COMP220: Graphics & Simulation

09: Debugging & Optimisation for Graphics

Learning outcomes

By the end of this week, you should be able to:

- **Understand** how to approach problems with OpenGL applications.
- **Utilize** a selection of tools and techniques to fix and enhance your GPU code.

Agenda

- Lecture (async):
  - **Introduce** a variety of methods for inspecting OpenGL code.
  - **Suggest** tools that might be useful for debugging and profiling GPU applications.

Writing Good Code

Programming Aims

1. Make it work
2. Make it not break - **debugging**
3. Make it work quickly - **profiling & optimisation**
4. Make it readable and maintainable - **code design**

Other People's Code

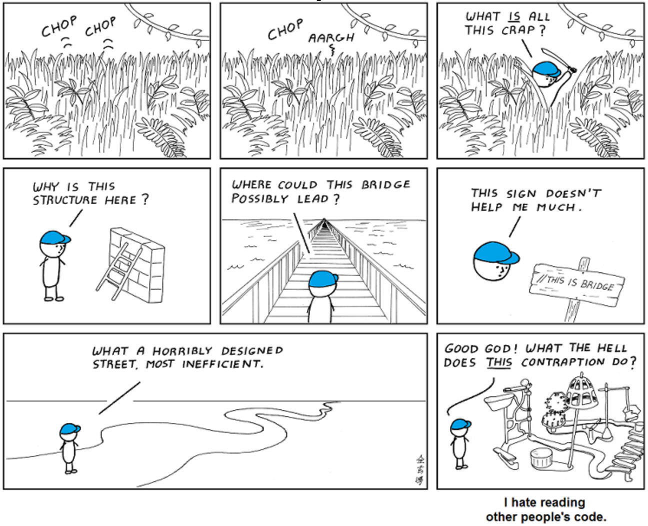
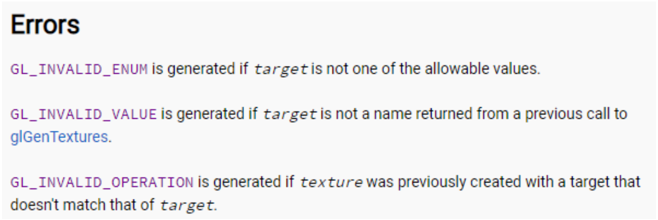

CHOP CHOP
CHOP
AARGH
WHAT IS ALL THIS CRAP?
WHY IS THIS STRUCTURE HERE?
WHERE COULD THIS BRIDGE POSSIBLY LEAD?
THIS SIGN DOESN'T HELP ME MUCH.
//THIS IS BRIDGE
WHAT A HORRIBLY DESIGNED STREET. MOST INEFFICIENT.
GOOD GOD! WHAT THE HELL DOES THIS CONTRAPTION DO?
I hate reading other people's code.

Image source: `https://abstrusegoose.com/432`

Debugging

OpenGL Error States

- `glGetError()` queries behind-the-scenes error flags to check state.
- Possible `glEnum` error codes for each function are listed in the documentation, e.g. for glBindTexture:



Errors

`GL_INVALID_ENUM` is generated if *`target`* is not one of the allowable values.

`GL_INVALID_VALUE` is generated if *`target`* is not a name returned from a previous call to glGenTextures.

`GL_INVALID_OPERATION` is generated if *`texture`* was previously created with a target that doesn't match that of *`target`*.

Debug Output

- Extension made core feature from v4.3
- Includes information about the cause and severity.

```
SDL_GL_SetAttribute(SDL_GL_CONTEXT_FLAGS,
        SDL_GL_CONTEXT_DEBUG_FLAG); // Set up debug context
glEnable(GL_DEBUG_OUTPUT);
glEnable(GL_DEBUG_OUTPUT_SYNCHRONOUS);
glDebugMessageCallback(debugMessage, NULL);
glDebugMessageControl(GL_DONT_CARE, GL_DONT_CARE,
        GL_DONT_CARE, 0, NULL, GL_TRUE);    // Filter errors

// Callback
void APIENTRY debugMessage(GLenum source, GLenum type,
    GLuint id, GLenum severity, GLsizei length,
    const GLchar *message, const void *userParam) {
    // Do something with the error info
    // (print, write to file etc.)
}
```

Debugging Shaders

- Basic information from **compilation error reports**.
- OpenGL GLSL **reference compiler** tests shader code against OpenGL specification.
- Can use **colour channels** to display values.
- Display **framebuffer contents** in the corner of the screen (similar to post-processing setup).
- More detailed inspection requires using a **3rd party tool** (depending on GPU vendor etc.).

Profiling & Optimisation

Writing Efficient GPU Code

- Same key principles apply as for CPU code!
- Certain operations are optimised in GLSL, eg. swizzling, built-in functions for linear interpolation, dot product etc.
- Write as much as possible in the vertex shader - remember there are fewer vertices than pixels!
- As always: base your changes on profiling results...

Next steps

- **Review** the additional asynchronous material for more information and resources on code design, debugging and profiling.