COMP220: Graphics & Simulation

5: Textures and models

Learning outcomes

- **Explain** how a 2D texture image can be wrapped onto a 3D model
- **Explain** how a complex 3D model is represented in memory
- **Write** programs which draw textured meshes to the screen

Basic texture mapping

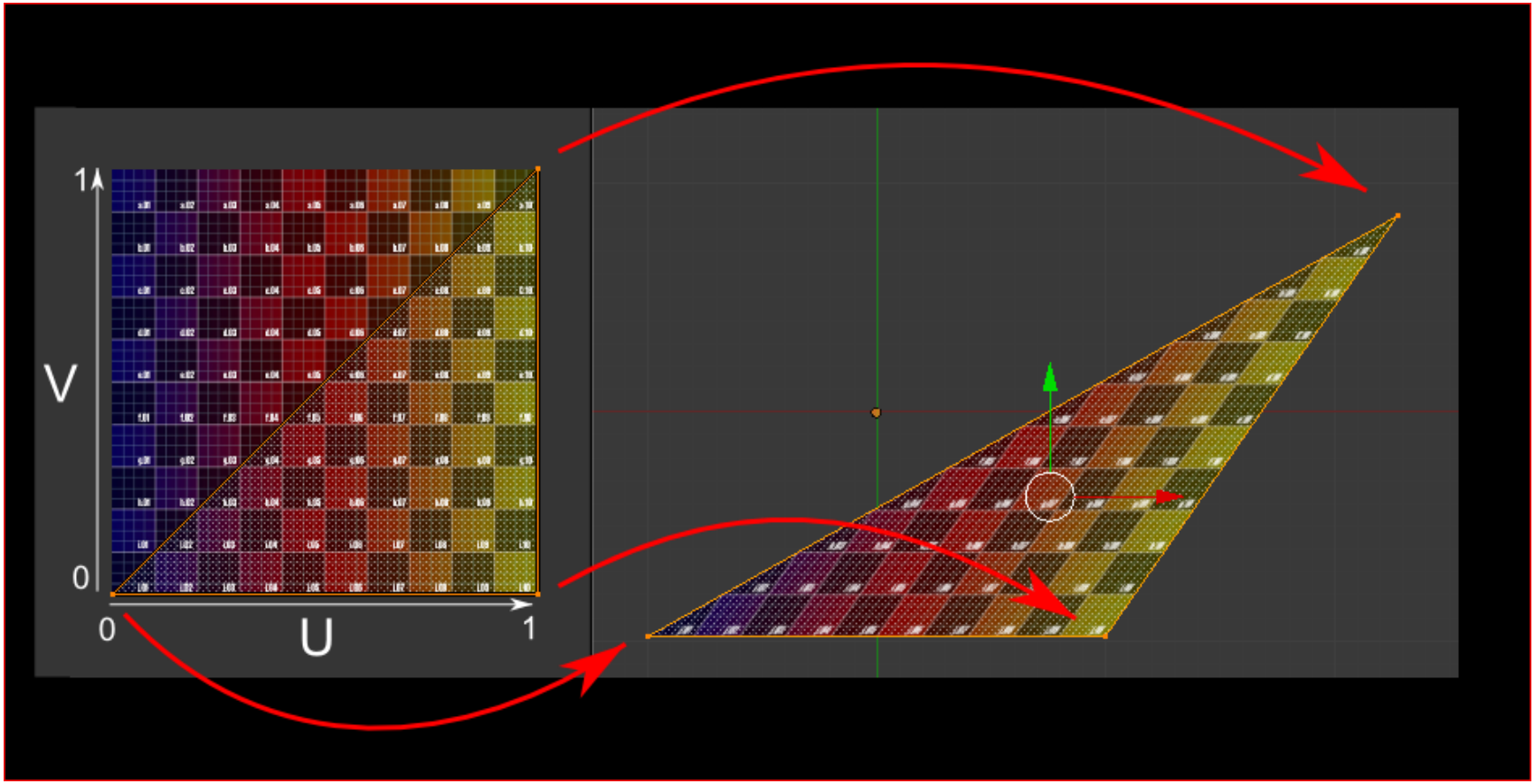
Loading textures from a file

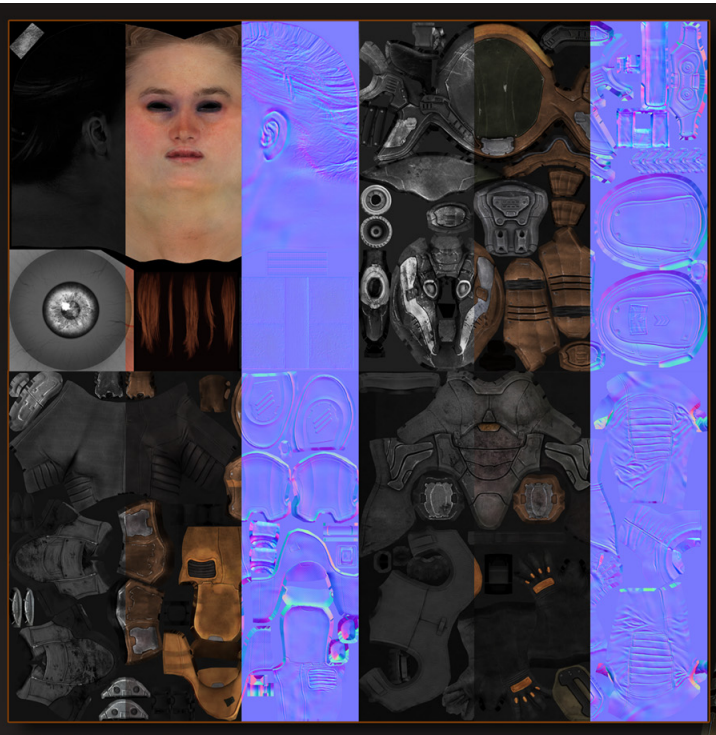
- The **SDL_Image library** lets us load images from JPG, PNG, BMP etc.
- Steps:
  - Load the image with `IMG_Load`
  - Create a texture with `glGenTextures`
  - Bind the texture with `glBindTexture`
  - Load the pixel data into the new texture with `glTexImage2D`
  - Set the texture filtering modes with `glTexParameteri` (more on this later)

Texture coordinates

- We use **UV coordinates** to refer to points in a texture
- *u* axis is horizontal and ranges from 0 (left) to 1 (right)
- *v* axis is vertical and ranges from 0 (bottom) to 1 (top)
- (So really just another name for *xy* coordinates in texture space)
- Basic idea of texture mapping: give each vertex a *uv* coordinate, and interpolate across the triangle

UV coordinates





Specular/Diffuse/Normal

UV layout/Masking maps

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Textures in GLSL

Fragment shader:

```
in vec2 textureCoords;
uniform sampler2D textureSampler;

void main()
{
    fragmentColour = texture(textureSampler,
        textureCoords);
}
```

Texture filtering

```
glTexParameteri(GL_TEXTURE_2D, GL_TEXTURE_MIN_FILTER,
    GL_LINEAR);
glTexParameteri(GL_TEXTURE_2D, GL_TEXTURE_MAG_FILTER,
    GL_LINEAR);
```

- **Linear interpolation** (`GL_LINEAR`) smooths between pixels
- **Nearest neighbour** (`GL_NEAREST`) is pixelated but may be slightly faster
- **Anisotropic filtering** improves the quality of linear interpolation but is slower
- **Mip-mapping** pre-calculates scaled down versions of the texture — improves quality but costs memory

Texture dimensions

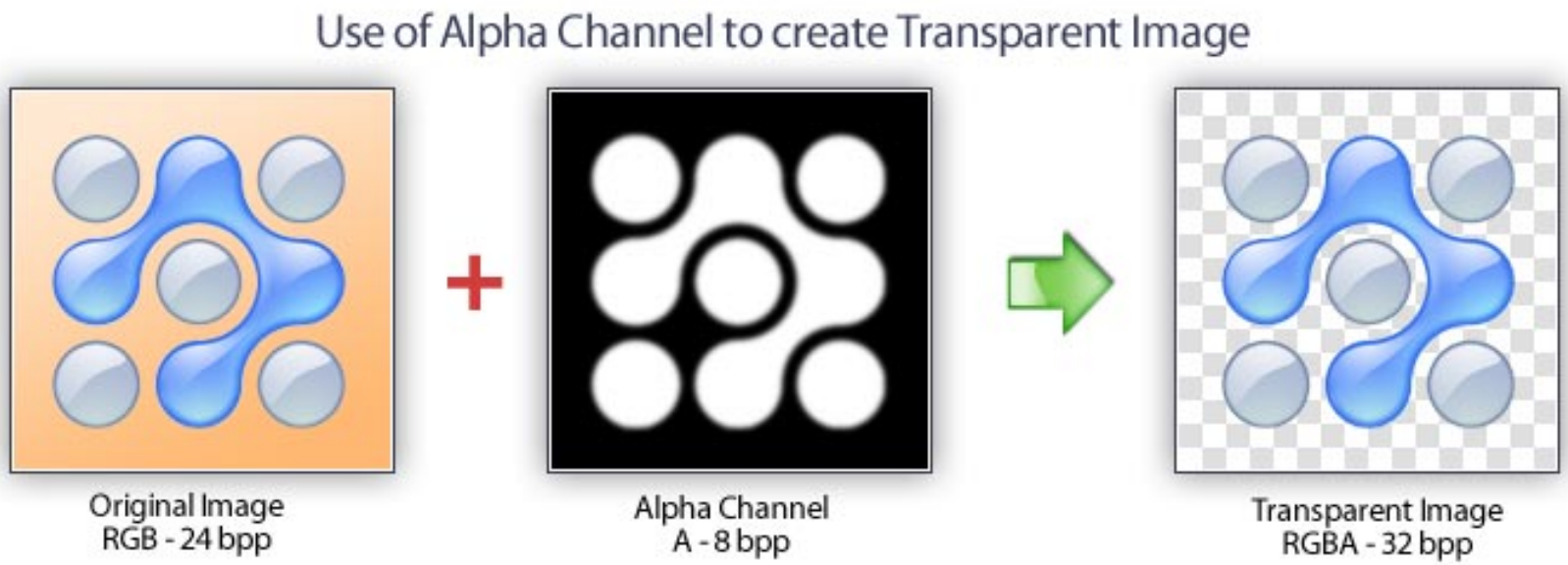
- In the old days, OpenGL required textures to have **power of two** dimensions
  - $2, 4, 8, 16, 32, 64, 128, 256, 512, 1024, \ldots$
- Nowadays **non-power of two (NPOT)** textures are widely supported
- Still better to stick to powers of two as some things work better (e.g. mipmapping)
- NB: **rectangular** textures are fine, but **square** textures make UV coordinates saner

Texture Mapping Example

Transparency

Alpha

- We are used to working with colours in **RGB** space
- We can also work in **RGBA** space, where A = alpha = transparency
- $A = 0 \implies$ fully transparent
- $A = 1$ (or $A = 255$) $\implies$ fully opaque



Alpha in OpenGL

- Use **`vec4`** instead of **`vec3`** for colours
- Textures can have an **alpha channel**
  - PNG supports alpha channels, JPG and BMP do not
- Need to enable **alpha blending**

```
glEnable(GL_BLEND);
glBlendFunc(GL_SRC_ALPHA, GL_ONE_MINUS_SRC_ALPHA);
```

- Other values can be passed to `glBlendFunc` for special effects (e.g. **additive blending** is often used for particle effects simulating light, fire, explosions etc.)

Transparency and depth testing

- Recall we are using **depth testing**
  - Each fragment on screen remembers its **depth** (distance from the camera)
  - A new fragment is drawn **only if** its depth value is **less** than the current depth value
  - I.e. don't draw objects that should be behind something that was already drawn
- But if the object in front is (semi-)transparent, we want to see the object behind it!
- Solution: draw semi-transparent objects **after** opaque objects, and in **back to front** order
- Further discussion: `http://www.opengl-tutorial.org/intermediate-tutorials/tutorial-10-transparency/`

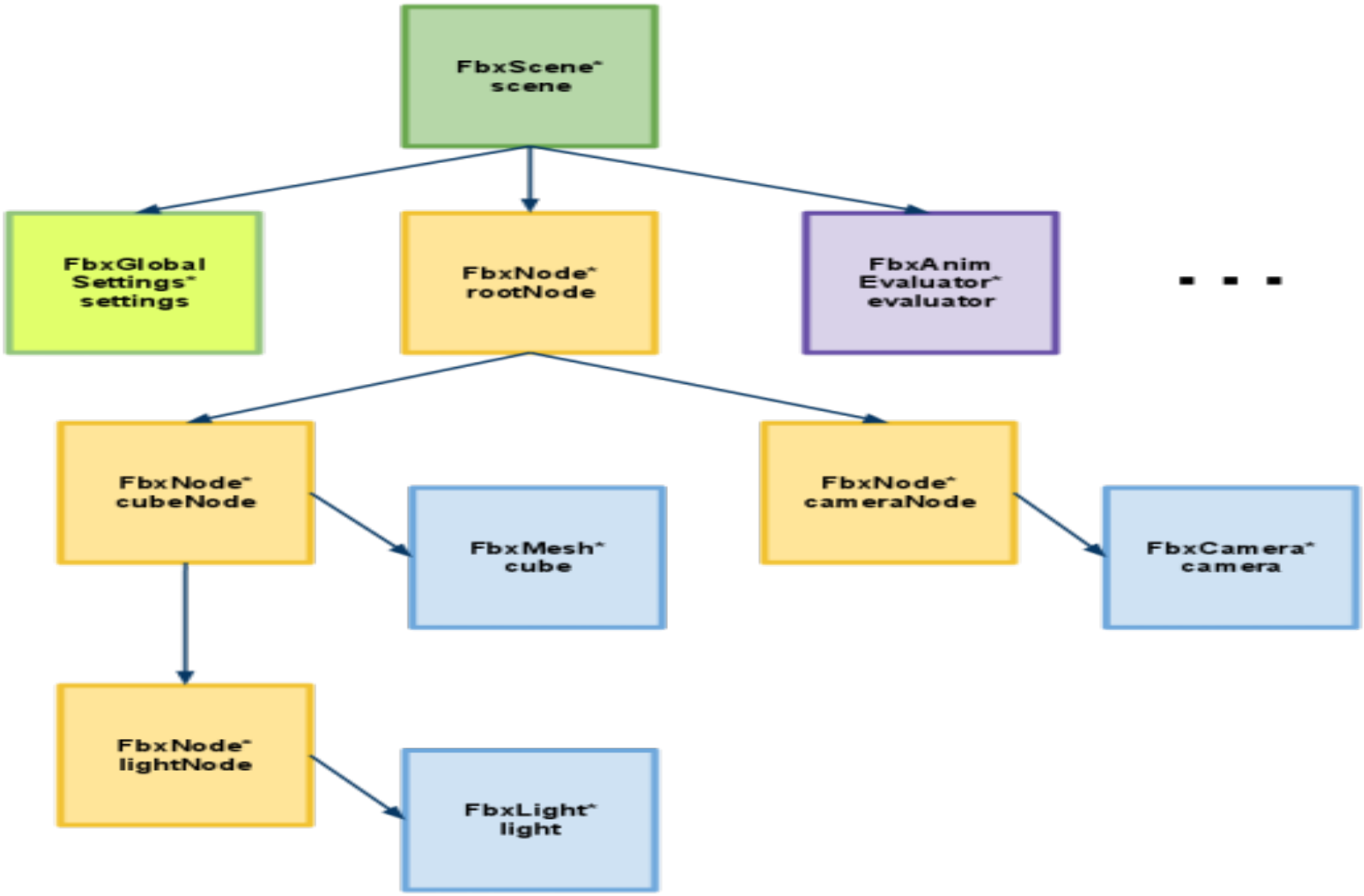
Texturing Example

More meshes

Mesh Formats

- Typically we invent our own mesh format (see Doom's MD6, Valve's smd formats)
- These formats are optimised for realtime rendering and are very efficient
- Usually developers write exporters for Maya or 3DSMax to support their format
- We are going to use FBX as our model format, this known as an 'interchange' format

Quick Tour of the FBX Format



Open Asset Import Library

- There is an FBX SDK published by Autodesk, this can be used to load FBX files
- We will use Asset Import Library to load FBX files
- This allows us to support multiple file formats include
  - FBX
  - OBJ
  - DAE (aka Collada)
  - MD5 (DOOM3)
  - SMD (Half Life 2, Portal etc)

Open Asset Import Library Example

Exercises

Exercise 1 - Texturing

- Load in a image using SDL Image
- Copy this image into a OpenGL Texture
- Add Texture Coordinates to your Cube or Square
- Map this texture onto the Cube or Square
- Finally change the texture to a transparent texture

Exercise 2 - Model Loading

- Create the following NFF models and load each one to the screen
  - Tetrahedron
  - Cube
  - Sphere
  - Cylinder
- `http://assimp.sourceforge.net/howtoBasicShapes.html`
- `https://github.com/assimp/assimp/tree/master/test/models/NFF/NFF`

Exercise 3 - More Complex Scene

- Create a GameObject class which contains the following as member variables
  - Vertex Buffer
  - Element Buffer
  - Vertex Array Object
  - Position, Scale, Rotation Vectors
  - Position, Scale, Rotation, Model Matrices
  - Open GL Texture
  - Number of vertices and Indices
- Add in functions to initialise and get each of these values
- Add in functions to update (calculate the model matrix) and render
- Create an instance of this Game Object and display it on the screen