Polygonal Model Simplification
Geometric Replacement

Replace complex objects with simpler objects

Reduces transformation and communication time

Rasterization time not changed

replacements should cover similar number of pixels
Automatic Simplification

Preprocess

create multiresolution representation

Run-time

extract appropriate resolution model based on viewing parameters and rendering load
Simplification Operations

Types of operations

- Vertex cluster
- Vertex remove
- Edge collapse
- Vertex pair

Each operation reduces model complexity by a small amount.

Apply many operations in succession to achieve large reductions.
Vertex Cluster

Merge vertices based on geometric proximity

Triangles with repeated vertices degenerate to edge or point

General and robust

Not usually attractive
Remove vertex and adjacent faces
Fill hole with new triangles (reduction of 2)
many possible triangulations (exponential)
Requires manifold surface around vertex
Preserves local topological structure
typically more attractive
Edge Collapse

Merge two edge vertices to one
choose position and attributes for vertex

Delete degenerate triangles
those containing both vertices (entire edge)
2 triangles for manifold edge

Smooth transitions
animate edge collapse(s) over time
Vertex Pair

Merge any two vertices
based on geometry, topology, etc.

More flexibility than edge collapse

More local control than vertex cluster
Performing Simplification

Measure cost of operation according to error measure

Crucial to simplification quality
Combine geometry and attribute errors

Place operations in queue according to error

Perform operations in queue

After performing operation, re-evaluate error of operations in neighborhood
Multi-resolution Representations

Static levels of detail

Dynamic representations

Progressive mesh

Wavelet-based subdivision mesh
Static Levels of Detail

- 69 k tris
- 11 k tris
- 2 k tris
- 575 tris
Static Levels of Detail

Preprocess
- Generate set of independent levels of detail

Run-time
- Select level of detail based on distance from viewpoint

Advantages
- Fairly efficient storage (2x original)
- No significant run-time overhead

Disadvantages
- Requires per-object simplification
- Not good for spatially large objects
Dynamic Levels of Detail

Pre-process
Generate tree of simplification operations

Run-time
Refine/coarsen current model according to viewpoint

Advantages
Allows finer control of tesselation

Disadvantages
More run-time computation and complexity
Difficult for retained-mode graphics
Video Examples

Simplification Envelopes

Cohen, Varshney, et al.. SIGGRAPH 96

View-Dependent Refinement of Progressive Meshes

Hoppe. SIGGRAPH 97

View-Dependent Simplification of Arbitrary Polygonal Environments

Luebke and Erikson. SIGGRAPH 97
Euclidean Distance Error

Error measured in 3D during simplification

Project 3D to 2D according to current view

Choose LOD/tesselation based on pixels of deviation
Computing Screen-space Error

\[ p = \frac{\varepsilon}{w} = \frac{\varepsilon}{2d \tan \theta} \]