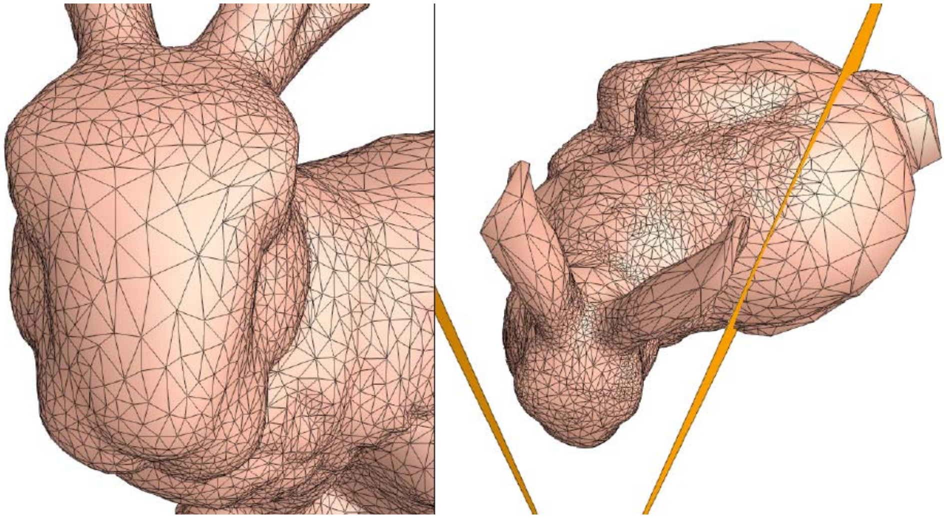
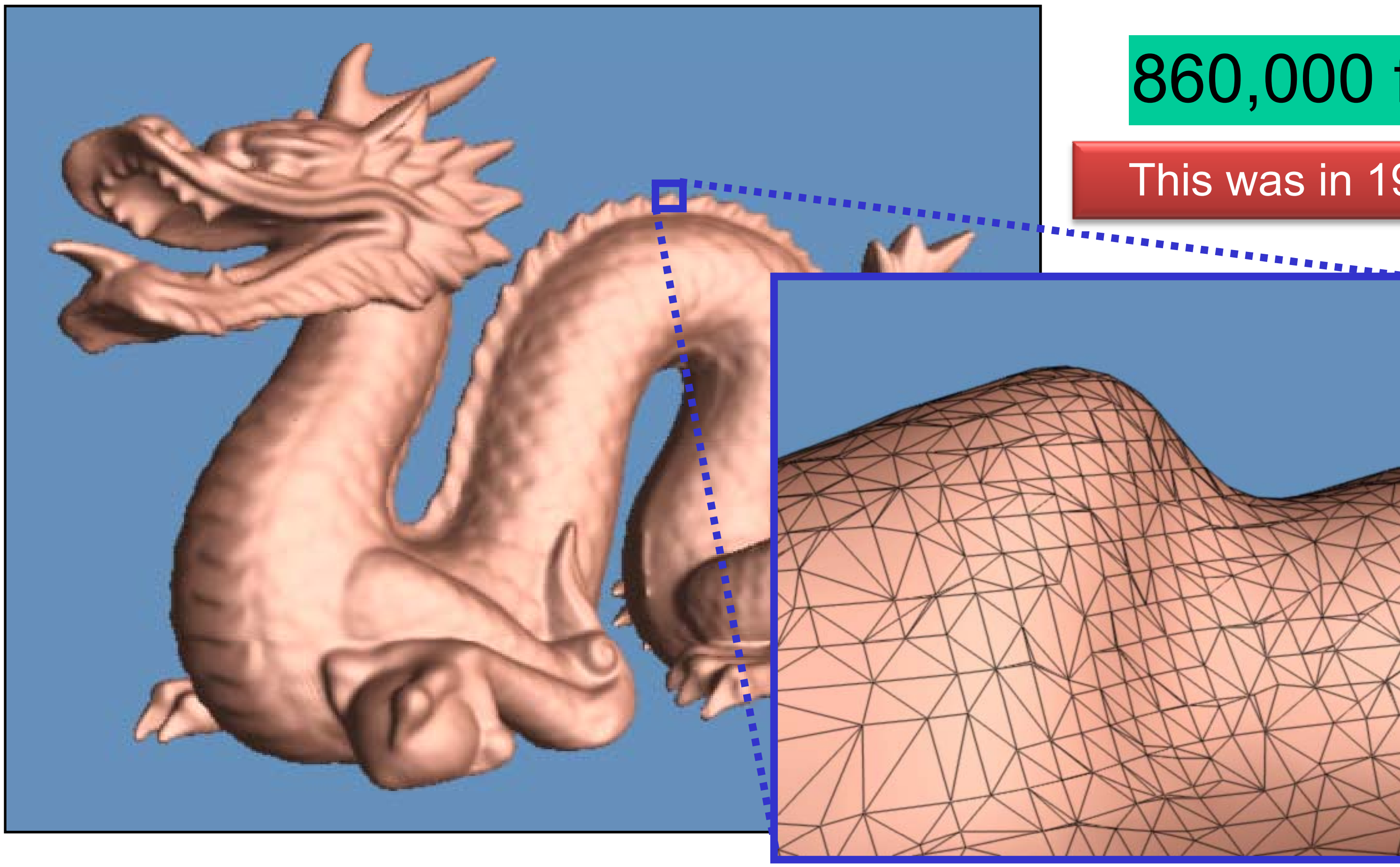
Progressive Meshes



Based on slides by H. Hoppe

Rendering Complex Meshes



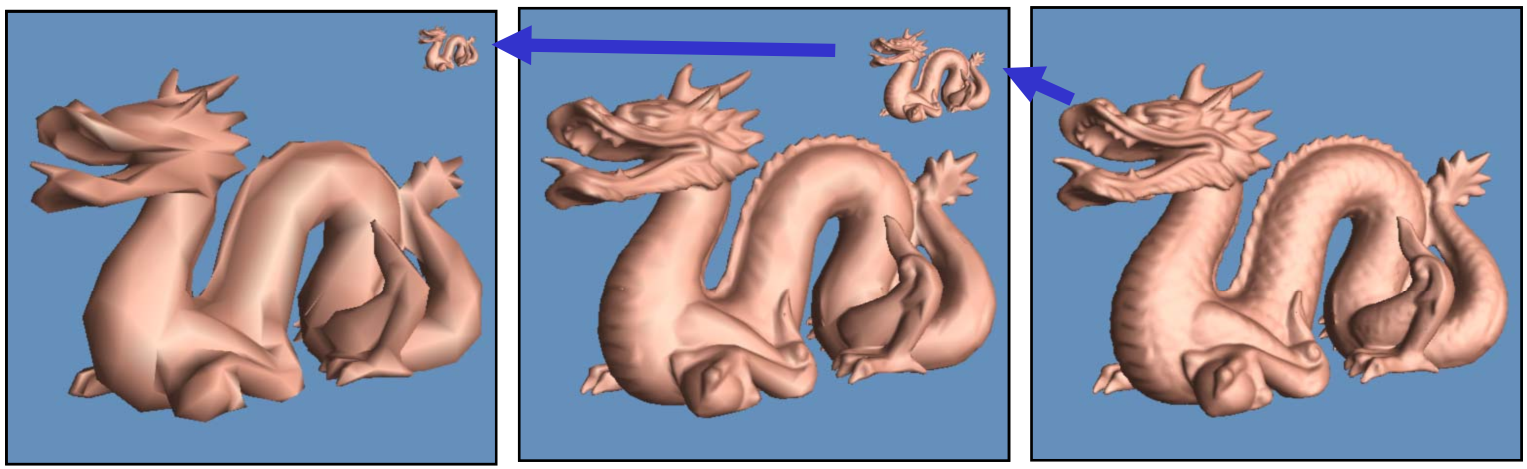
860,000 faces!

This was in 1996, no GPU!

And in 2010?

- Fast rendering is done in hardware
  - Prefer GPU processing to CPU processing
  - Discrete LOD more efficient
  - Latest GPUs can handle more than 1G polygons/sec
- So why should we care?
  - Other applications – efficient transmission
  - Mobile devices
  - Nice algorithm

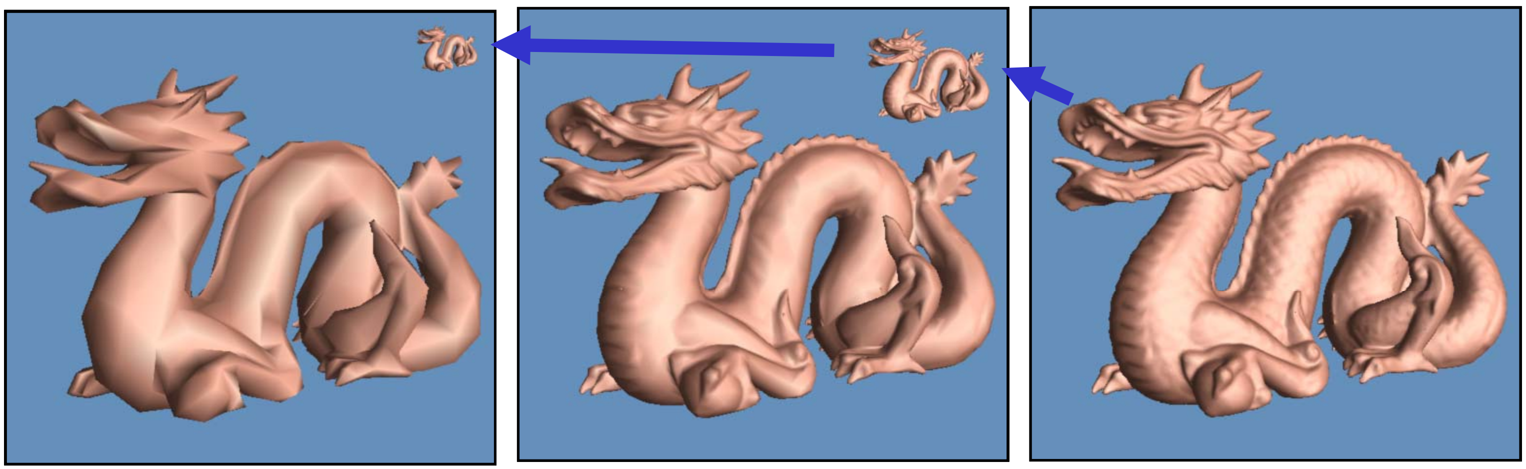
Discrete Level-of-Detail



2,000 faces 10,000 faces 50,000 faces

pop pop

Progressive Meshes



2,000 faces 10,000 faces 50,000 faces

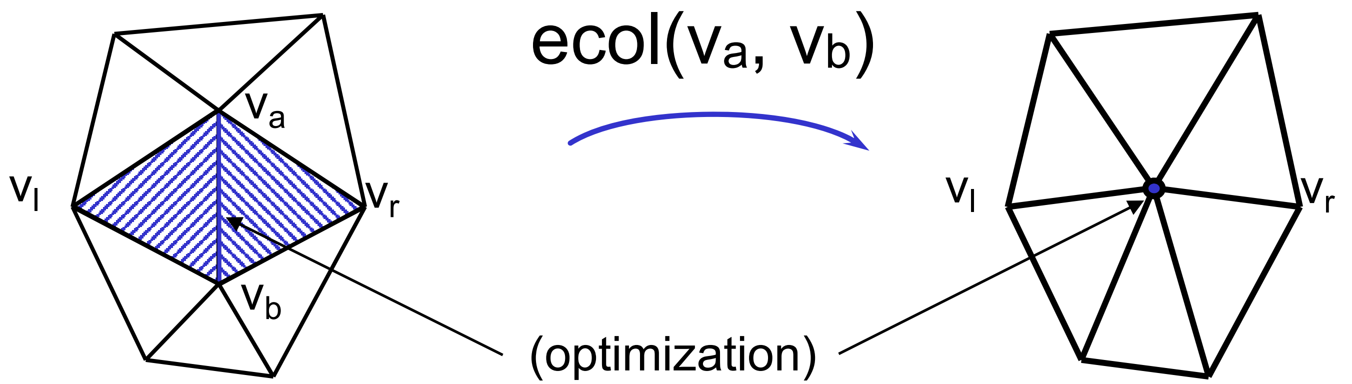
progressive mesh representation

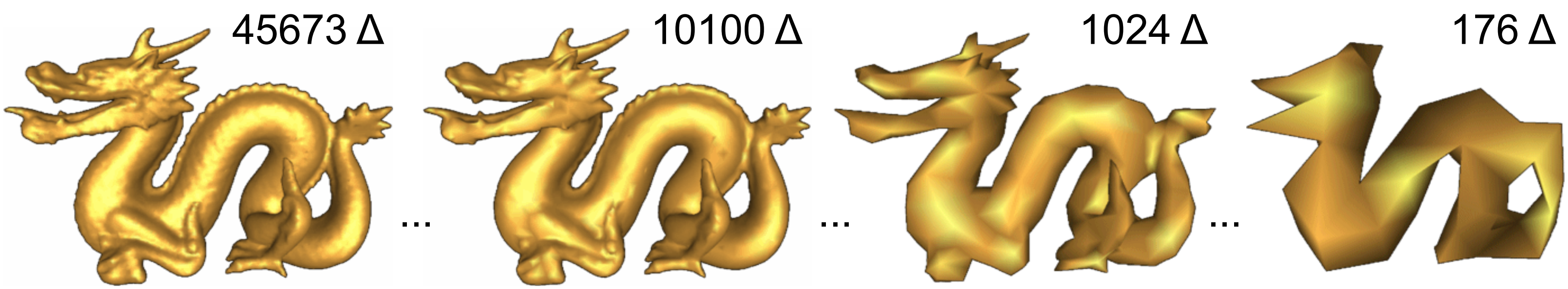
linear sequence → view-independent LOD

Progressive Meshes

- Different representation of triangular meshes
- Simplify meshes through sequence of *edge collapse* transformations
- Record sequence of inverse transformations (*vertex splits*)

Simplifications: Edge Collapse

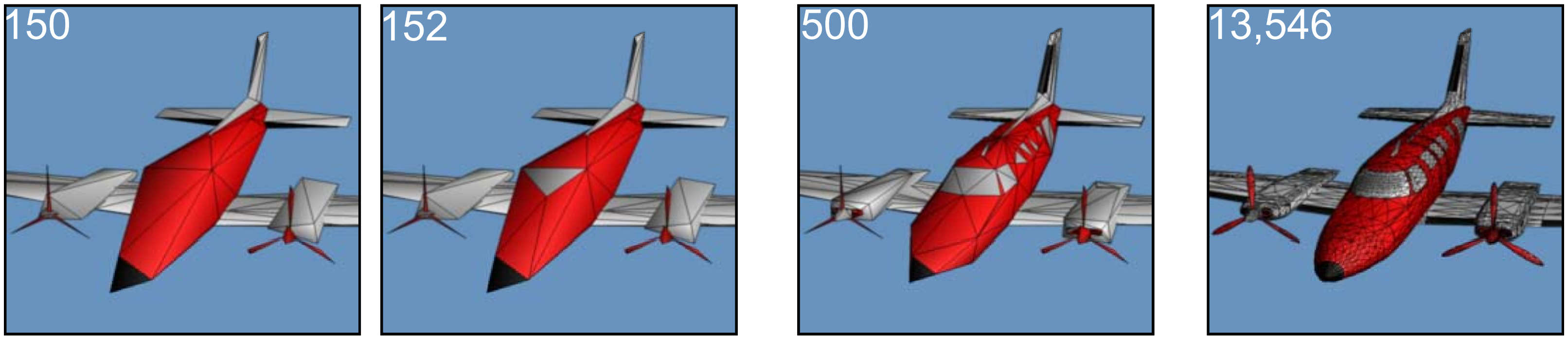




$$M^n = M^{22760} \longrightarrow \cdots \longrightarrow M^{5000} \longrightarrow \cdots \longrightarrow M^{500} \longrightarrow \cdots \longrightarrow M^0$$

$ecol_{n-1}$ $\qquad$ $ecol_i$ $\qquad$ $ecol_0$

Progressive Meshes

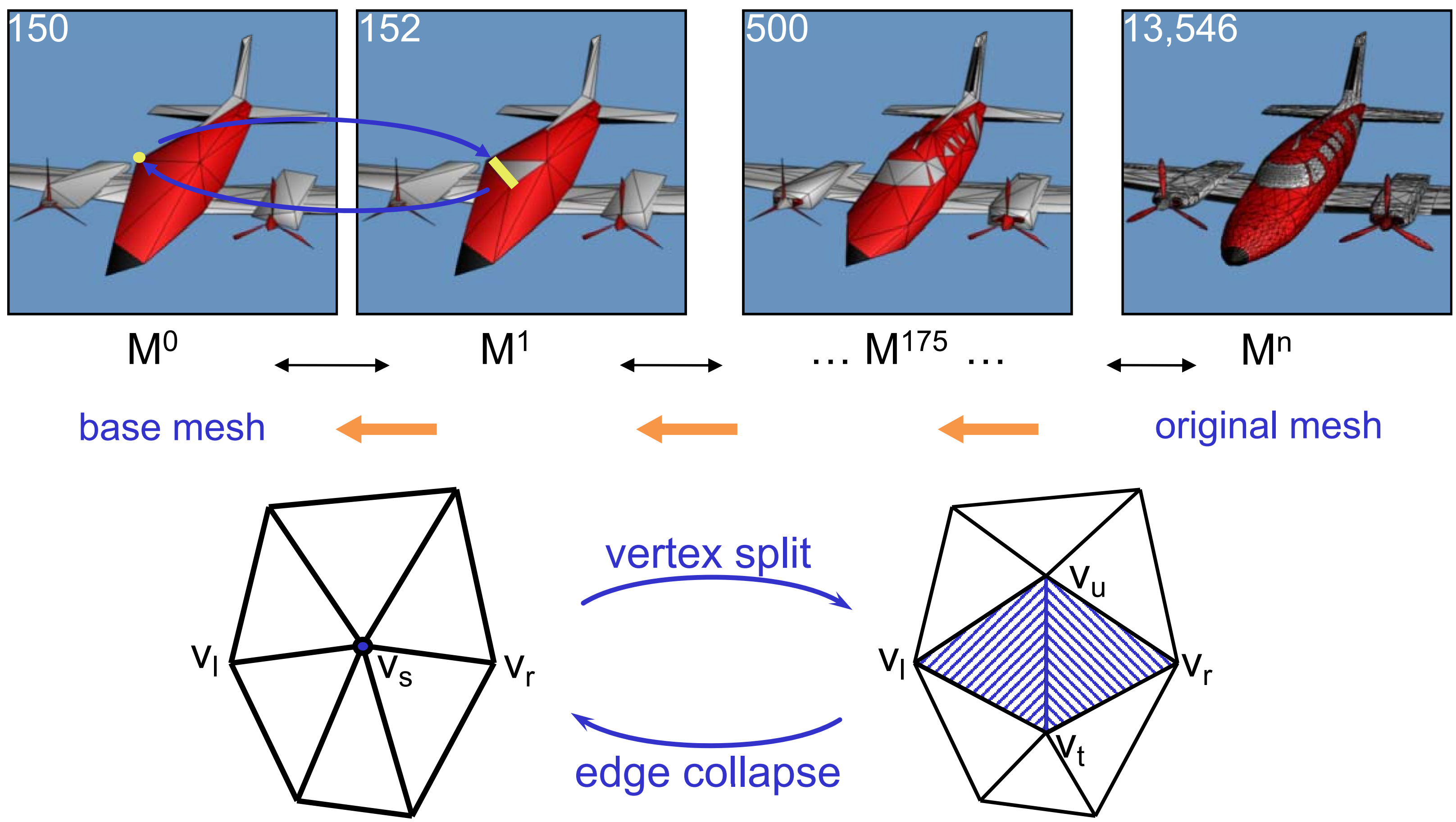


M^0 ↔ M^1 ↔ … M^{175} … ↔ M^n

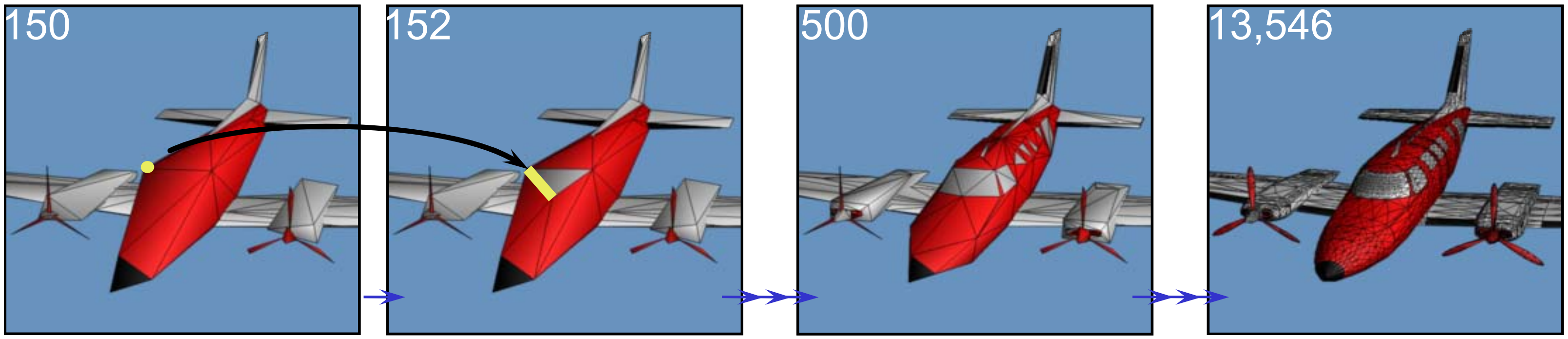
base mesh

original mesh

Progressive Meshes



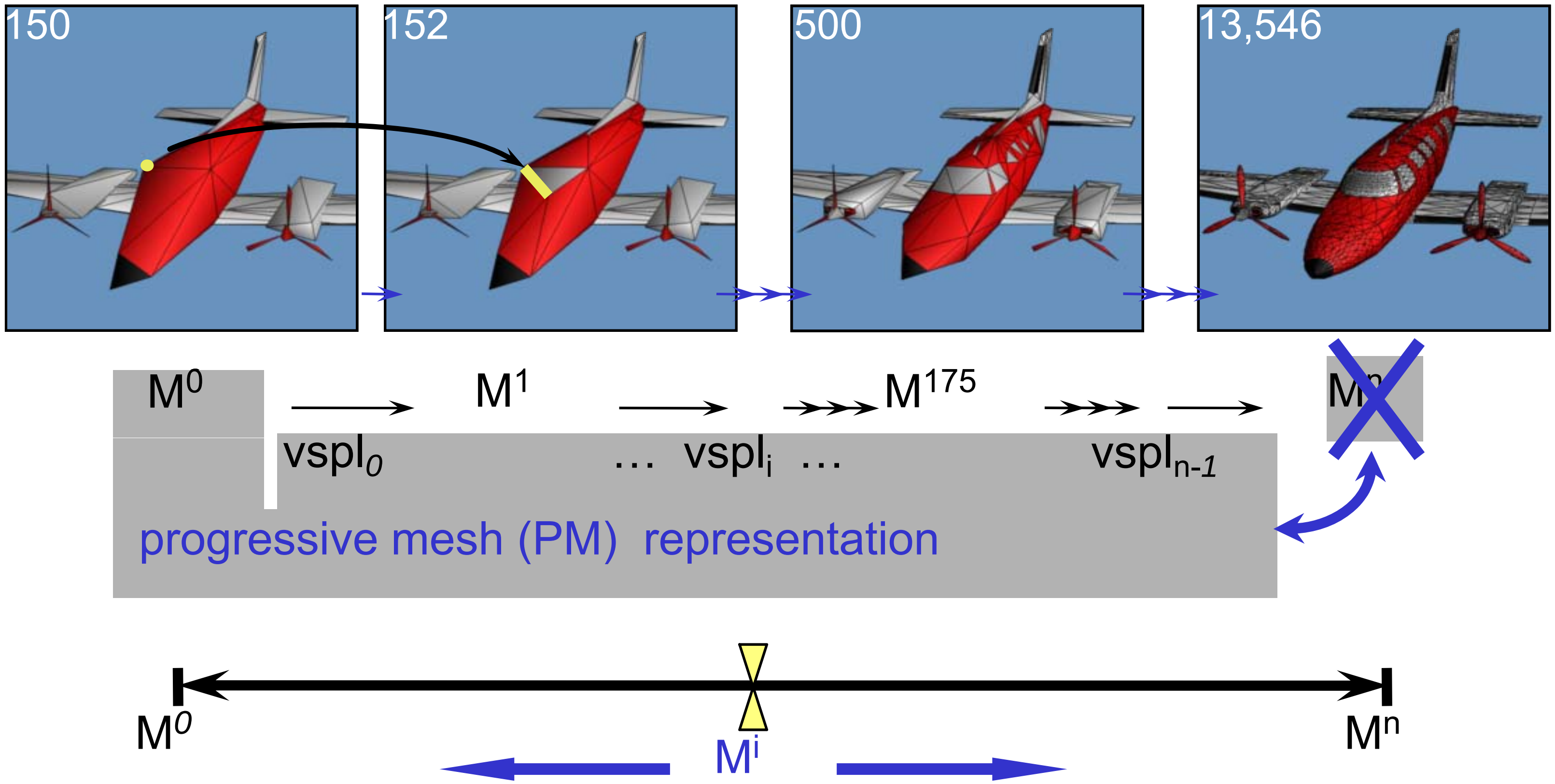
The PM Representation



$M^0 \longrightarrow M^1 \longrightarrow \cdots \longrightarrow M^{175} \longrightarrow \cdots \longrightarrow M^n$

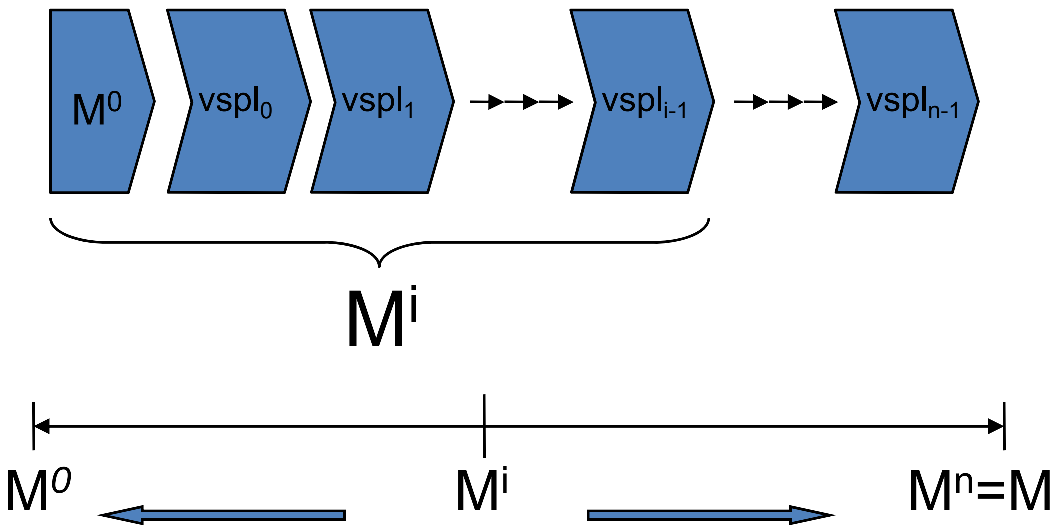
The PM Representation

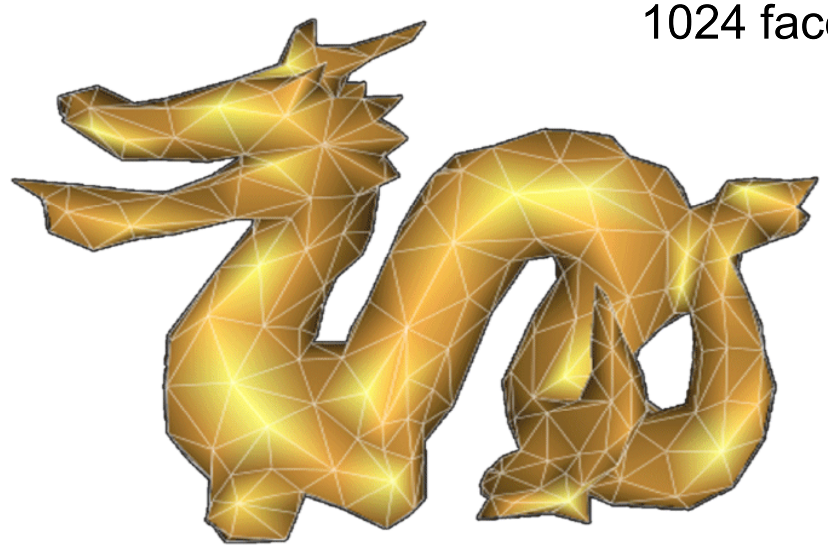
The PM Representation



Application: Continuous-Resolution LOD

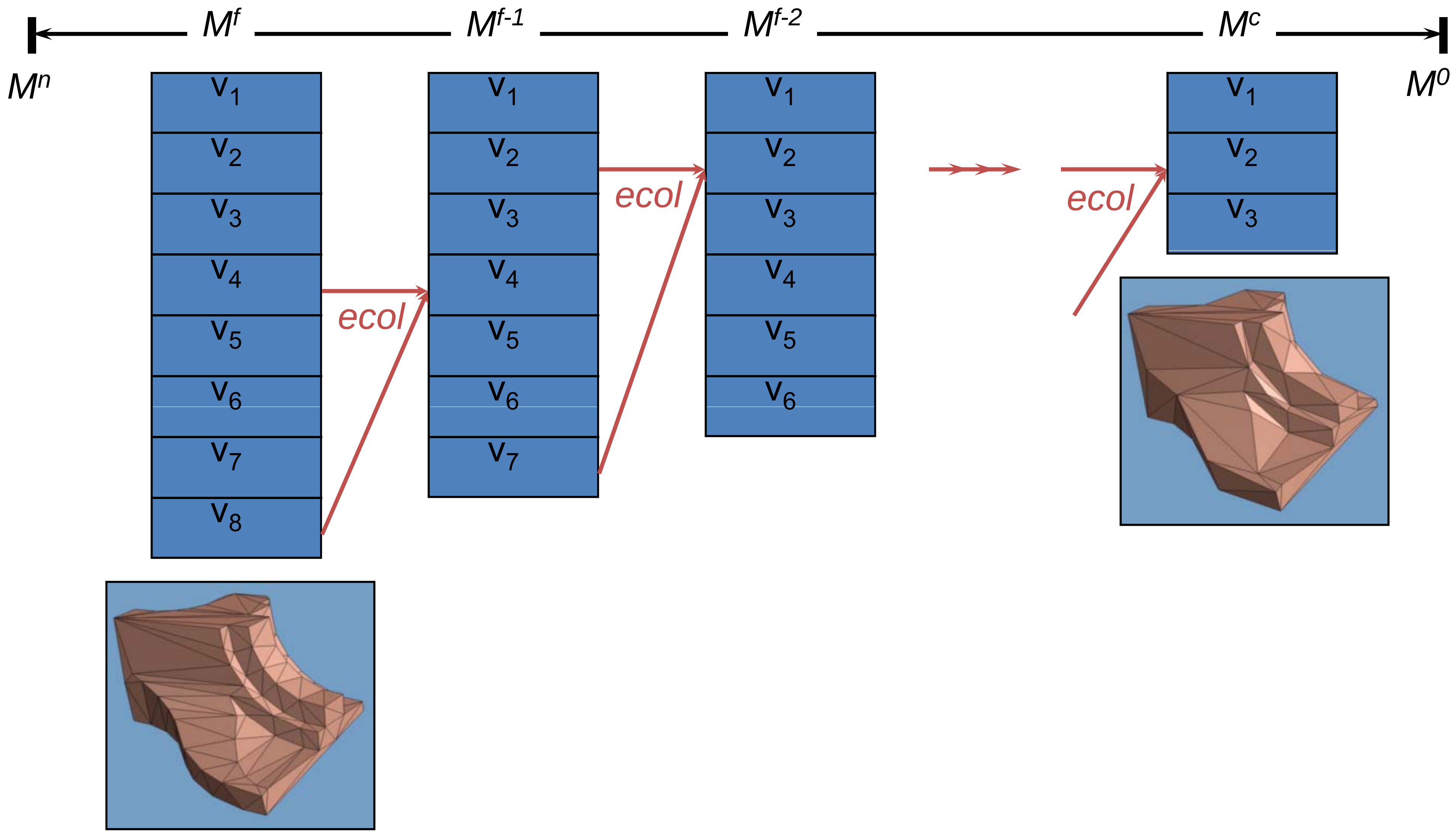
- From PM, extract M^i of any desired complexity





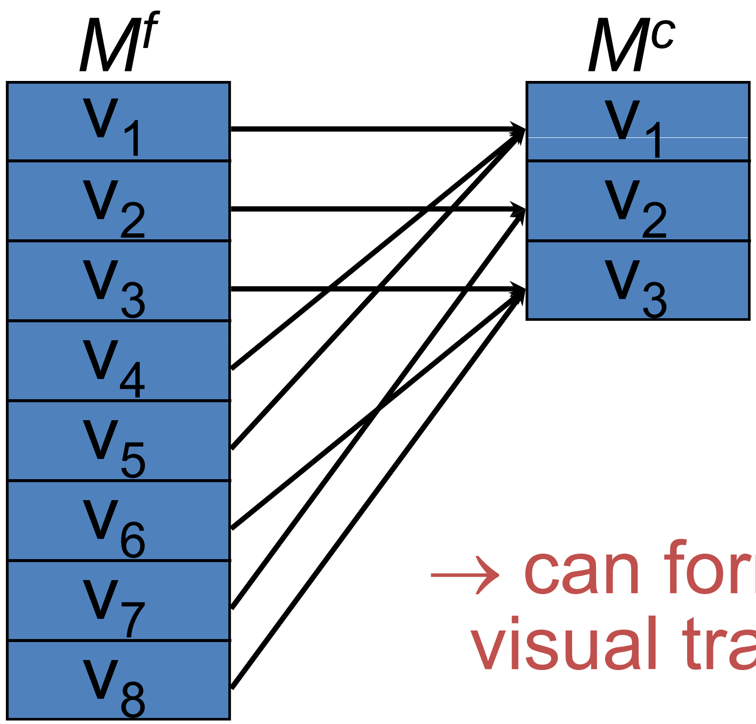
1024 faces

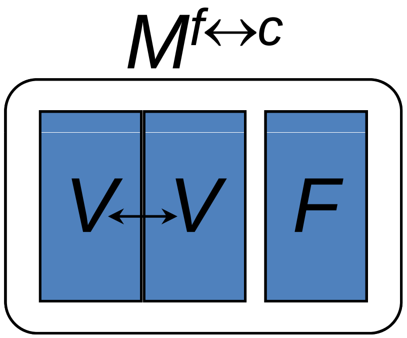
Property: Vertex correspondence



Application: Smooth transitions

Correspondence is a surjection:



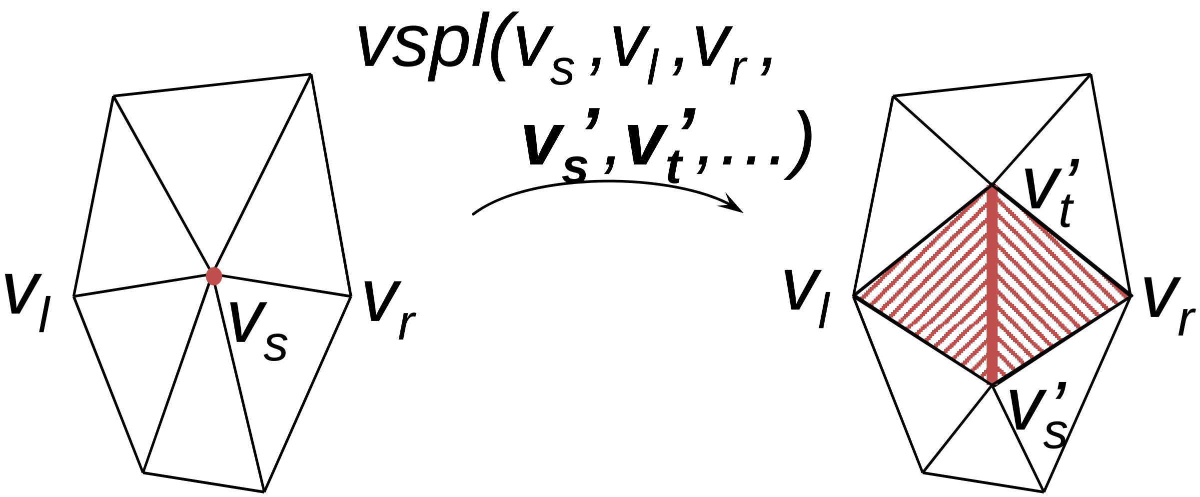


→ can form a smooth visual transition: *geomorph*

Smooth transitions

- Movie

Mesh Compression



Record deltas:

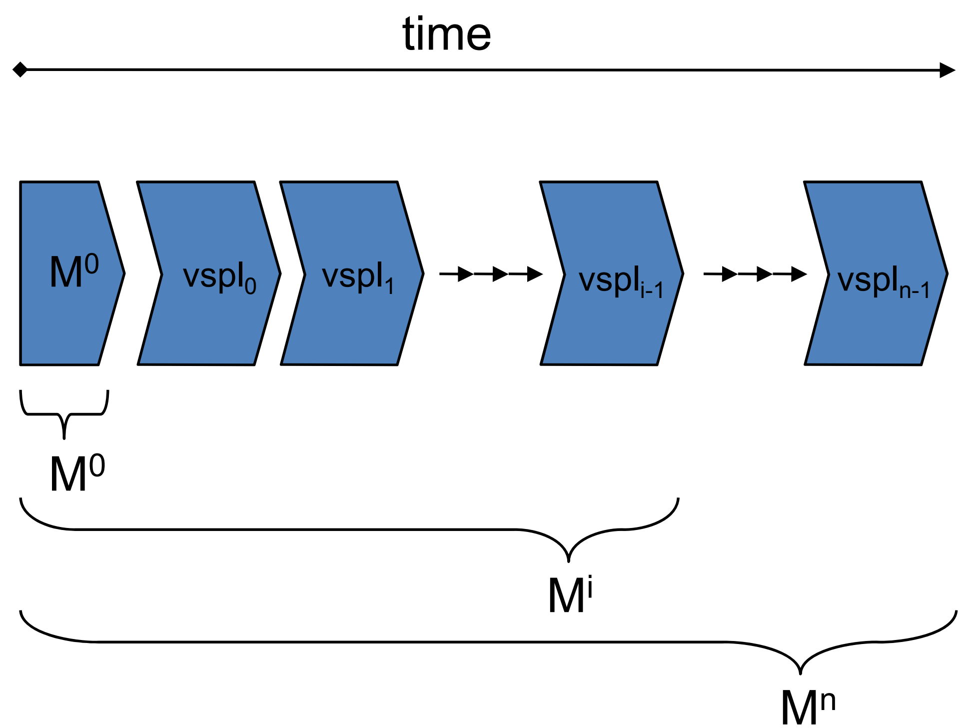
- $v_t' - v_s$
- $v_s' - v_s$
- …

Encoding of *vspl* records:

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

Progressive Transmission

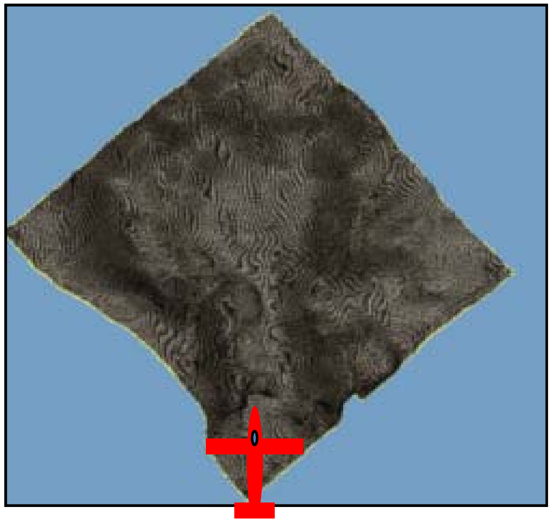
Transmit records progressively:

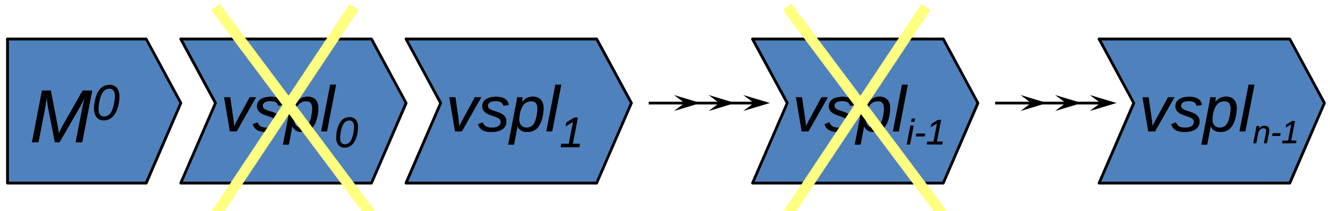


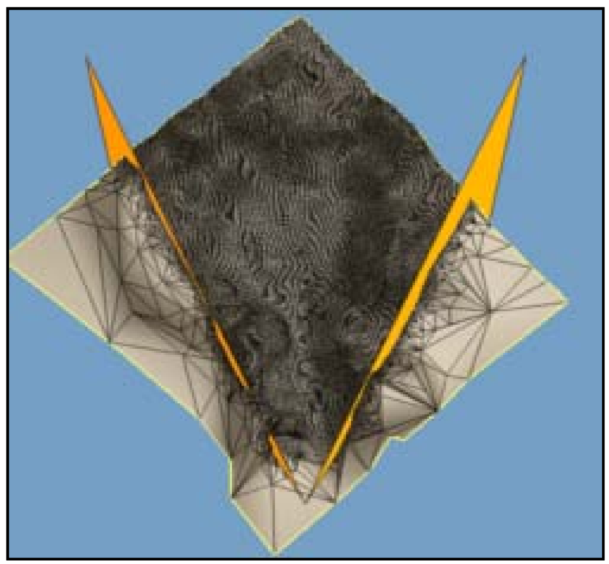
Receiver displays:

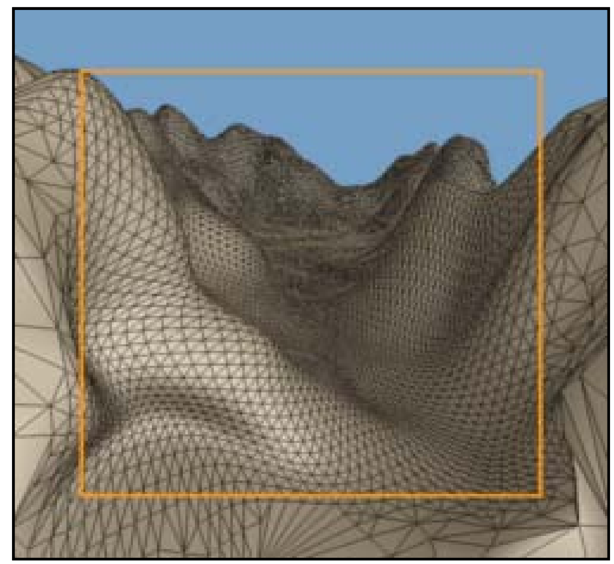
(progressive JPEG, MPEG-4)

Selective refinement



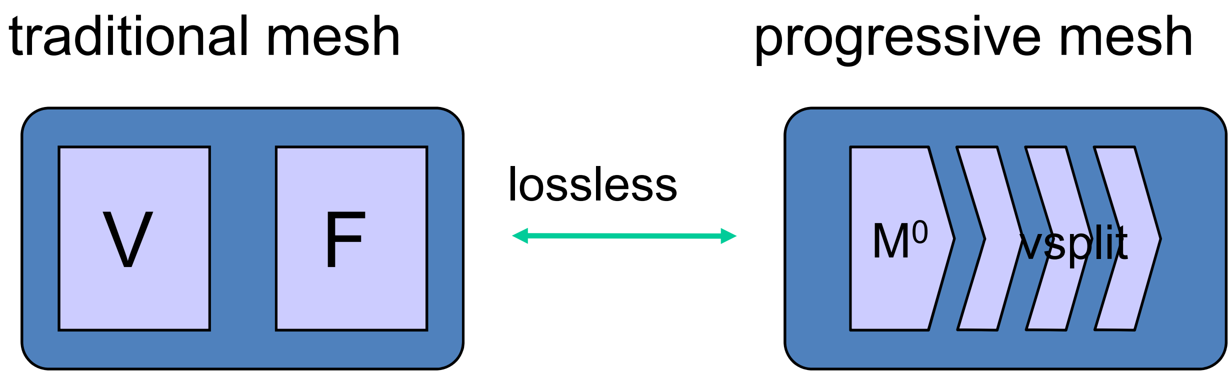






(e.g. view frustum)

PM Benefits

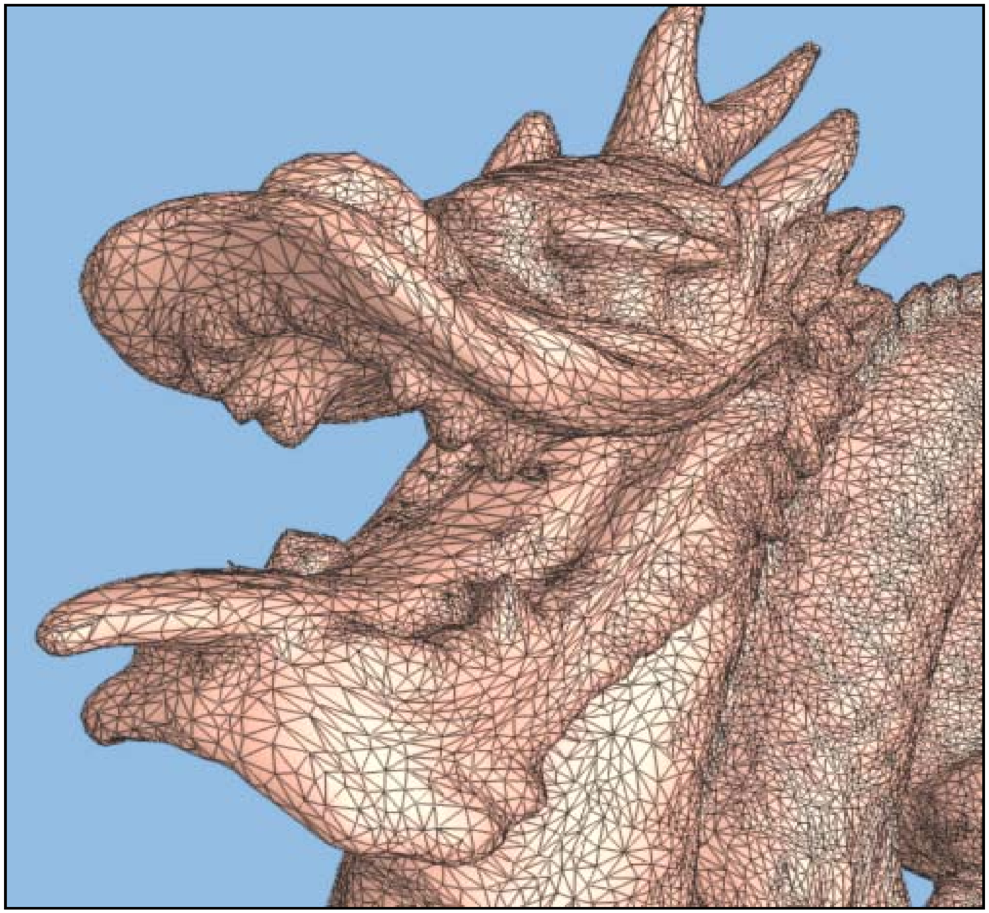


- single resolution

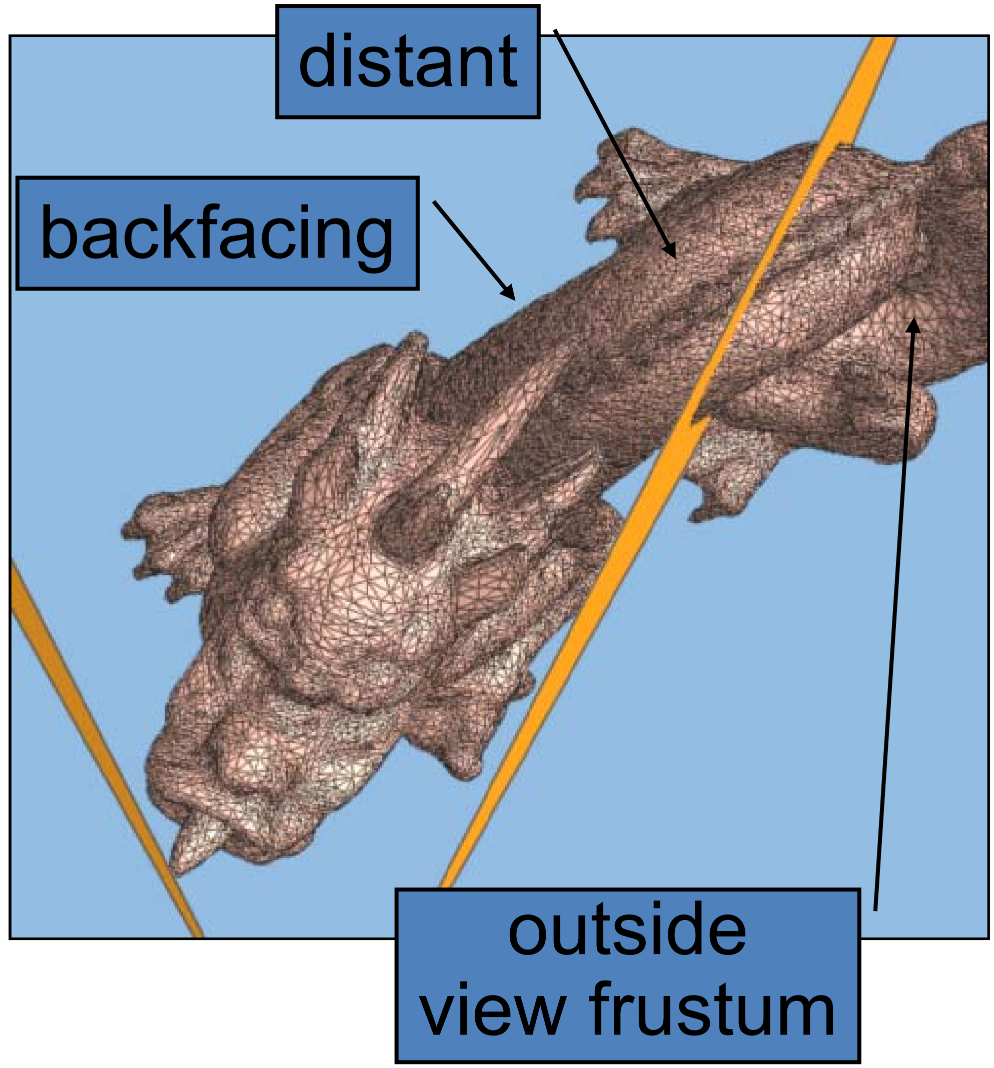
- progressive transmission
- continuous-resolution
- smooth LOD
- geometry compression

- Optimization process
  - various metrics (speed vs. accuracy)
  - typically performed off-line

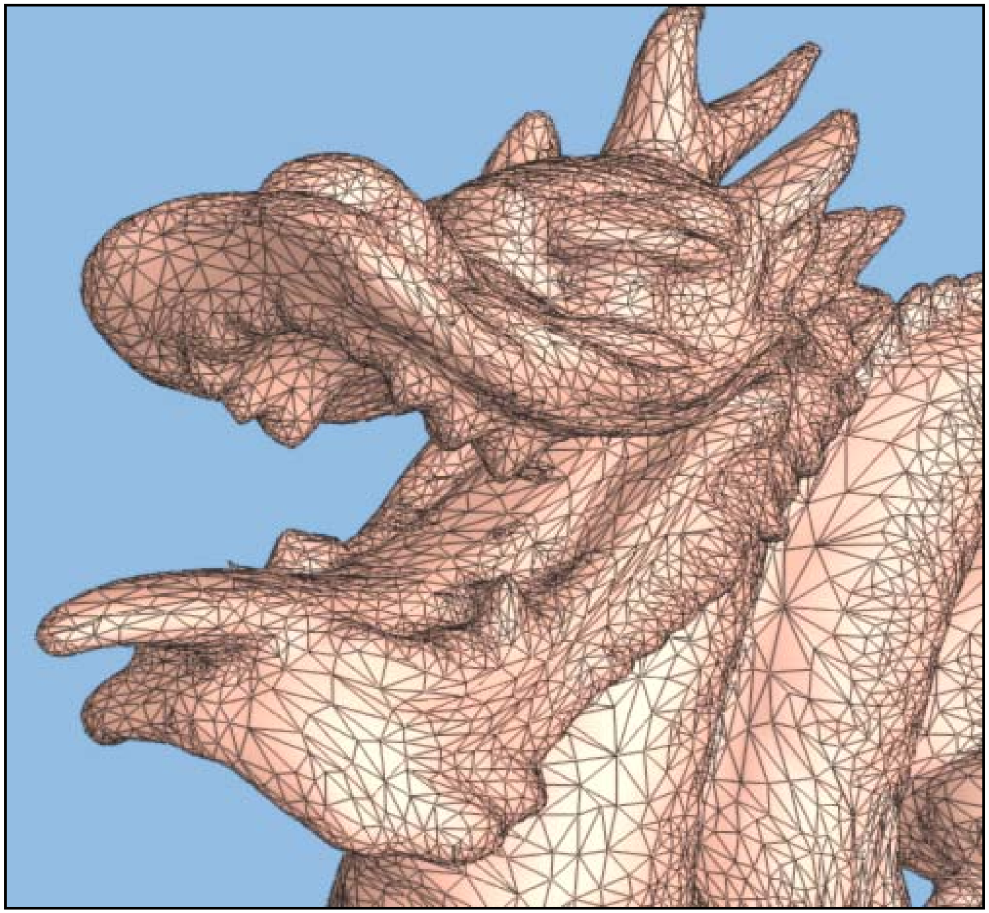
View-Independent LOD: Difficulties



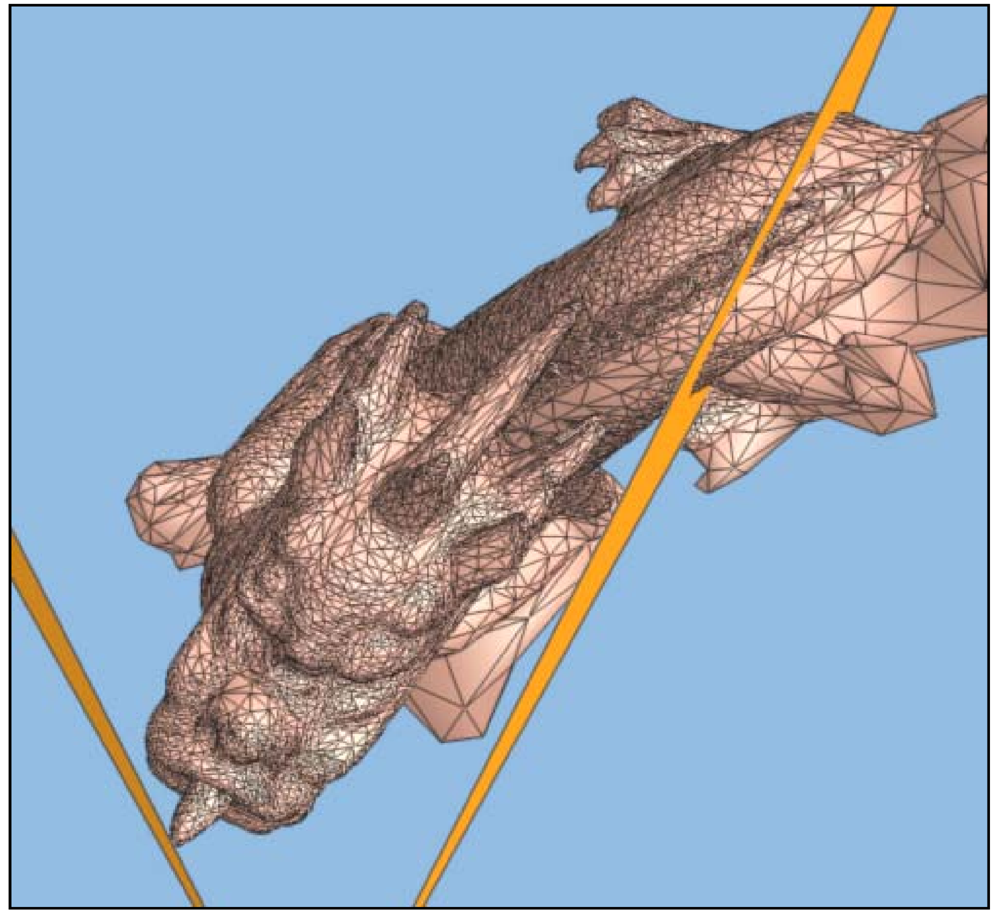
100,000 faces



View-dependent LOD

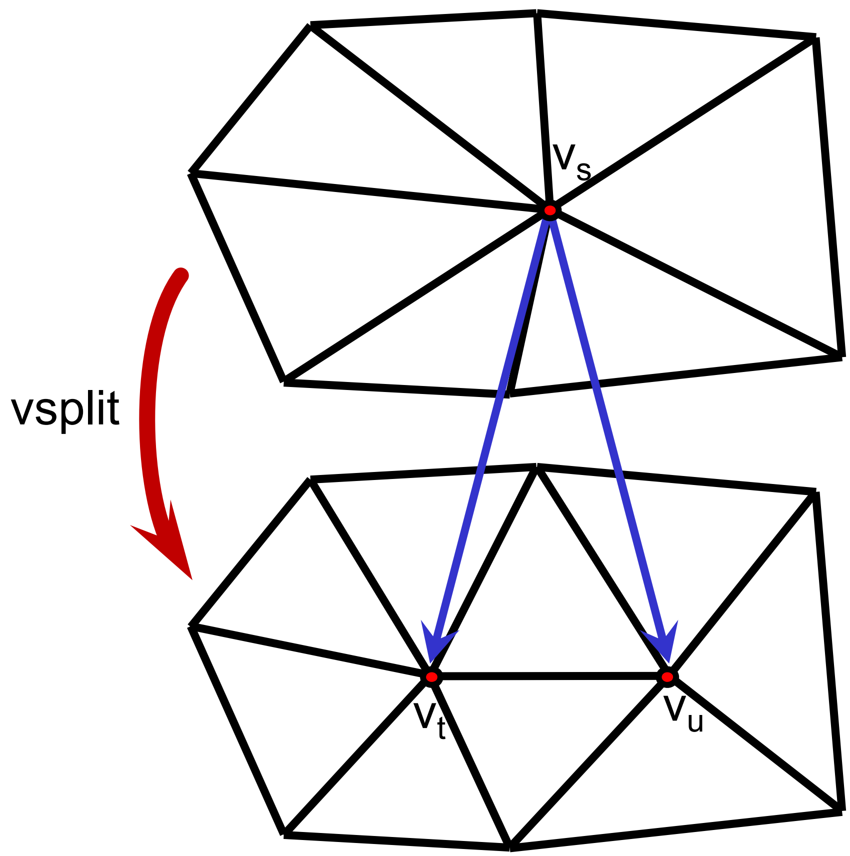


29,400 faces

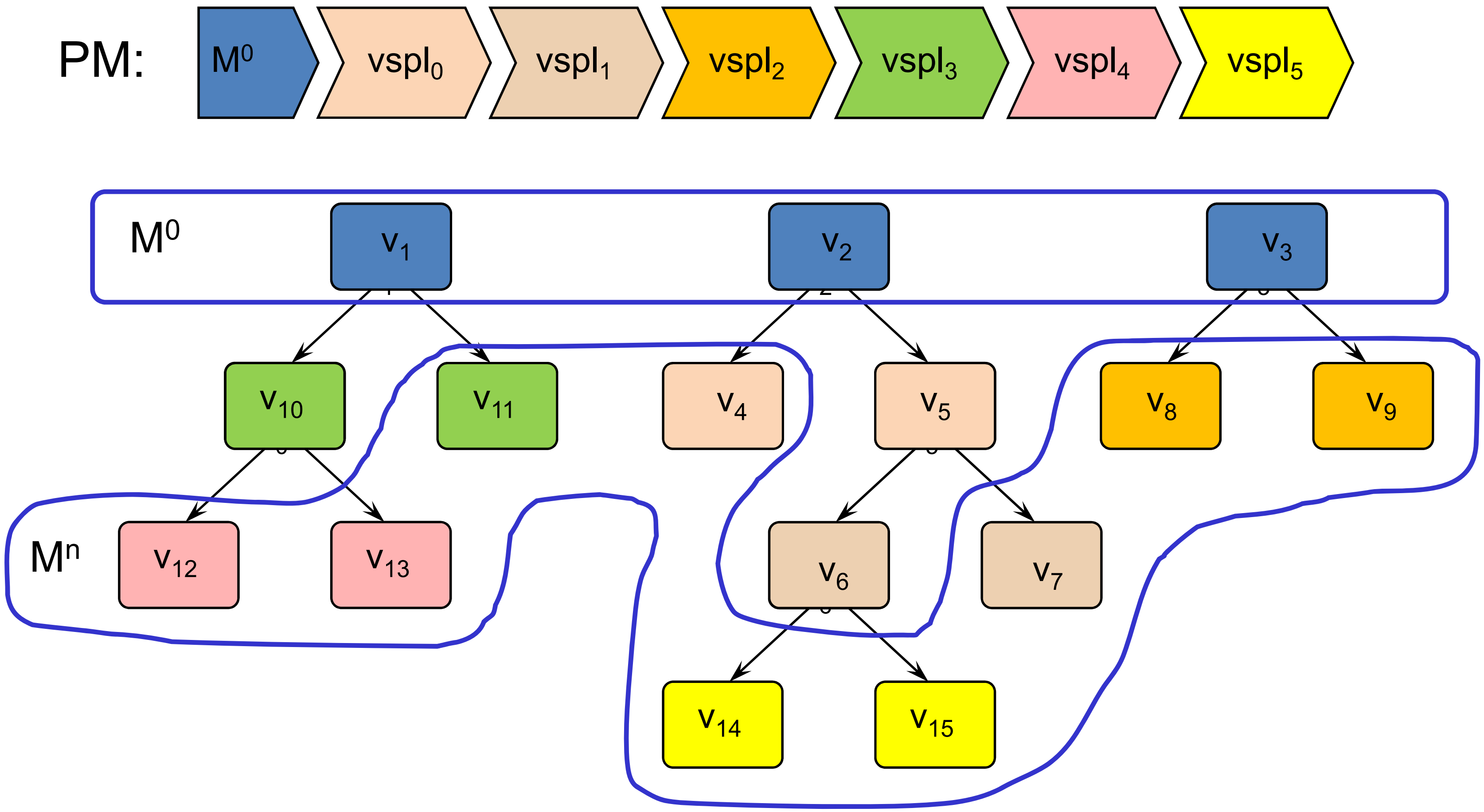


different LOD's coexist over surface

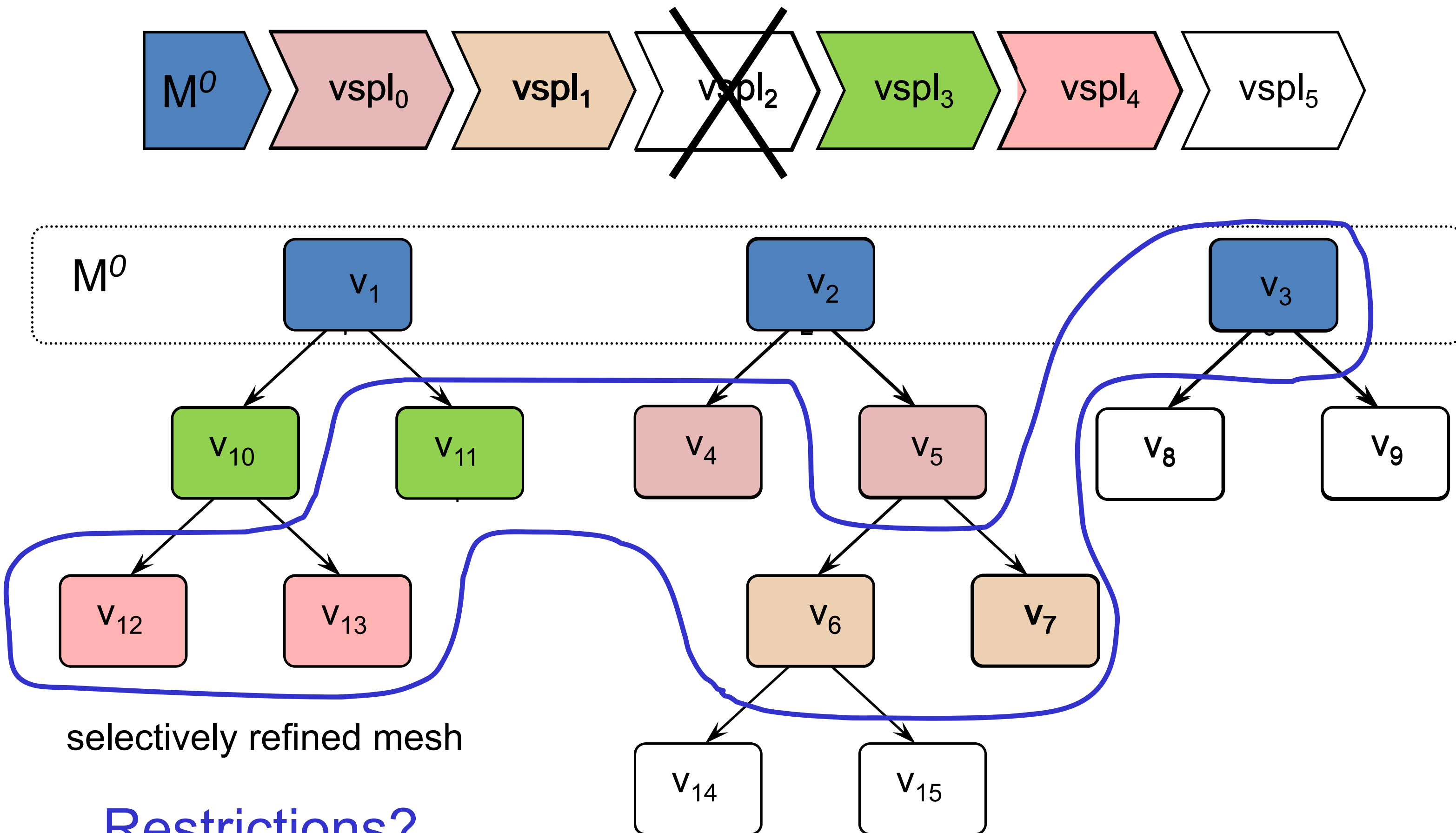
Parent-child Vertex Relations



Vertex Hierarchy



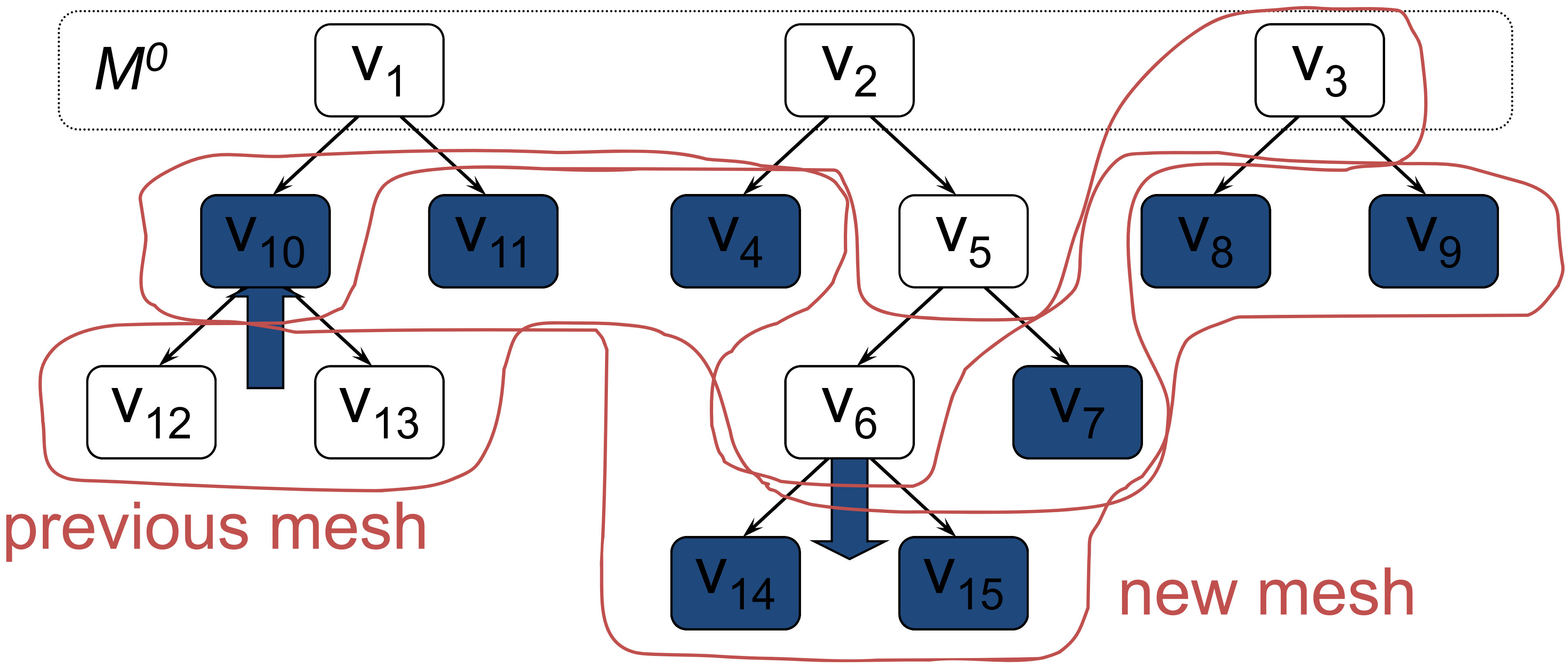
Selective Refinement



selectively refined mesh

Restrictions?

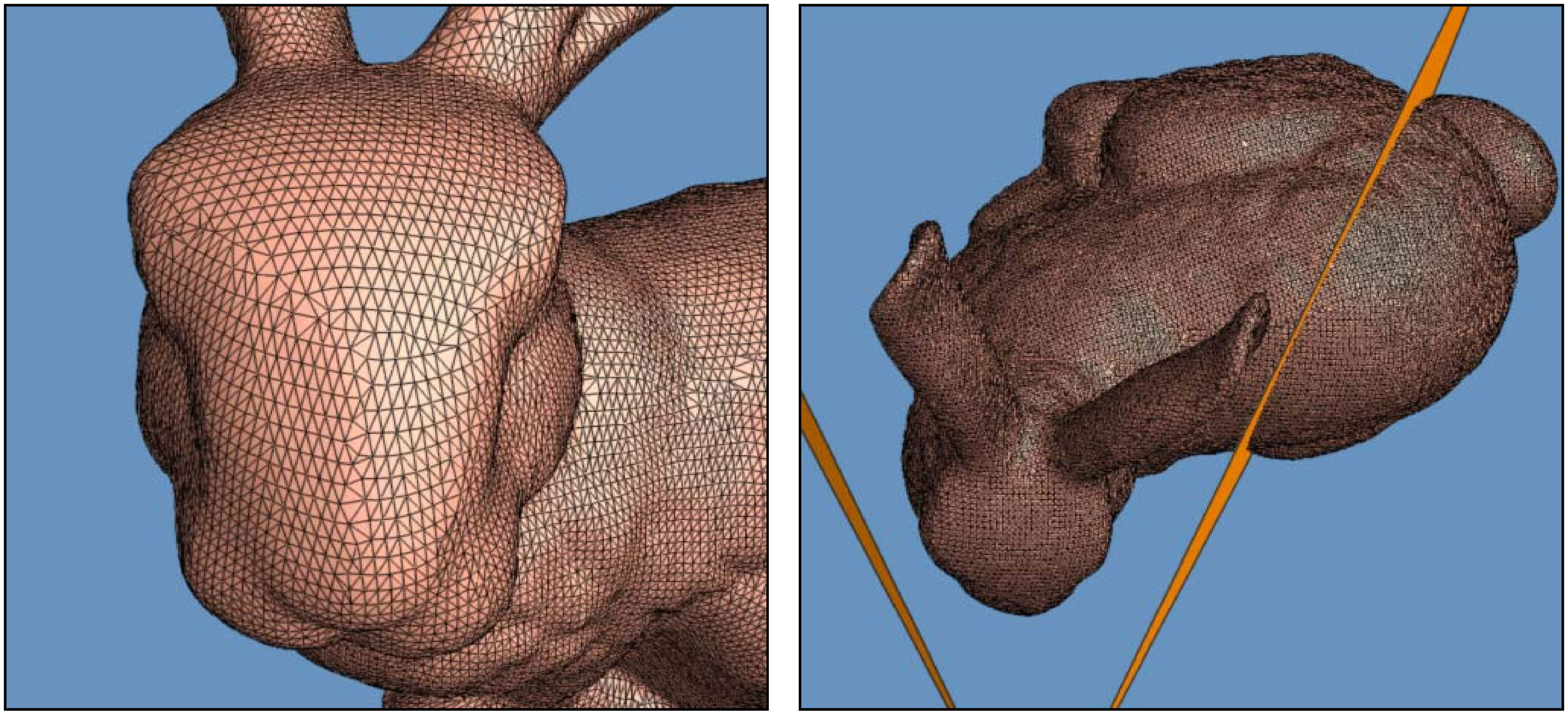
Runtime algorithm



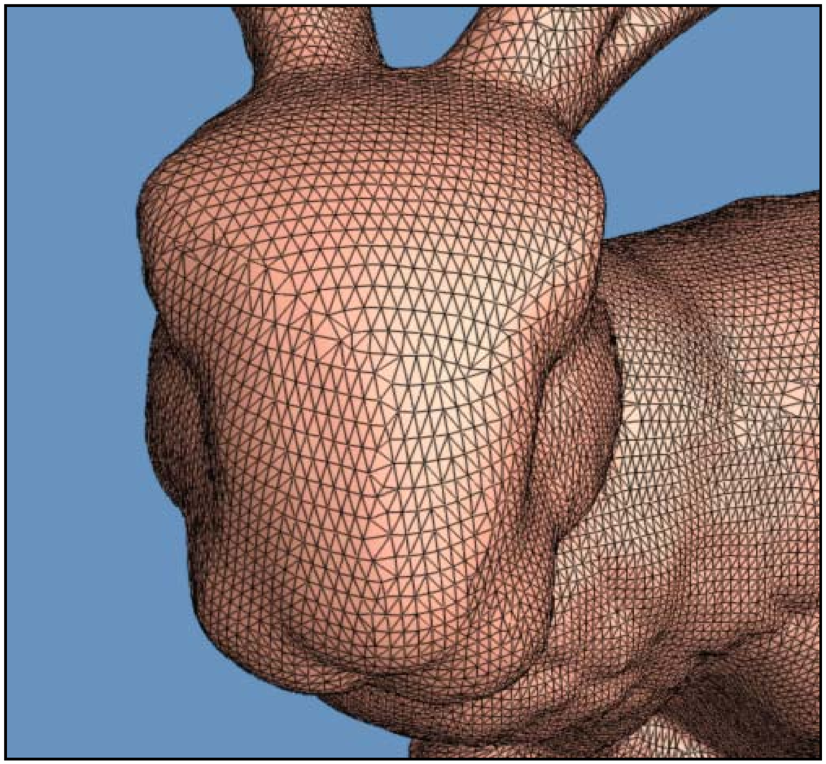
Refinement Criteria

- 3 criteria:
  - view frustum
  - surface orientation
  - screen-space geometric error

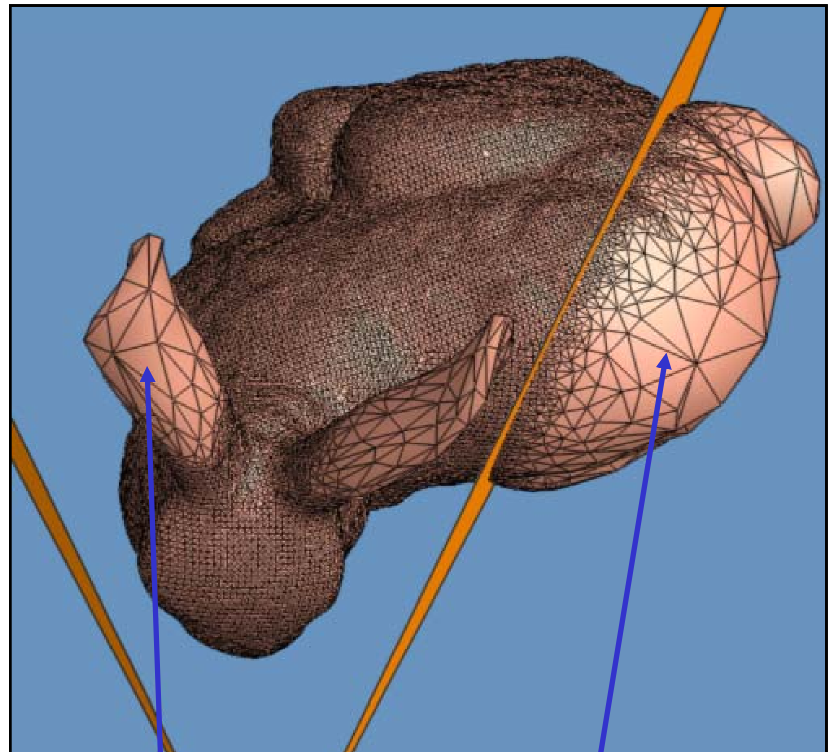
(1) View Frustum



(1) View Frustum



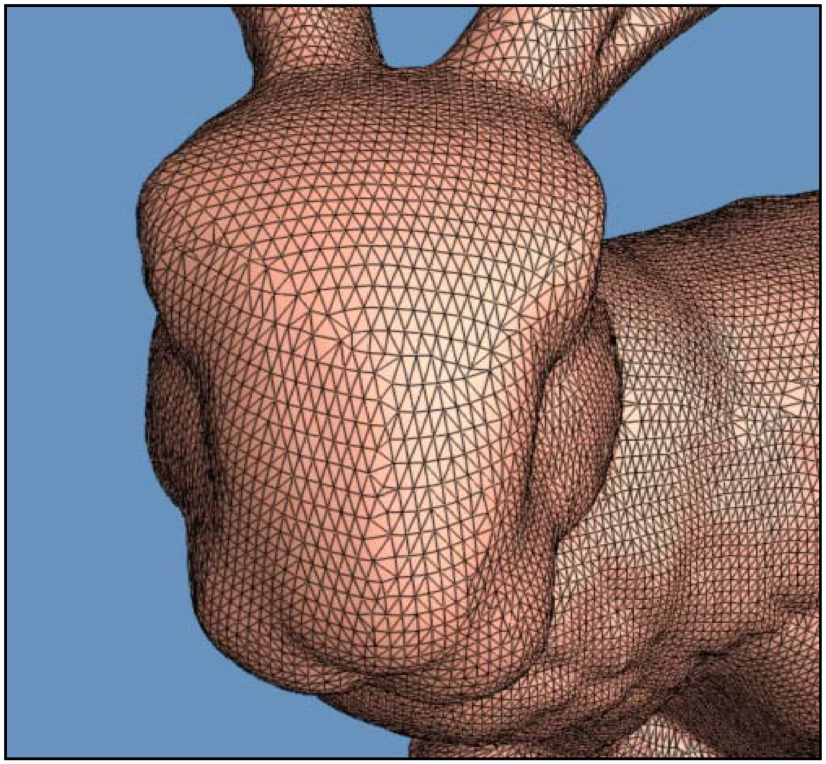
view is unchanged



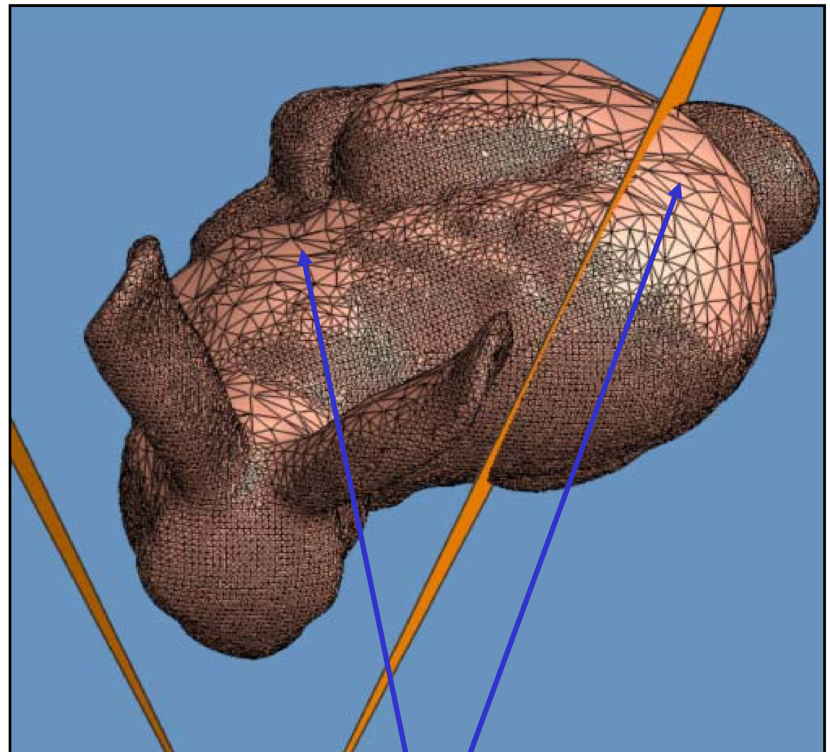
too high

too far right

(2) Surface Orientation

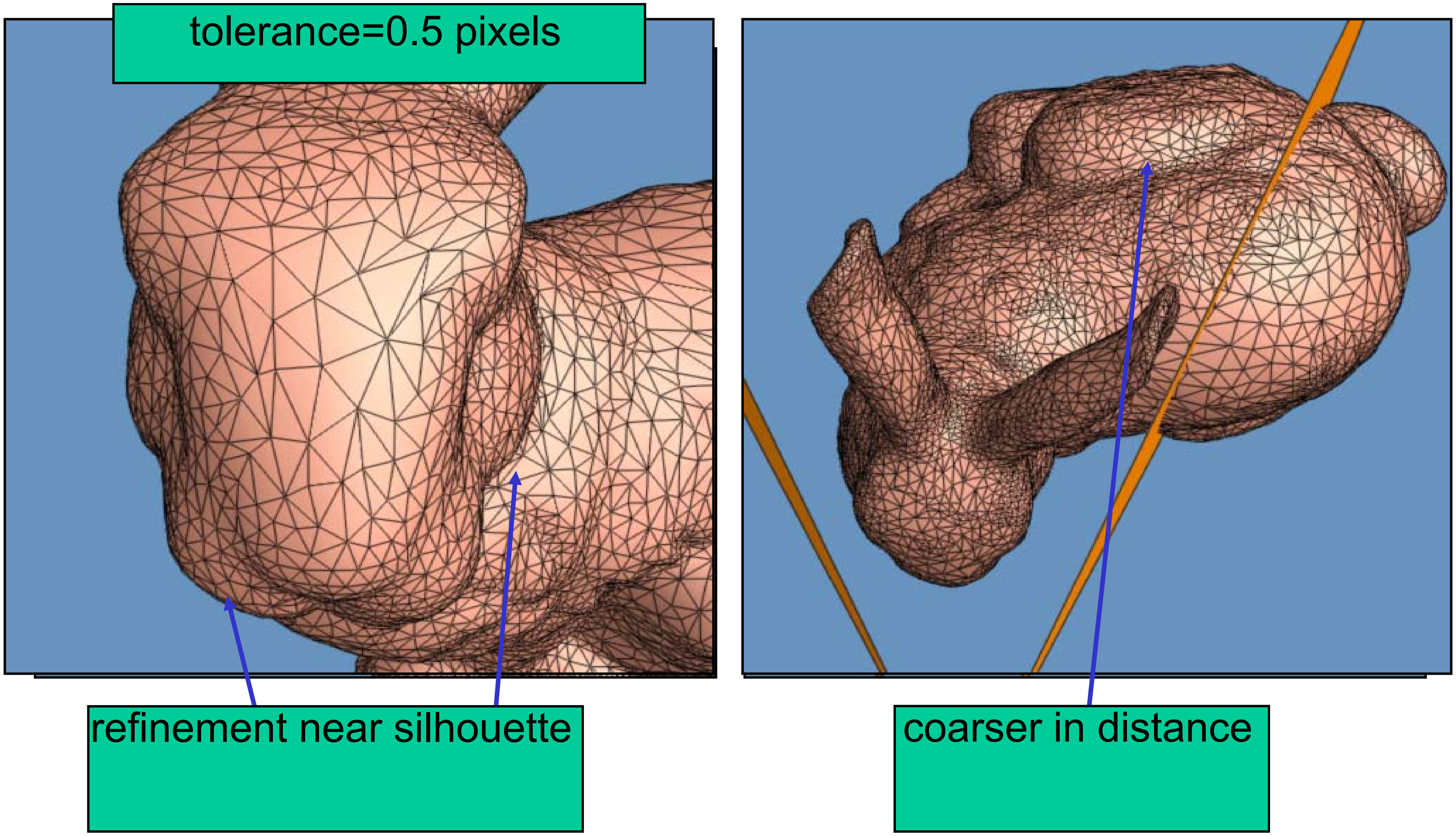


view is unchanged

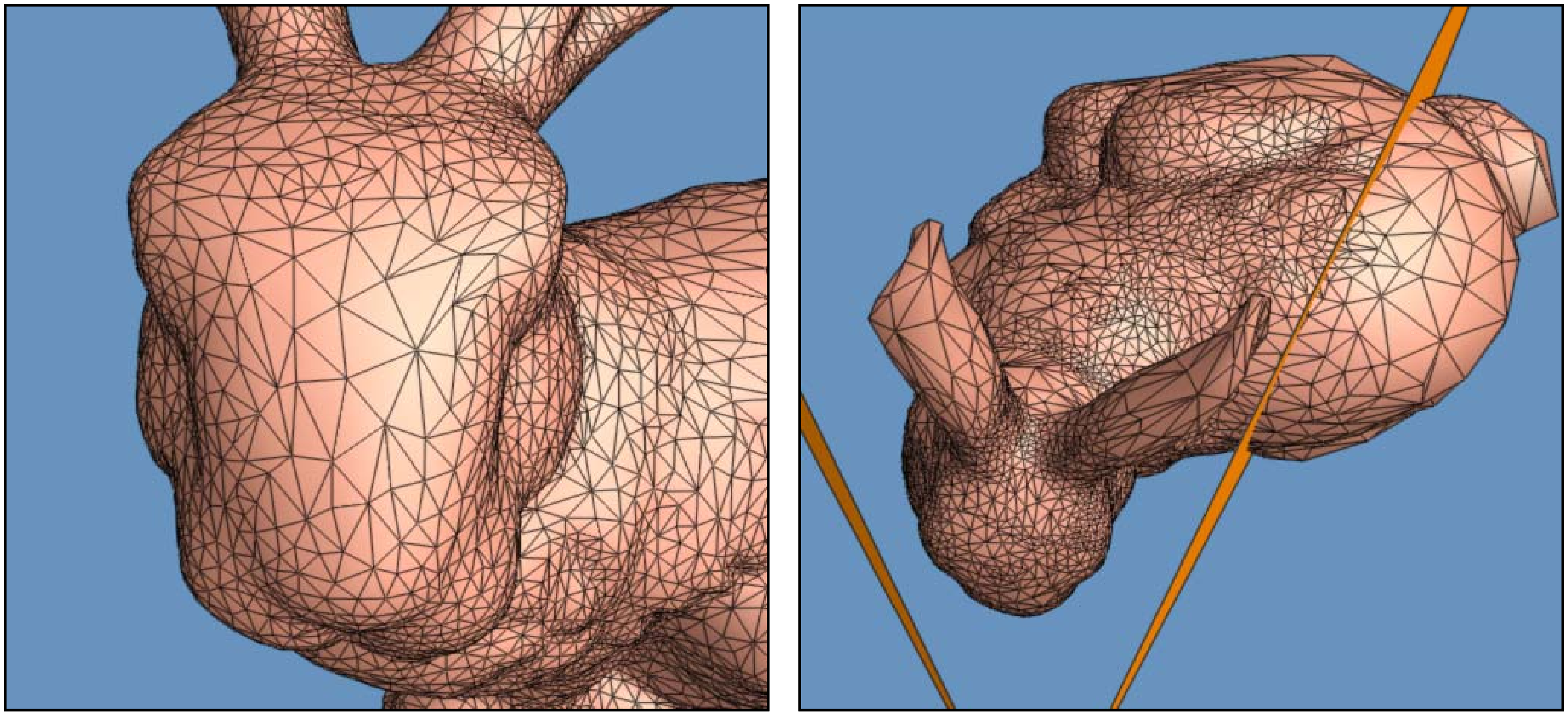


oriented away

(3) Screen-space Geometric Error



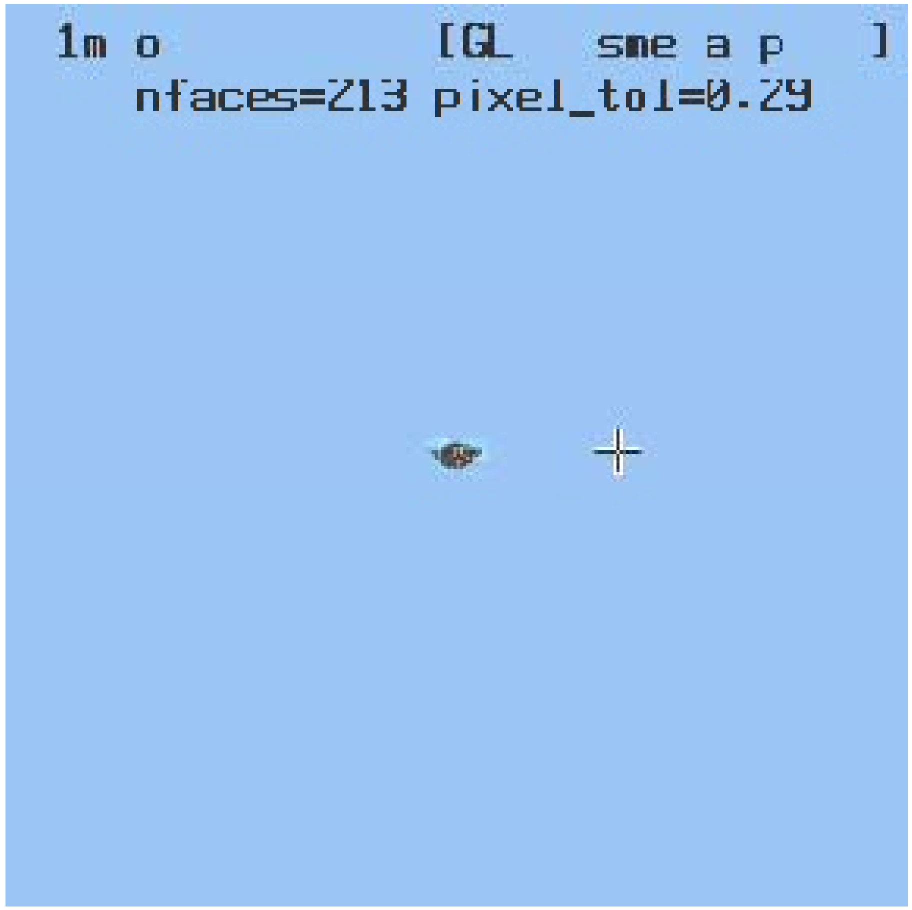
All Three Criteria Together



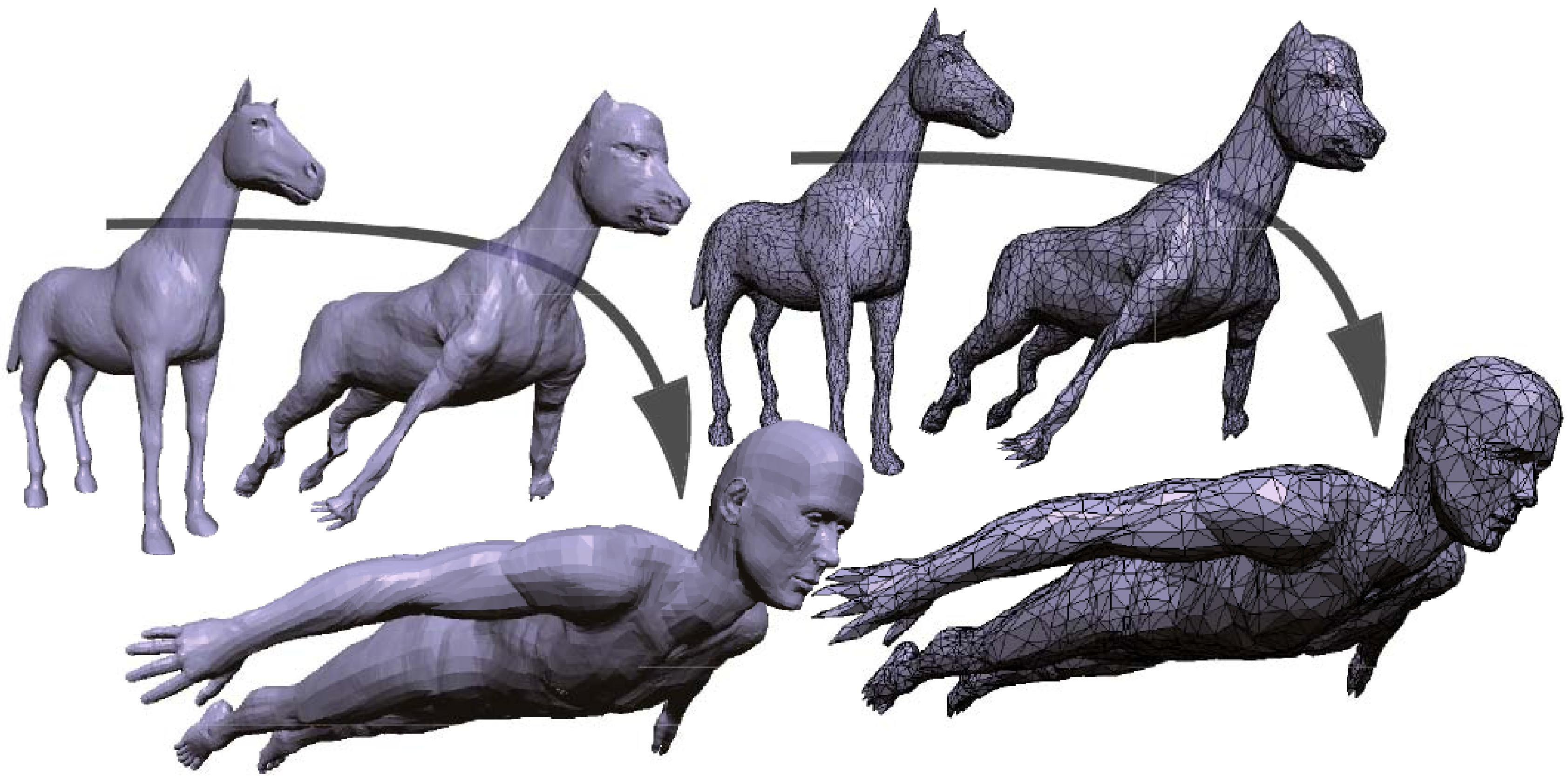
69,473 faces → 10,528 faces

1.9 frame/sec → 6.7 frame/sec

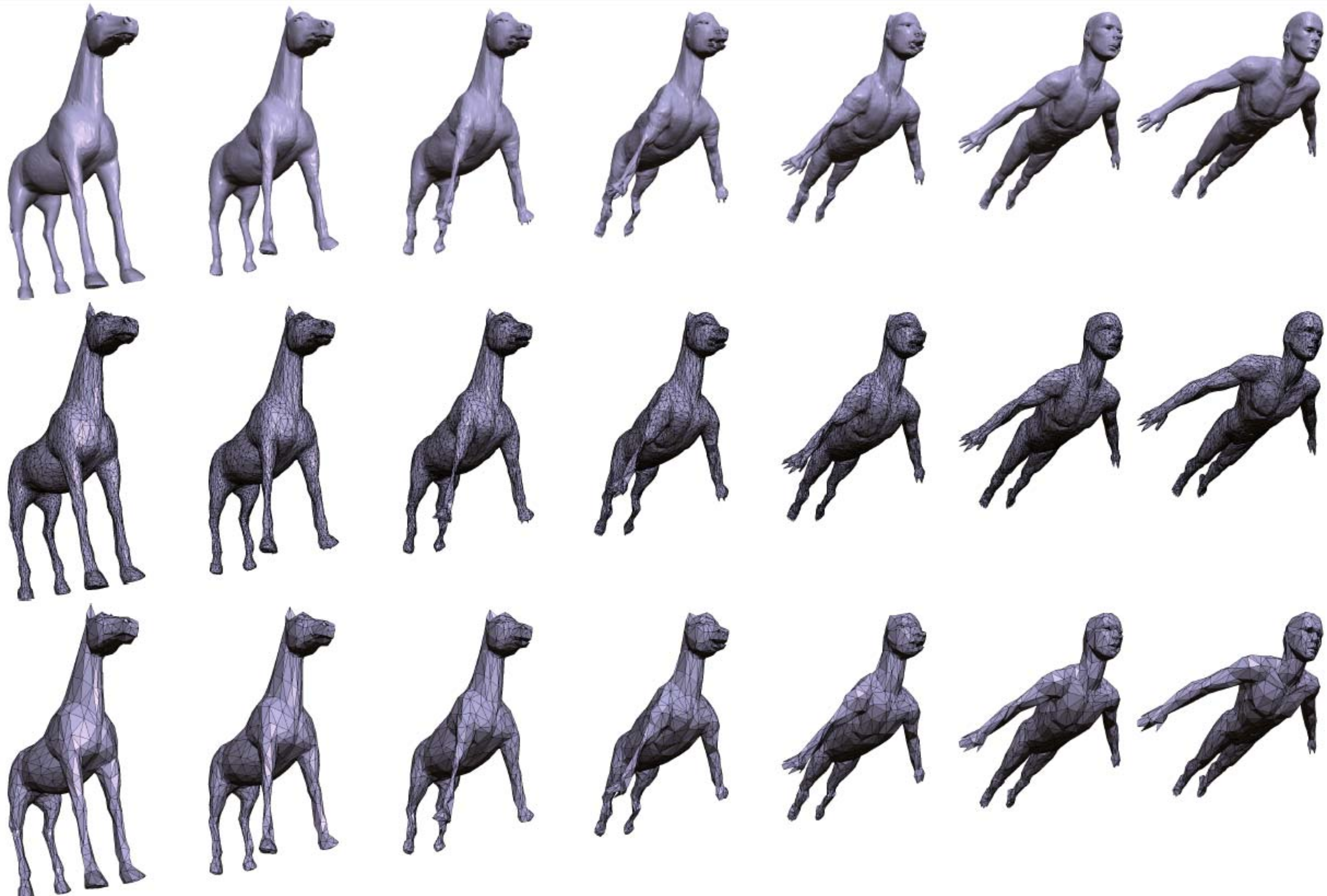
Video



Extensions: Progressive Deforming Meshes



Progressive Deforming Meshes



Progressive Deforming Meshes

Video

References

- “Progressive meshes”, H. Hoppe, Siggraph ’96
- “View-dependent refinement of progressive meshes”, H. Hoppe, Siggraph ’97
- “Progressive multiresolution meshes for deforming surfaces”, Kircher et al., SCA ‘05