

Lecture 8

Progressive Meshes

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Progressive Meshes

- Motivations
- Progressive Triangular Meshes
 - Connectivity
 - Geometry
- Progressive Tetrahedral Meshes (Progressive Simplicial Complex)

Complex Meshes



43,000 faces



lots of faces!

Challenges:

- Expensive to store, transmit, render, and edit

Level of Detail

- Decreasing the complexity of a 3D object representation
 - as it moves away from the viewer
 - or based on other metrics (object importance, eye-space position...)
- Applied on geometry, texture, material...



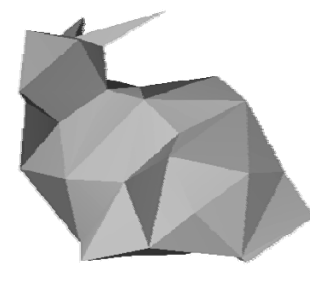
69,451 polys



2,502 polys



251 polys

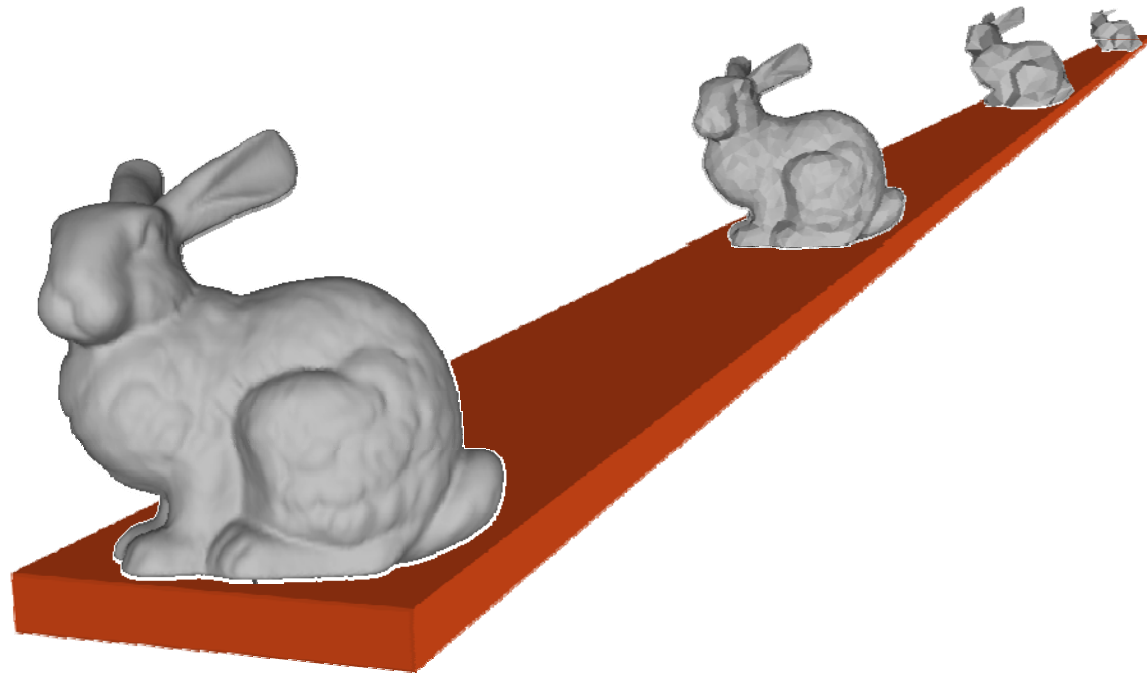


76 polys

Courtesy Stanford 3D Scanning Repository

Level of Detail

- Distant objects use coarser LODs:

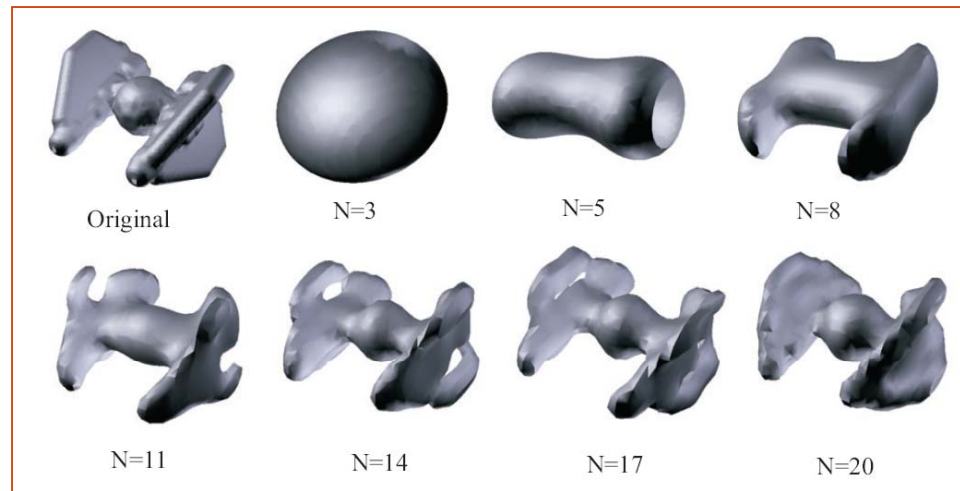
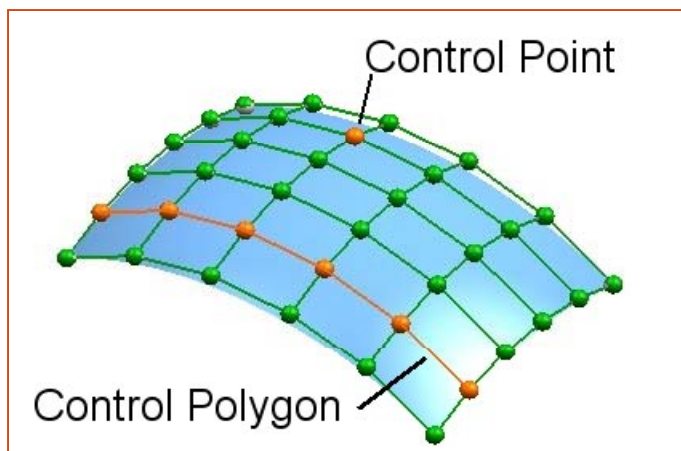
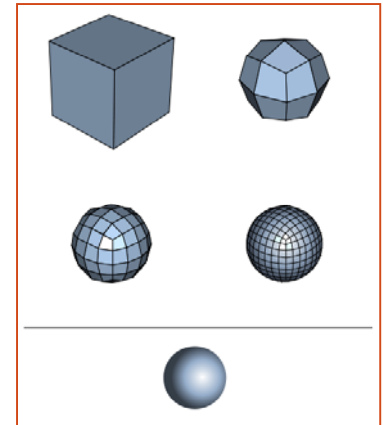


Multiresolutional Modeling, Processing and Analysis

A webpage about Multiresolutional modeling by Michael Garland:

<http://www.cs.cmu.edu/afs/cs/user/garland/www/multires/index.html>

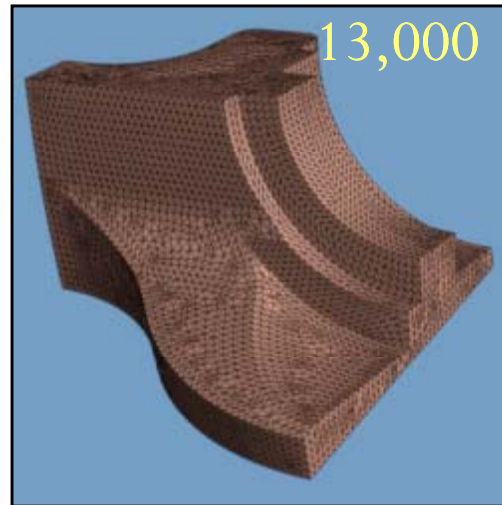
- Subdivision Surface
- Spline
- Wavelet
- ...



Motivations

- Applications of multiresolution techniques :
Compression, Progressive transmission and display,
Level-of-detail Control, Multiresolution editing...
- A mesh simplification procedure for general input meshes
 - Preserve various properties (colors, normals, ...)
 - Lossless
 - Continuous-resolution
 - Efficient (time and space)
 - Progressive transmission

Mesh Simplification



[Schroeder-etal92]

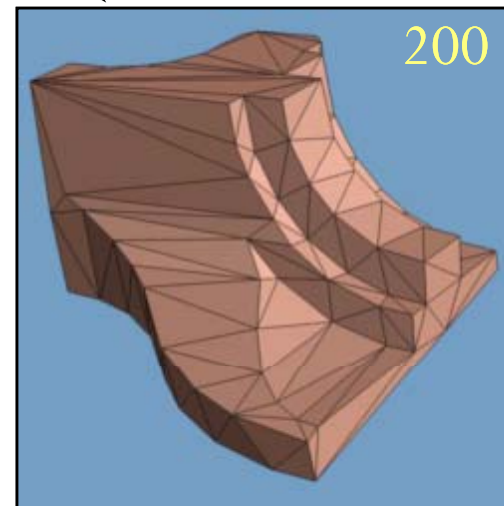
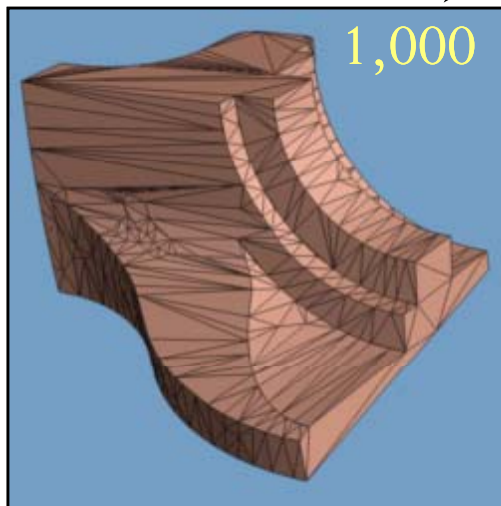
[Turk92]

[Hoppe-etal93]

[Rossignac-Borrel93]

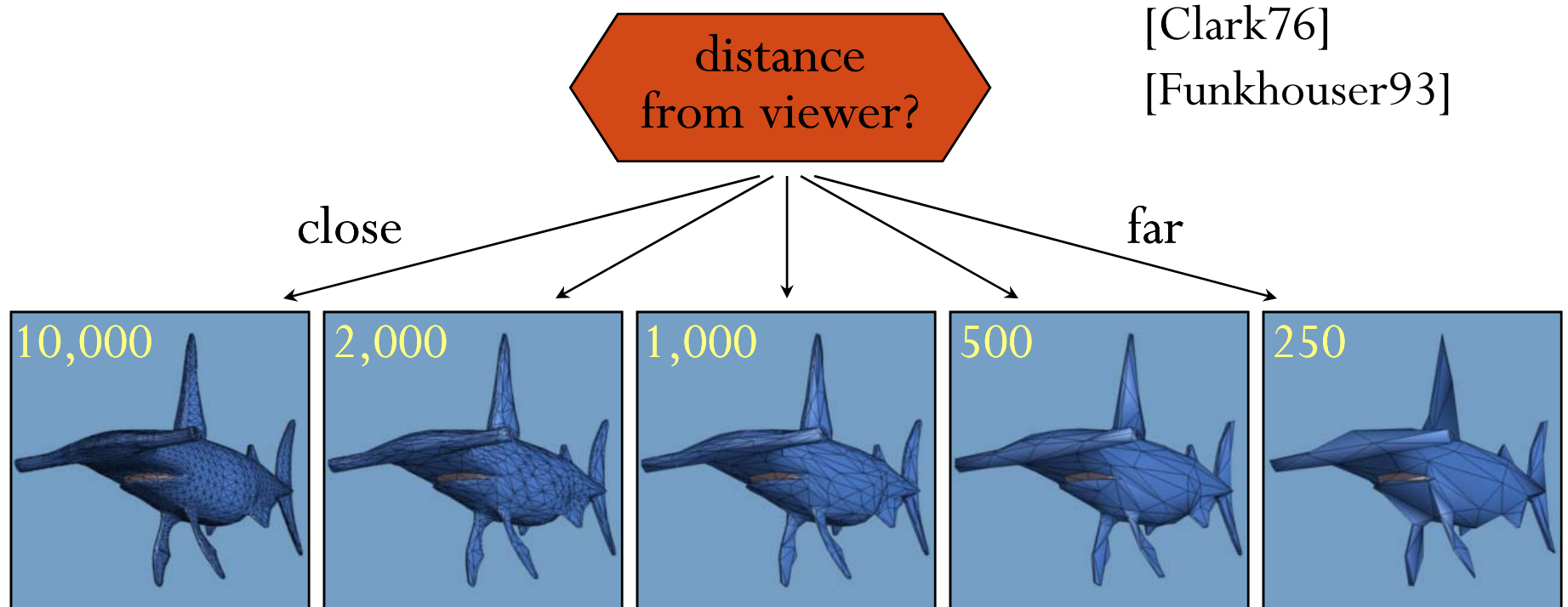
[Cohen-etal96]

...



.....
?

Level-of-detail (LOD)



[Clark76]

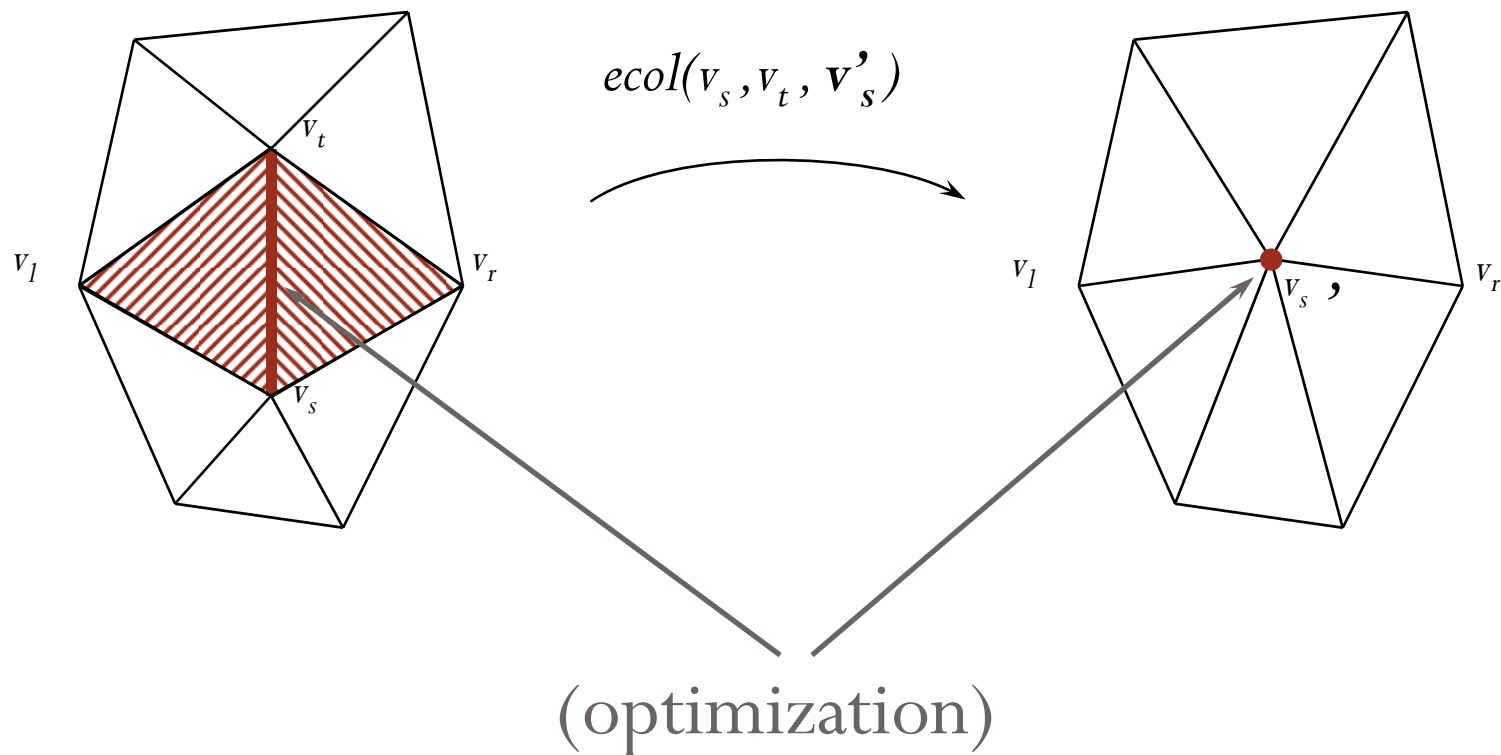
[Funkhouser93]

Concern: transitions may “pop”

→ would like smooth LOD

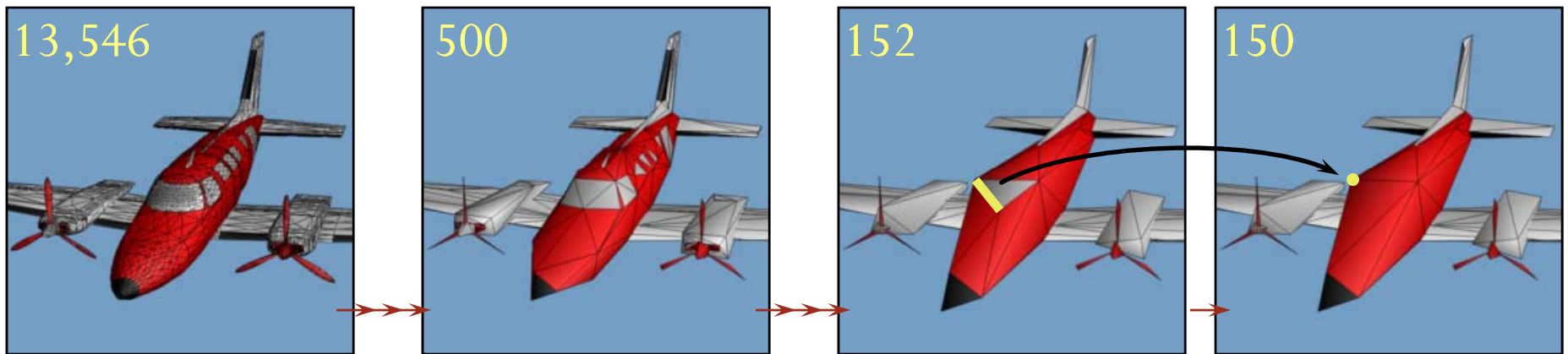
Mesh simplification procedure

- Idea: apply sequence of edge collapses:



Can be easily implemented using Half-Edge Data Structure!

Simplification process

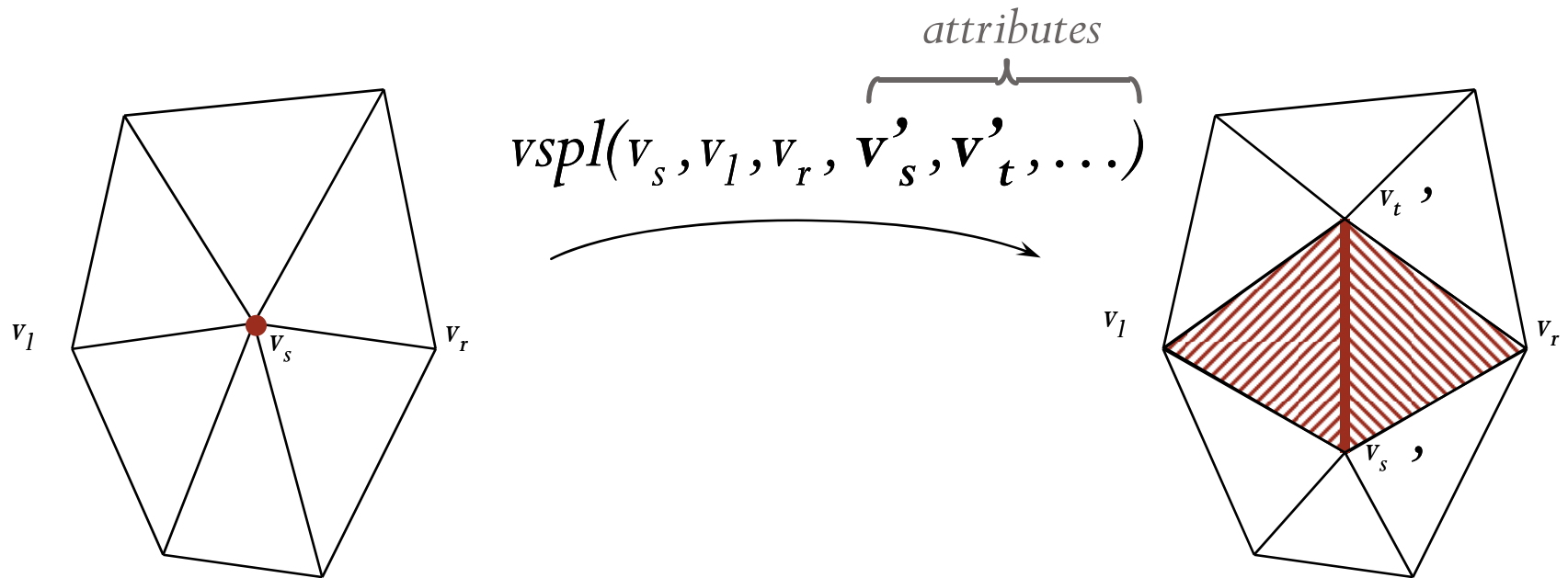


$$\hat{M} = M^n \xrightarrow{\text{ecol}_{n-1}} \dots \xrightarrow{\text{ecol}_i} M^1 \xrightarrow{\text{ecol}_0} M^0$$

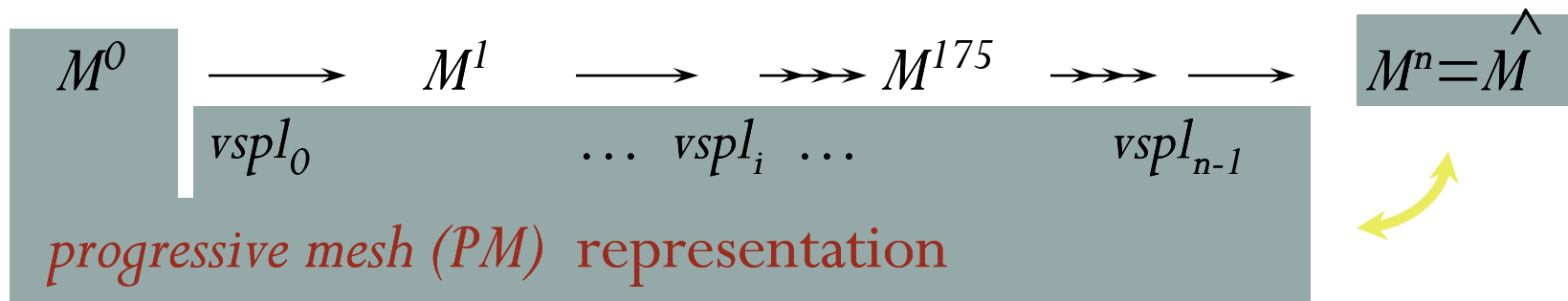
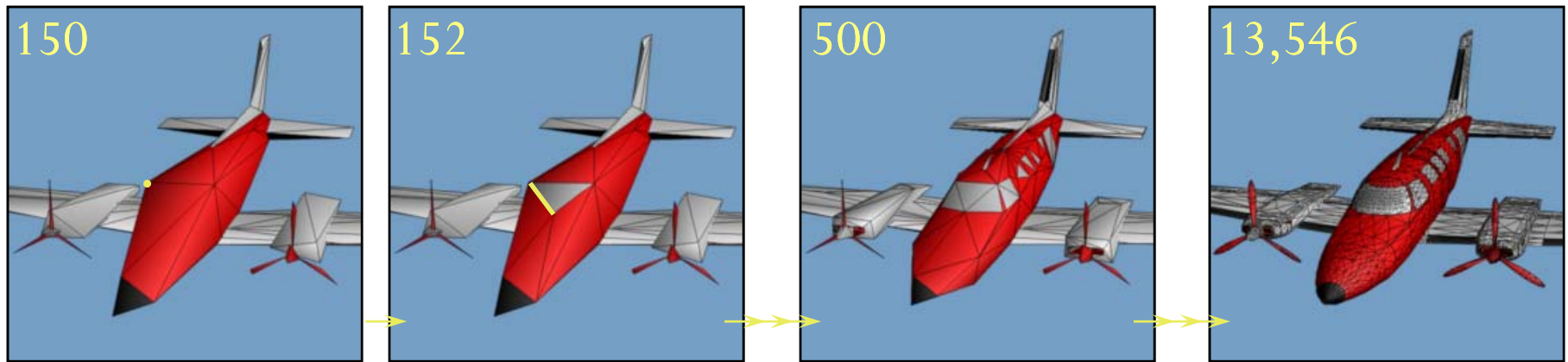
Note: The number 175 is present in the original image above the second arrow, but it is not represented in the mathematical notation above.

Invertible

Vertex split transformation:

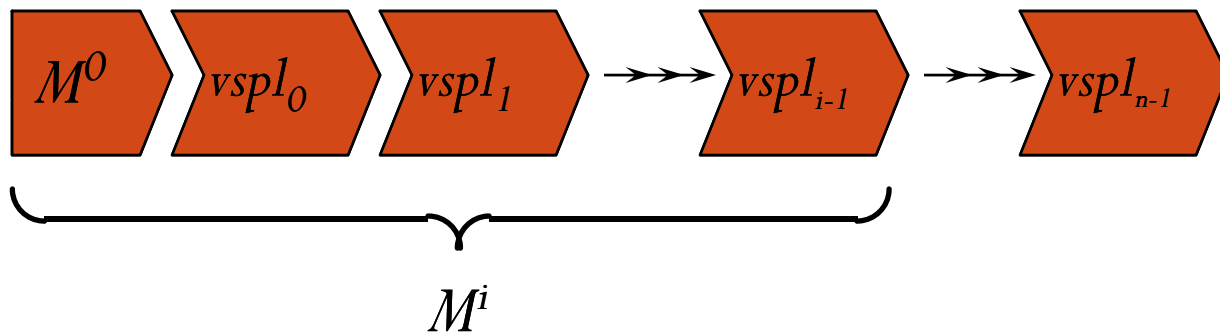


Reconstruction process

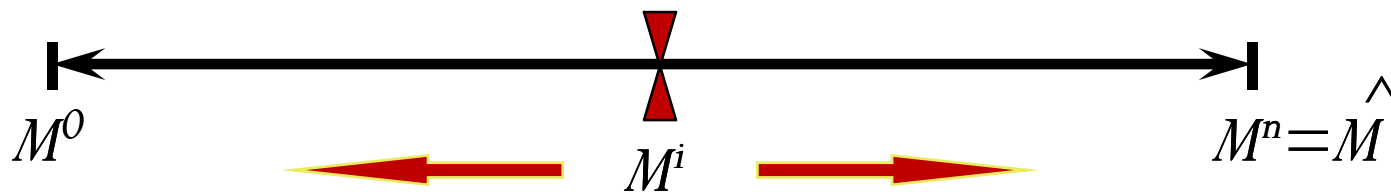
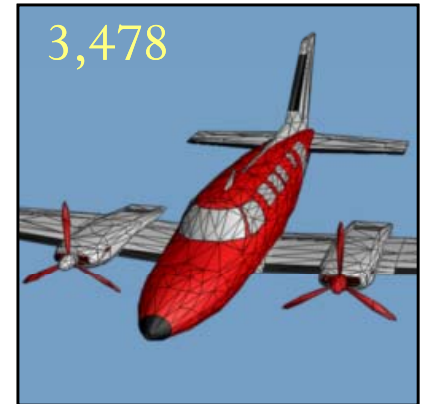


Continuous-resolution LOD

From PM, extract M^i of any desired complexity.



3,478 faces?



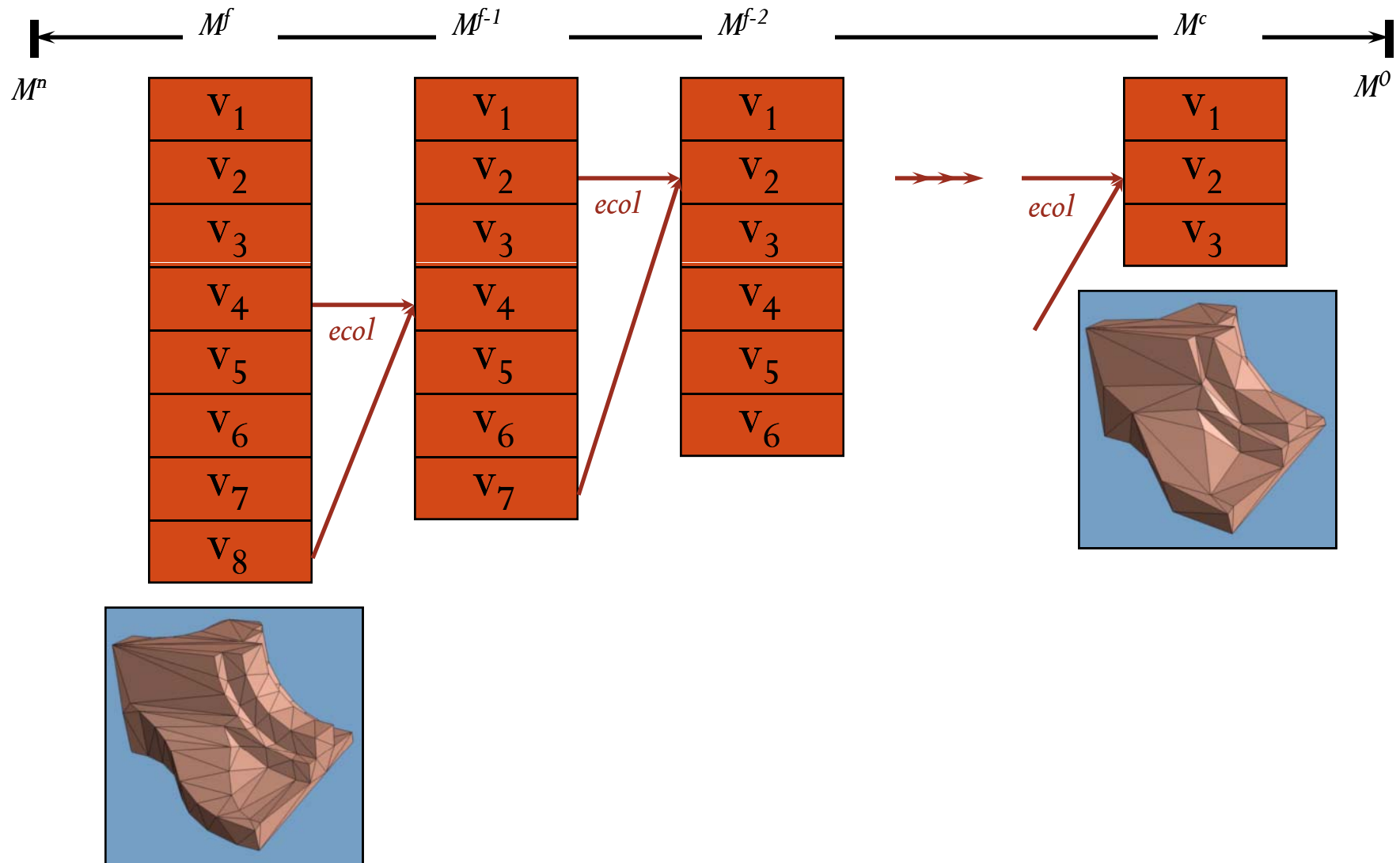
200K faces/sec!

100K faces/sec!

(166 MHz Pentium)

[Video](#)

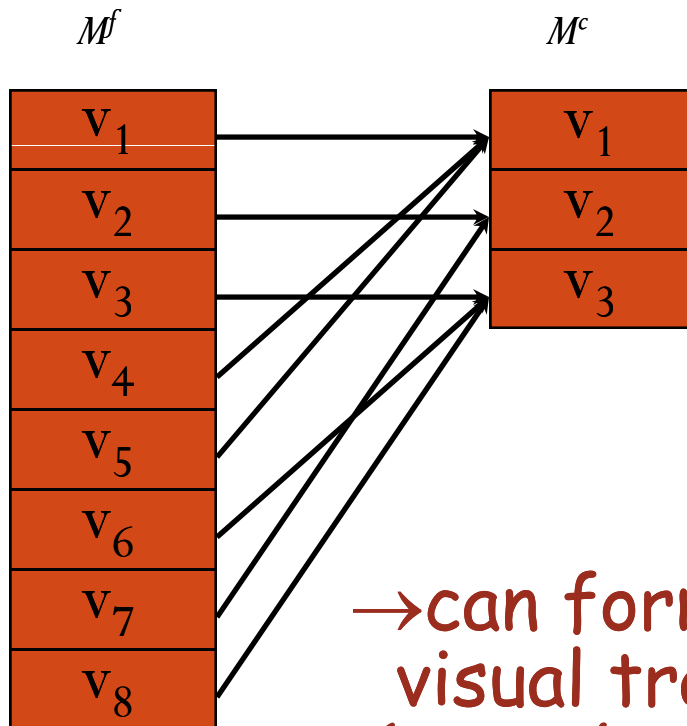
Property: Vertex correspondence



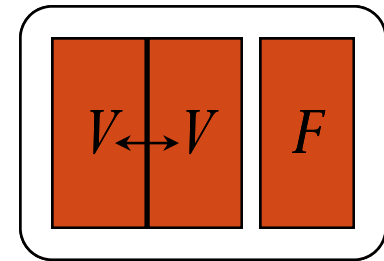
Application: Smooth transitions

Correspondence is a surjection:

Video

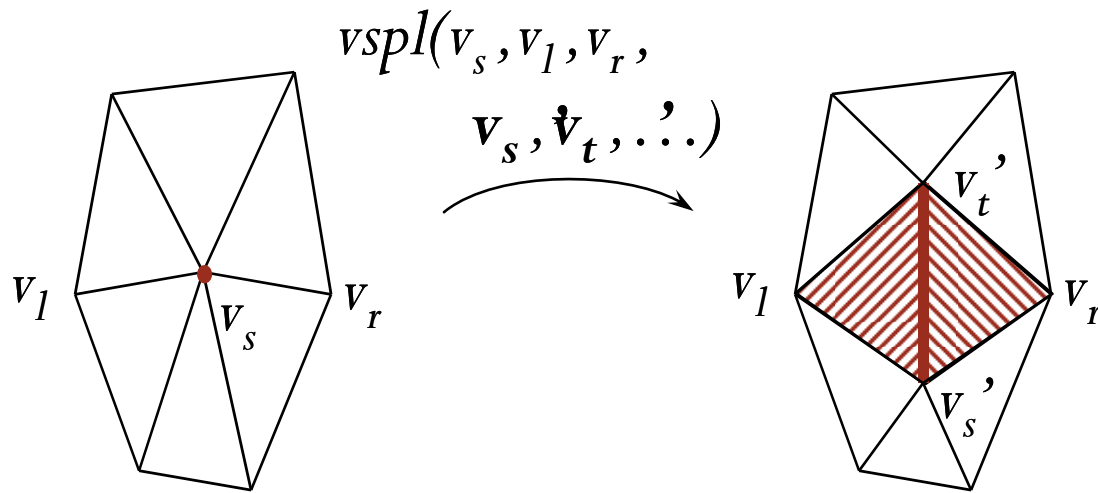


$M^{f \leftrightarrow c}$



→ can form a smooth
visual transition: *geomorph*
(Initial status:
topologically M^f , geometrically $M^{f \rightarrow c}$)

Application: Mesh compression



Record deltas:

- $v_t' - v_s$
- $v_s' - v_s$
- ...

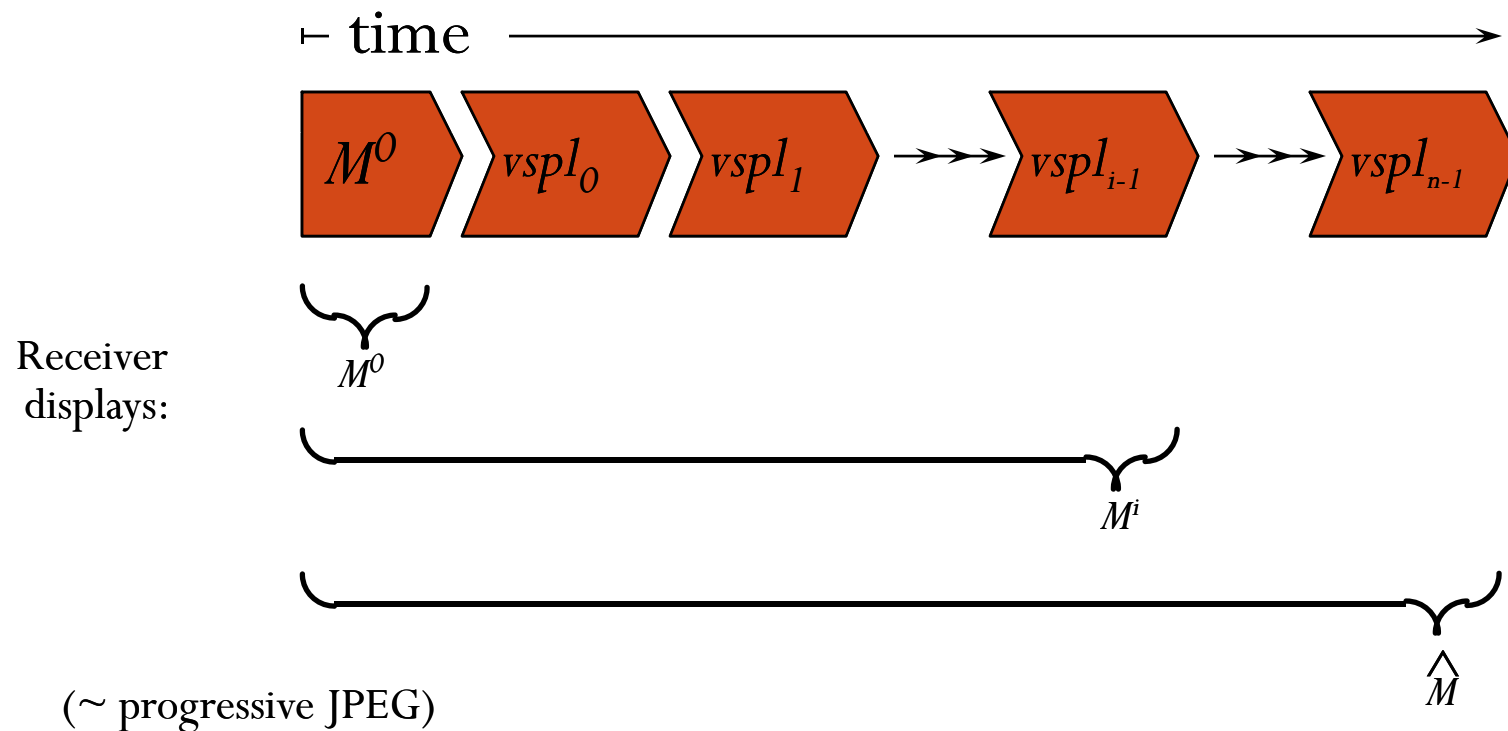
Encoding of *vspl* records:

- connectivity: ~ good triangle strips
- attributes: excellent delta-encoding

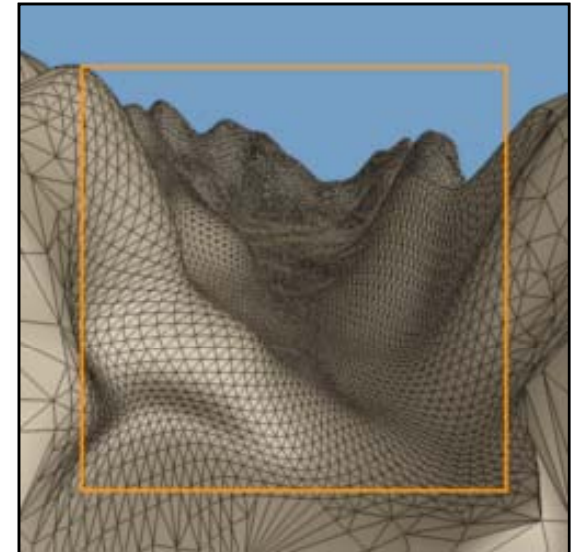
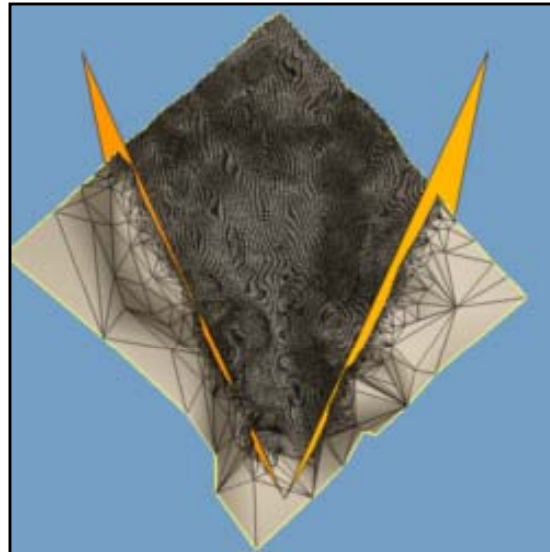
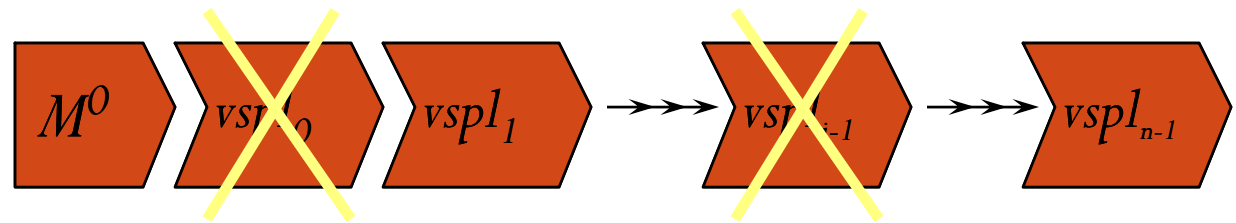
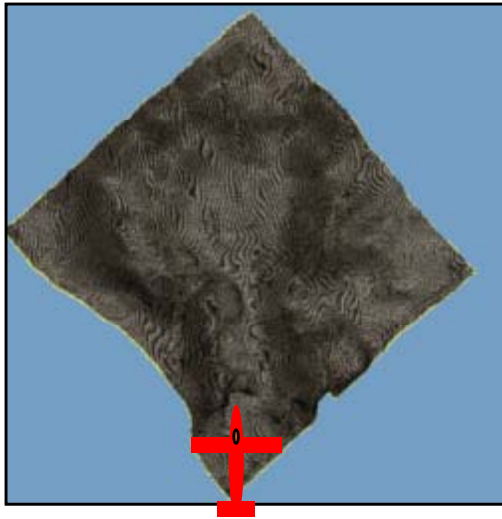
[Deering95]

Application: Progressive transmission

Transmit records progressively:



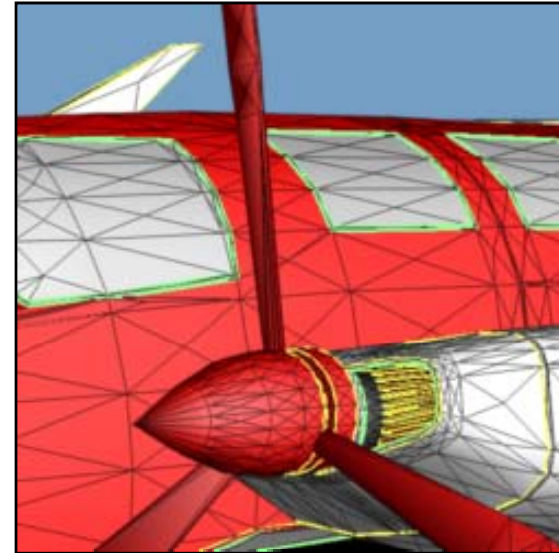
Application: Selective refinement



(e.g. view frustum)

How to select edge collapses?

- Preserve *appearance*:
 - geometric shape
 - scalar fields (e.g. color)
 - discontinuity curves



$$E = \sum_{\text{points}} \int (e_{\text{shape}} + e_{\text{scalars}}) dA + \sum_{\text{points}} \int (e_{\text{disc}}) dL$$

Selecting edge collapses

- Greedy algorithm: always collapse edge resulting in smallest ΔE

Simplification rates: ~ 30 faces/sec

[Hoppe Siggraph 96]

- off-line process
- could use simpler heuristics