

CAP5705 Computer Graphics
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Program #1 Mesh Manipulation
DUE: September 11th, 11:59 pm

[Overview](#) | [Details](#) | [Resources](#) | [Getting Help](#) | [Submitting](#)

Overview

In graphics, triangle meshes are commonly used to approximate object surfaces. As presented in class and chapter 12 of your textbook, an indexed triangle set is a mesh data structure consisting of groups of triangles with shared vertices, and indices that indicate how to connect them together to produce a surface. Mesh structures enable quick access to adjacency information for applications that require mesh operations like subdivision, mesh editing and mesh compression.

You will create meshes of simple primitives and implement processing functions to alter their appearance. You will gain experience with data structures and file formats for storing meshes. Grading is based on the following criteria; (1) Source code completion and correctness 30% (2) Warm-up 10% (3) Create Mesh 20% (4) Apply Textures 10% (5) Adjust camera and lights 5% (6) Smooth surfaces 15% (7) One page report 10%.

Details

Getting Started

Extract the file `proj1_mesh.zip` to your local folder. The source code framework is in the `src` folder. Datasets (meshes and textures) are found in the `data` folder. Other helpful materials are in the `docs` folder. Keep the same directory structure throughout the assignment.

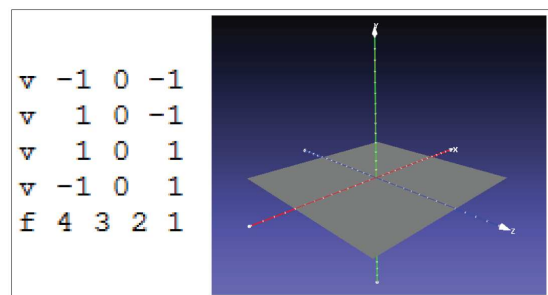
To build the `proj1_mesh` application on linux, type `make` in the `src/mainsrc` folder. This also generates a visual studio c++ solution file. Use any platform but make sure your code compiles and runs on Ubuntu Virtual Box before you submit (see `docs` for instructions). Included in the package is `libst`, an open source openGL wrapper, and `tinyobjloader` (by Syoyo Fujita), an OBJ file object loader. The program is executed from the main function in the file `mainsrc/main.cpp`. Examine the functions in `main.cc`. The titles reflect their function.

Run `proj1_mesh` and specify a 3-D model. Look at the `MouseMotionCallback` to see how to navigate the scene. You will complete implementation for the `MySphere Class`. **Search `MySphere.cpp` for TO DO. You will insert or alter code at these locations to complete the assignment.**

Warm-Up

Primitives are represented as vertex positions (3-D vectors of x , y and z coordinates), Normals, textures and other parameters. Use an indexed triangle set to create a square pyramid, and a cube centered at the origin $(0,0,0)$ by typing vertices and indices in `.obj` files (`my-cube.obj`, `mypyramid.obj`). `OBJ` files are text files that list one vertex per line followed by the ordered vertex indices for connection.

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The cube has six square faces and 8 vertices. The pyramid has a square in the $x-z$ plane, going from $-1-1$ on each axis and an apex at $(0,1,0)$. When specifying your vertex indices, use a counter clockwise direction with normals pointing outward. An example is shown in figure 1. Note that indices begin at 1 (rather than zero). The *.obj* file format is described in *docs/objfileformat.pdf*. For additional examples, use a text editor to open one of the *.obj* files in the *data* folder. Save screen shots of your cube and pyramid models (see the *KeyCallback* function to see how to do this).

Create Mesh

Create a triangle mesh of a unit sphere centered at the origin $(0,0,0)$. Part of the work has been done for you. An icosphere is a type of geodesic dome where triangles are distributed evenly. As shown in Figure 2, the base of the icosphere is an icosahedron (a regular polyhedron with 20 equilateral triangles). Create an icosahedron (see *docs/icosahedron/*), then recursively divide it into triangles by splitting each triangle into 4 smaller triangles. Follow comments in the function *MyShpere::Create(int levels)*. A keypress event in *KeyCallback* executes this function. Your sphere is saved as *mysphere.obj* in the *data* folder. You will submit this file. Remember to load and view your sphere to test it. Use the options in *KeyCallback* to help you set and navigate the scene.

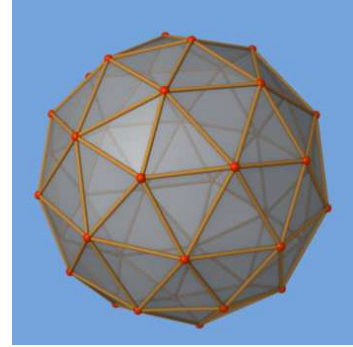


Figure 2: Unit Shpere

Mesh Processing

Toggle the number of subdivision surfaces of your sphere. Use *gManualTriangleMesh->LoopSubdivide()* (provided) in *KeyCallback*. Observe how the level of detail in the surface approximation changes. Save screen shots of a coarse, medium and a smooth subdivision.

Apply Materials and Textures

Texture mapping applies 2-D images to 3-D geometry to add detail information without increasing geometric complexity. Use the textures and models in the *data* folder to create a 3-D textured model. You will use a two-stage mapping process that incorporates an intermediate shape to apply the texture. You are provided source code for the function *CalculateTextureCoordinatesViaSphericalProxy()* which computes the texture coordinates using a sphere intermediate object centered at the origin. The spatial coordinates of the model vertices are first mapped from Cartesian coordinates to spherical coordinates using the following equations:

$$R = \sqrt{x^2 + y^2 + z^2}, \quad \phi = \tan^{-1} \left(\frac{y}{x} \right), \quad \theta = \cos^{-1} \left(\frac{z}{\sqrt{x^2 + y^2 + z^2}} \right) \quad (1)$$

and finally texture coordinates are parameterized in u and v :

$$u = \frac{\phi}{2\pi}, \quad v = \frac{\theta}{\pi} \quad (2)$$

Comments in the code explain implementation details. Toggle the *textureType* variable using keypress events to create displacement and normal mapping textures. You will need to adjust the camera position, and lighting parameters for the best results. The next section explains how.

Adjust Camera and Lights

OpenGL uses a camera defined by an *up*, *lookat*, and *position* vector to view the scene. Search the main function for *camera*. Try to understand how the camera is manipulated to change the view. Use the mouse to position the camera and take a snap shot of the best view of your textured model.

Lights make surfaces visible. You may adjust the ambient, diffuse and specular lighting parameters (search for these). Save a screenshot of the best view of the model texture.

Report Write a one page document that includes the following:

- List any difficulties you had with the assignment.
- Include all screen shots from the assignment.
- Add any special instructions I need to run your code.
- Explain any challenges (e.g. Why your code does not run. Bugs?)

Resources

The OpenGL Programming Guide, available online <https://www.opengl.org/sdk/> is a good reference. Appendix A also provides information about GLUT (now FreeGlut) and GLEW. Chapter 12 of the textbook, Fundamentals in Computer Graphics, covers meshes. Information about the *.obj* file format is in the *docs* folder.

If you are not in the CISE department, and would like computer lab access, you can register for a CISE account at <https://www.cise.ufl.edu/help/account>. The source packet proj1_mesh.zip will run on machines in the computer labs on the first floor of the CSE building. Labs are open 24 hours (see <https://www.cise.ufl.edu/help/access>). **Remember to back-up your work regularly!!!** Use version control to store your work. DO NOT PUBLISH SOLUTIONS.

Getting Help

Source Code Please do not re-invent the wheel. Use the source code framework (and comments) and review the notes in the docs folder.

Discussion Group Post questions to Canvas (everyone benefits in this case), or send me an email at ctoler@cise.ufl.edu. I will check both daily.

Office Hours Visit CSE 332 (or lab CSE 319) during office hours MWF 1:30 to 2:30pm.

Collaborating Work independently. Remember to always credit outside sources you use in your code. University policies on academic integrity must be followed.

Submitting

Upload your proj1_mesh.zip file to Canvas. It should include:

- Source code.
- Make file.
- One page report.
- Screen shots of your mesh and processing results (For full points include at least 3 different subdivision levels, texture mapped sphere, your loaded cube and pyramid models, results from changing camera, and light parameters).
- *mycube.obj*, *mypyramid.obj* and *mysphere.obj*
- Other information you would like us to know (bugs, difficulties)