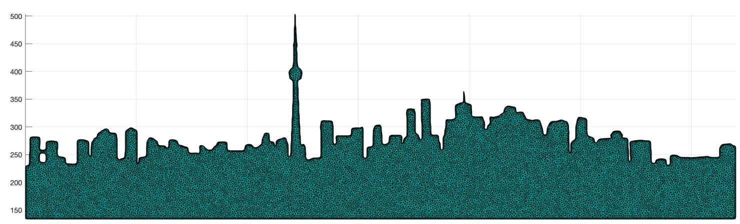
Basic Mesh Modeling

There are many websites and datasets dedicated to real-world 3D objects you can test your final algorithms on. However, earlier in the prototyping process, we often want to test our code on simpler, synthetic meshes whose parameters we can control. `gptoolbox` includes functionality to generate 3D geometry by extruding 2D meshes, as well as by proceduraly creating meshes of simple 3D objects.

2D extruded meshes

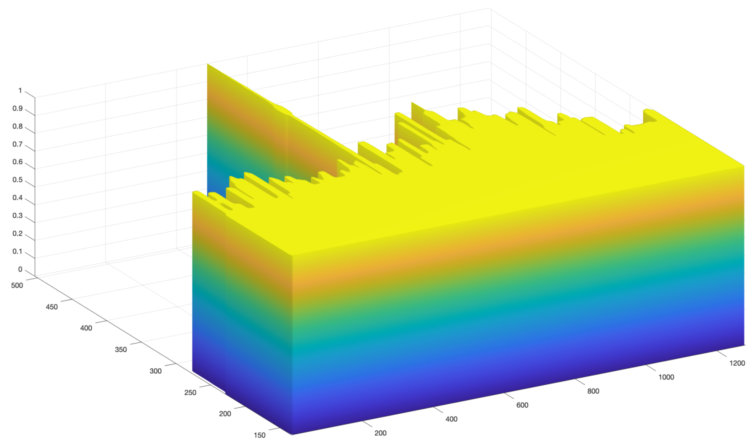
In tutorial item 201, we covered the process of creating 2D polylines using `gptoolbox`, and in tutorial item 202, we learnt to triangulate them using `gptoolbox`'s wrapper of `triangle`. As an example, we can generate a mesh of the Toronto skyline (remember to pass the holes to `triangle` as an argument):

```
>> [V,E] = png2poly('data/toronto.png',10,Inf);
>> [U,G] = triangle(V,E,[30,245],'Flags','-q20a10');
>> tsurf(G,U)
>> axis equal
```



We can generate a 3D surface mesh by extruding this 2D one:

```
>> [Ue,Ge] = extrude(U,G);
>> tsurf(Ge,Ue,falpha(1,0),fsoft,fphong)
```



Finally, if our algorithm requires solid geometry, we need only tetrahedralize our mesh with (this may take a while)

```
>> [V,T,F] = tetgen(Ue,Ge);
```

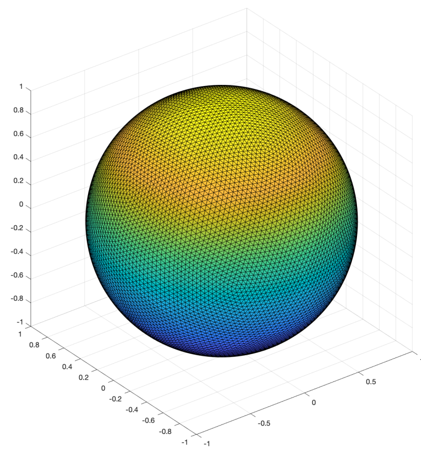
This a simple, fast way of getting valid geometry to test our 3D algorirthms on before we go ahead with more principled testing on general artist-designed or industrial shapes. Of course, being able to have this workflow entirely in Matlab comes with a lot of benefits: for example, we can design a function that calls `get_pencil_curve`, tetrahedralizes an extruded version of our drawn closed curve, and runs our research algorithm on it. This allows for very fast testing on a diverse set of shapes, so you can better understand the instances in which your algorithm can fail or not.

Basic procedural meshes

There are some simple geometric shapes we want to be able to quickly and reliably generate, with clear parameters we can tune for convergence analysis of differential operators, for example. With `gptoolbox`, we can create a triangle mesh of a sphere by running

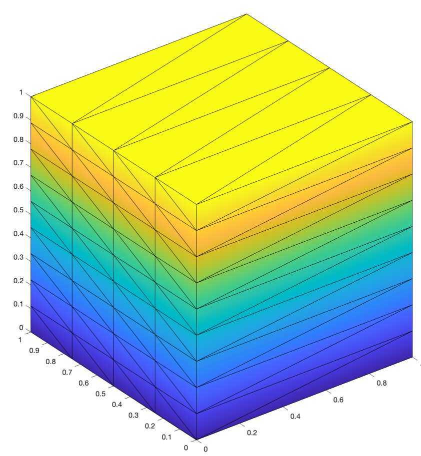
```
>> [V,F] = subdivided_sphere(5);
>> tsurf(F,V,fsoft,fphong)
>> axis equal
```

which subdivides an icosahedron (by a number of times in the function argument) and pastes vertex positions to a sphere:

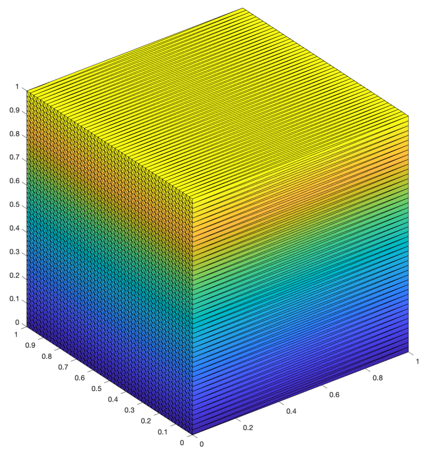


Similarly, using `gptoolbox` you can quickly generate a cube, with the arguments determining the number of vertices on each dimension:

```
>> [V,F] = cube(2,5,10);
>> tsurf(F,V,fsoft,fphong)
>> axis equal
```

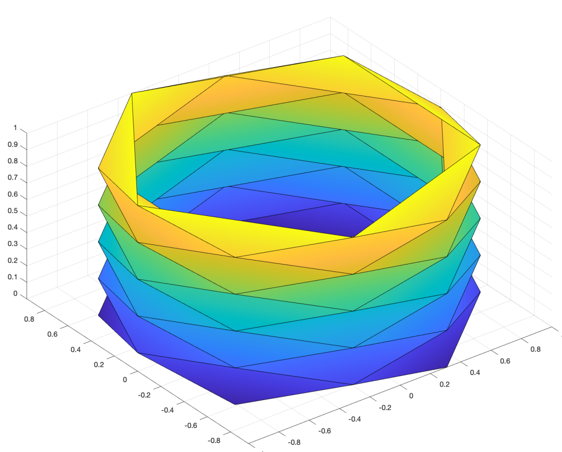


Note how if we increase the number of vertices on only two dimensions of the cube, for example, the mesh will become increasingly fine but also increasingly low quality:



This makes this shape a good choice to test the robustness of differential geometry operators, since we often know anayltical groundtruths for a shape as simple as a cube but we can make the triangulation arbitrarily bad. In the same vein, `gptoolbox` can generate a Schwarz's lantern, a specific way of triangulating a cylinder which serves as an example of the unintuitive convergence of some geometric quantities when discretized:

```
>> [V,F] = schwarz_lantern(10,5);
>> tsurf(F,V,fsoft,fphong)
>> axis equal
```



If, on the other hand, we just want a reliable mesh of a 3D cylinder, we could just call `cylinder_mesh`.

Exercises

Now it's time for you to get used to these functions. Why don't you use the skeleton scripts in `exercise/` to create a more general framework for 3D modeling that you can use in your own research projects, as well as to test the fascinating convergence properties of the Schwarz lantern.