.gls1"
// #version 150
in vec4 color;
in vec2 texCoord;
uniform sampler2D texture_2D; /* Note: If using multi
each texture
*different tex
sampler unifo
The (fragment) shade
simultaneously.
*/
uniform int Texture_app_flag; // 0: no texture applic
// 1: texutre color
// 2: (obj color) * (te
out vec4 fColor;
void main()
{
if (Texture_app_flag == 0)
fColor = color;
else if (Texture_app_flag == 1)
fColor = texture(texture_2D, texCoord);
else // Texture_app_flag == 2
fColor = color * texture(texture_2D, texCoord
}
texture unit*. **/
const vec4 eye(0.0, 0.0, 3.6, 1.0);
vec4 at(0.0, 0.0, 0.0, 1.0);
vec4 up(0.0, 1.0, 0.0, 0.0);
mat4 mv = LookAt(eye, at, up); // model-view matrix using Correct LookAt()
// Pass on the quad_color to the uniform var "uColor" in vertex shader
glUniform4fv(glGetUniformLocation(program, "uColor"), 1, quad_color);
// Pass on the value of texture_app_flag to the fragment shader
glUniform1i(glGetUniformLocation(program, "Texture_app_flag"),
texture_app_flag);
// Draw the first quad with translation only
mat4 model_view = mv * Translate(0.8, 0.0, 0.0);
glUniformMatrix4fv(ModelView, 1, GL_TRUE, model_view);
drawObj(quad_buffer, 6);
// Draw the 2nd quad with both rotation & translation
model_view = mv * Translate(-1.4, 0.0, -0.6) * Rotate(-35, 0.0, 1.0, 0.0);
glUniformMatrix4fv(ModelView, 1, GL_TRUE, model_view);
drawObj(quad_buffer, 6);
glutSwapBuffers();
}
void reshape(int w, int h)
{
glViewport(0, 0, (GLsizei) w, (GLsizei) h);
aspect = (GLfloat) w/(GLfloat) h;
glutPostRedisplay();
}
void keyboard(unsigned char key, int x, int y)
Convert and edit PDFs
2:41 PM

14


Mute
Stop Video
Security
Participants
Polls
New Share
Pause Share
Annotate
Remote Control
More
You are screen sharing
Stop Share
NYU Classes : CS 4533
Launch Meeting - Zoo
Handout-checker-new
Mouse
Select
Text
Draw
Stamp
Spotlight
Eraser
Format
Undo
Redo
Clear
Save
(2.5, 1.5) ≡ (0.5, 0.5)
GL-CLAM
GL_REPEAT
2x2 checkerboard
4x4
10 x 6 checker pattern
riangles, for the quad (a b c d).
unction ---*/
e uniform location
void init(void)
{
glEnable(GL_DEPTH_TEST);
glClearColor(0.529, 0.807, 0.92, 1.0); /* sky blue */
makeCheckImage();
glPixelStorei(GL_UNPACK_ALIGNMENT, 1);
/*--- Create and Initialize a texture object ---*/
glGenTextures(1, &texName); // Generate texture obj name(s)
glActiveTexture(GL_TEXTURE0); // Set the active texture unit to be 0
glBindTexture(GL_TEXTURE_2D, texName); // Bind the texture to this texture unit
glTexParameteri(GL_TEXTURE_2D, GL_TEXTURE_WRAP_S, GL_REPEAT);
glTexParameteri(GL_TEXTURE_2D, GL_TEXTURE_WRAP_T, GL_REPEAT);
glTexParameteri(GL_TEXTURE_2D, GL_TEXTURE_MAG_FILTER, GL_NEAREST);
glTexParameteri(GL_TEXTURE_2D, GL_TEXTURE_MIN_FILTER, GL_NEAREST);
glTexImage2D(GL_TEXTURE_2D, 0, GL_RGBA, checkImageWidth, checkImageHeight,
0, GL_RGBA, GL_UNSIGNED_BYTE, checkImage);
/** Note: If using multiple textures, repeat the above process starting from
glActiveTexture(), but each time use a *different texture unit*,
so that each texture is bound to a *different texture unit*. **/
/*--- Create and initialize vertex buffer object for quad ---*/
glGenBuffers(1, &quad_buffer);
glBindBuffer(GL_ARRAY_BUFFER, quad_buffer);
glBufferData(GL_ARRAY_BUFFER, sizeof(quad_vert)+sizeof(quad_texCoord),
NULL, GL_STATIC_DRAW);
glBufferSubData(GL_ARRAY_BUFFER, 0, sizeof(quad_vert), quad_vert);
glBufferSubData(GL_ARRAY_BUFFER, sizeof(quad_vert),
sizeof(quad_texCoord), quad_texCoord);
// Load shaders and create a shader program (to be used in display())
program = InitShader("vTexture.glsl", "fTexture.glsl");
}
//----------
// drawObj(buffer, num_vertices):
// draw the object that is associated with the vertex buffer object "buffer"
// and has "num_vertices" vertices.
//
PM

15


Mute
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Handout-checker-new
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Stamp
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Eraser
Format
Undo
Redo
Clear
Save
texture element: texel.
Texel
pixel
Texture
(Magnification)
polygon
(Minification)
Texture
polygon
GL_LINEAR
riangles, for the quad (a b c d).
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glBindTexture(GL_TEXTURE_2D, texName); // Bind the texture to this texture unit
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glTexParameteri(GL_TEXTURE_2D, GL_TEXTURE_WRAP_T, GL_REPEAT);
glTexParameteri(GL_TEXTURE_2D, GL_TEXTURE_MAG_FILTER, GL_NEAREST);
glTexParameteri(GL_TEXTURE_2D, GL_TEXTURE_MIN_FILTER, GL_NEAREST);
glTexImage2D(GL_TEXTURE_2D, 0, GL_RGBA, checkImageWidth, checkImageHeight,
0, GL_RGBA, GL_UNSIGNED_BYTE, checkImage);
/** Note: If using multiple textures, repeat the above process starting from
glActiveTexture(), but each time use a *different texture unit*,
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glBufferSubData(GL_ARRAY_BUFFER, 0, sizeof(quad_vert), quad_vert);
glBufferSubData(GL_ARRAY_BUFFER, sizeof(quad_vert),
sizeof(quad_texCoord), quad_texCoord);
// Load shaders and create a shader program (to be used in display())
program = InitShader("vTexture.glsl", "fTexture.glsl");
}
//----------
// drawObj(buffer, num_vertices):
// draw the object that is associated with the vertex buffer object "buffer"
// and has "num_vertices" vertices.
//
PM

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