Discussion 8
CSE 167

Outline

- FAQ and More OpenGL Quirks
  - Skybox and Textures
  - Disco Ball
- Introduction to Project 4
  - Lighting (Directional lights and Toon Shading)
  - Implementing Collision Detection

Any Questions on Project 3?

So Your Skybox Ain’t Displayin’...

Check the following suggestions:

- Can your program render a cube to screen?
- Are you actually parsing all 6 skybox pictures in your code and generating the textures correctly?
- Did you properly activate the relevant texture unit and bind the cubemap texture before the draw call?

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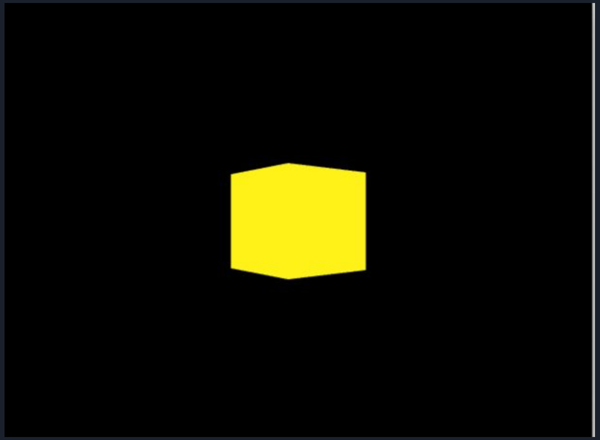
A Cube to Render

- A skybox looks like a big cube with textures painted over its inside walls
- Render a cube then make it big!
- The starter code from Project 1 has a cube class...



Using Textures in OpenGL

From the OpenGL Programming Guide v4.3:

Using OpenGL's texture-mapping capabilities requires the following steps

1. Create a texture object and load texel data to it
2. Include texture coordinates with your vertices.
    a. In this case, the cubemap's vertices serve as the texture coordinates
3. Associate a texture sampler with each texture map in your shader
4. Retrieve the texel values using the texture sampler

The following slides are taken from learnopengl.com and The OpenGL Programming Guide v4.3

1) Create a Texture

- Similar to how one would create and store data in a VBO
- Use glGenTextures to reserve a name/ID for the texture

```
void glGenTextures(GLsizei n, GLuint *textures);
```

- Use glBindTexture to give the texture actual properties
- ***glBindTexture(GL_TEXTURE_CUBE_MAP, texID)*** to bind a cubemap to a given texture
    - *texID* is a GLuint texture reserved using glGenTextures
    - The 1st time this is called on *texID*, it will be assigned a type of *GL_TEXTURE_CUBE_MAP*
    - Subsequent calls on *texID* will activate it
    - Binding to 0 = removing any texture from GL_TEXTURE_CUBE_MAP

1) (cont'd) Load Data

```
int width, height, nrChannels;
unsigned char *data;
for(unsigned int i = 0; i < textures_faces.size(); i++)
{
    data = stbi_load(textures_faces[i].c_str(), &width, &height, &nrChannels, 0);
    glTexImage2D(
        GL_TEXTURE_CUBE_MAP_POSITIVE_X + i,
        0, GL_RGB, width, height, 0, GL_RGB, GL_UNSIGNED_BYTE, data
    );
}
```

- We use stb_image to load image data into memory.
- glTexImage2D will load data into the texture object.
- Make sure you bind the texture you're going to modify first!

2) Associate texture coordinates per vertex

```
#version 330 core
layout (location = 0) in vec3 aPos;
layout (location = 1) in vec2 aTexCoords;

out vec2 TexCoords;

uniform mat4 model;
uniform mat4 view;
uniform mat4 projection;

void main()
{
    TexCoords = aTexCoords;
    gl_Position = projection * view * model * vec4(aPos, 1.0);
}
```

→

```
#version 330 core
layout (location = 0) in vec3 aPos;

out vec3 TexCoords;

uniform mat4 projection;
uniform mat4 view;

void main()
{
    TexCoords = aPos;
    gl_Position = projection * view * vec4(aPos, 1.0);
}
```

- For a cubemap, the texture coordinates are 3D vectors.
- If the cubemap is centered at the world origin (0, 0, 0), we can just use the vertex positions!
- Otherwise, you may have to load in a VBO of texture coordinates

3) - 4) Use a Texture Sampler to get Texel Data

Retrieve texel value using texture coordinates

```
#version 330 core
out vec4 FragColor;

in vec3 TexCoords;

uniform samplerCube skybox;

void main()
{
    FragColor = texture(skybox, TexCoords);
}
```

Tell OpenGL how the Texture Sampler deals with “edge cases”

```
glTexParameteri(GL_TEXTURE_CUBE_MAP, GL_TEXTURE_MIN_FILTER, GL_LINEAR);
glTexParameteri(GL_TEXTURE_CUBE_MAP, GL_TEXTURE_MAG_FILTER, GL_LINEAR);
glTexParameteri(GL_TEXTURE_CUBE_MAP, GL_TEXTURE_WRAP_S, GL_CLAMP_TO_EDGE);
glTexParameteri(GL_TEXTURE_CUBE_MAP, GL_TEXTURE_WRAP_T, GL_CLAMP_TO_EDGE);
glTexParameteri(GL_TEXTURE_CUBE_MAP, GL_TEXTURE_WRAP_R, GL_CLAMP_TO_EDGE);
```

But What About LearnOpenGL's Tutorial?

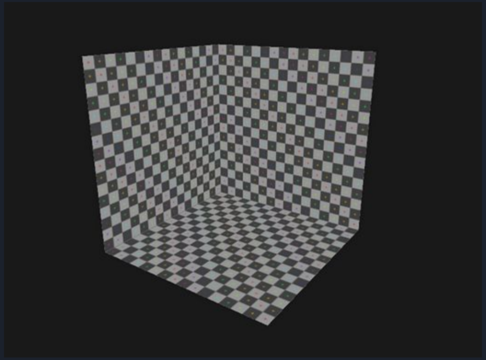
- What is glDepthMask(GL_FALSE)?
  - It disables the z-buffer algorithm, meaning that the cube will just write over the entire frame regardless of distance to the camera.
  - **We're using a really big cube so we don't use it.**
- Why are they using a small cube?
  - They use the depth mask trick and drawing the cube to the color buffer first. Any subsequent draw call to another object will just overwrite the pixels
  - Removing the translation part of the view matrix using mat4(mat3(view)) means that the cube is always rendered as if the camera was centered at (0,0,0)
- What about glDepthFunc?
  - It's part of the optimized implementation of the skybox. It sets how depth values are compared.
  - The optimization trick is pretty cool but **you don't need to know about it**

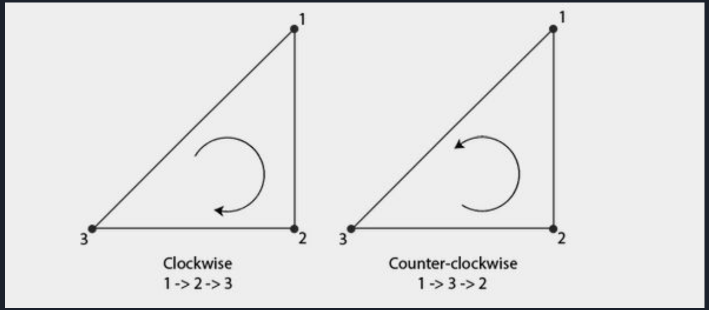
Skybox Culling

- To use single-sided rendering, call following functions
  - glEnable(GL_CULL_FACE);
  - glCullFace(GL_FRONT);

OR

- glEnable(GL_CULL_FACE);
- glCullFace(GL_BACK);
- Should be called before you call draw your skybox





Disco Ball Reflections

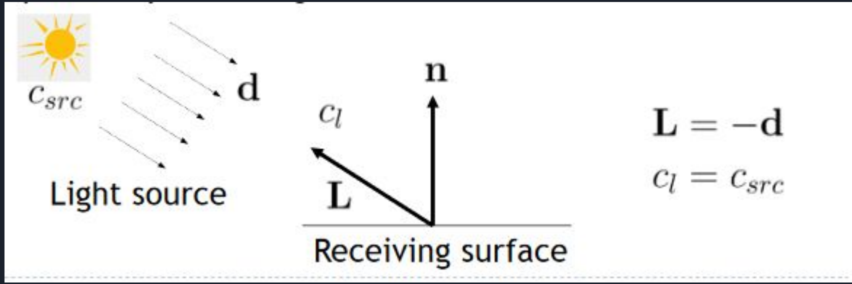
- Reflections look off?
  - Try calling glDisable(GL_CULL_FACE) right after you draw your skybox, so it does not interfere with other objects being drawn

Project 4 
Among Us in 167


Recommended Settings
Map: Polus
Impostors: 1 (Limit: 0)
Confirm Ejects: On
Emergency Meetings: 1
Emergency Cooldown: 15s
Discussion Time: 15s
Voting Time: 120s
Player Speed: 1x
Crewmate Vision: 1x
Impostor Vision: 1.5x
Kill Cooldown: 45s
Kill Distance: Normal
Visual Tasks: On
Common Tasks: 1
Long Tasks: 1
Short Tasks: 2
Ping: 60 ms
SwayzeA
Haker
PUBLIC
Code
HVFJRQ
CUSTOMIZE

Directional Lights

- Light from a certain direction
- Passing in light direction to shader, as opposed to light position
  - No attenuation (light is infinitely far away)
  - Remember to negate passed in direction before using in calculations **(L = -d)**
  - https://learnopengl.com/Lighting/Multiple-lights



Toon Shading

- Silhouette edge detection
- Discretize shading

Silhouette Edge Detection

- Gives black outline to edges of your obj
    - Emphasize pixels with normals perpendicular to viewing direction.
- Edge = max(0, dot(n,v));
    - n = normal
    - v = viewing direction
- If Edge < 0.01, draw black.

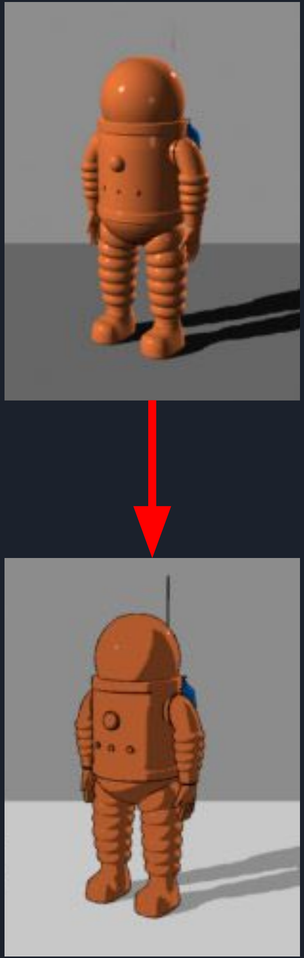
Discretize Shading

- Create thresholds to create fewer shades, creating a cartoonish look

Intensity: Calculate diffuse and specular to calculate intensity,

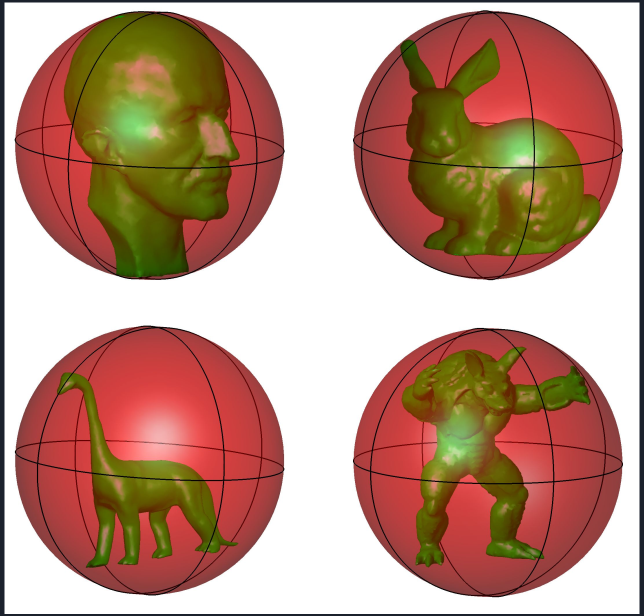
$$\text{diffuse} = \mathbf{n} \cdot \mathbf{L} \qquad \text{specular} = (\mathbf{n} \cdot \mathbf{h})^s$$

```
if (intensity > 0.95)
    color = float4(1.0,1,1,1.0) * color;
else if (intensity > 0.5)
    color = float4(0.7,0.7,0.7,1.0) * color;
else if (intensity > 0.05)
    color = float4(0.35,0.35,0.35,1.0) * color;
else
    color = float4(0.1,0.1,0.1,1.0) * color;
```



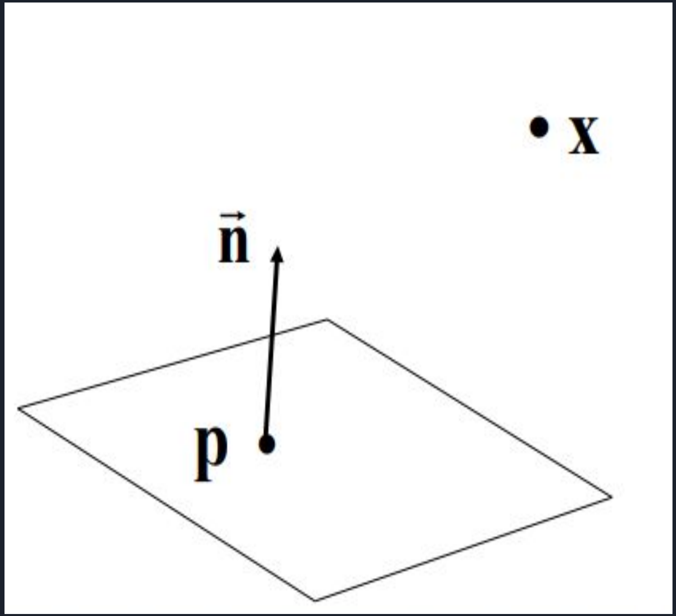
Bounding Spheres

- Encase the entire object in a tight sphere
- Pros
  - Easy to understand
  - Sphere/sphere & sphere/plane intersection testing inexpensive and simpler to implement
- Cons
  - Not a snug fit for the objects => inaccuracy compared to bounding boxes or comparing each individual triangle
- Just need two pieces of info
  - Radius
  - Center



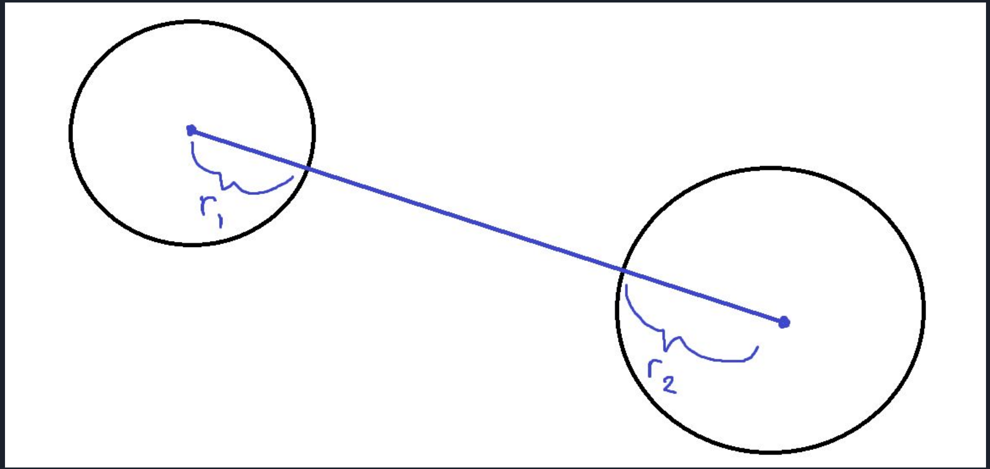
Bounding Plane

- Can be represented by a normal vector n and a distance from origin to plane dot(p, n) where p is some point on the plane
- 6 of these make a bounding box



Sphere-Sphere Collisions

- Simple
- If the distance between the two centers is < r1 + r2, then we have an intersection!



Sphere-Plane Intersection

- Essentially:
    a. Plug center into point-plane distance formula (see Lecture 13: Visibility Culling)
    b. If dist <= r, we have an intersection!