# Tessellating The Go Stone

## Generating a triangle mesh for the go stone

*Posted by Glenn Fiedler (http://web.archive.org/web/20181107181438/https://gafferongames.com/about) on Wednesday, February 20, 2013*

## Introduction

Hi, I'm Glenn Fiedler. Welcome to **Virtual Go** (http://web.archive.org/web/20181107181438/https://gafferongames.com/categories/virtual-go/), my project to create a physically accurate computer simulation of a Go board and stones.

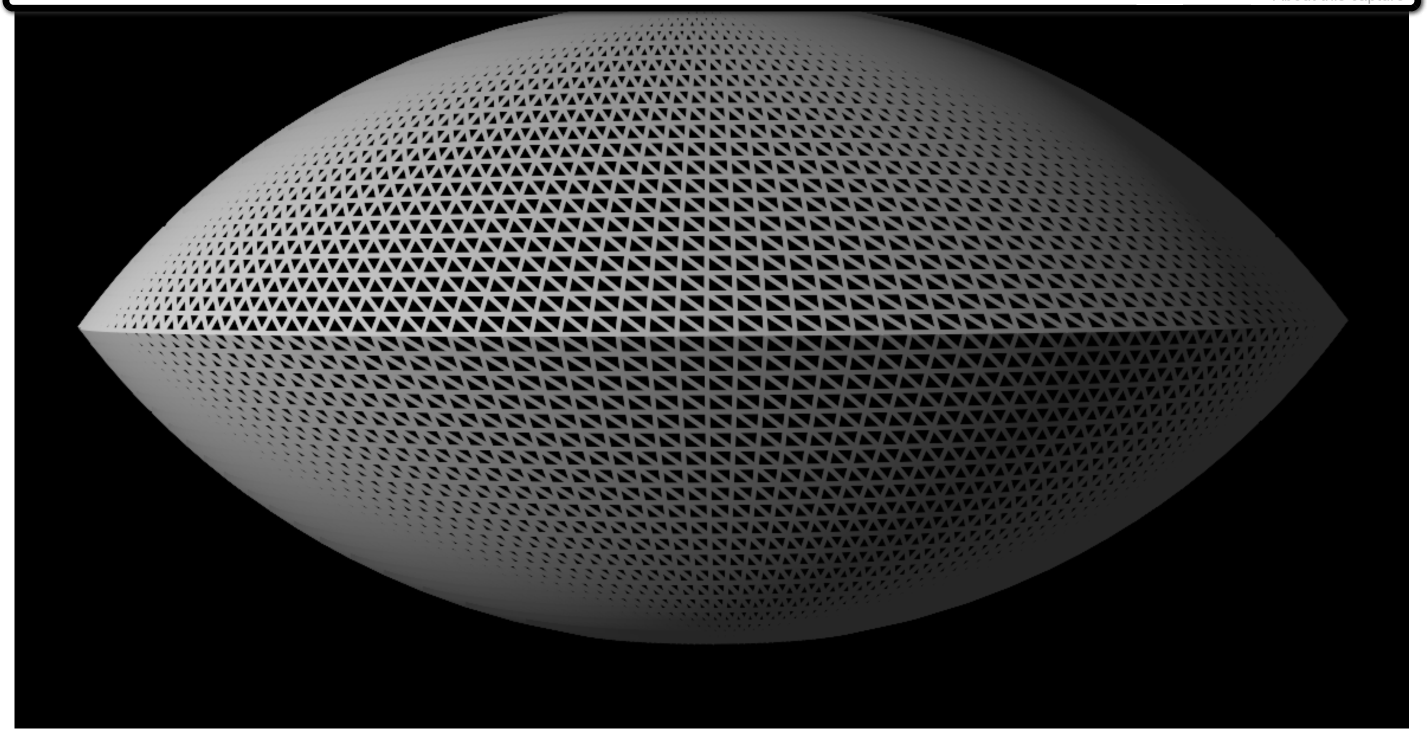
In this article we want to draw the go stone using OpenGL (http://web.archive.org/web/20181107181438/https://www.opengl.org/).

Unfortunately we can't just tell the graphics card, "Hey! Please draw the intersection of two spheres with radius r and d apart with a bevel torus $r_1$ and $r_2$!", because modern 3D graphics cards work by drawing triangles. We have to take our mathematical definition of the go stone and turn it into a set of triangles that the graphics card can render.

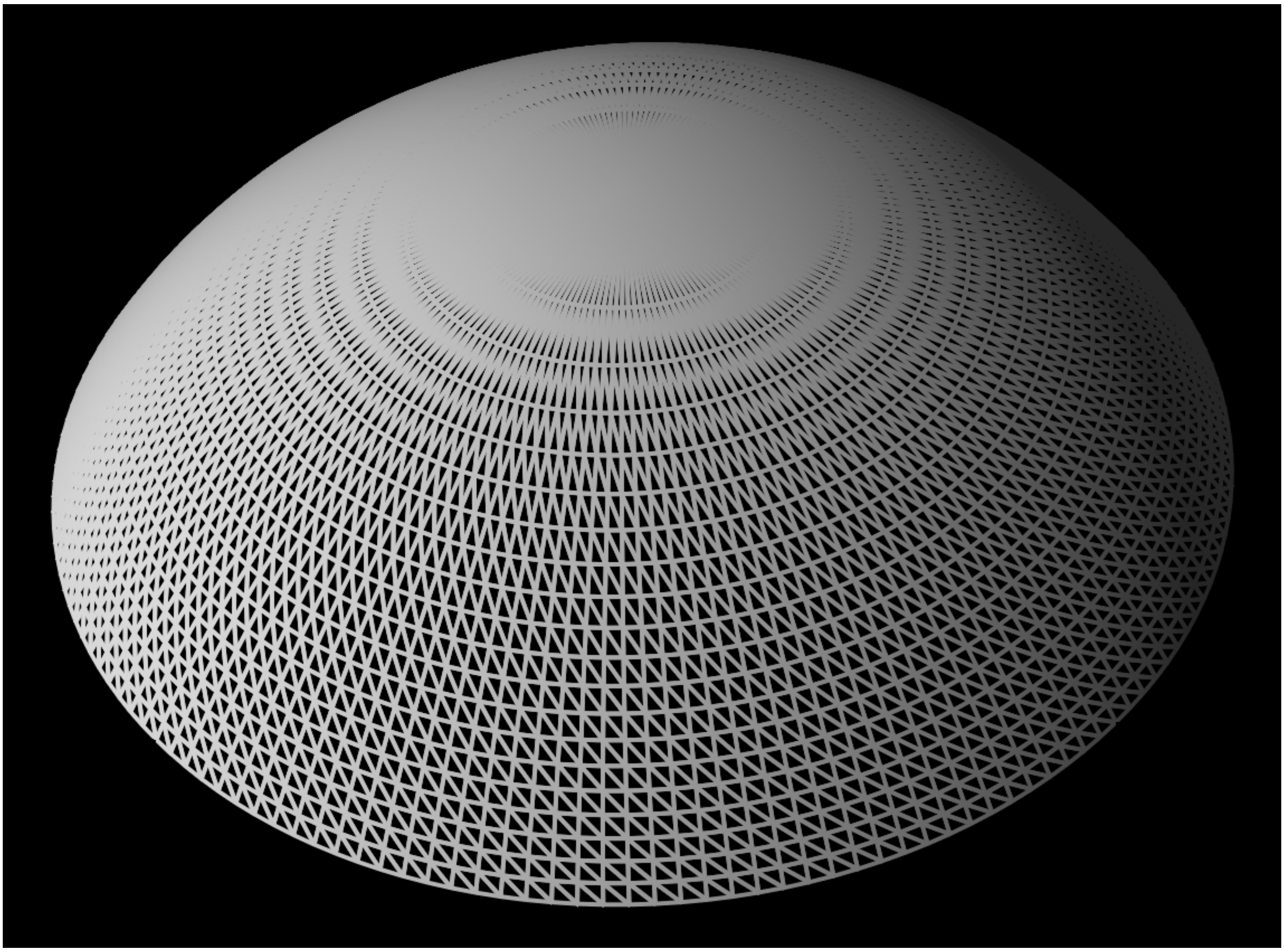
This is called tessellation and there are several different ways to do it.

## Longitude And Lattitude

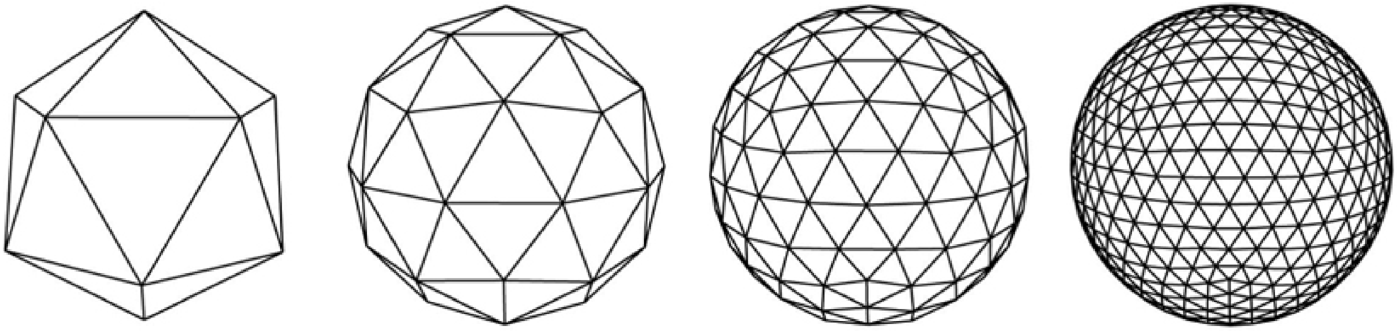
The first way that I tried was to consider sphere rendering like a globe with longitude/latitude. I started with a ring around the 'equator' of the go stone, stepping these rings up to the top of the sphere like the north pole on a globe.



Unfortunately, just like longitude/latitude on a globe, tessellating this way leads to very distorted mapping around the pole and a lot of wasted triangles:

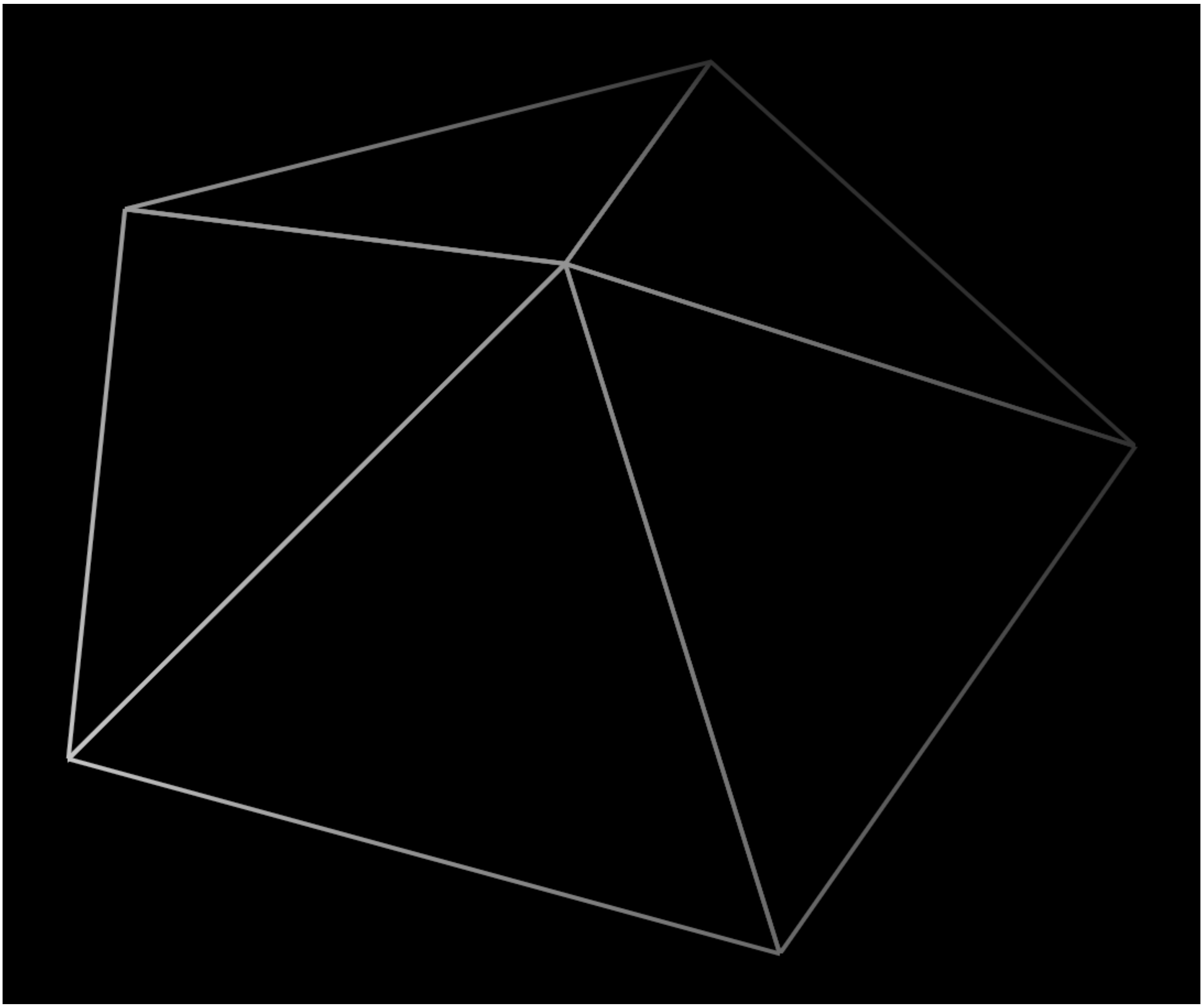


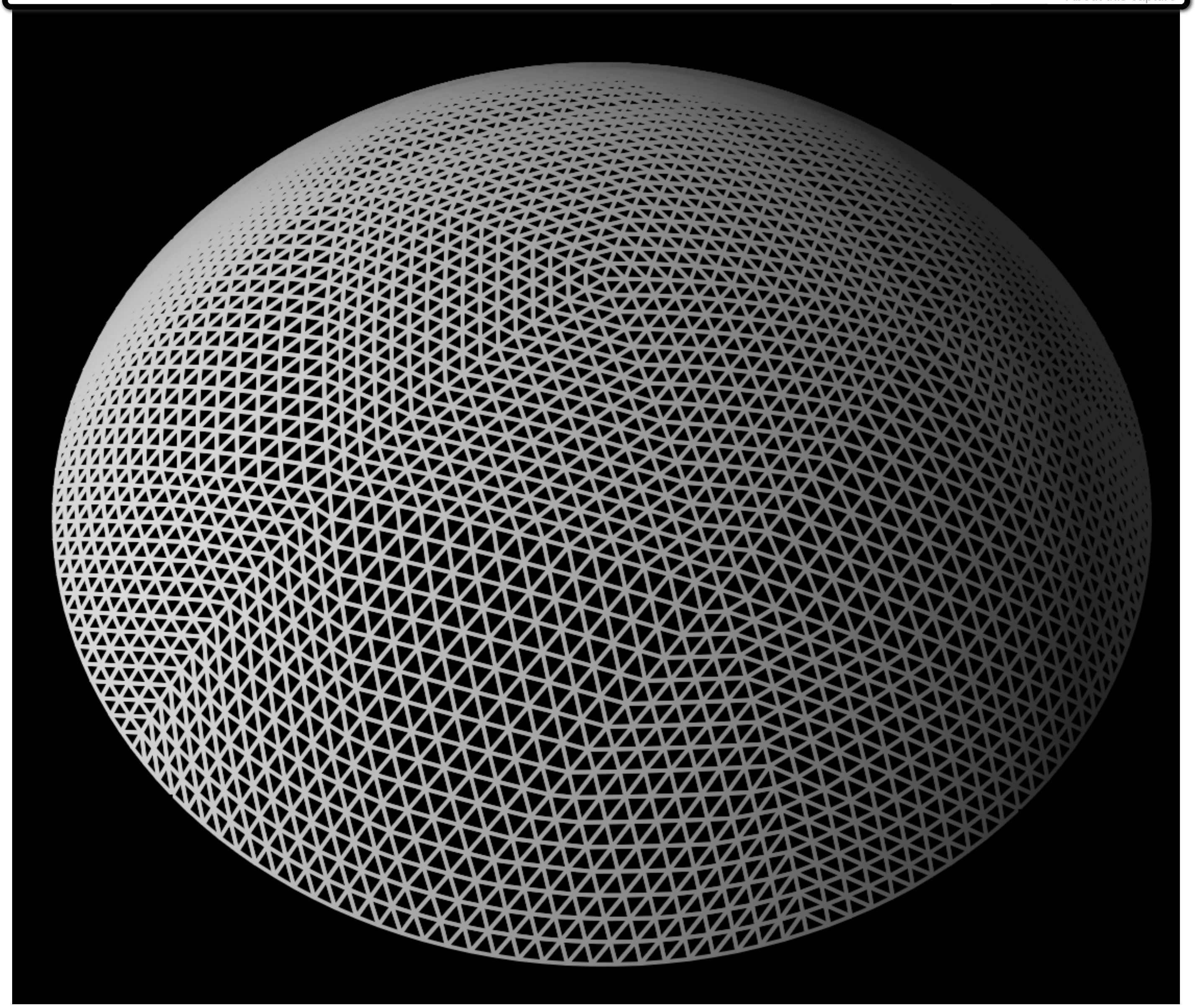
## Triangle Subdivision



Since the go stone only needs the top 1⁄3 or 1⁄4 of a sphere, I didn't want to subdivide a whole sphere only to throw most of it away. So I designed my own subdivision algorithm to generate only the top section of a sphere.

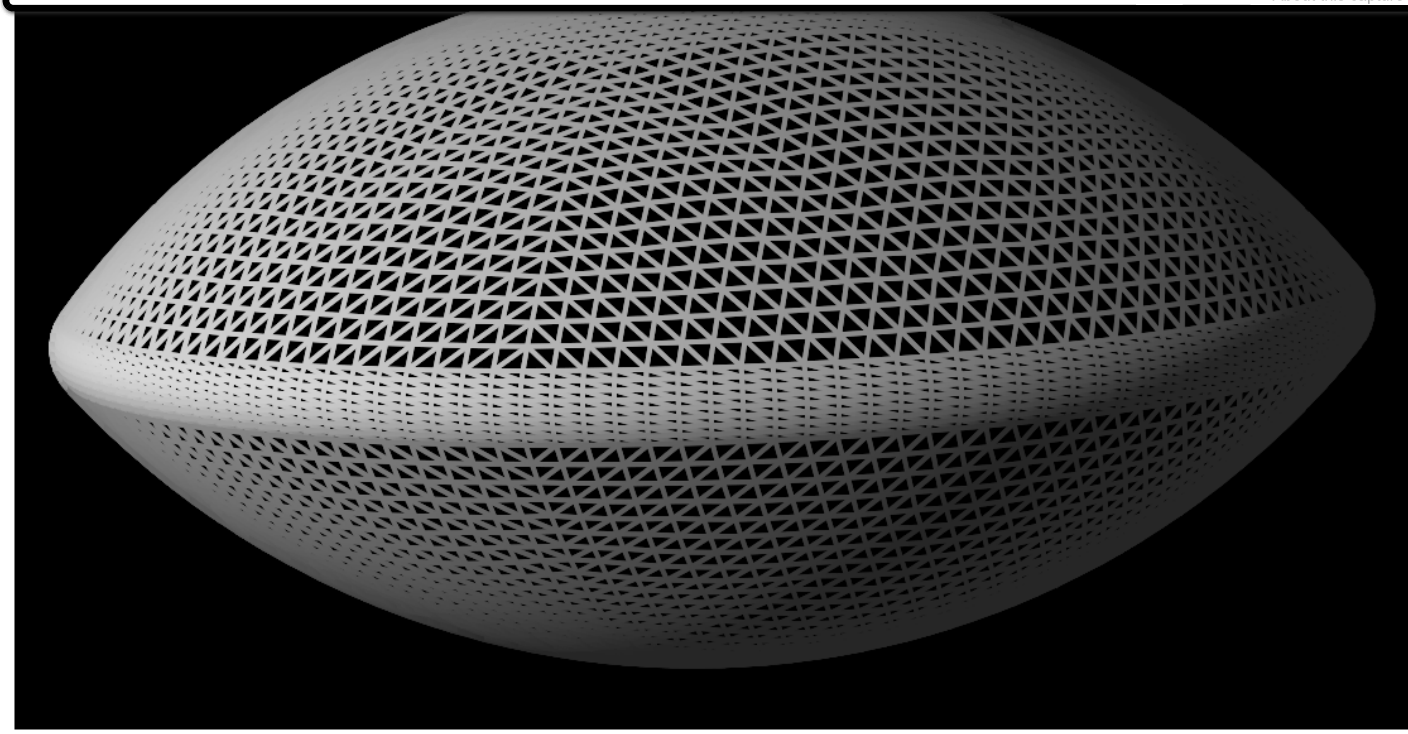
After some trial and error I found that a pentagon plus a center vertex at the pole of the sphere was a good initial generator that minimized the distortion that occurs during subdivision. The only tricky part is that when subdividing you need to keep track of whether the edge is a sphere edge or a circle edge, as the subdivided vertex must be projected differently.





## Tessellating The Bevel

Now we need to tesselate the bevel. To do this I take the vertices which form the circle edge at the bottom of the top sphere surface and calculate the angle of each vertex about the y axis. I then use these angles to sweep around the torus ensuring that the torus vertices weld perfectly with the top and bottom sphere sections.



## Vertex Welding

Due to how recursive subdivision works a lot of duplicate vertices are generated.

I'd rather not have the graphics card waste time transforming the same vertex over and over, so as I add vertices to the mesh I hash vertex positions into a 3D grid (~1mm cells) and reuse an existing vertex if the position and normals match within some small epsilon value.

With vertex welding the reduction in vertices is dramatic: 53000 to just 6500.

For more information on vertex welding please refer to the discussion in Real-Time Collision Detection (http://web.archive.org/web/20181107181438/https://www.amazon.com/Real-Time-Collision-Detection-Interactive-Technology/dp/1558607323/ref=sr_1_1?ie=UTF8&qid=1363029675&sr=8-1&keywords=real+time+collision+detection) by Christer Ericson (http://web.archive.org/web/20181107181438/http://realtimecollisiondetection.net/blog/).

**NEXT ARTICLE:** How The Go Stone Moves (http://web.archive.org/web/20181107181438/https://gafferongames.com/post/how_the_go_stone_moves/)

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