LEI / LCC
Departamento de Informática
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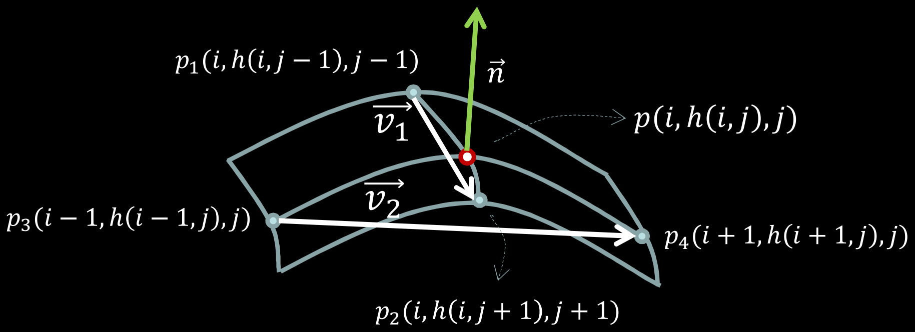
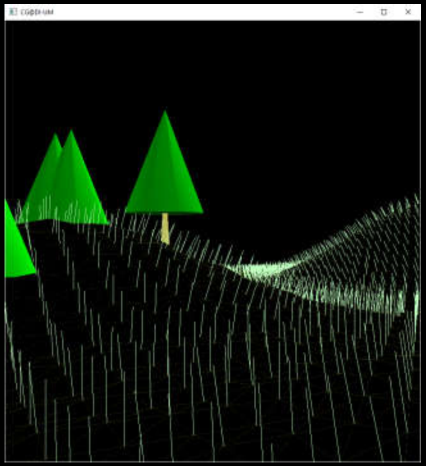
Terrain II

Adding light and texture to the terrain

Terrain Normals

- Cross product of the partial derivatives provides an approximation to the surface normal
- Secant approximation for partial derivatives



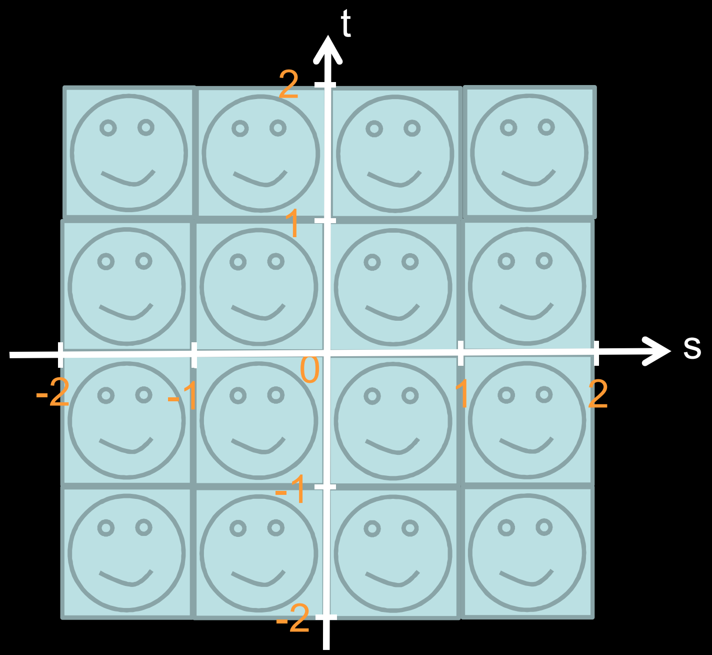


$$\overrightarrow{v_1} = p_2 - p_1$$
$$\overrightarrow{v_2} = p_4 - p_3$$

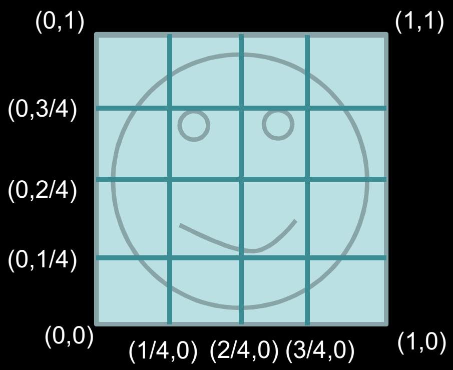
$$\boxed{\vec{n} = \frac{\overrightarrow{v_1} \times \overrightarrow{v_2}}{|\overrightarrow{v_1} \times \overrightarrow{v_2}|}}$$

What to do in the borders?

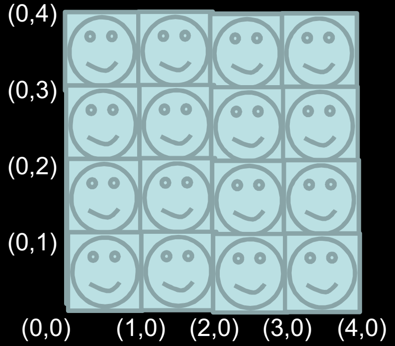
Texture Coordinates



the grid viewed from above



Texture fills the whole terrain



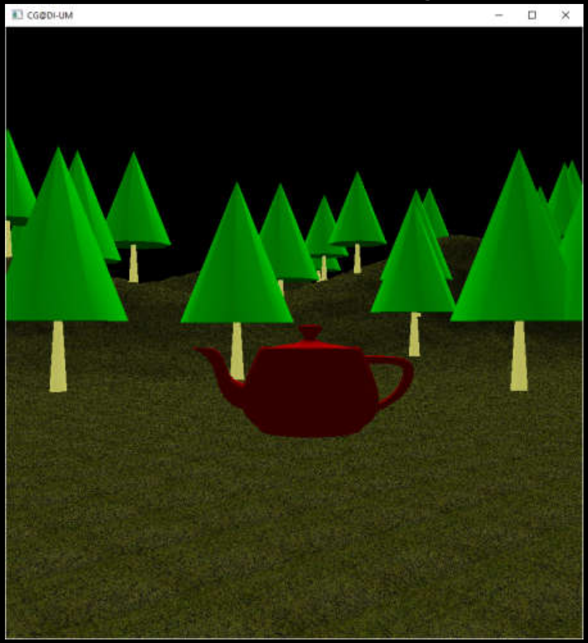
Repeating the texture

Loading a texture

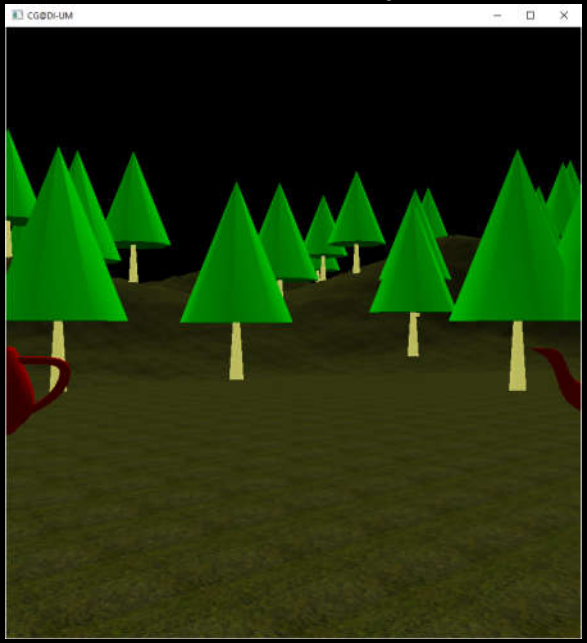
```
unsigned int t,tw,th;
unsigned char *texData;
ilGenImages(1,&t);
ilBindImage(t);
ilLoadImage((ILstring)"relva1.jpg");
tw = ilGetInteger(IL_IMAGE_WIDTH);
th = ilGetInteger(IL_IMAGE_HEIGHT);
ilConvertImage(IL_RGBA, IL_UNSIGNED_BYTE);
texData = ilGetData();

glGenTextures(1,&texture);

glBindTexture(GL_TEXTURE_2D,texture);
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_LINEAR);
glTexParameteri(GL_TEXTURE_2D,GL_TEXTURE_MIN_FILTER,     GL_LINEAR);

glTexImage2D(GL_TEXTURE_2D, 0, GL_RGBA, tw, th, 0, GL_RGBA, GL_UNSIGNED_BYTE, texData);
```

Mipmapping

No mipmapping



Mipmapping



Mipmapping

- Ask OpenGL to generate mipmaps

```
glGenerateMipmap(GL_TEXTURE_2D)
```

- Valid filtering modes available for `GL_TEXTURE_MIN_FILTER`:

```
GL_NEAREST_MIPMAP_NEAREST
GL_NEAREST_MIPMAP_LINEAR
GL_LINEAR_MIPMAP_NEAREST
GL_LINEAR_MIPMAP_LINEAR
```

- Use these modes in the code presented in slide 4

GL init

```
glEnable(GL_LIGHTING);
glEnable(GL_LIGHT0);
glEnable(GL_TEXTURE_2D);

glEnableClientState(GL_VERTEX_ARRAY);
glEnableClientState(GL_NORMAL_ARRAY);
glEnableClientState(GL_TEXTURE_COORD_ARRAY);
```

Prepare the terrain

```
void prepareTerrain() {

      for (int i = 1; i < imageWidth - 2 ; i++) {
          for(int j = 1 ; j < imageWidth -1; j++) {
               // fill arrays for position, normal and texcoord to create strips...
         }
      }

      glGenBuffers(3, buffers);

      glBindBuffer(GL_ARRAY_BUFFER, buffers[0]);
      glBufferData(GL_ARRAY_BUFFER, position.size() * sizeof(float), &(position[0]),GL_STATIC_DRAW);

      glBindBuffer(GL_ARRAY_BUFFER, buffers[1]);
      glBufferData(GL_ARRAY_BUFFER, normal.size() * sizeof(float), &(normal[0]),GL_STATIC_DRAW);

      glBindBuffer(GL_ARRAY_BUFFER, buffers[2]);
      glBufferData(GL_ARRAY_BUFFER, texCoord.size() * sizeof(float), &(texCoord[0]),GL_STATIC_DRAW);
 }
```

Render the terrain

```
void renderTerrain() {

    GLfloat white[] = {1.0f, 1.0f, 0.0f, 1.0f};
    glMaterialfv(GL_FRONT, GL_AMBIENT_AND_DIFFUSE, white);

    // bind the texture
    glBindTexture(GL_TEXTURE_2D, texture);

    glBindBuffer(GL_ARRAY_BUFFER, buffers[0]);
    glVertexPointer(3, GL_FLOAT, 0, 0);

    glBindBuffer(GL_ARRAY_BUFFER, buffers[1]);
    glNormalPointer(GL_FLOAT, 0, 0);

    glBindBuffer(GL_ARRAY_BUFFER, buffers[2]);
    glTexCoordPointer(2, GL_FLOAT, 0, 0);

    for (int i = 1; i < imageWidth - 2; i++) {
        glDrawArrays(GL_TRIANGLE_STRIP, (imageWidth-2) * 2 * i, (imageWidth-2) * 2);
    }
}
```

Assignment

- Define normals and texture coordinates for the terrain
  - see function `prepareTerrain and renderTerrain`
- Find `// to do` and fill the required code
- Compare the results with and without mipmapping
  - see function `loadTexture`:
    - replace the filter
    - add `glGenerateMipmap`

Questions

- When computing the normals we took advantage of the fact that the terrain is represented by a regular grid.
  - Is this approach applicable in generic 3D models?
  - How can we compute normals for irregular grids?
- Measure the performance with and without mipmapping.