Level Of Detail
Simplification
Compression

Today’s Class
- Consistency in Online Maps
- Image Simplification Example: Map Making
- 3D Geometry Compression/Optimization/Simplification
- Mesh Processing in VTK
- More on Mesh Simplification/Subdivision
- Discussion: Your Readings & Progress Reports

Consistency (or lack of) in Online Maps

Justin O’Beirne  http://www.41latitude.com/post/1053847167/consistency

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Image Simplification/Compression

- Pixel-based vs. Vector Graphics (image formats)
- Application-Specific Requirements
  - Detail Accuracy vs. Summary
- Example: Map making
  - Ok to summarize small ponds as “wetland area”?
  - Ok to eliminate islands < 1 sq mile?
  - Ok to not draw 2 lane highways/small roads?
  - Draw variation in thickness of river or fixed width?
  - Ok to simplify complex coastline/complex river path?

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3D Geometry Simplification Goals

- Compression?
  - Reduce storage space/data transfer
    - Reduce # of vertices/triangles
    - Reduce representation cost for each coordinate data value (double/float/int/short/char/etc.)
- OpenGL draw cost?
  - Optimize # of vertices/triangles sent to graphics card
    - vertex array
    - quads vs. triangles vs. triangle strip vs. triangle fan
- Simplify Geometry/Connectivity/Topology

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What is a mesh?

- Set of points and triangles (or generally, polygons) defined on the points
- Discrete representation of a continuous surface

What can we do with it?

- Smooth/subdivide it
- Decimate it

Triangle Strips / Triangle Fans

- Up to 66% more efficient?

Cohen-Steiner, Alliez & Desbrun
Variational Shape Approximation
SIGGRAPH 2004

Intoduction to VTK: Mesh Processing
Subdivision

- Make a mesh look “better”
- Add more triangles
- Hopefully in good/smart/clever positions so that the new mesh looks “smoother” than the old one
- VTK Filters
  - vtkButterflySubdivisionFilter
  - vtkLoopSubdivisionFilter
  - vtkLinearSubdivisionFilter
  - vtkWindowedSincPolyDataFilter

Subdivision in VTK

```cpp
vtkLinearSubdivisionFilter* subdivisionFilter = vtkLinearSubdivisionFilter::New();
subdivisionFilter->SetNumberOfSubdivisions(2);
subdivisionFilter->Update();
```

Example: [http://www.vtk.org/Wiki/VTK/Examples/Cxx/Meshes/Subdivision](http://www.vtk.org/Wiki/VTK/Examples/Cxx/Meshes/Subdivision)

Decimation

- Reduce the number of triangles
- Hopefully in good/smart/clever ways so that the new mesh looks similar to the old one
- Often done for more efficient processing
- VTK Filters
  - vtkDecimatePro
  - vtkQuadricClustering
  - vtkQuadricDecimation

Decimation in VTK

```cpp
vtkQuadricDecimation* decimateFilter = vtkQuadricDecimation::New();
decimateFilter->SetNumberOfSubdivisions(2);
decimateFilter->Update();
```

Examples:
- [http://www.vtk.org/Wiki/VTK/Examples/Cxx/Meshes/QuadricDecimation](http://www.vtk.org/Wiki/VTK/Examples/Cxx/Meshes/QuadricDecimation)
- [http://www.vtk.org/Wiki/VTK/Examples/Cxx/Meshes/QuadricClustering](http://www.vtk.org/Wiki/VTK/Examples/Cxx/Meshes/QuadricClustering)

Level of Detail (LOD)

- Adaptively change the number of triangles in a mesh based on whether or not you will be able to tell the difference in the rendering
- If the mesh is far away from the camera, you will not be able to see the fine detail, so don’t waste time rendering it
- In the extreme case, the whole mesh is rendered in only ONE pixel, so whether it has 10,000 or just 10 triangles, it will look the same

LOD in VTK

- Create a mapper for each version of the mesh
- Instead of creating multiple actors, create a vtkLODProp3D which you will add all of the mappers to
- You can also specify properties (color, shading, etc [vtkProperty]) for each renderer
LOD in VTK

```c
vtkLODProp3D* prop =
  vtkLODProp3D::New();
prop->AddLOD(lowResMapper, propertyLowRes, 0.0);
prop->AddLOD(highResMapper, propertyHighRes, 0.0);
```

(The last parameter is the approximate rendering time for the specified actor. Setting it to zero indicates that you do not have an initial guess of the time.)

Example:

https://www.vtk.org/Wiki/VTK/Examples/Cxx/Visualization/LODProp3D

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Mesh Simplification

- Local operation: edge collapse
- Choose collapse that has the least impact on geometry & discrete/scalar attributes

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Selective Refinement

![Selective Refinement](Hugues_Hoppe_Progressive_Meshes_SIGGRAPH_1996.png)

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Preserving Discontinuity Curves

![Preserving Discontinuity Curves](Hugues_Hoppe_Progressive_Meshes_SIGGRAPH_1996.png)

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Other Simplification Strategies

- Remove a vertex & surrounding triangles, re-triangulate the hole
- Merge Nearby Vertices – will likely change the topology...

![Other Simplification Strategies](Garland_Heckbert_Surface_Simplification_UseQuadricErrorMetrics_SIGGRAPH_1997.png)
When to Preserve Topology?

Figure 3: On the left is a regular grid of 100 closely spaced cubes. In the middle, an approximation built using only edge contractions demonstrates unacceptable fragmentation. On the right, the result of using more general pair contractions to achieve aggregation is an approximation much closer to the original.

from Garland & Heckbert, "Surface Simplification Using Quadric Error Metrics" SIGGRAPH 1997

Line Subdivision: Chaikin's Algorithm

Doo-Sabin Subdivision

Doo-Sabin Subdivision

Loop Subdivision

Loop Subdivision

Shirley, Fundamentals of Computer Graphics

[SIGGRAPH 2000 course notes
Subdivision for Modeling and Animation (page 70)]
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