Fluid simulator report
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Code structure

The main changes to the structure of the project were caused by the addition of the GUI (hence mainwindow.cpp etc.). The OpenGLWindow class (extending QOpenGLWindow) was downgraded to an OpenGLWidget class (extending QOpenGLWidget), to make room for UI controls. Also, some shaders were added.

File	Classes contained	Description
Bake.cpp/.h	VoxelFace Matrix2D SevenPointLagrangianMatrix Matrix3D TwoStepMatrix3D GridTuple GridsHolder	Contains classes relevant to the grids used for the numerical simulation (pressure, velocity components (u,v,w), temperature, etc.)
MainWindow.cpp/.h	MainWindow (extends QMainWindow)	Class for the main window of the application.
main.cpp	-	Main execution file
OpenGLWidget.cpp/.h	OpenGLWidget OpenGLWidget::FrameData	Contains data and functions pertaining to the OpenGL scene.
mainwindow.ui	-	Qt QML file describing the UI interface.
shaders/*.glsl	-	The GLSL shader files.

Fluid simulation methods

Due to time constraints, the project simulates only smoke, using the MAC staggered grid method outlined in the background research report. The bouyancy force that the smoke was subjected to used the *Boussinesq* approximation (in the *body()* function). The projection phase used the MICCG(0) algorithm (Modified Incomplete Cholesky Conjugate Gradient, Level Zero).

These methods are described in more depth in the background research report, as well as in the 2007 Siggraph course on fluid simulation.

Speed and memory performance

Although the program was originally written using immediate mode (with *glBegin* and *glEnd*), due to its simplicity. Since this method has been deprecated primarily for performance reasons, it was modified to use Vertex Buffer Objects (generated by *glGenBuffers*) and shaders. This together with vertex pointers and *glBufferSubData* also allowed for easier maintainability, which can be tricky due to the entire data or the scene being stored in a single VBO.

The viewport mouse controls were implemented using a transformation matrix as a uniform for the vertex shaders, replacing the deprecated immediate-mode calls to *glRotate* and *glTransform*.

Although the fluid simulator was originally supposed to use translucent cubes to display the smoke, this would require depth-sorting the cubes every time the camera moves, which would downgrade performance too much. Using varied-size points to represent the smoke concentration also led to less memory being spent (3 position floats and one size float = 4 floats per cell, as opposed to 3 position and 4 color for each of 36 vertices of a cell cube = 252 floats per cell).

The solids (the red green and blue stuff) were voxelized from grid data with a method that attempted to minimize the number of faces required (compared to using two tris for every exposed solid cell wall). This significantly improved performance.

Also for the purpose of efficiency, and to avoid memory leaks, the grid objects used for numerical simulation were wrapped in unique pointers, and discarded as soon as the baking process was completed (at the end of *bake()*).