Mesh Simplification

Motivation
- Reduce information content
- Accelerate rendering
- Multi-resolution models

Level of Detail (LOD)
- Refined mesh for close objects
- Simplified mesh for far

Implementation Details
- Use priority queue (e.g. heap)
- Fast access to element with minimal error
- Fast update

Methodology
- Sequence of local operations
  - Involve near neighbors - only small patch affected in each operation
  - Each operation introduces error
  - Find and apply operation which introduces the least error

Simplification Operations (1)
- Decimation
  - Vertex removal:
    - $v \leftarrow v-1$
    - $f \leftarrow f-2$

Simplification Operations (2)
- Decimation
  - Edge collapse
    - $v \leftarrow v-1$
    - $f \leftarrow f-2$

Simplification Operations (3)
- Contraction
  - Pair contraction
  - Vertices may move

Error Control
- Local error: Compare new patch with previous iteration
  - Fast
  - Accumulates error
  - Memory-less
- Global error: Compare new patch with original mesh
  - Slow
  - Better quality control
  - Can be used as termination condition
  - Must remember the original mesh throughout the algorithm

Local vs. Global Error
- 2000 faces
- 488 faces
- 488 faces

Simplification Error Metrics
- Measures
  - Distance to plane
  - Curvature
  - Usually approximated
  - Average plane
  - Discrete curvature

The Basic Algorithm
- Repeat
  - Select the element with minimal error
  - Perform simplification operation
    - Remove vertex
    - Update error of affected vertices
  - Until reduction goal is met

Vertex Removal Algorithm
- Simplification operation: Vertex removal
- Error metric: Distance to average plane
- May preserve mesh features (creases)

Triangulating the Hole
- Vertex removal produces non-planar loop
- Split loop recursively
- Split plane orthogonal to the average plane
- Control aspect ratio
- Triangulation may fail
Pros and Cons

Pros:
- Efficient
- Simple to implement and use
- Few input parameters to control quality
- Reasonable approximation
- Works on very large meshes
- Preserves topology
- Vertices are a subset of the original mesh

Cons:
- Error is not bounded
- Local error evaluation causes error to accumulate