LAB REPORT: LAB 1

TNM079, MODELING AND ANIMATION

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Abstract

This lab report describes the process used to implement some key components for a half edge mesh structure. More specifically the process of finding all neighbouring faces in the one-ring of a vertex, finding all the neighbouring vertices in the same one-ring, what equations were used for calculating the area and volume of an object and a short mention of Gaussian curvature. The results point towards the process being able to be used to load simple objects but having some flaws when it comes to the colour mapping. A way to fix these issues would be to implement mean curvature, but this was not attempted.

1 Background

A set of three vertices are connected to each other in pairs of half edges, after creating each half edge the so called "inner ring" is connected with the help of the already implemented *prev* and *next* components. Once the edges are connected a $face$ is created and in turn connected to one of the edges, making sure to calculate it's normal vector. The last step consists of connecting each of the inner edges to the $face$. The main purpose is to get the structure seen in Figure 1, with a normal pointing outward and the inner ring going in a counter clockwise direction.

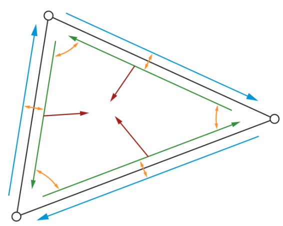

Figure 1: "An incomplete halfedge mesh consisting of one triangle." *Image taken from lab instructions.*

To find all *faces* in a vertex's one-ring (FindNeighborFaces) in counter clockwise order the *prev* edge and connected face of the wanted vertex is saved. Using a loop, each face connected to edge currently being looked at is stored inside of a vertex before moving onto the previous pair of the current edge. The loop continues until the starting edge is reached.

To find all *vertices* in the same one-ring (FindNeighborVertices) a similar approach is used. In a loop, the edge connected to the given vertex as well as pointers to the *next* and *prev* edges is used to store the vertex of the *next* edge inside of a vector. Once that vertex is stored the *prev* edges pair is visited and added to the vector, this continues until the starting edge is reached. To calculate the vertex normal the FindNeighborFaces function is called to get a list of all faces in the object before going through the list, summing up each face normal before normalizing the sum using $glm :: normalize$.

The process of calculating the surface area of the entire mesh is rather simplistic, it is done by summing together the areas of all triangles using the Equation 1, .

$$A_S = \int S dA \approx \sum_{i \in S} A(f_i) \tag{1}$$

To calculate the volume of the object another approach is used. The idea is to consider a vector field flowing through the object. As the fluid traverses through the object the amount coming out on the other side can either be smaller or larger than that of the incoming fluid. If the amount coming out is less than what came in, the object can be seen as a sink, while in the opposite case it is called a source. Using this knowledge it is possible to derive an equation to calculate the volume, in this case, Equation 2.

$$3V = \sum_{i \in S} \frac{(v_1 + v_2 + v_3)_{f_i}}{3} \cdot n(f_i) A(f_i) \tag{2}$$

Finally the Gaussian curvature, in the program called VertexCurvature, was implemented. As per instruction, the code for this function was copied from SimpleMesh.cpp and no further changes were made.

2 Results

Figure 2 consists of a unit sphere which was loaded in using the pre-implemented GUI using the half edge mesh option. When loaded the program stated that it consisted of 1984 faces, 2978 edges, and 994 vertices. The area and volume of the sphere, calculated as described in 1, was 12.551 and 4.1519 respectively. As seen in the Figure there are quite a few strange looking issues with how the surface is coloured using the face curvature. This is mostly due to how the face curvature is not good enough at interpreting the surface, which is only amplified by the blockiness of the sphere, leading to strange patterns.

Figure 3 shows the same unit sphere as the one in Figure 2 but with Gaussian curvature visualized. The curvature of the unit sphere after applying vertex curvature was ranged from 0.252875 to 0.504374. With a correct approximation we would expect to see values closer to one for both the lowest and highest curvature, however, as the sphere is built up of a rather small amount of faces the surface is not as smooth as it could be and the area of each triangle differs greatly depending on where on the sphere you are looking. As the area greatly affects the calculation of the curvature, as the value is divided by the area, the resulting curvature is much lower than what we look for in a more correct representation.

To show that the strange patterns in the colour mapping seen on both previous figures are not the result of wrongly directed normals Figure 4 was created. This figure shows that the direction of each normal is pointed outwards and therefore not the reason for the colouring issue.

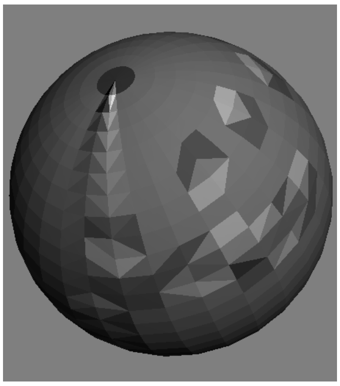

Figure 2: A unit sphere using face curvature for colour mapping.

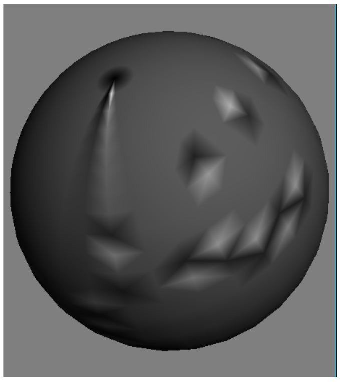

Figure 3: The same unit sphere as in Figure 2 but with Gaussian curvature for colour mapping.

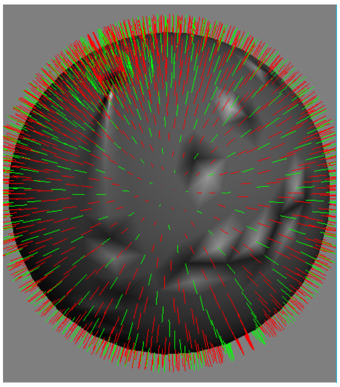

Figure 4: The same unit sphere as in Figure 3 with each triangles normal visualized .

3 Conclusion

Half edge meshes are incredibly useful when used to calculate normals over larger areas, finding the one-ring of a given vertex and when you wish to know which edges are connected to which face, amongst other things. Gaussian curvature is also very useful in creating a smoother looking surface without having to alter the number of triangles used in the mesh. The main problem however is that the Gaussian curvature (and face curvature) are not complex enough to correctly work with surfaces we want to perceive as round even though it consists of many edges, leading to some strange colour issues. The ”easiest” way to fix this, or at the very least get a better representation, is to implement the mean curvature, but this was not attempted.

4 Lab partner and grade

For the records: My lab partner was Felix Lindgren. All assignments for grade 3 were completed, hence, I should get grade 3.