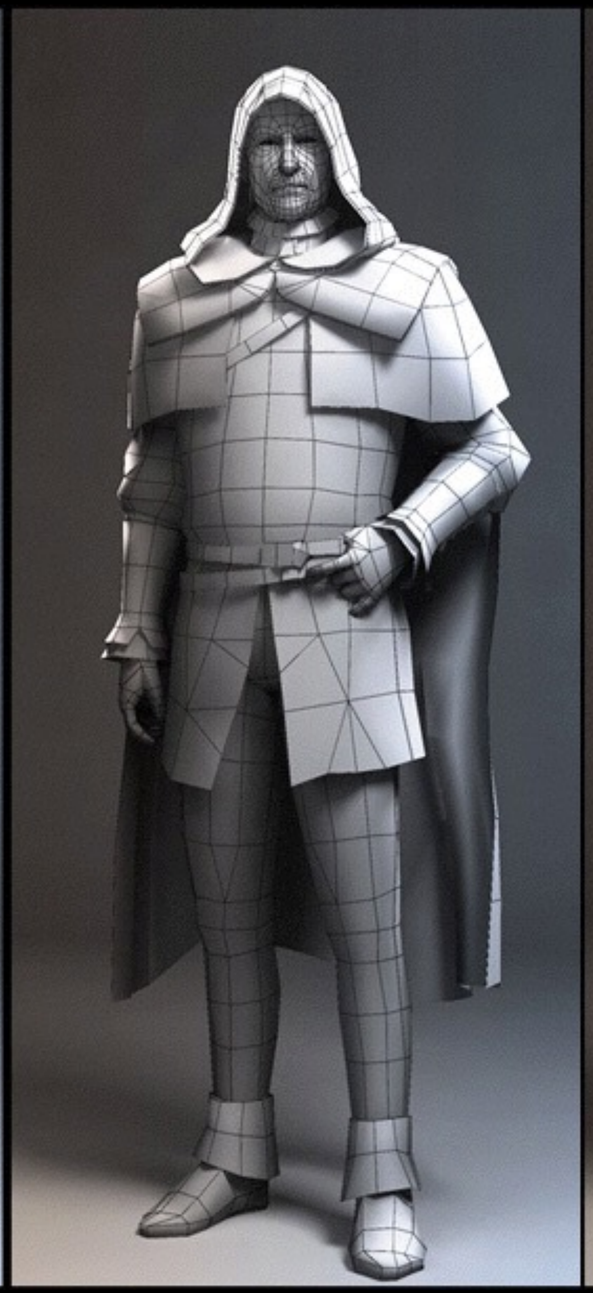
Texturing Mapping

CS GY-6533 / UY-4533


ASSASSINS CREED II
IN-GAME MODEL
btw 4 - 6000 tris

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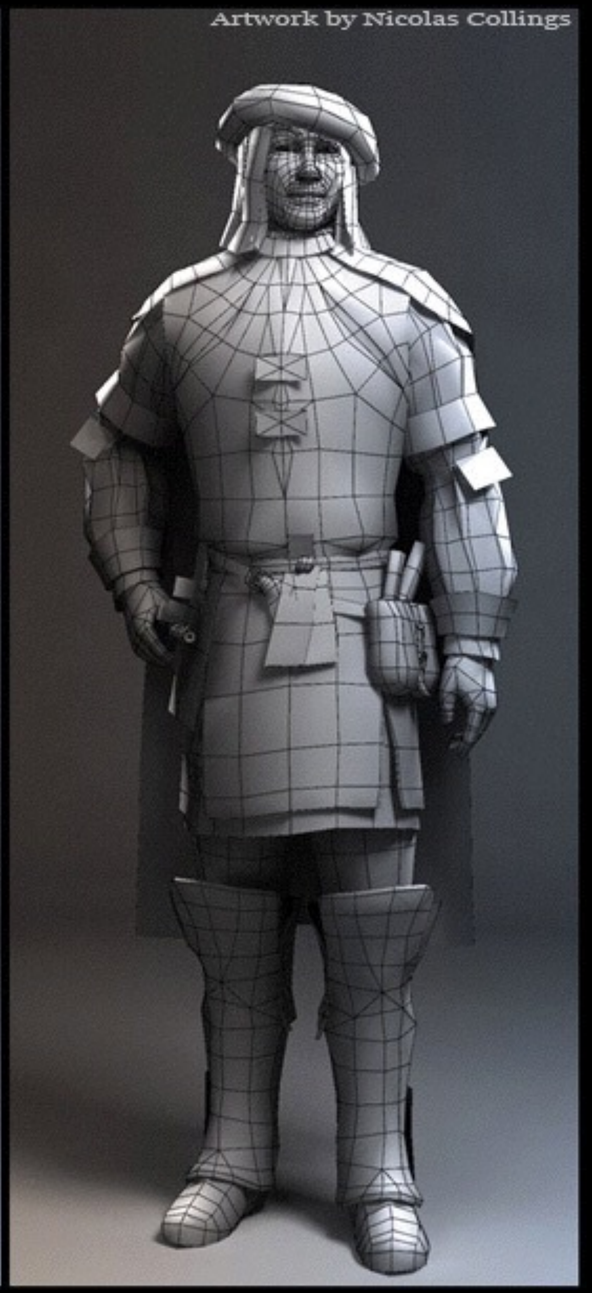
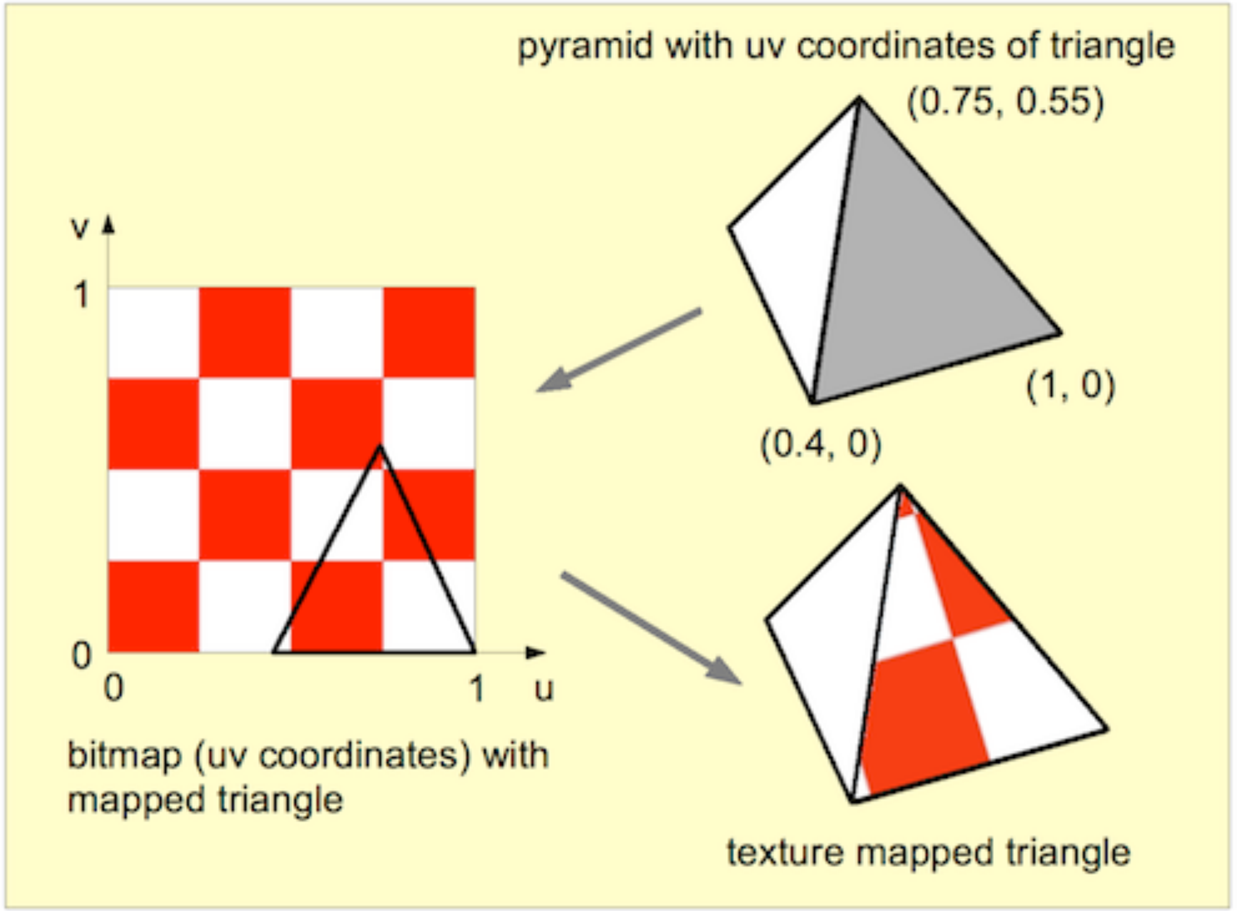
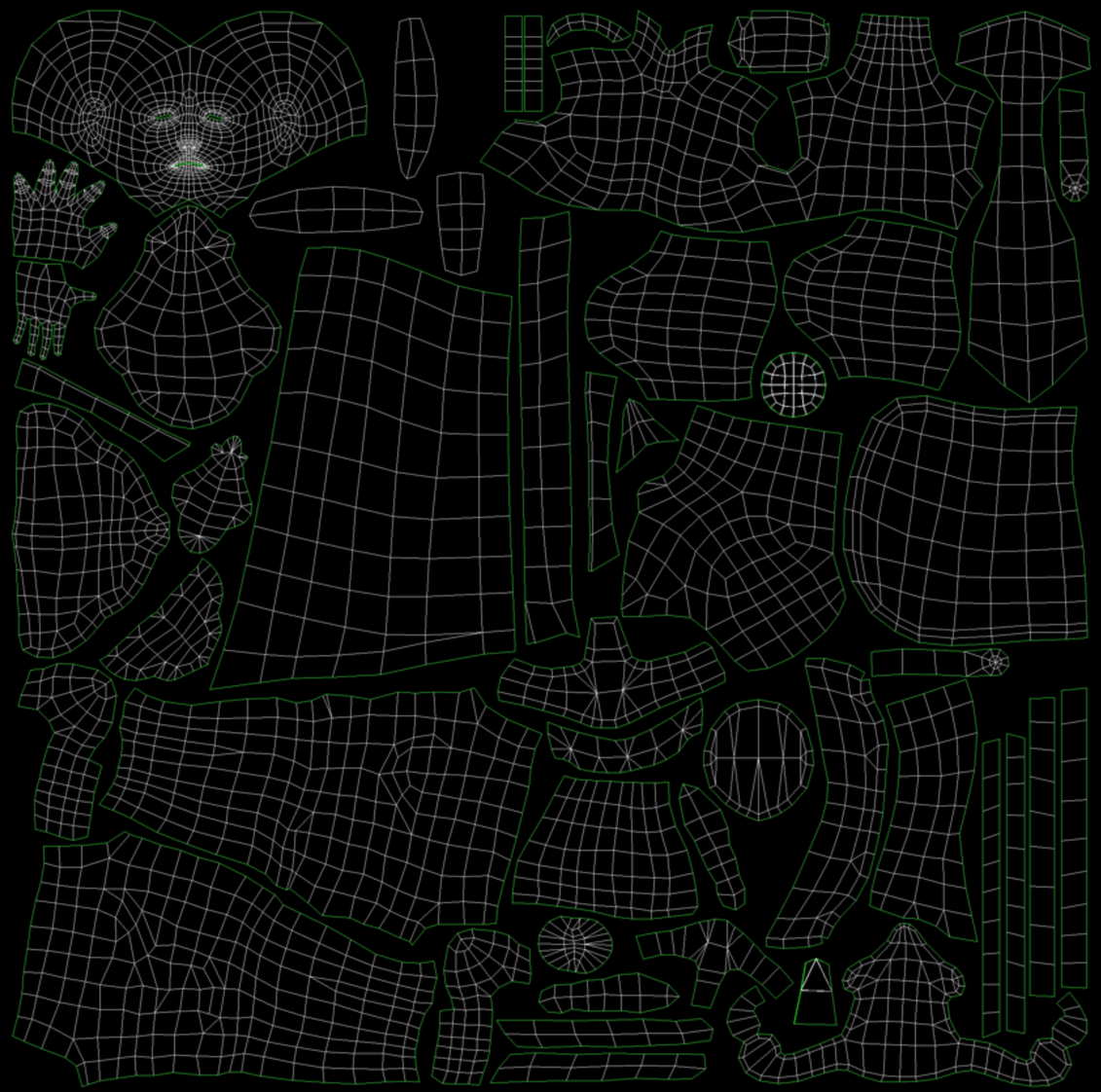

Artwork by Nicolas Collings

UV coordinates


pyramid with uv coordinates of triangle
(0.75, 0.55)
(1, 0)
(0.4, 0)
v
1
0
0
1
u
bitmap (uv coordinates) with
mapped triangle
texture mapped triangle



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Basic texturing

Vertex program

```
attribute vec4 position;
attribute vec2 texCoord;

uniform mat4 modelViewMatrix;
uniform mat4 projectionMatrix;

varying vec2 varyingTexCoord;

void main() {
  varyingTexCoord = texCoord;
  gl_Position = projectionMatrix * modelViewMatrix * position;
}
```

Fragment program

```
varying vec2 varyingTexCoord;
uniform sampler2D diffuseTexture;

void main() {
    gl_FragColor = texture2D(diffuseTexture, varyingTexCoord);
}
```

Need to add texture coordinate to our vertex structure.

```
struct VertexPNT {
    Cvec3f p, n;
    Cvec2f t;

    VertexPNT() {}
    VertexPNT(float x, float y, float z, float nx, float ny, float nz) : p(x,y,z), n(nx, ny, nz) {}

    VertexPNT& operator = (const GenericVertex& v) {
        p = v.pos;
        n = v.normal;
        t = v.tex;
        return *this;
    }
};

// . . .

glEnableVertexAttribArray(texCoordAttribute);
glVertexAttribPointer(texCoordAttribute, 2, GL_FLOAT, GL_FALSE, sizeof(VertexPNT), (void*)offsetof(VertexPNT, t));
glEnableVertexAttribArray(texCoordAttribute);
```

Texture uniforms in GLSL are integer indexes of the GPU texture unit.
On the C++ side, they must be bound to the appropriate texture unit using **glActiveTexture.**

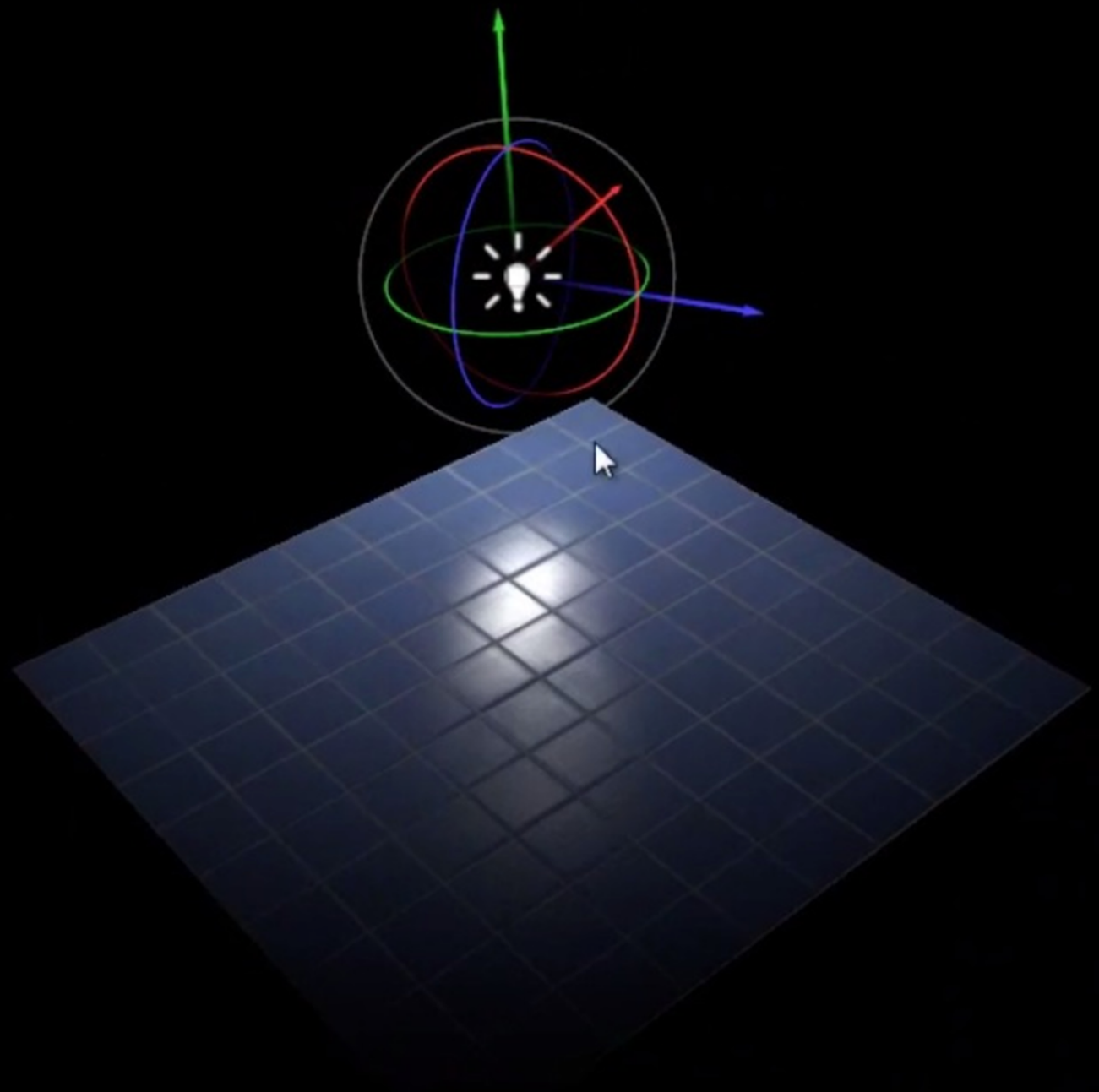
```
GLuint diffuseTexture;
GLuint diffuseTextureUniformLocation;


// ...

diffuseTexture = loadGLTexture(“someimage.png”);
diffuseTextureUniformLocation = glGetUniformLocation(program, "diffuseTexture");

// ...

glUniform1i(diffuseTextureUniformLocation, 0);
glActiveTexture(GL_TEXTURE0);
glBindTexture(GL_TEXTURE_2D, diffuseTexture);
```

```
#define TINYOBJLOADER_IMPLEMENTATION
#include “tiny_obj_loader.h"

////

void loadObjFile(const std::string &fileName, std::vector<VertexPN> &outVertices, std::vector<unsigned short> &outIndices) {
    tinyobj::attrib_t attrib;
    std::vector<tinyobj::shape_t> shapes;
    std::vector<tinyobj::material_t> materials;
    std::string err;

    bool ret = tinyobj::LoadObj(&attrib, &shapes, &materials, &err, fileName.c_str(), NULL, true);

    if(ret) {
        for(int i=0; i < shapes.size(); i++) {
            for(int j=0; j < shapes[i].mesh.indices.size(); j++) {

                unsigned int vertexOffset = shapes[i].mesh.indices[j].vertex_index * 3;
                unsigned int normalOffset = shapes[i].mesh.indices[j].normal_index * 3;
                unsigned int texOffset = shapes[i].mesh.indices[j].texcoord_index * 2;

                VertexPNT v;
                v.p[0] = attrib.vertices[vertexOffset];
                v.p[1] = attrib.vertices[vertexOffset+1];
                v.p[2] = attrib.vertices[vertexOffset+2];

                v.n[0] = attrib.normals[normalOffset];
                v.n[1] = attrib.normals[normalOffset+1];
                v.n[2] = attrib.normals[normalOffset+2];

                v.t[0] = attrib.texcoords[texOffset];
                v.t[1] = 1.0-attrib.texcoords[texOffset+1];

                outVertices(v);
                outIndices(cubeVertices.size()-1);
            }
        }
    } else {
        std::cout << err << std::endl;
        assert(false);
    }
}
```

Combining with lighting

```
vec3 intensity = (texture2D(diffuseTexture, varyingTexCoord).xyz * diffuseColor) + specularColor;
gl_FragColor = vec4(intensity.xyz, 1.0);
```

Specular maps



Specular Map

```
vec3 intensity = (texture2D(diffuseTexture, varyingTexCoord).xyz * diffuseColor)
+ (specularColor * texture2D(specularTexture, varyingTexCoord).x);
```

Multiple textures

GLSL

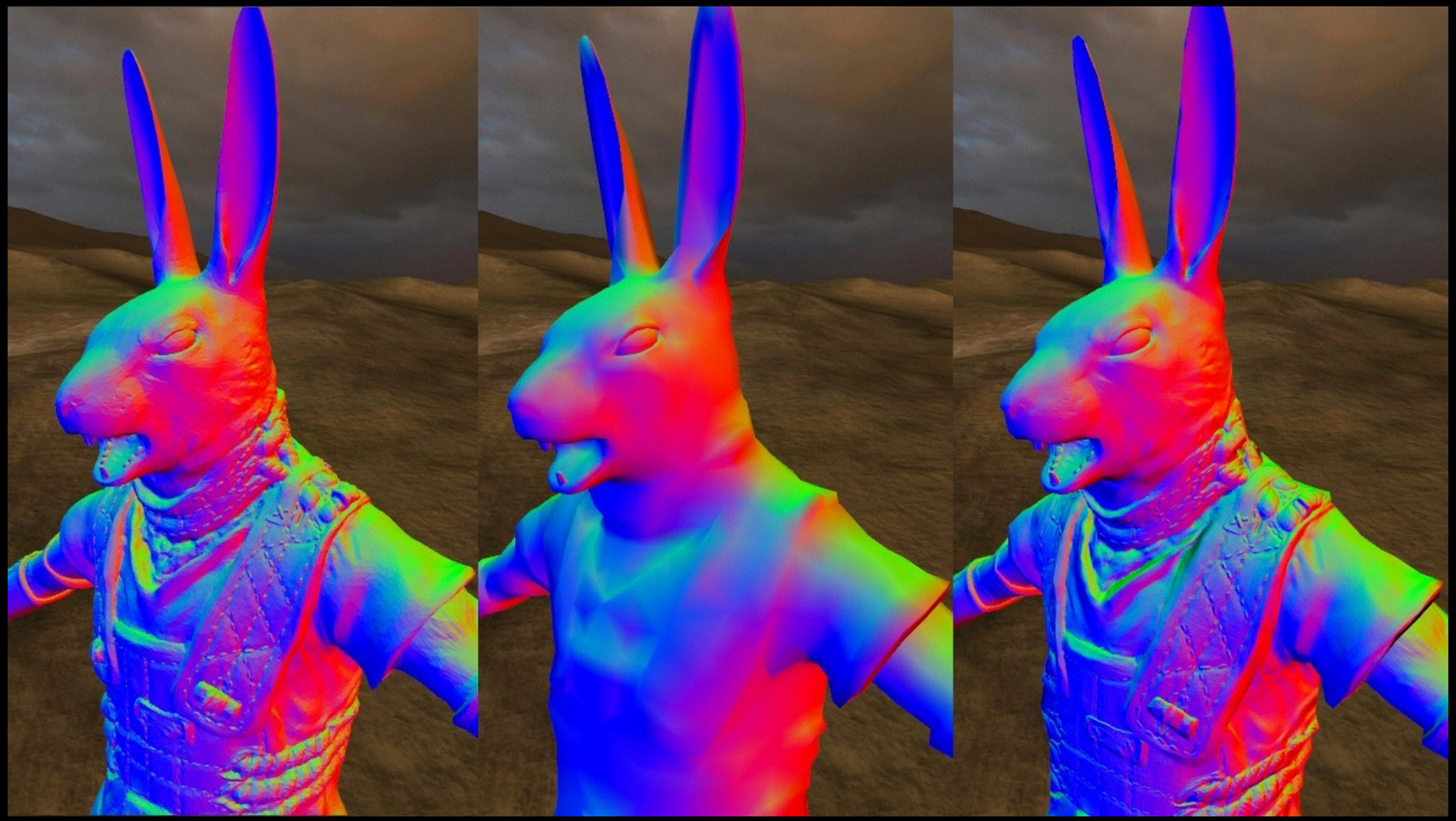
```
uniform sampler2D diffuseTexture;
uniform sampler2D specularTexture;

// . . .
```

C++

```
GLuint diffuseUniformLocation;
GLuint specularUniformLocation;

// . . .

diffuseUniformLocation = glGetUniformLocation(program, "diffuseTexture");
specularUniformLocation = glGetUniformLocation(program, “specularTexture");

// . . .

glUniform1i(diffuseUniformLocation, 0);
glActiveTexture(GL_TEXTURE0);
glBindTexture(GL_TEXTURE_2D, diffuseTexture);

glUniform1i(specularUniformLocation, 1);
glActiveTexture(GL_TEXTURE1);
glBindTexture(GL_TEXTURE_2D, specularTexture);
```

Be aware of GPU limits for texture units (usually 16 or 32).

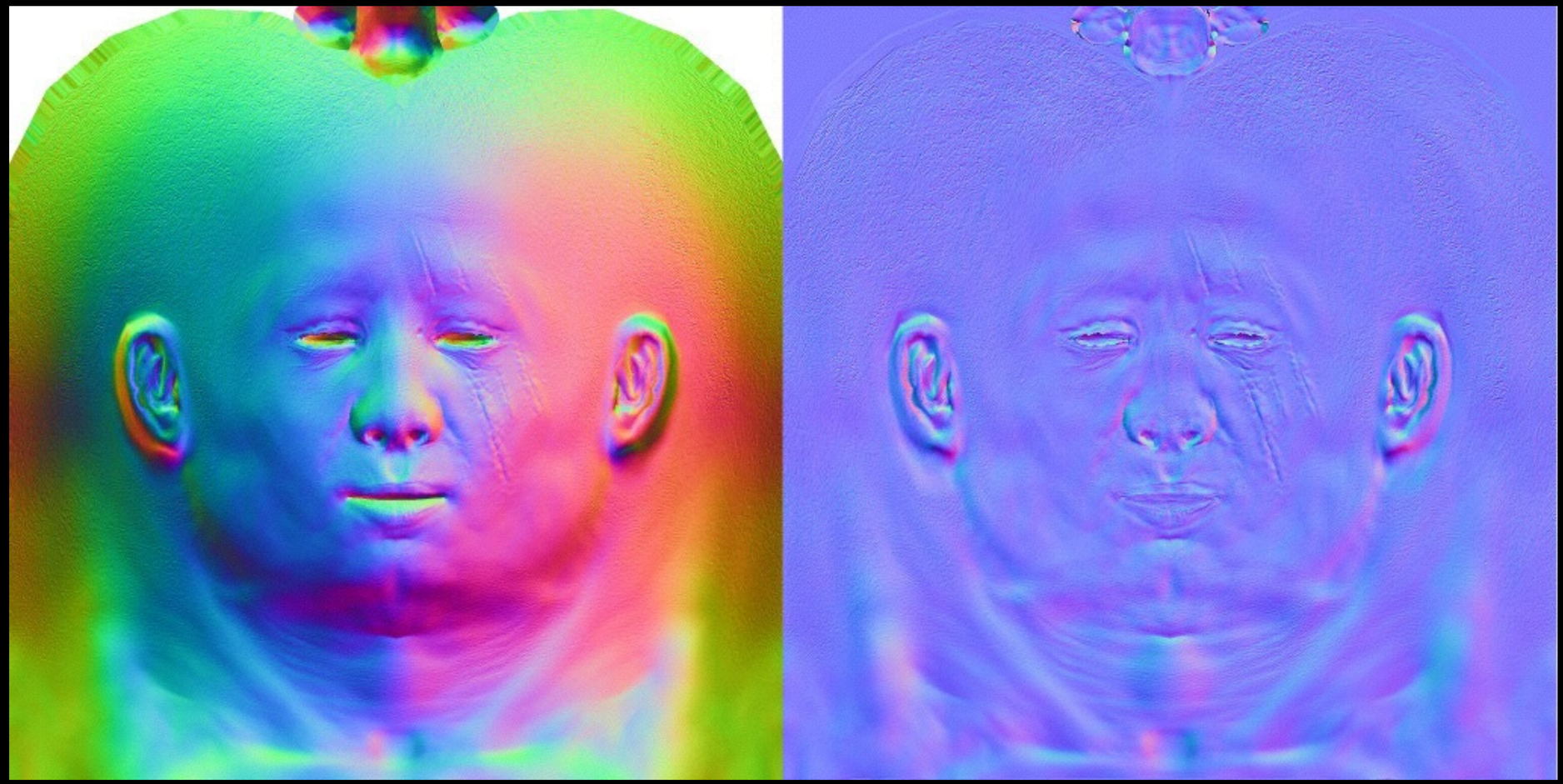
Normal maps



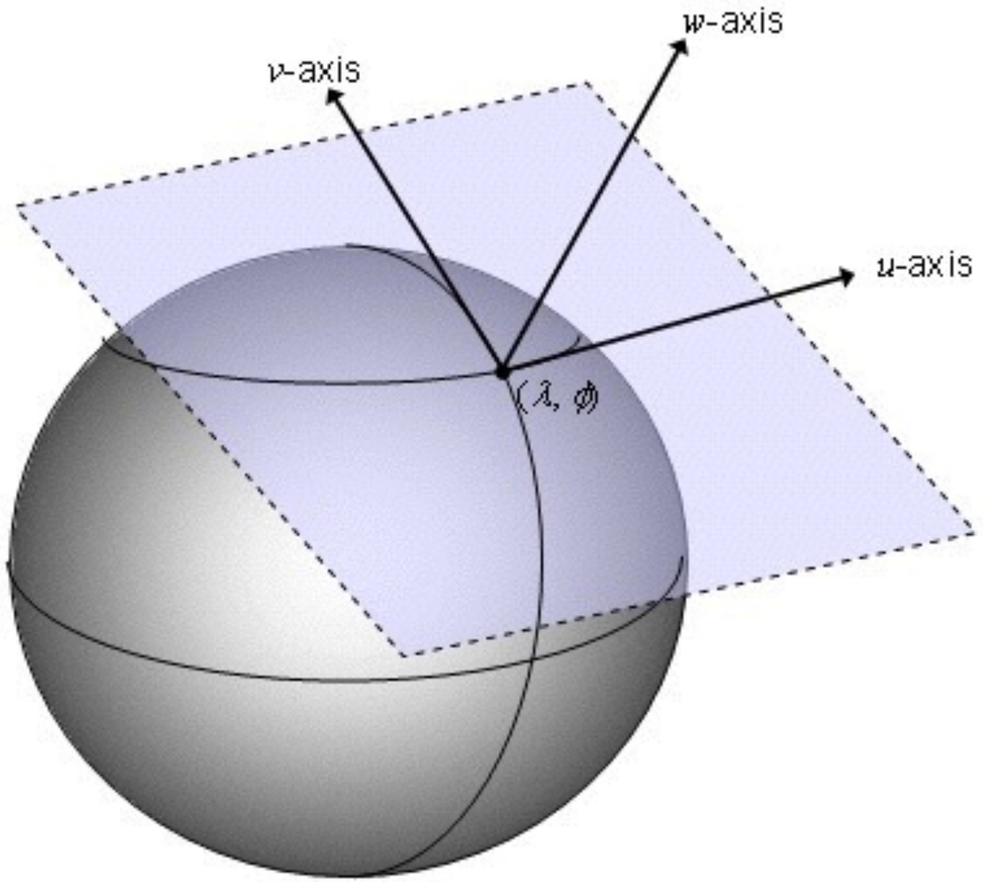

Geometry
Higher Res
SDiv 1
Cage
Del Higher
ZMapper
rev-E
Current Texture
ZTexture01_NRM3_NRM
Width=2048
Height=2048
Depth=32

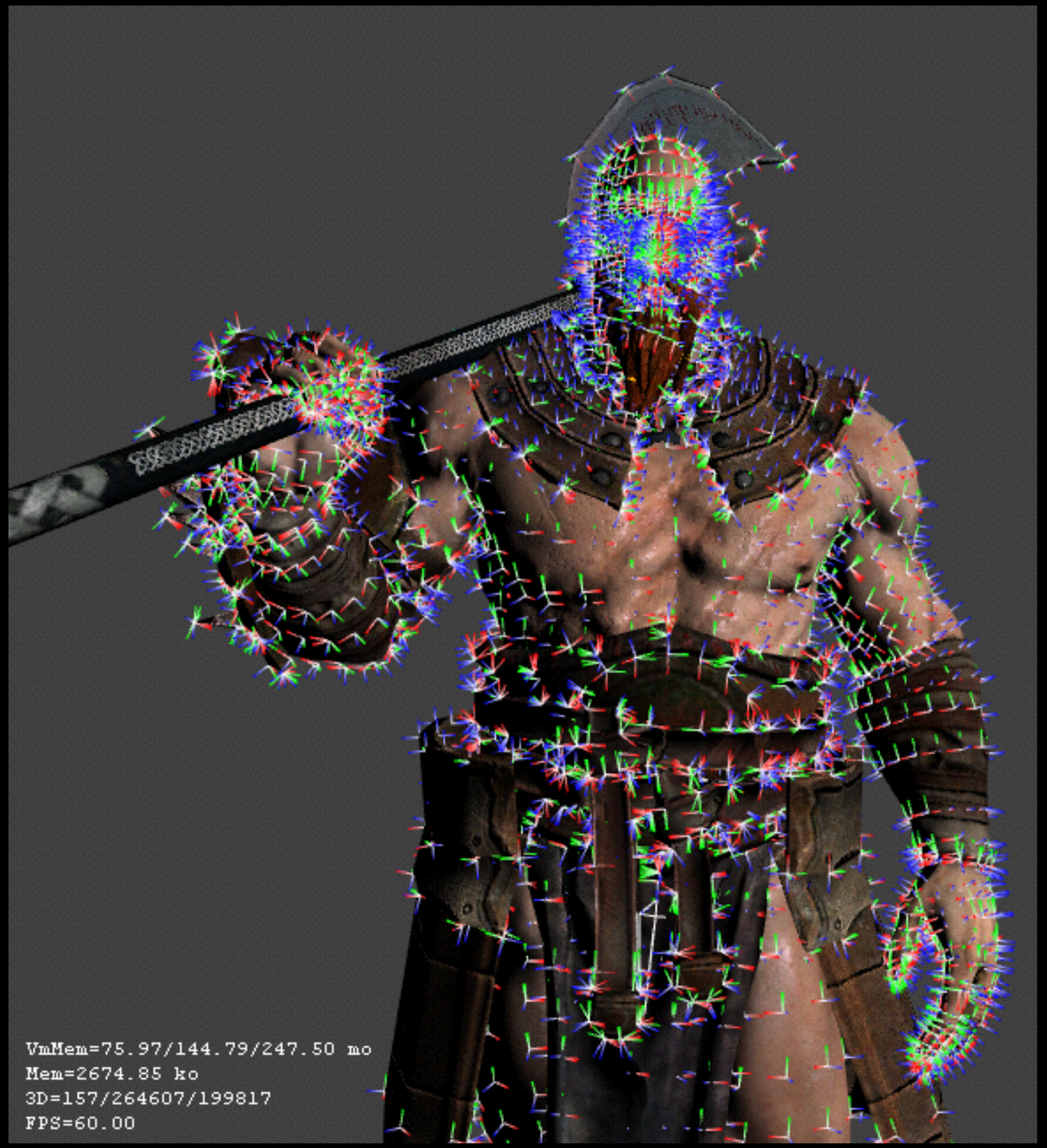
Object space normal map

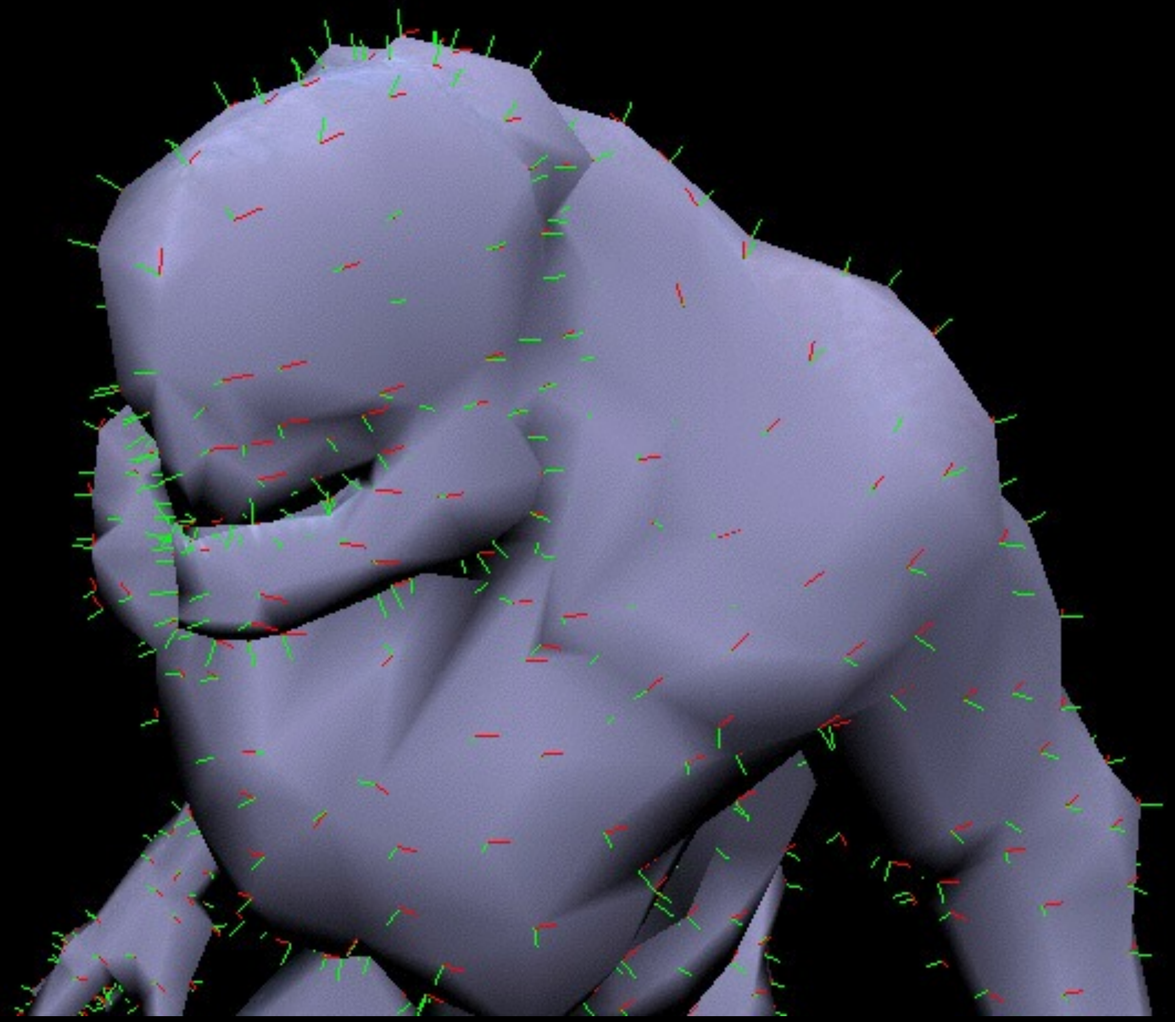
Tangent space normal map



Tangent space


w-axis
v-axis
u-axis
(λ, φ)


VmMem=75.97/144.79/247.50 mo
Mem=2674.85 ko
3D=157/264607/199817
FPS=60.00



Vertex program

```
attribute vec4 normal;
attribute vec4 binormal;
attribute vec4 tangent;

varying mat3 varyingTBNMatrix;

// . . .

varyingTBNMatrix = mat3(normalize((normalMatrix * tangent).xyz), normalize((normalMatrix *
binormal).xyz), normalize((normalMatrix * normal).xyz));
```

Fragment program

```
uniform sampler2D normalTexture;
varying mat3 varyingTBNMatrix;

// . . .

vec3 textureNormal = normalize((texture2D(normalTexture, varyingTexCoord).xyz * 2.0) -1.0);
textureNormal = normalize(varyingTBNMatrix * textureNormal);
```

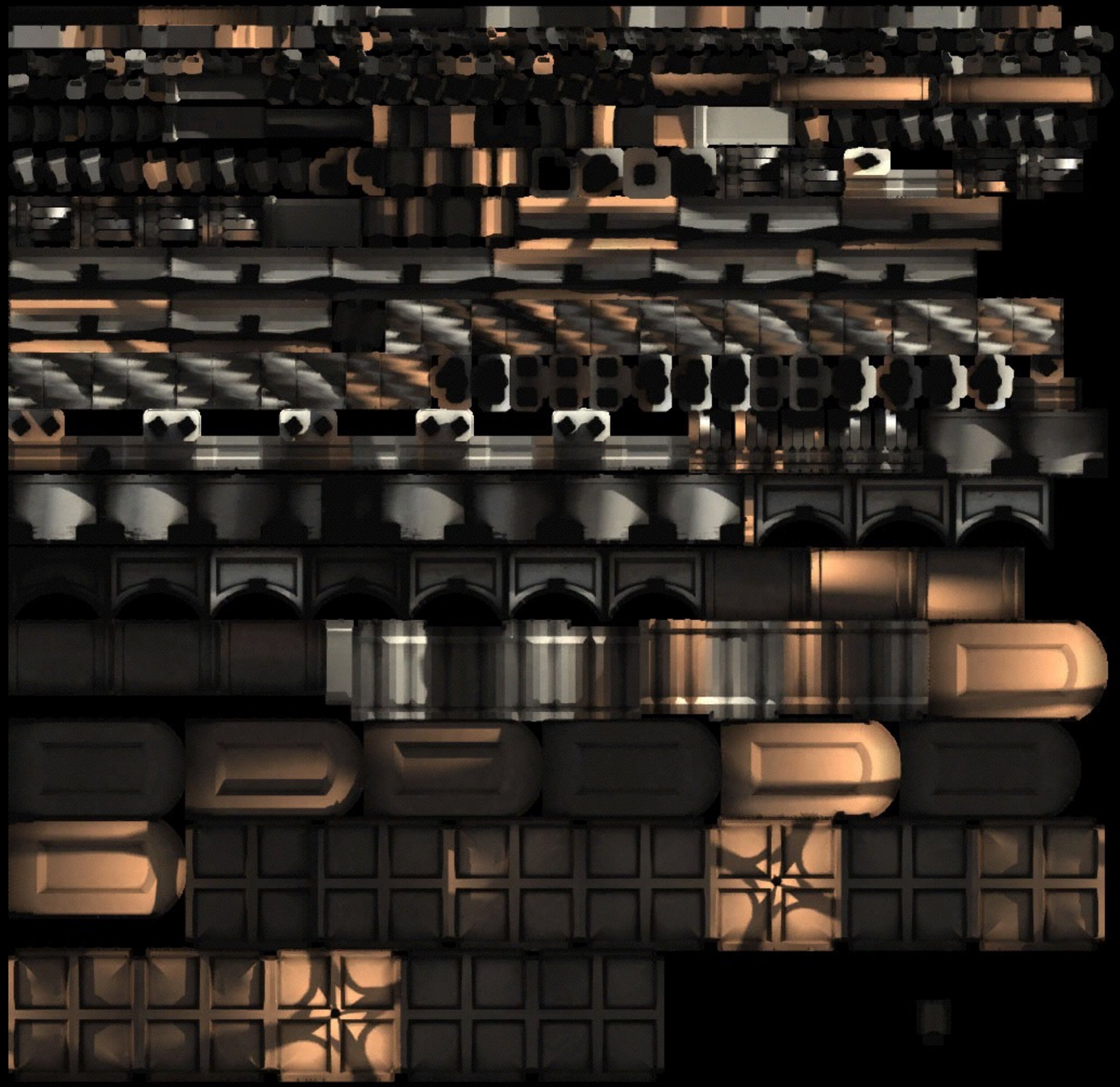
```
struct VertexPNTBTG {
    Cvec3f p, n, b, tg;
    Cvec2f t;

    VertexPNTBTG() {}
    VertexPNTBTG(float x, float y, float z, float nx, float ny, float nz) : p(x,y,z), n(nx, ny, nz) {}

    VertexPNTBTG& operator = (const GenericVertex& v) {
        p = v.pos;
        n = v.normal;
        t = v.tex;
        b = v.binormal;
        tg = v.tangent;
        return *this;
    }
};

// . . .

glEnableVertexAttribArray(binormalAttribute);
glVertexAttribPointer(binormalAttribute, 3, GL_FLOAT, GL_FALSE, sizeof(VertexPNTBTG), (void*)offsetof(VertexPNTBTG, b));
glEnableVertexAttribArray(binormalAttribute);

glEnableVertexAttribArray(tangentAttribute);
glVertexAttribPointer(tangentAttribute, 3, GL_FLOAT, GL_FALSE, sizeof(VertexPNTBTG), (void*)offsetof(VertexPNTBTG, tg));
glEnableVertexAttribArray(tangentAttribute);
```

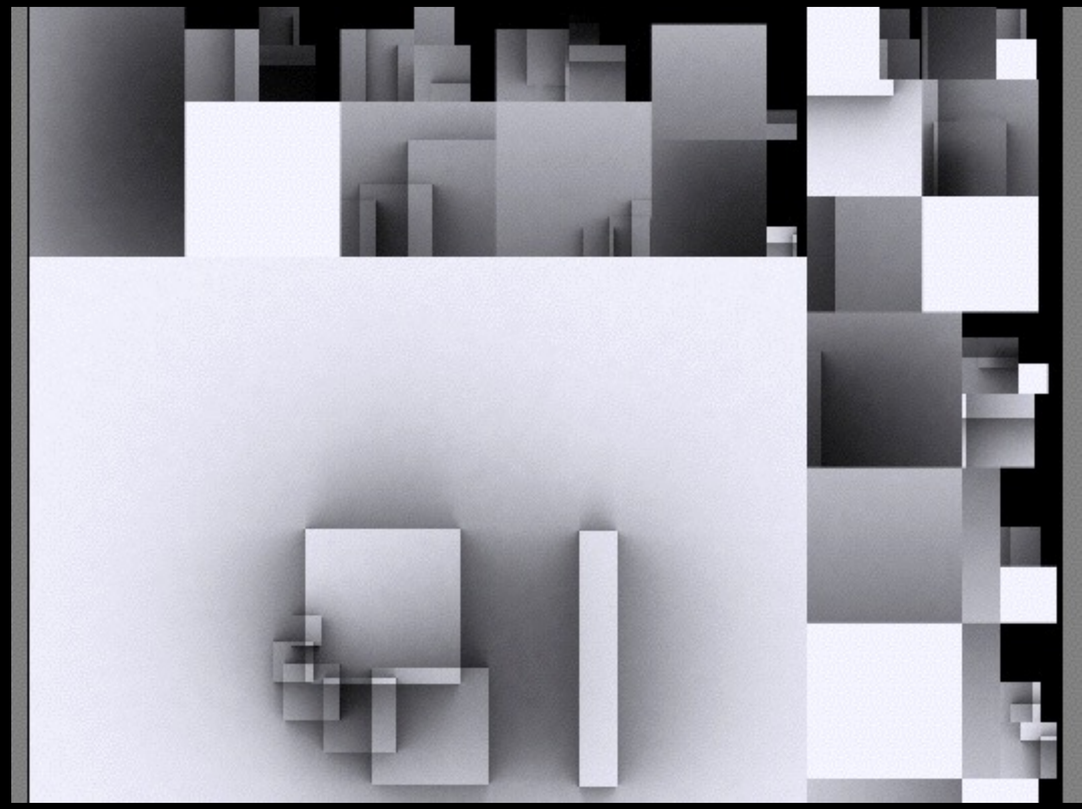
Calculating tangents and binormals.

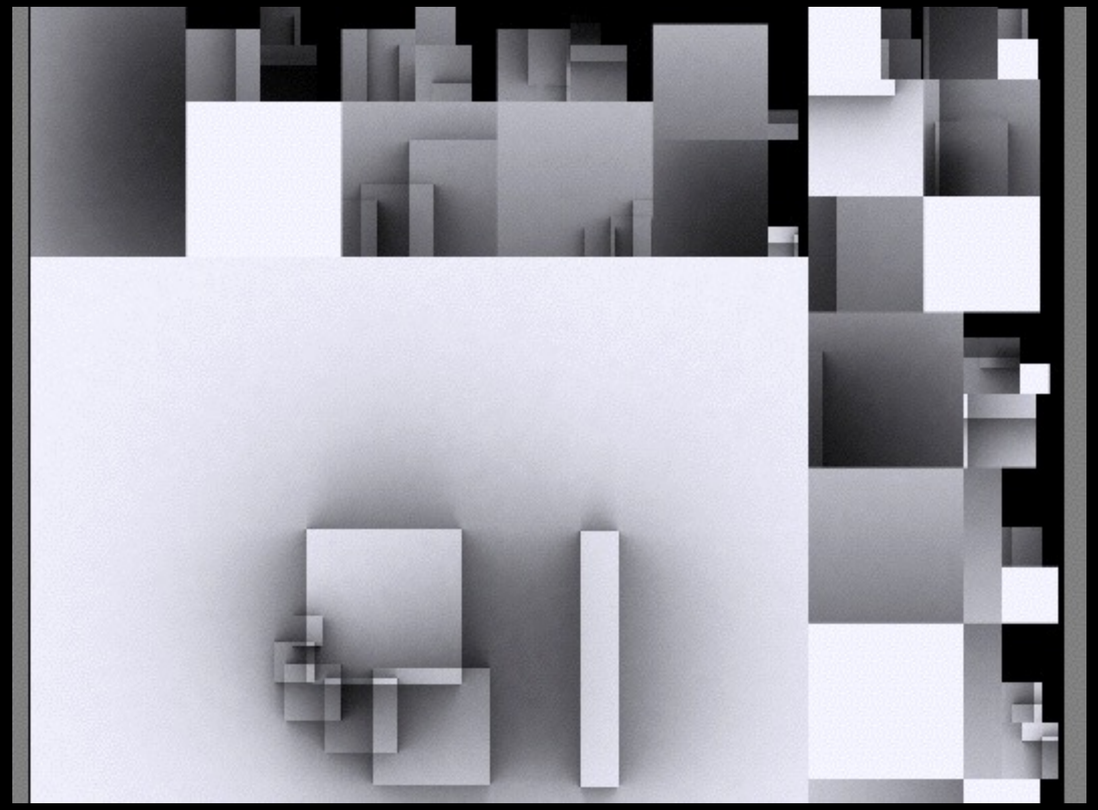
```
void calculateFaceTangent(const Cvec3f &v1, const Cvec3f &v2, const Cvec3f &v3, const Cvec2f &texCoord1, const Cvec2f &texCoord2,
const Cvec2f &texCoord3, Cvec3f &tangent, Cvec3f &binormal) {

    Cvec3f side0 = v1 - v2;
    Cvec3f side1 = v3 - v1;
    Cvec3f normal = cross(side1, side0);
    normalize(normal);
    float deltaV0 = texCoord1[1] - texCoord2[1];
    float deltaV1 = texCoord3[1] - texCoord1[1];
    tangent = side0 * deltaV1 - side1 * deltaV0;
    normalize(tangent);

    float deltaU0 = texCoord1[0] - texCoord2[0];
    float deltaU1 = texCoord3[0] - texCoord1[0];

    binormal = side0 * deltaU1 - side1 * deltaU0;
    normalize(binormal);
    Cvec3f tangentCross = cross(tangent, binormal);

    if (dot(tangentCross, normal) < 0.0f) {
        tangent = tangent * -1;
    }
}
```

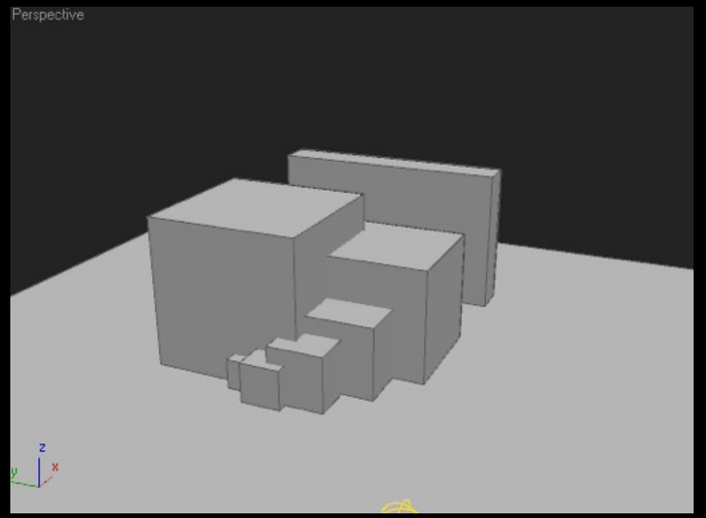
```
    for(int i=0; i < cubeVertices.size(); i += 3) {
        Cvec3f tangent;
        Cvec3f binormal;

        calculateFaceTangent(cubeVertices[i].p, cubeVertices[i+1].p, cubeVertices[i+2].p,
cubeVertices[i].t, cubeVertices[i+1].t, cubeVertices[i+2].t, tangent, binormal);

        cubeVertices[i].tg = tangent;
        cubeVertices[i+1].tg = tangent;
        cubeVertices[i+2].tg = tangent;

        cubeVertices[i].b = binormal;
        cubeVertices[i+1].b = binormal;
        cubeVertices[i+2].b = binormal;
    }
```

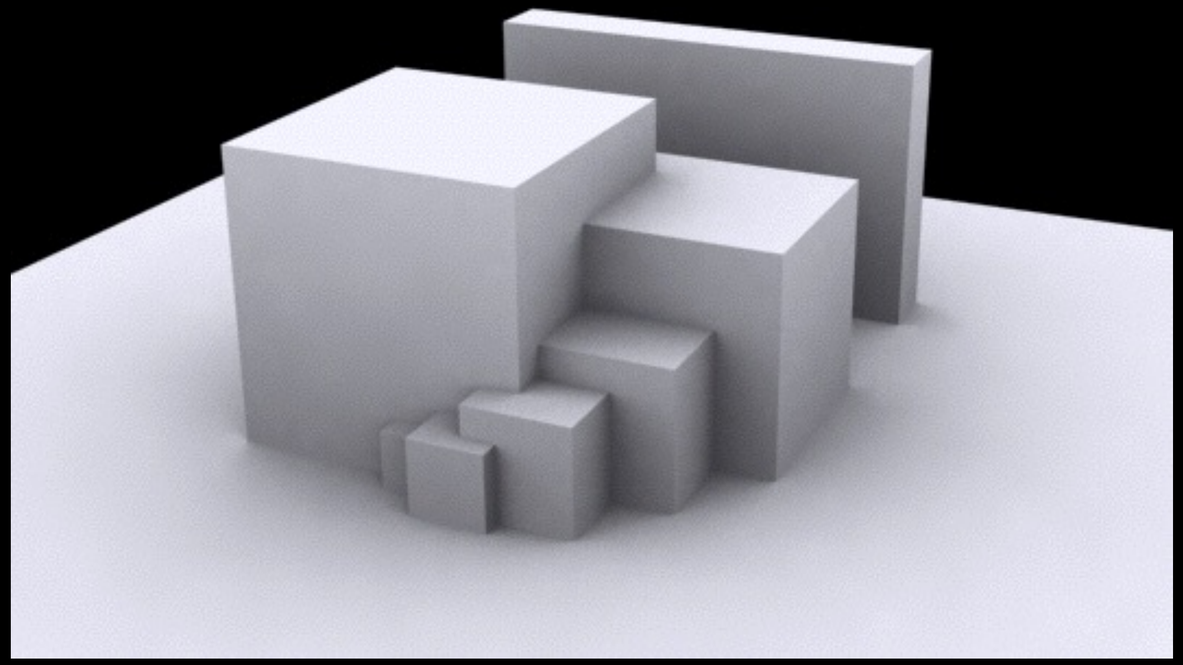
Multiple UVs and lightmaps








Perspective



Assignment #3

- Create a simple scene with multiple positional lights.

- Use a normal map and a specular map on at least one object.

- Use either the object loader or the geometry generator to create objects in your scene.