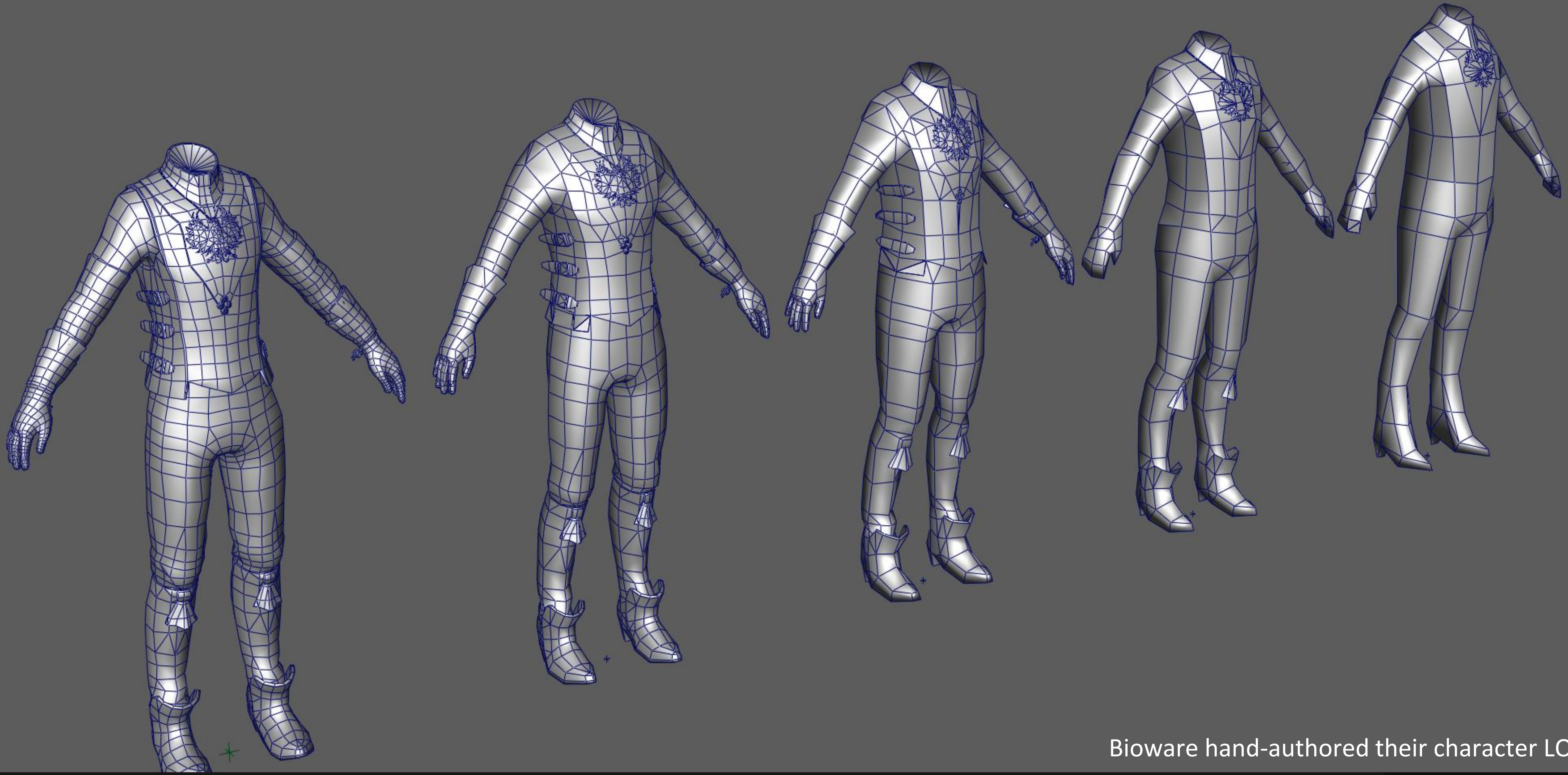
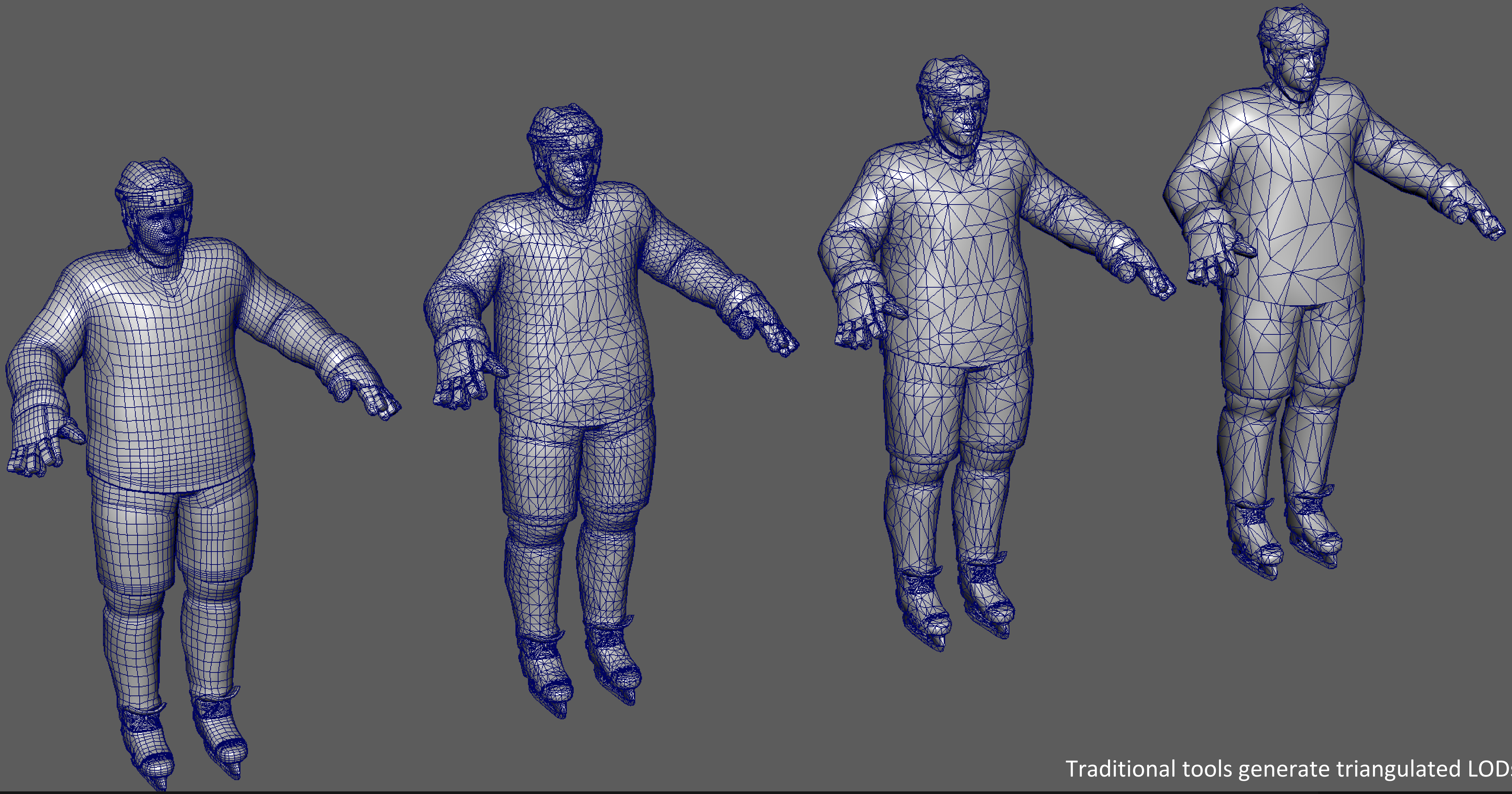
Quad mesh simplification in Frostbite

Ashton Mason
Senior Software Engineer

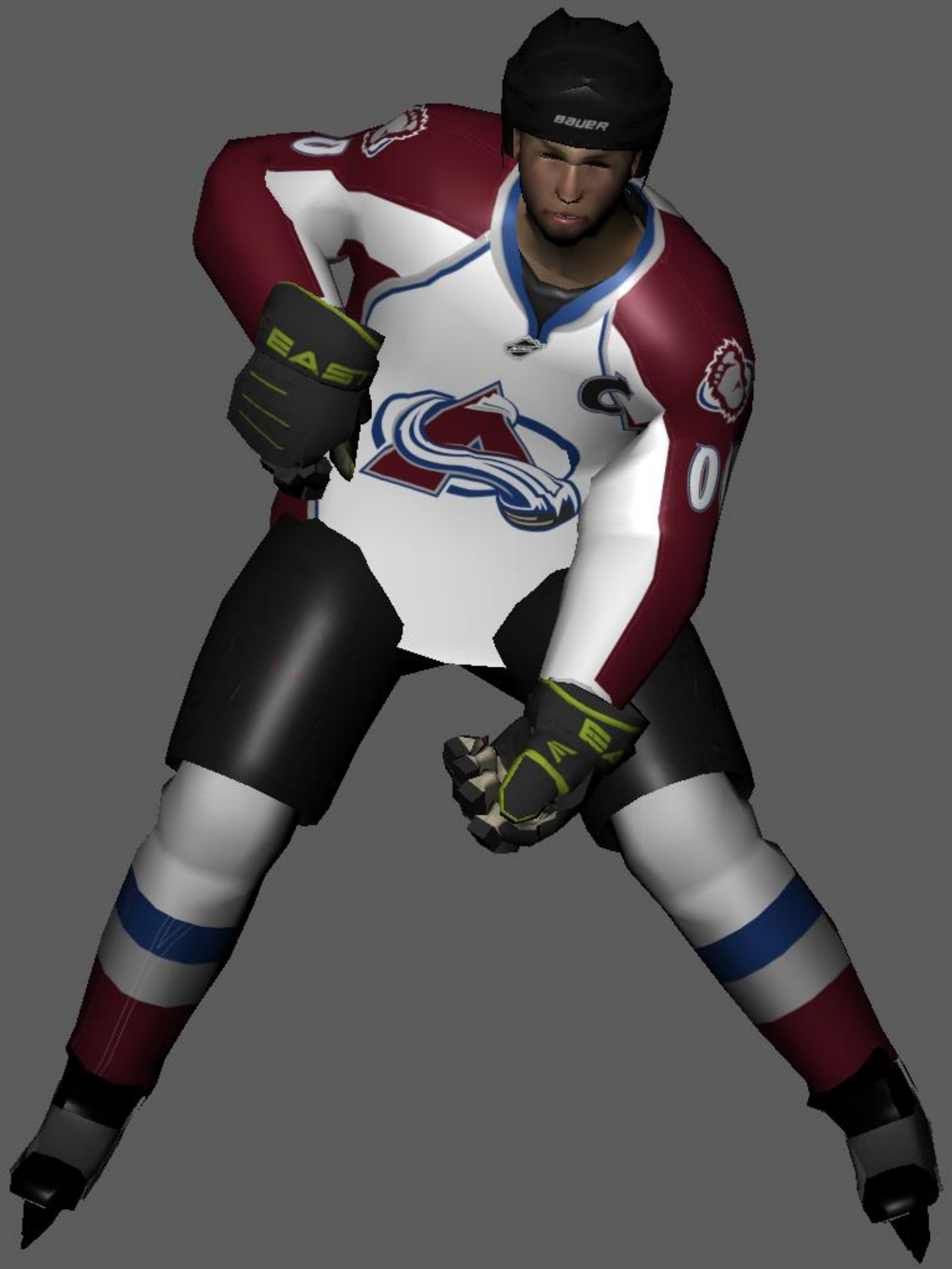


Bioware hand-authored their character LODs

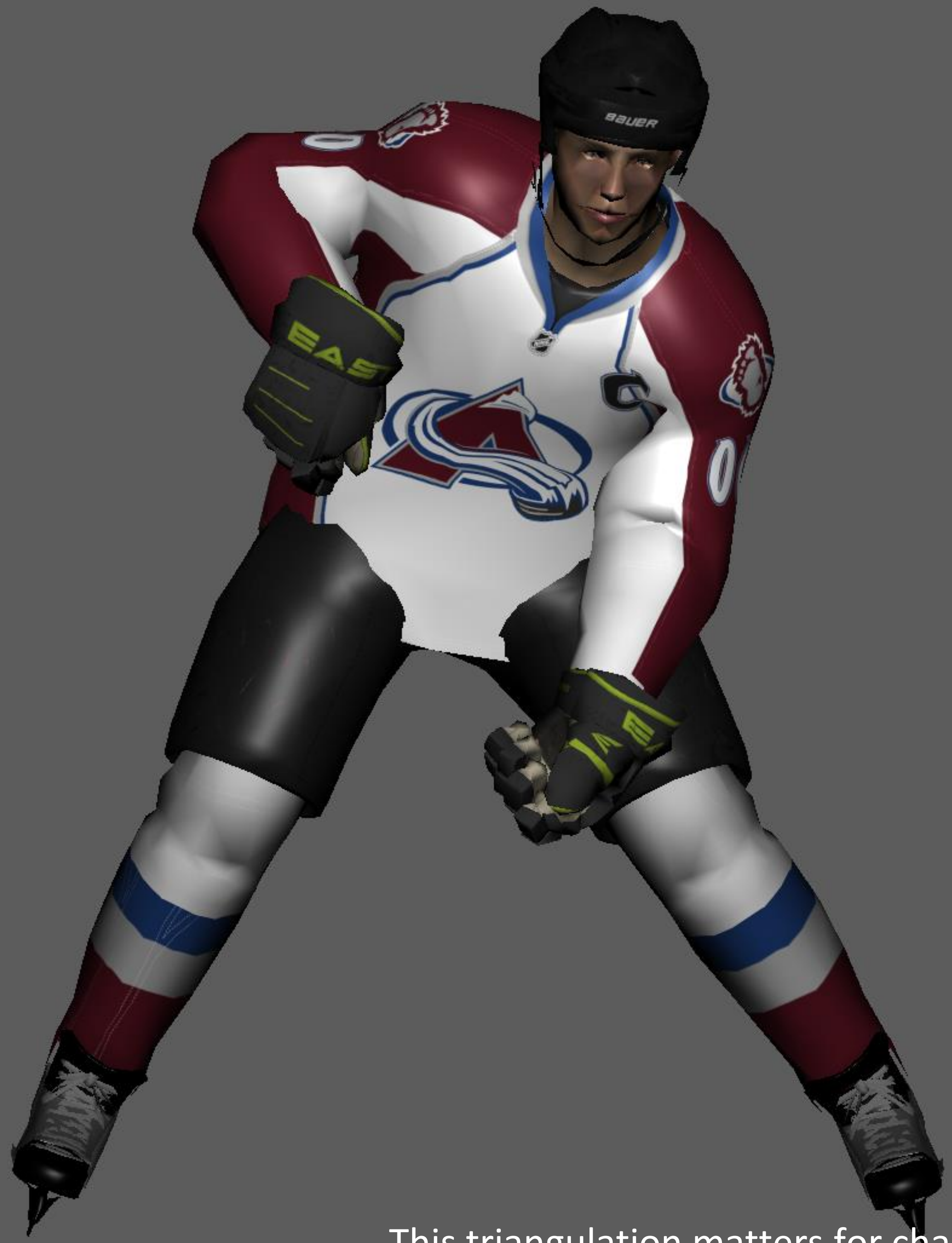


Traditional tools generate triangulated LODs

lod3
quads

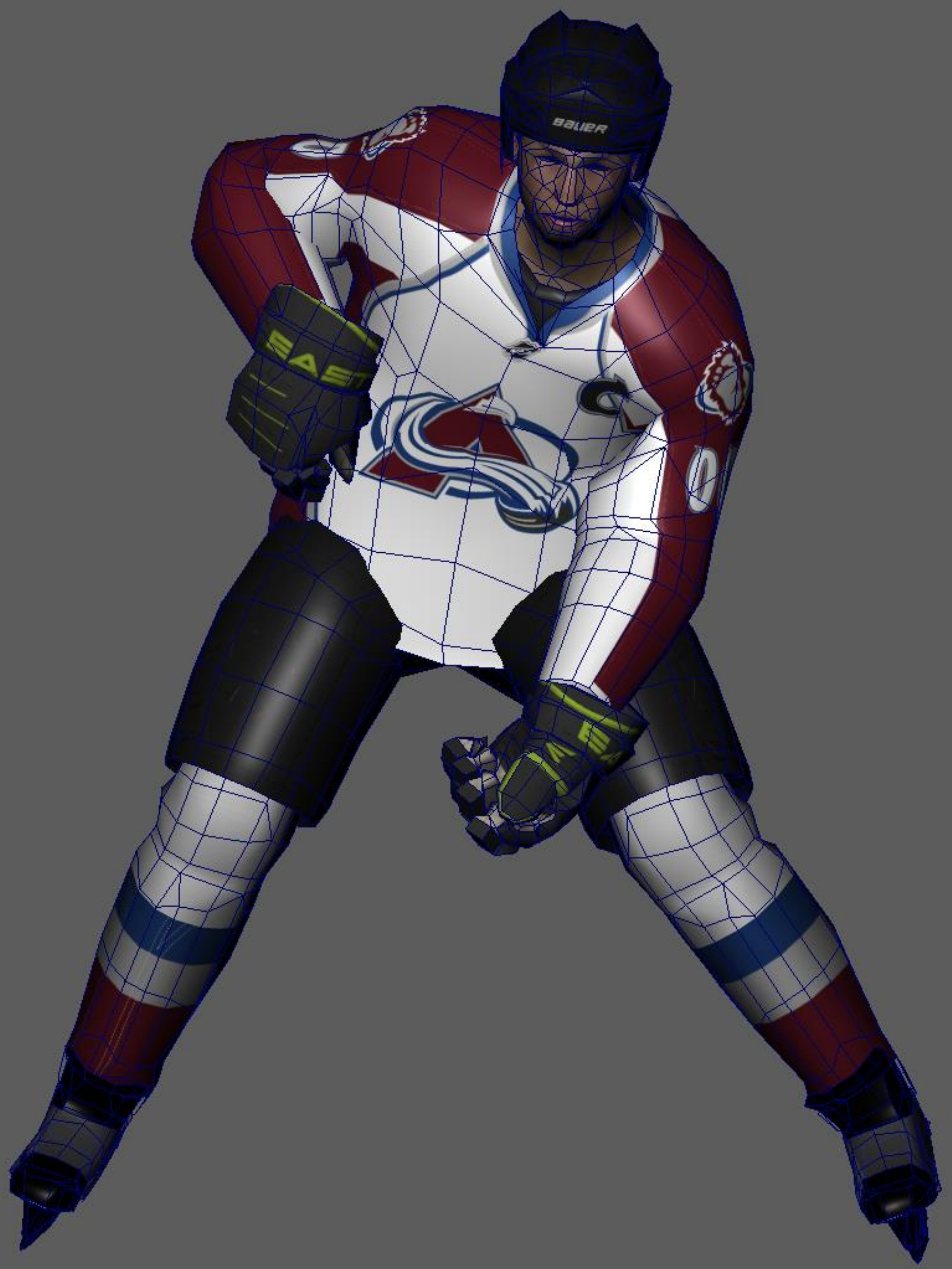


lod3
triangles

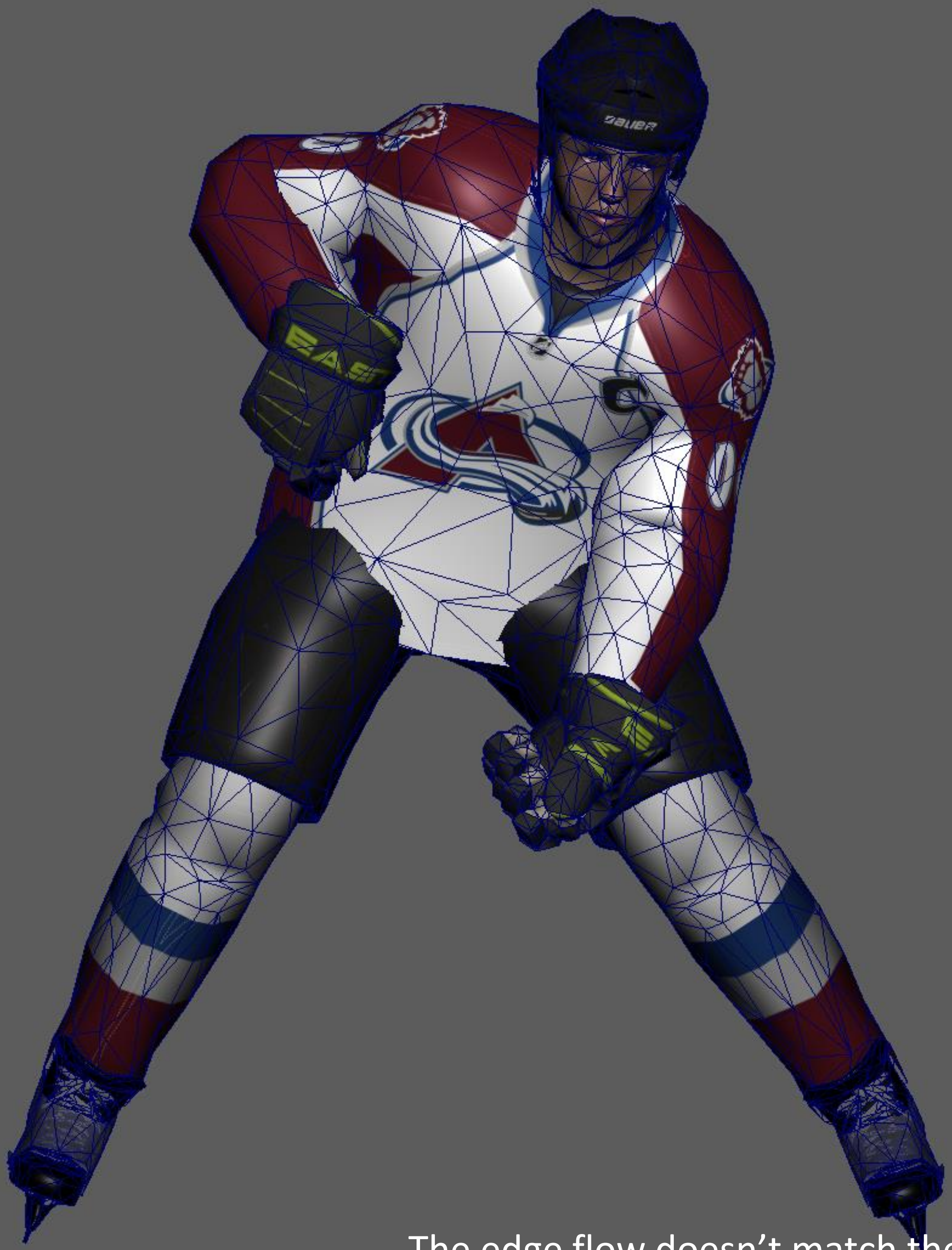


This triangulation matters for character models

lod3
quads



lod3
triangles

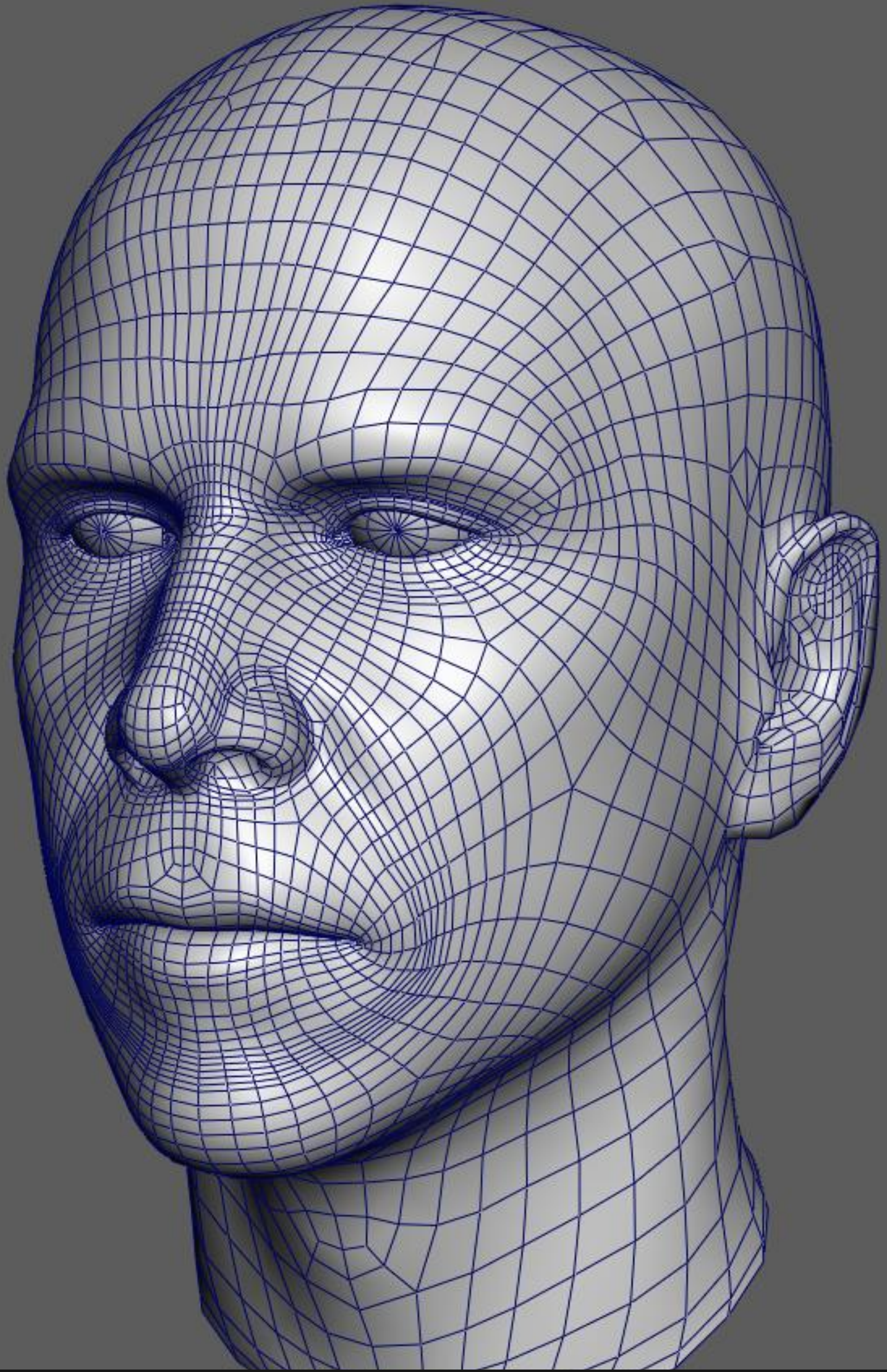


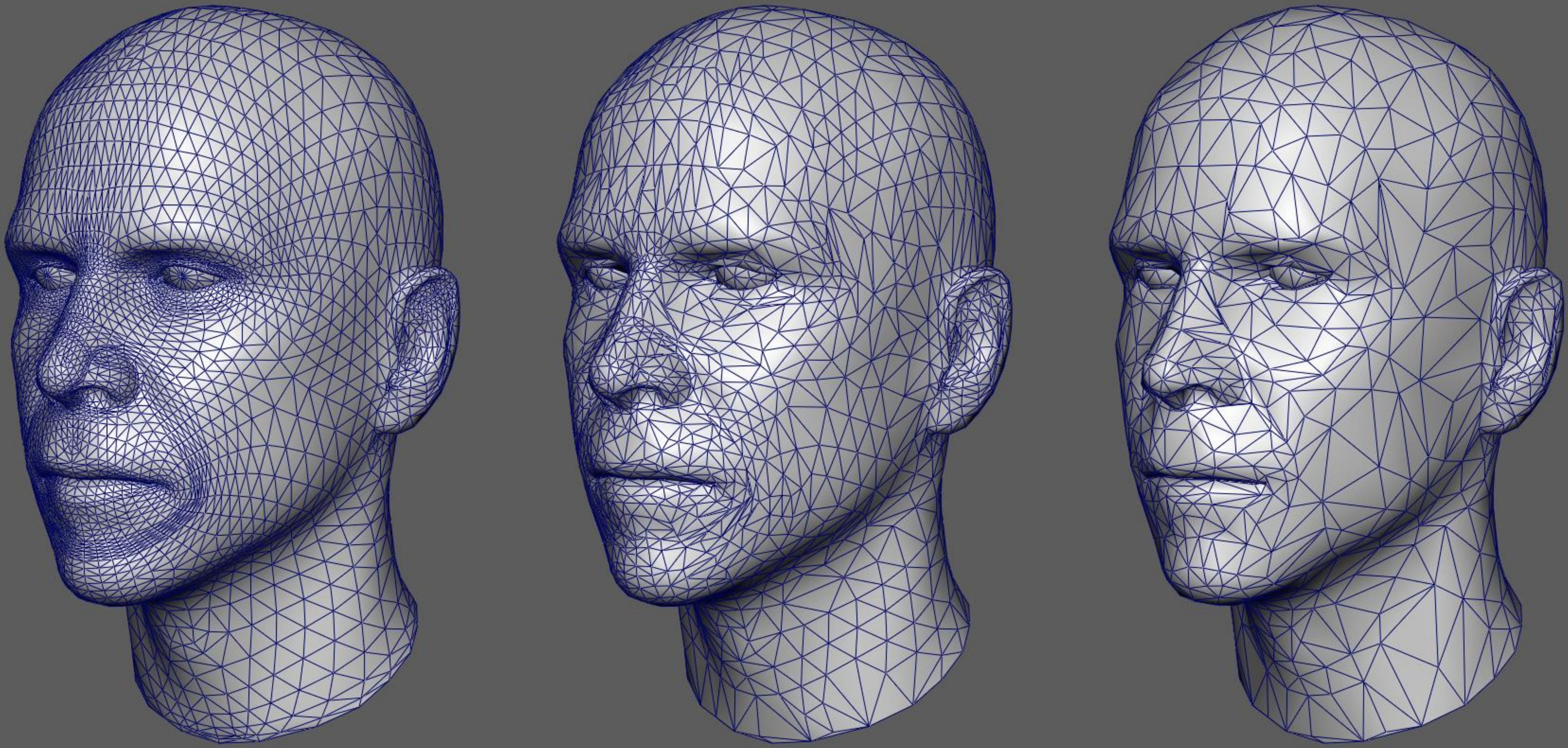
The edge flow doesn’t match the deformation

Let’s get started

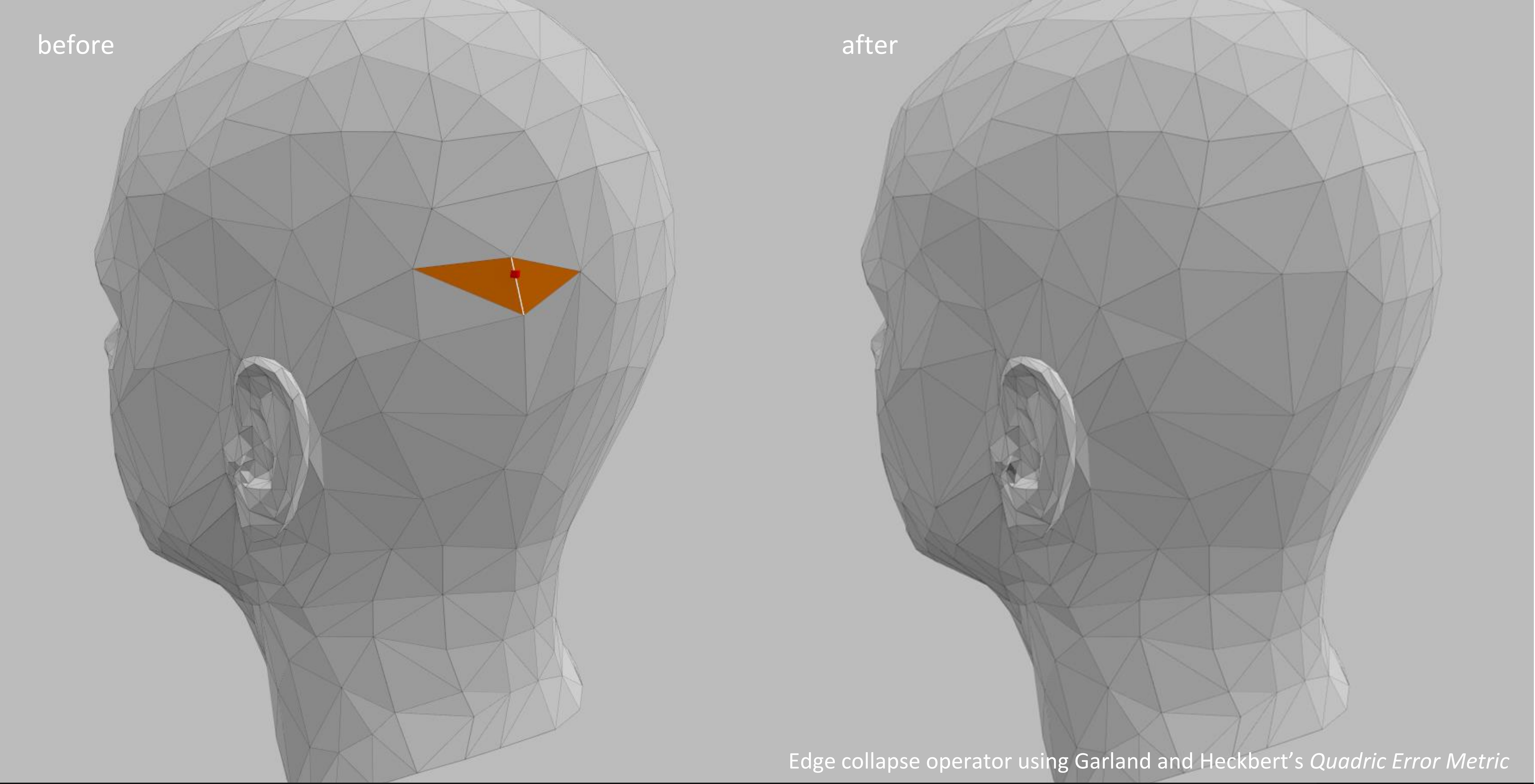
1. Topology
2. Priority
3. Symmetry
4. Results

Topology

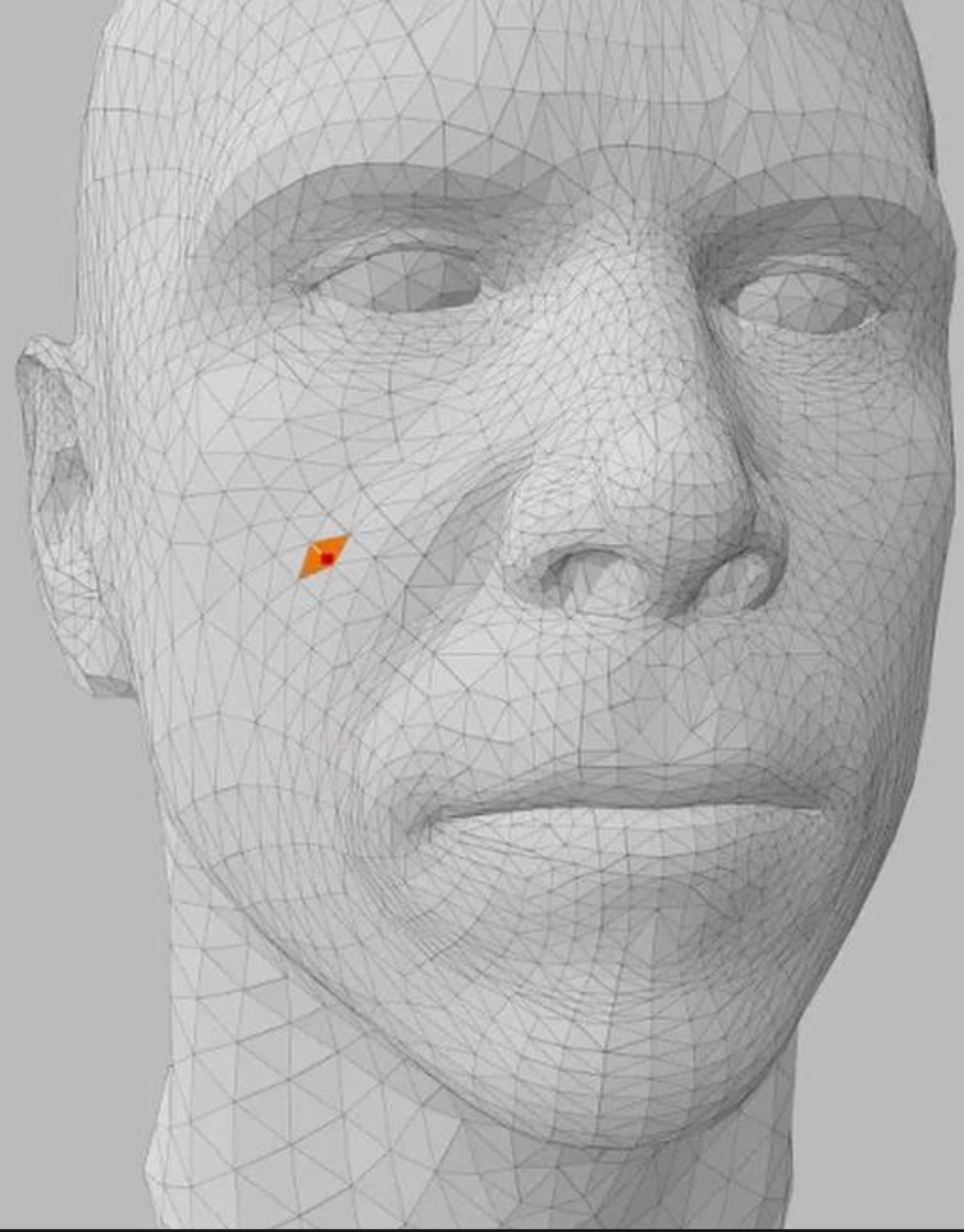




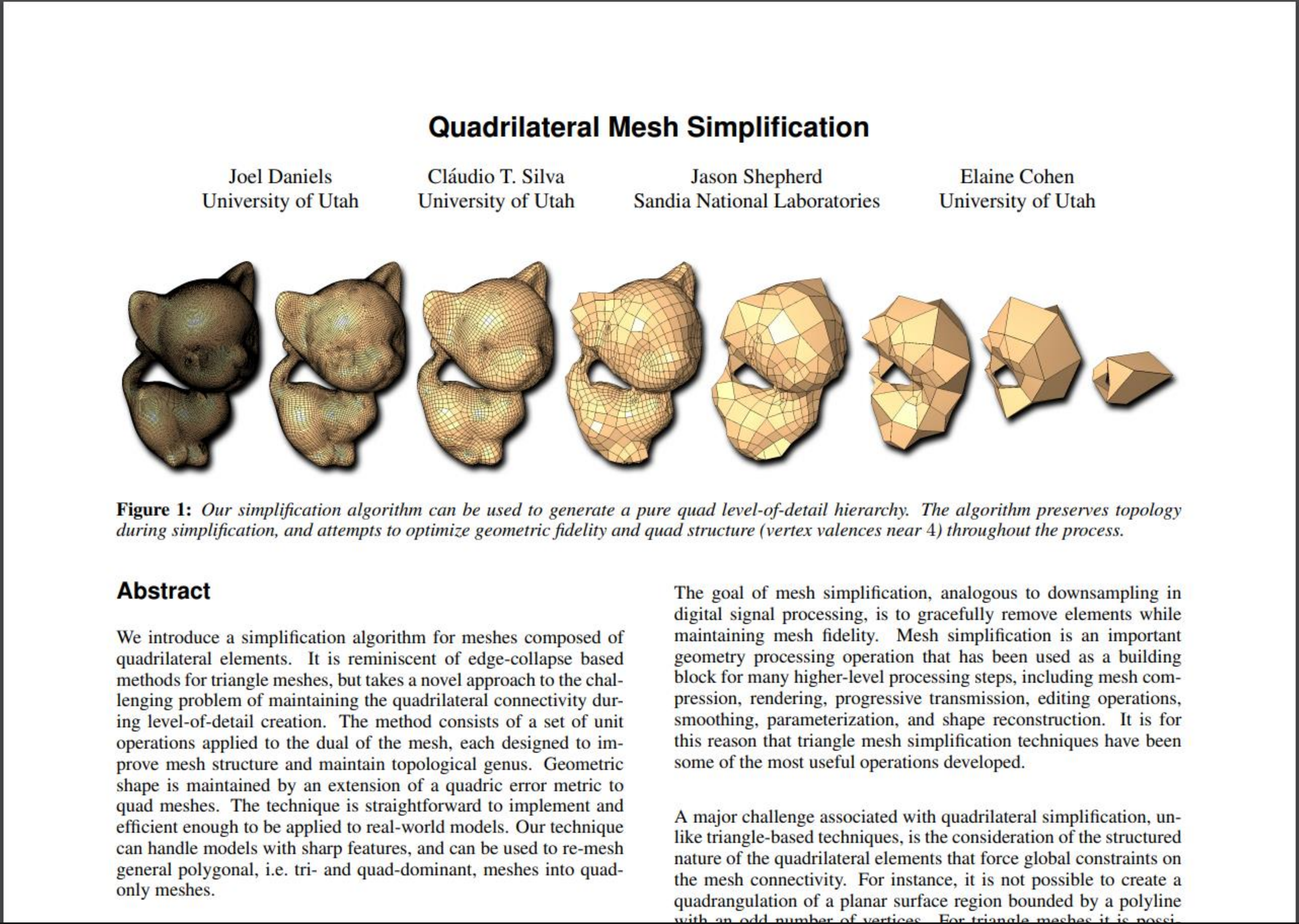
Traditional generated LODs



Edge collapse operator using Garland and Heckbert's *Quadric Error Metric*



Edge collapse candidates on a priority queue sorted by cost



Quadrilateral Mesh Simplification

Joel Daniels
University of Utah

Cláudio T. Silva
University of Utah

Jason Shepherd
Sandia National Laboratories

Elaine Cohen
University of Utah

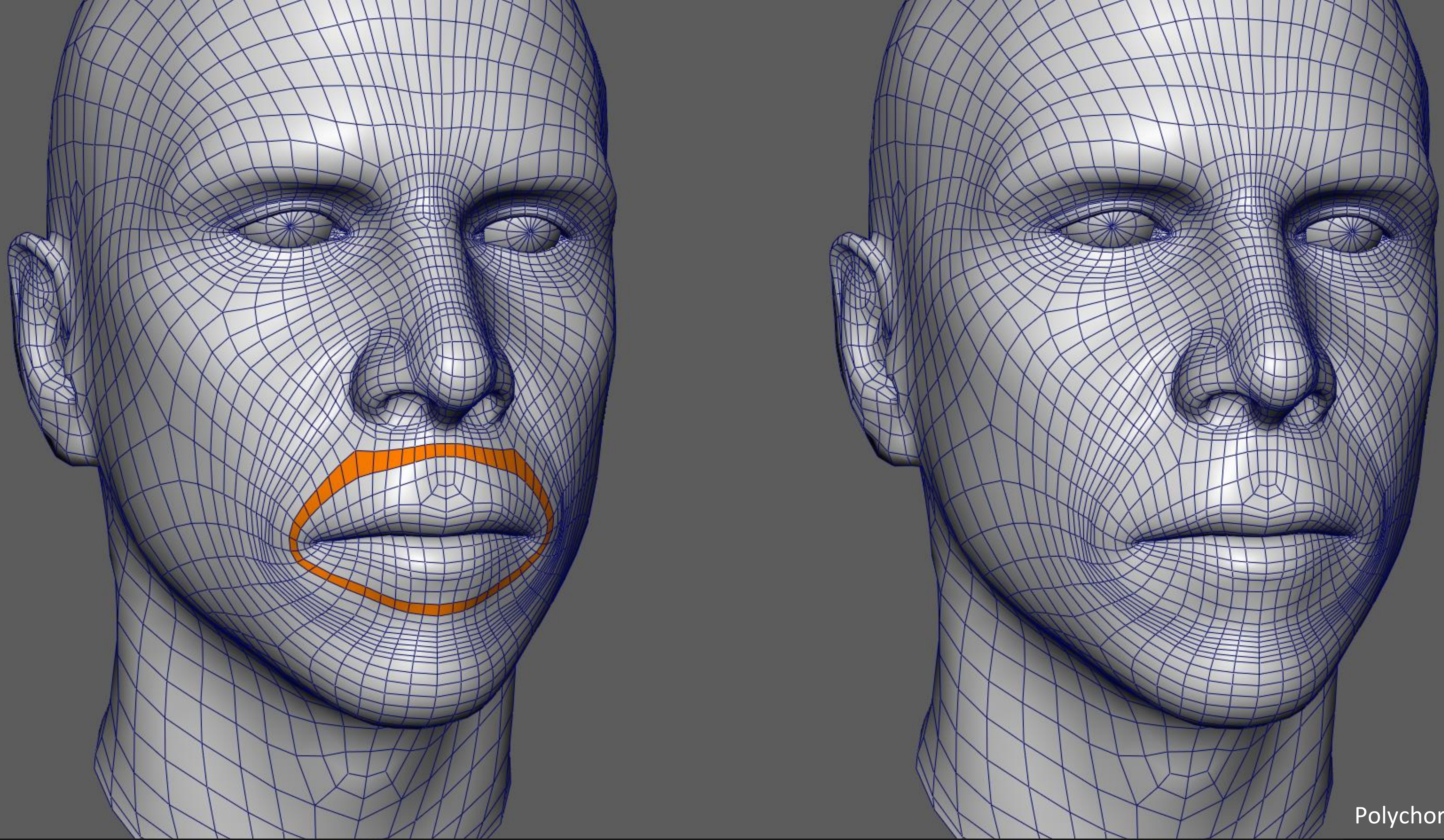
Figure 1: *Our simplification algorithm can be used to generate a pure quad level-of-detail hierarchy. The algorithm preserves topology during simplification, and attempts to optimize geometric fidelity and quad structure (vertex valences near* 4*) throughout the process.*

Abstract

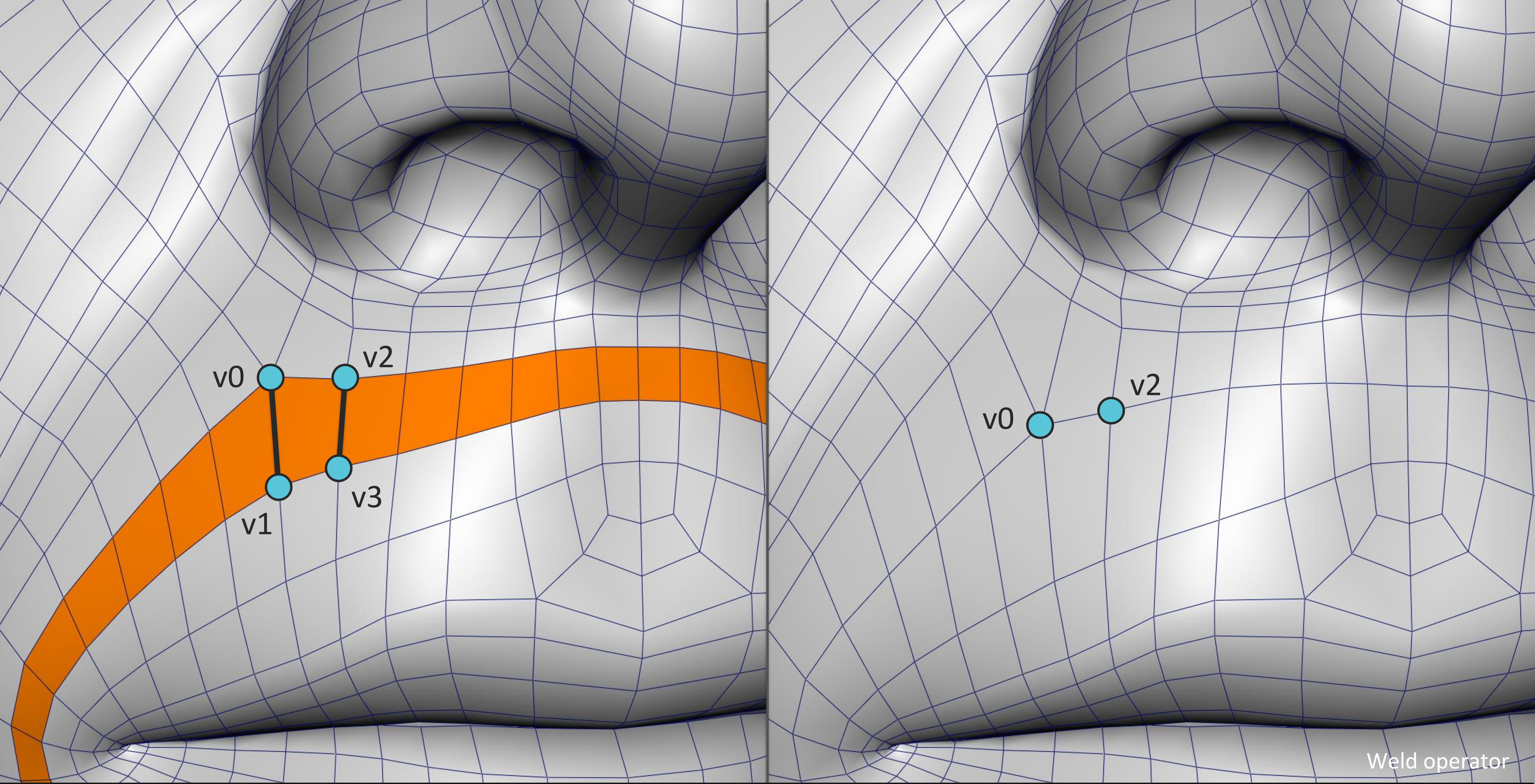
We introduce a simplification algorithm for meshes composed of quadrilateral elements. It is reminiscent of edge-collapse based methods for triangle meshes, but takes a novel approach to the challenging problem of maintaining the quadrilateral connectivity during level-of-detail creation. The method consists of a set of unit operations applied to the dual of the mesh, each designed to improve mesh structure and maintain topological genus. Geometric shape is maintained by an extension of a quadric error metric to quad meshes. The technique is straightforward to implement and efficient enough to be applied to real-world models. Our technique can handle models with sharp features, and can be used to re-mesh general polygonal, i.e. tri- and quad-dominant, meshes into quad-only meshes.

The goal of mesh simplification, analogous to downsampling in digital signal processing, is to gracefully remove elements while maintaining mesh fidelity. Mesh simplification is an important geometry processing operation that has been used as a building block for many higher-level processing steps, including mesh compression, rendering, progressive transmission, editing operations, smoothing, parameterization, and shape reconstruction. It is for this reason that triangle mesh simplification techniques have been some of the most useful operations developed.

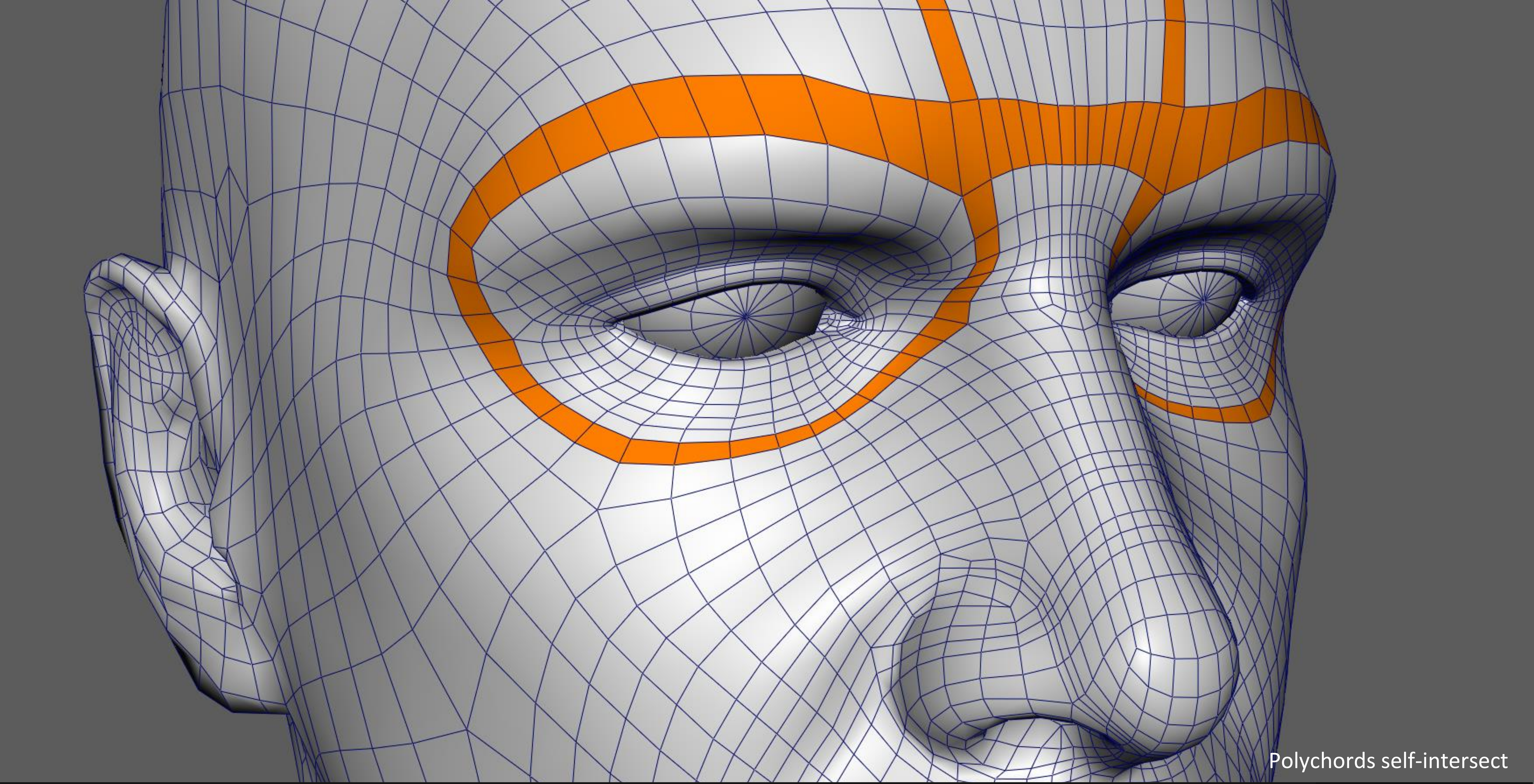
A major challenge associated with quadrilateral simplification, unlike triangle-based techniques, is the consideration of the structured nature of the quadrilateral elements that force global constraints on the mesh connectivity. For instance, it is not possible to create a quadrangulation of a planar surface region bounded by a polyline with an odd number of vertices. For triangle meshes it is possi-



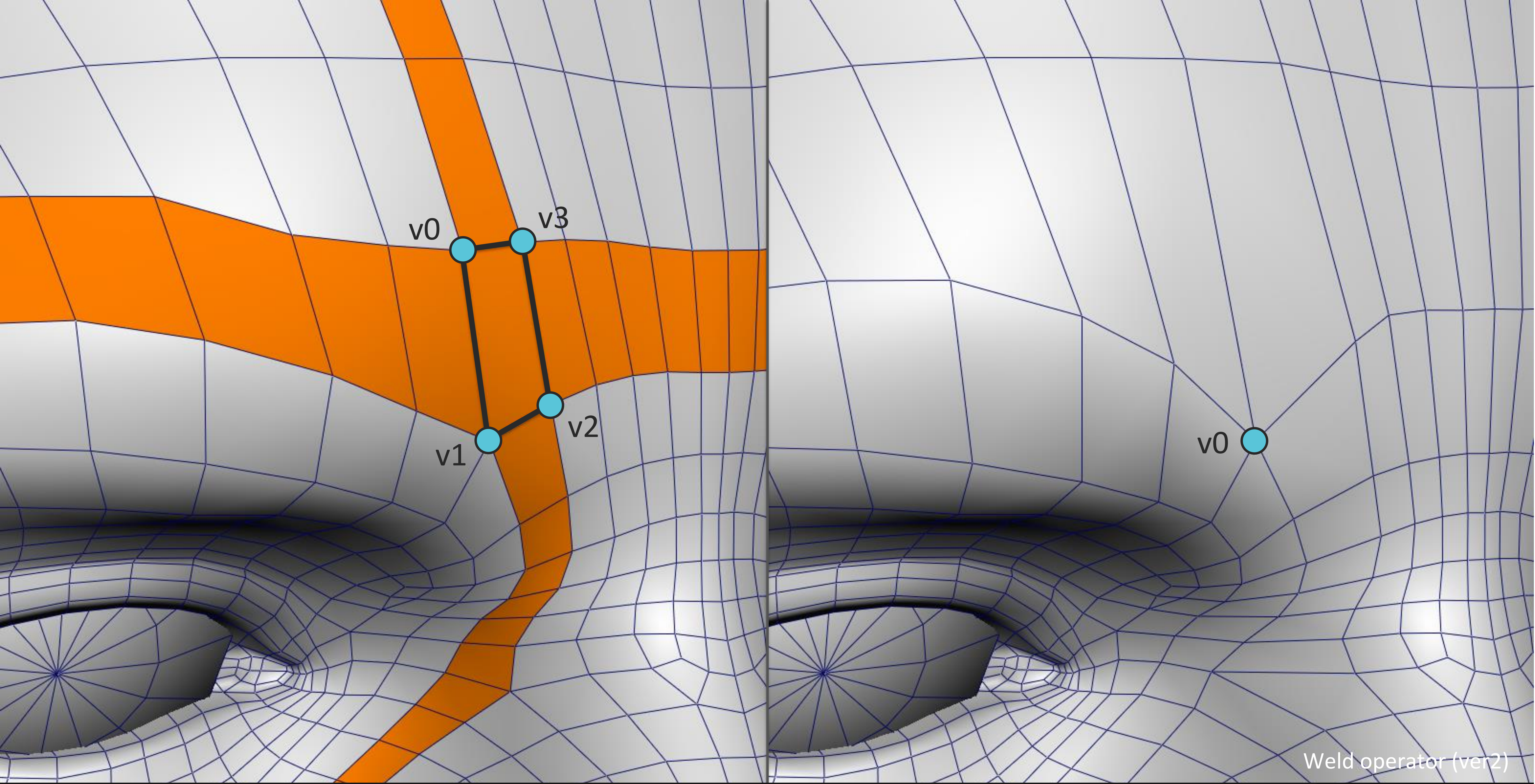
Polychord collapse



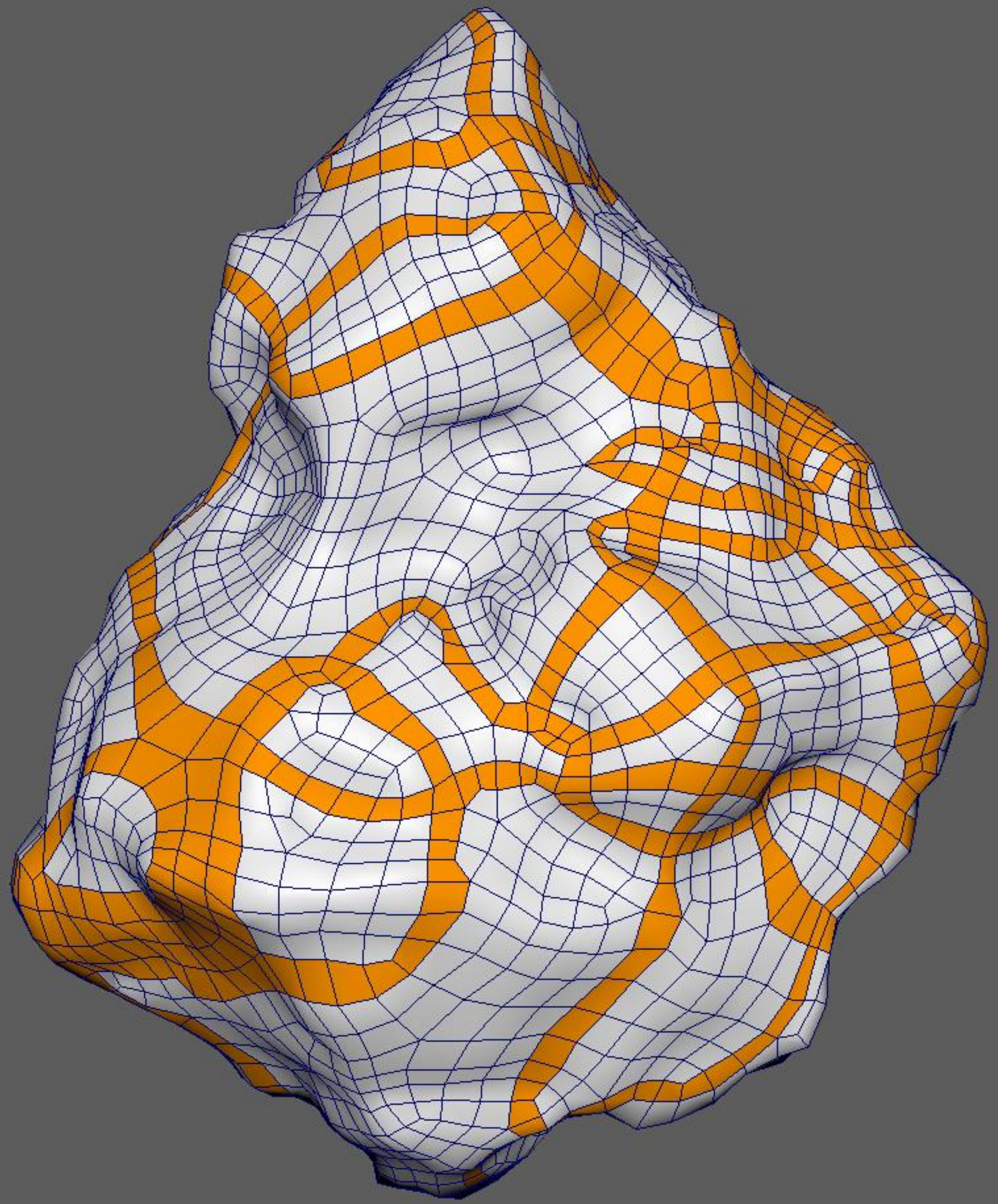
Weld operator



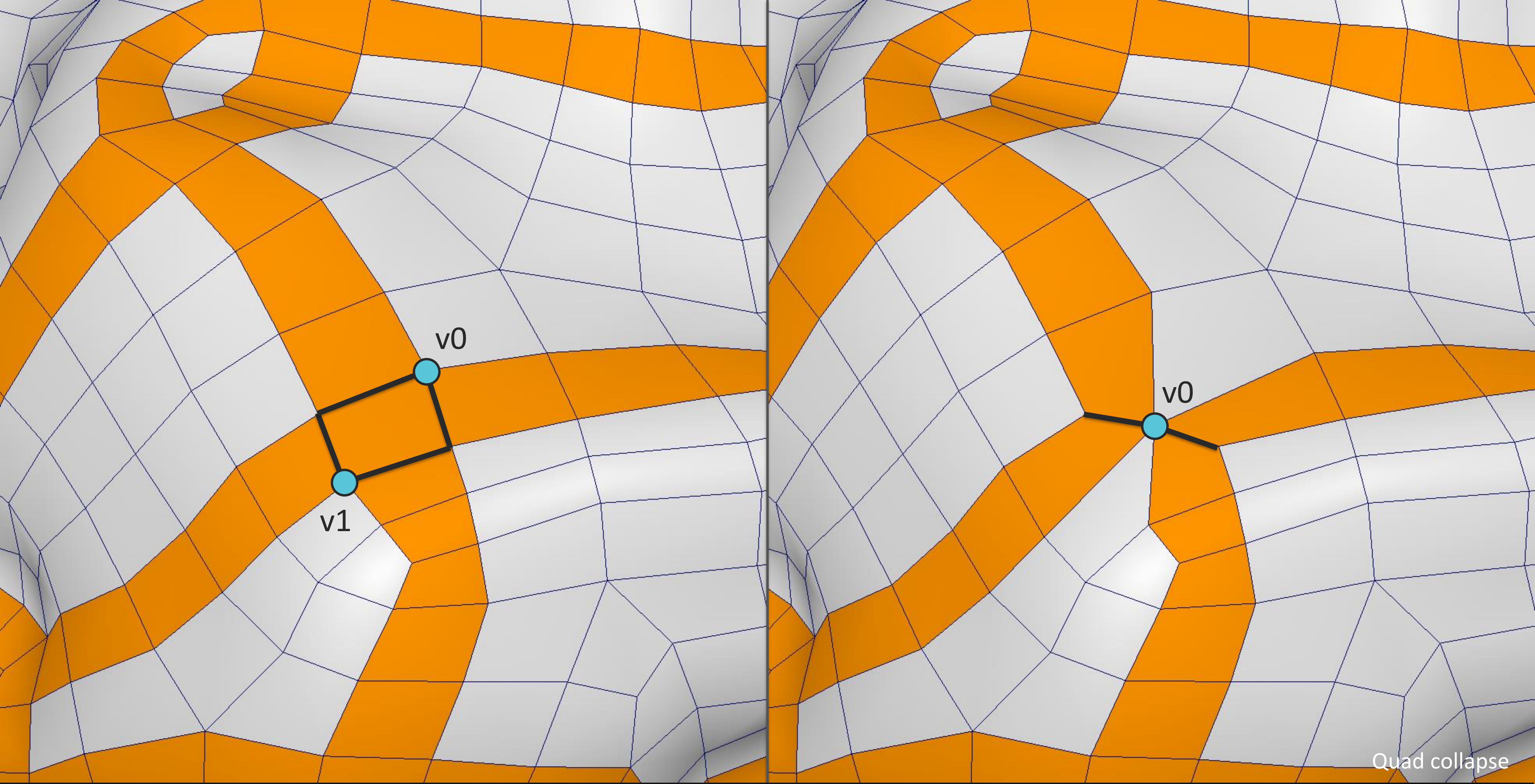
Polychords self-intersect



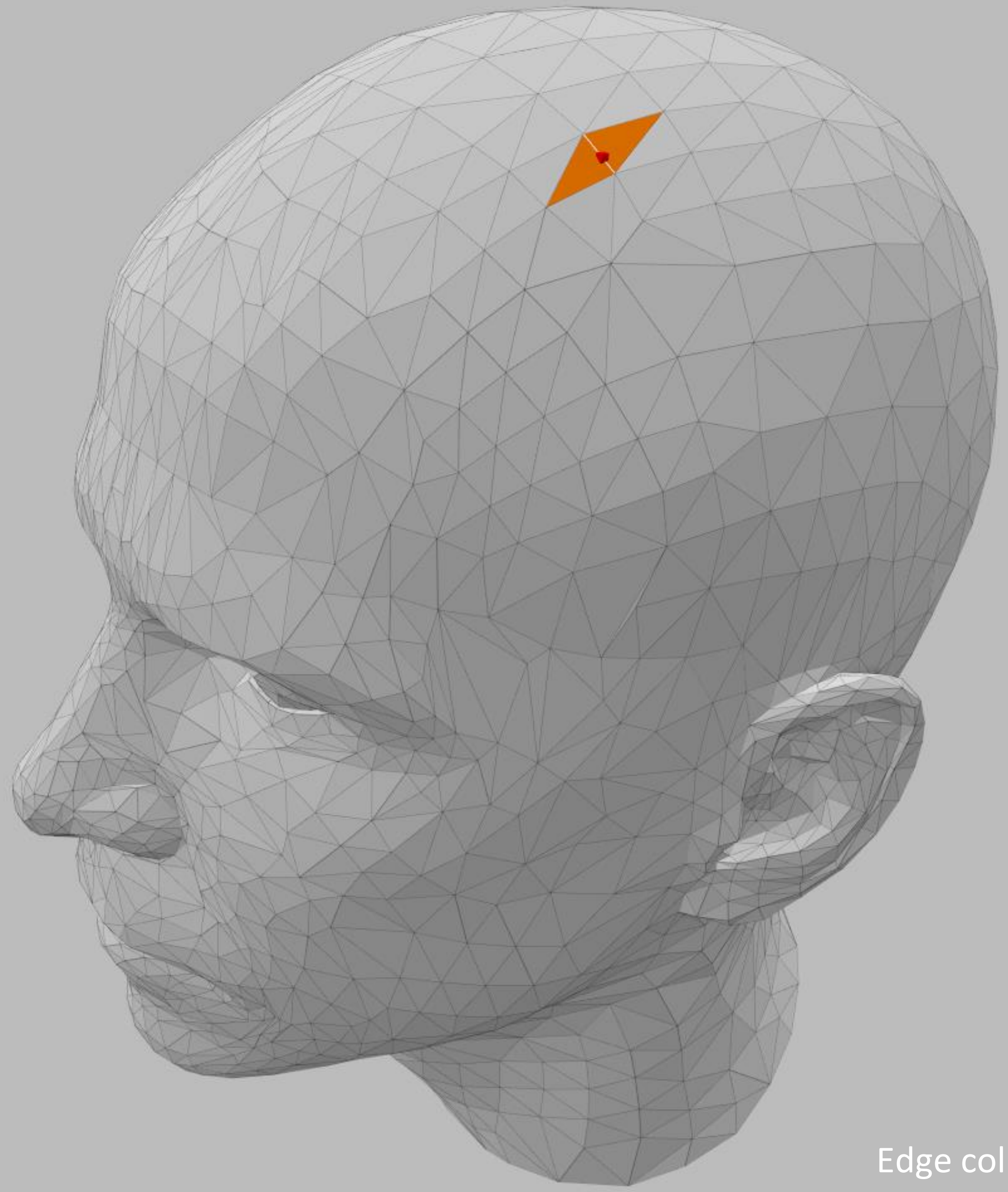
Weld operator (ver2)



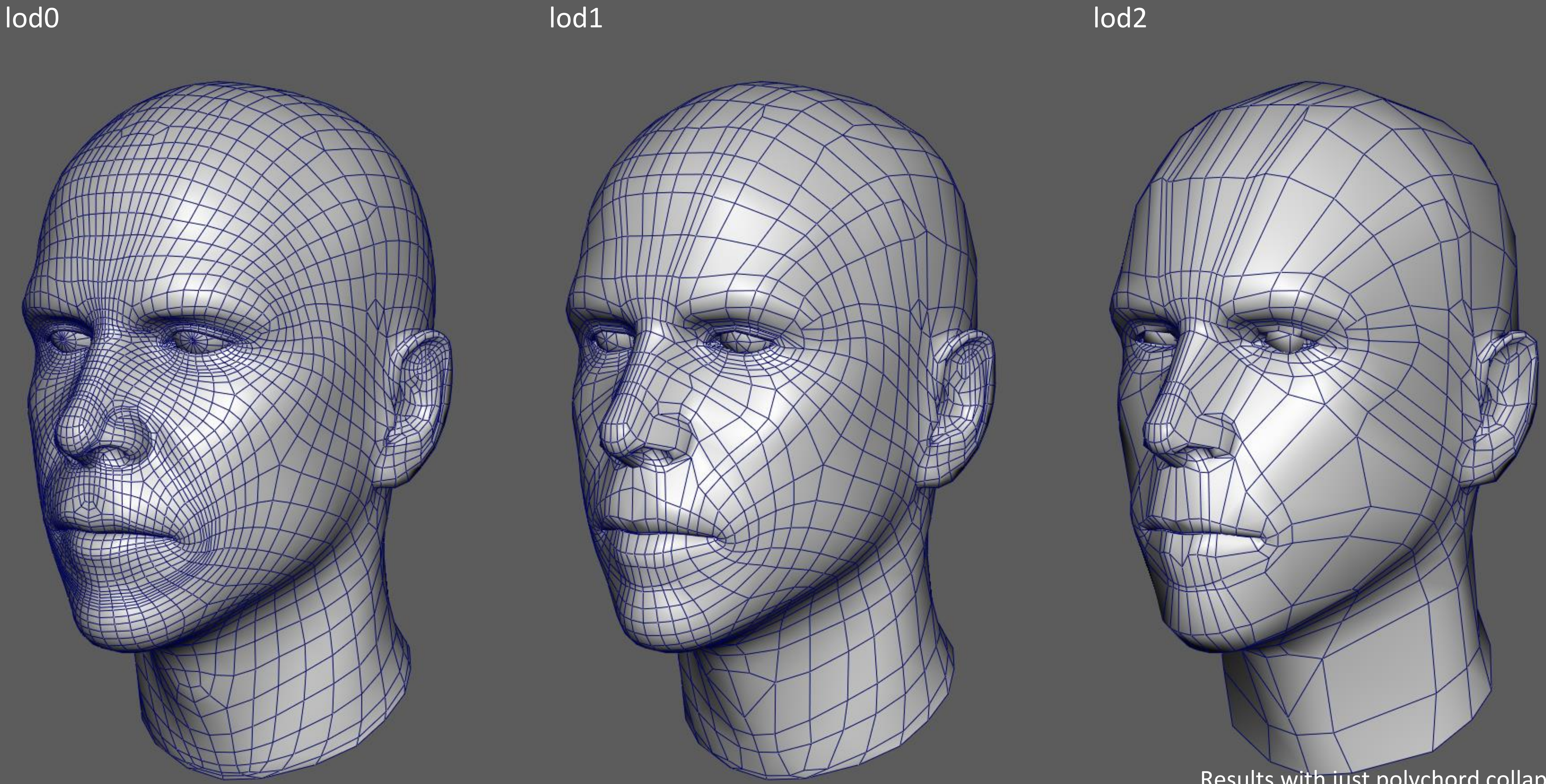
One long polychord



Quad collapse



Edge collapse is just a special case



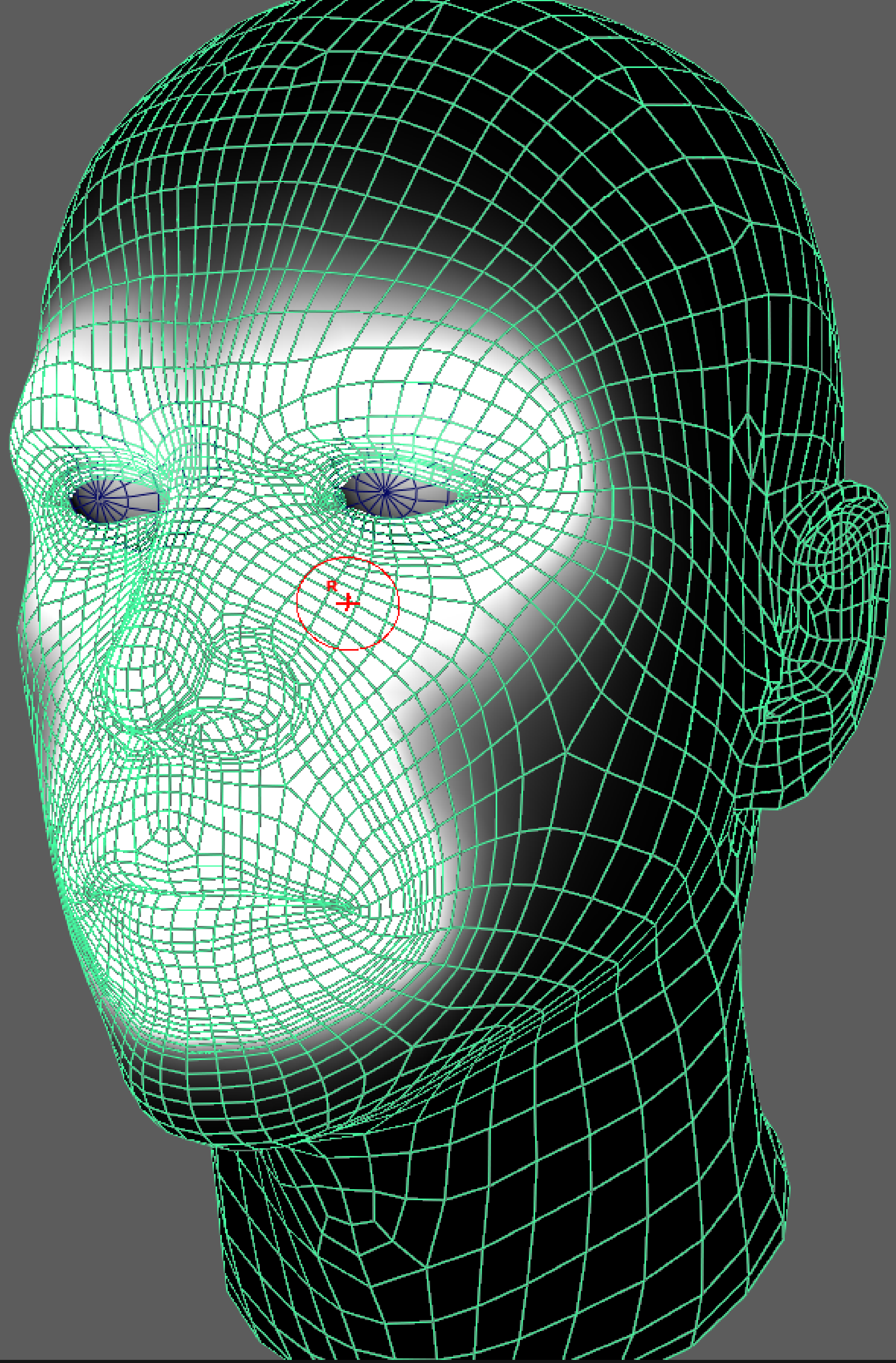
lod0

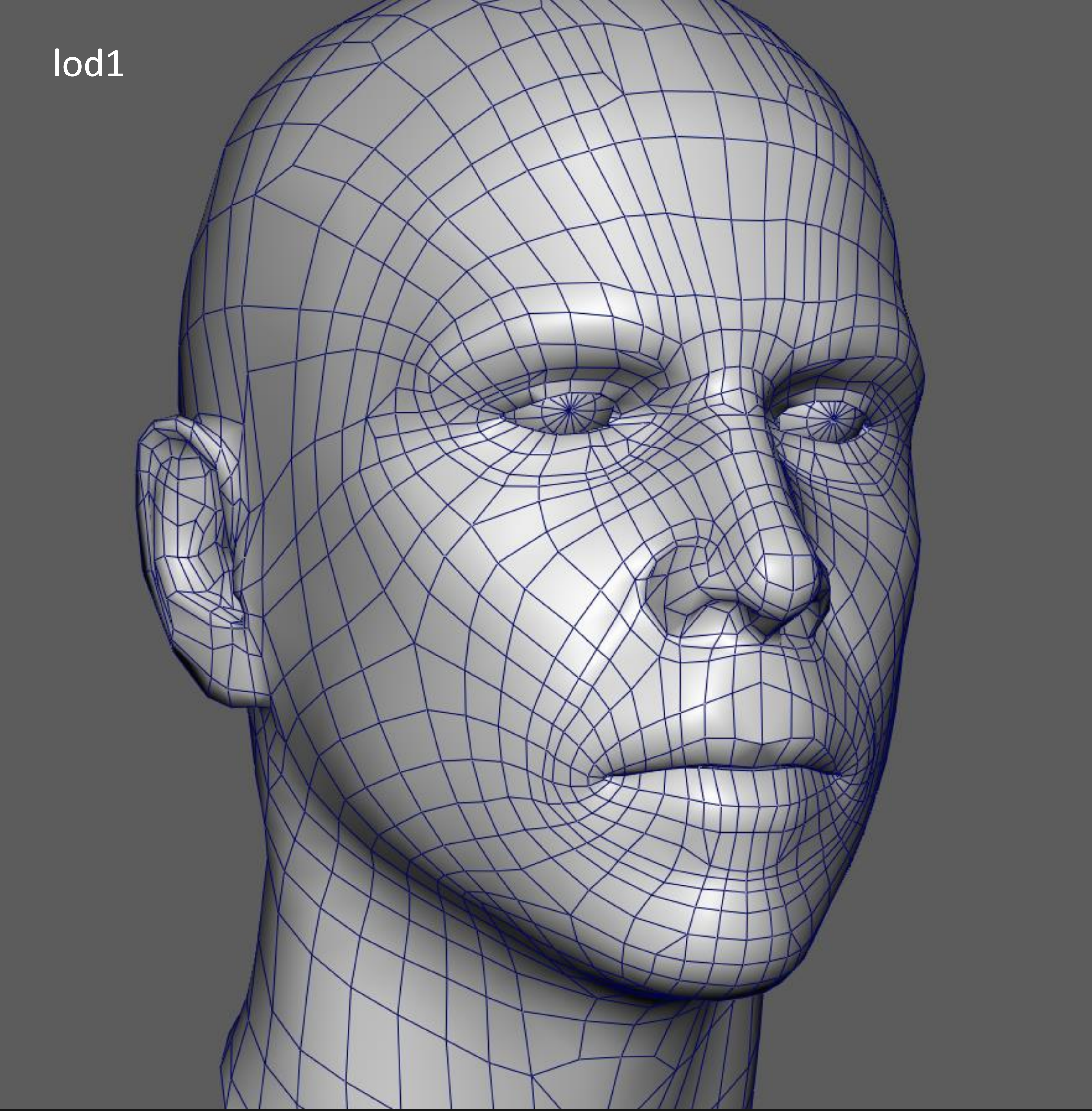
lod1

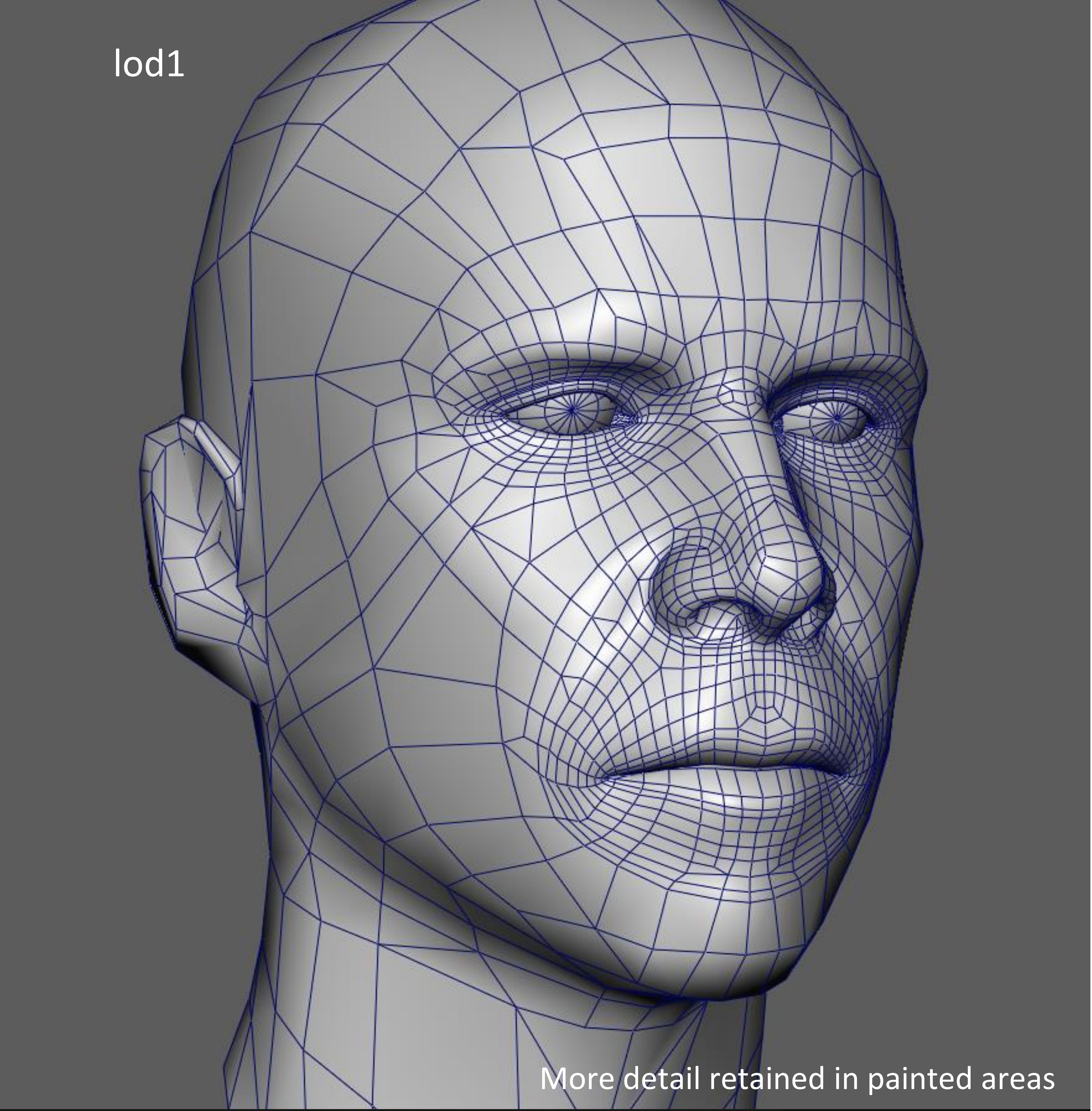
lod2

Results with just polychord collapse

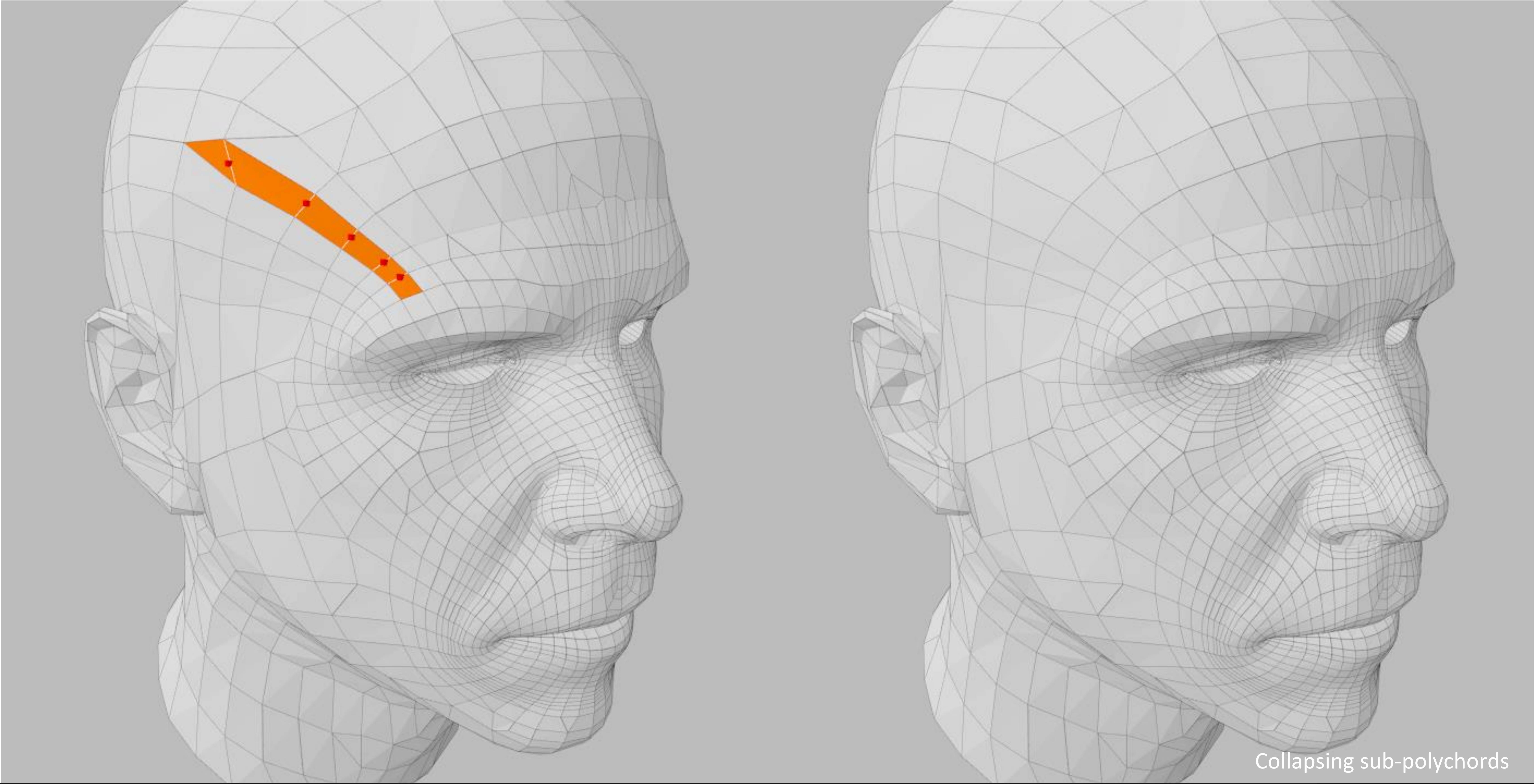
Priority



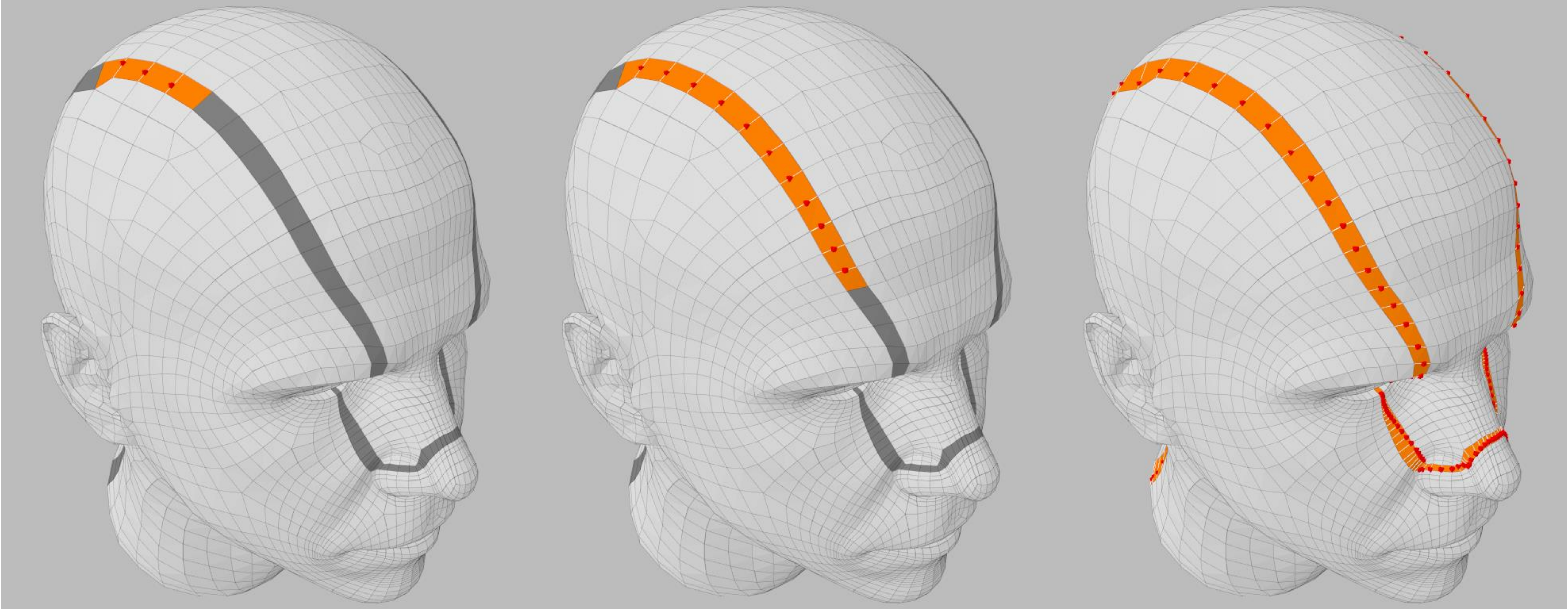




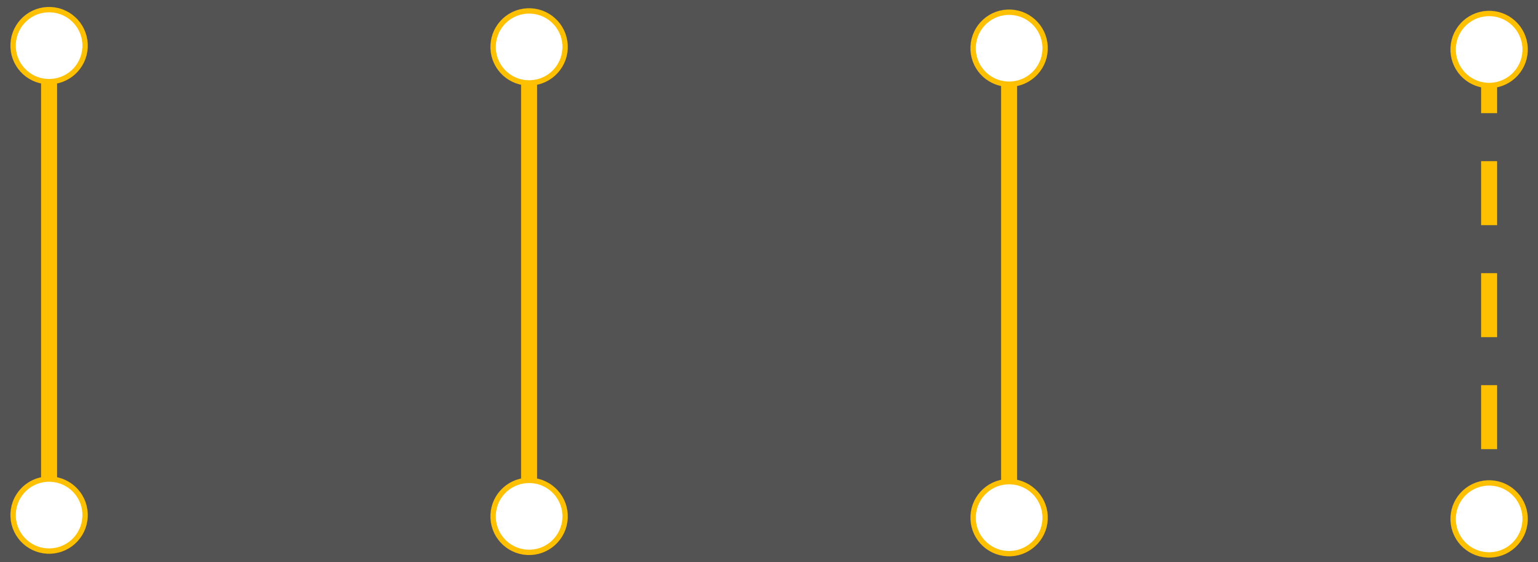
More detail retained in painted areas



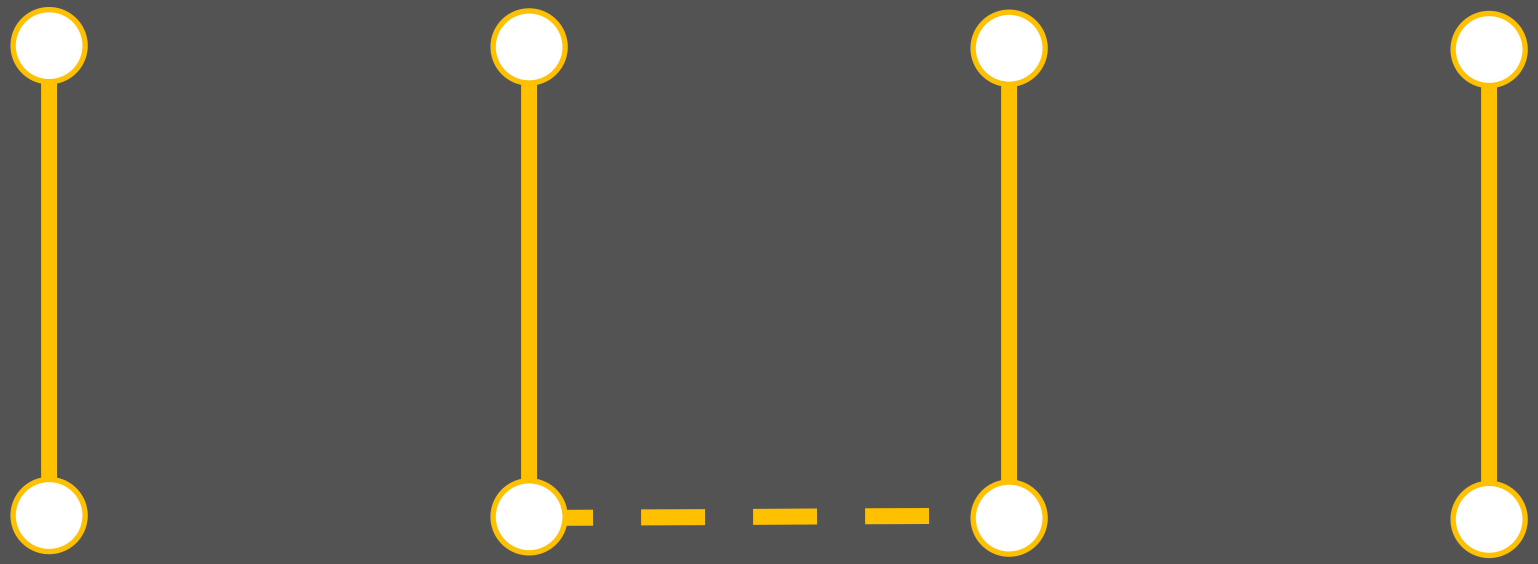
Collapsing sub-polychords



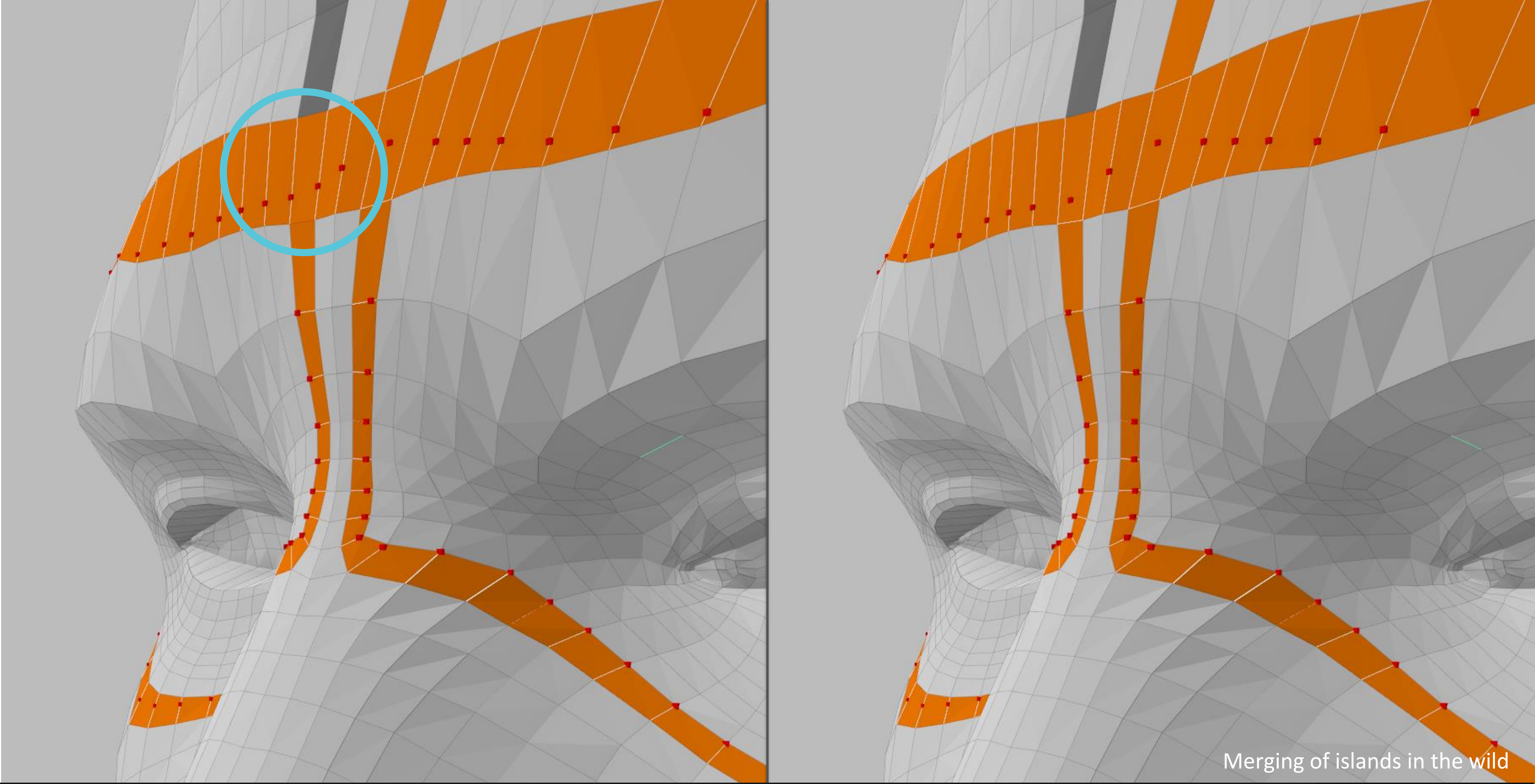
Greedy sub-polychord search



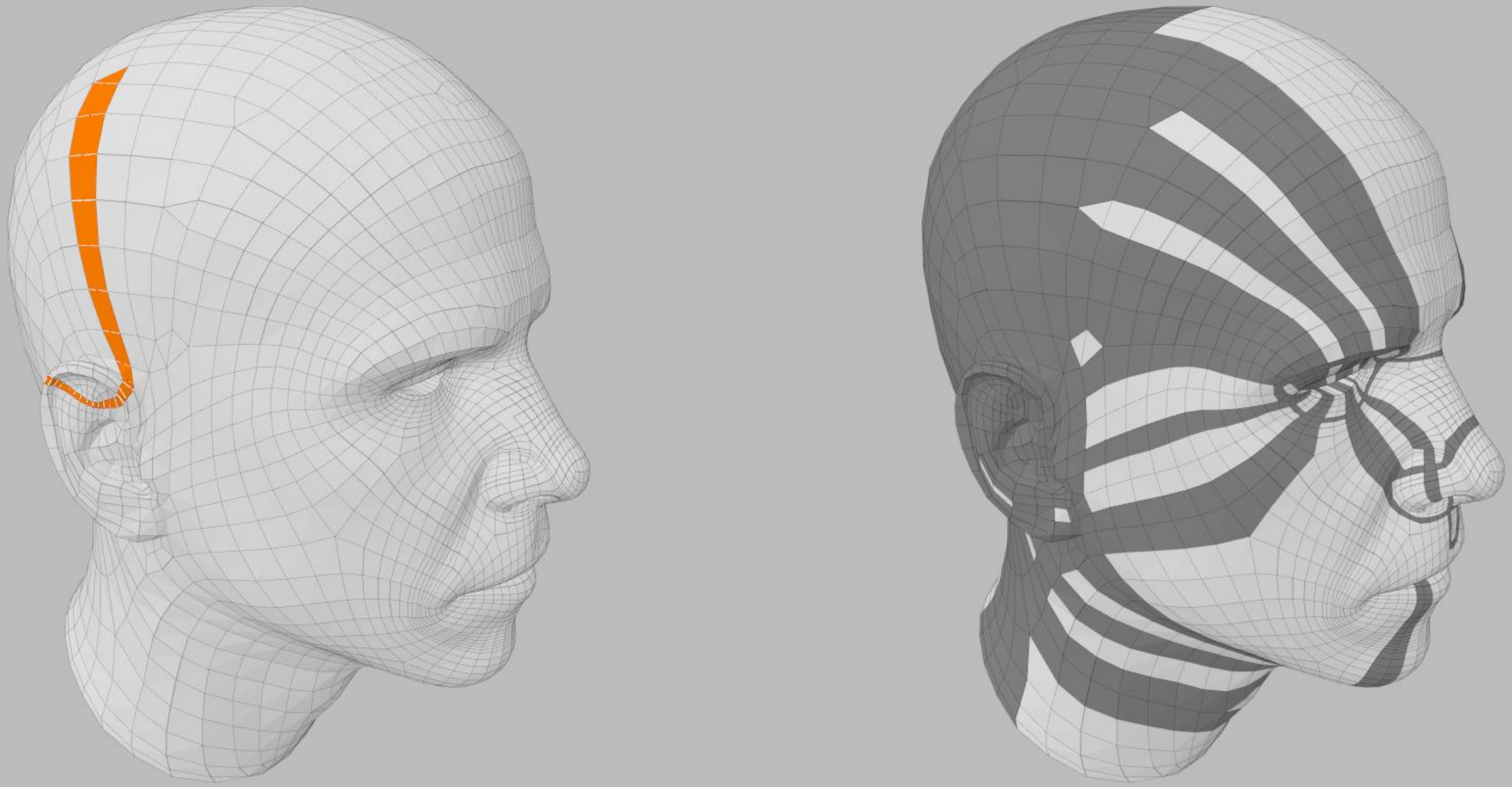
Incremental update of collapse data structure



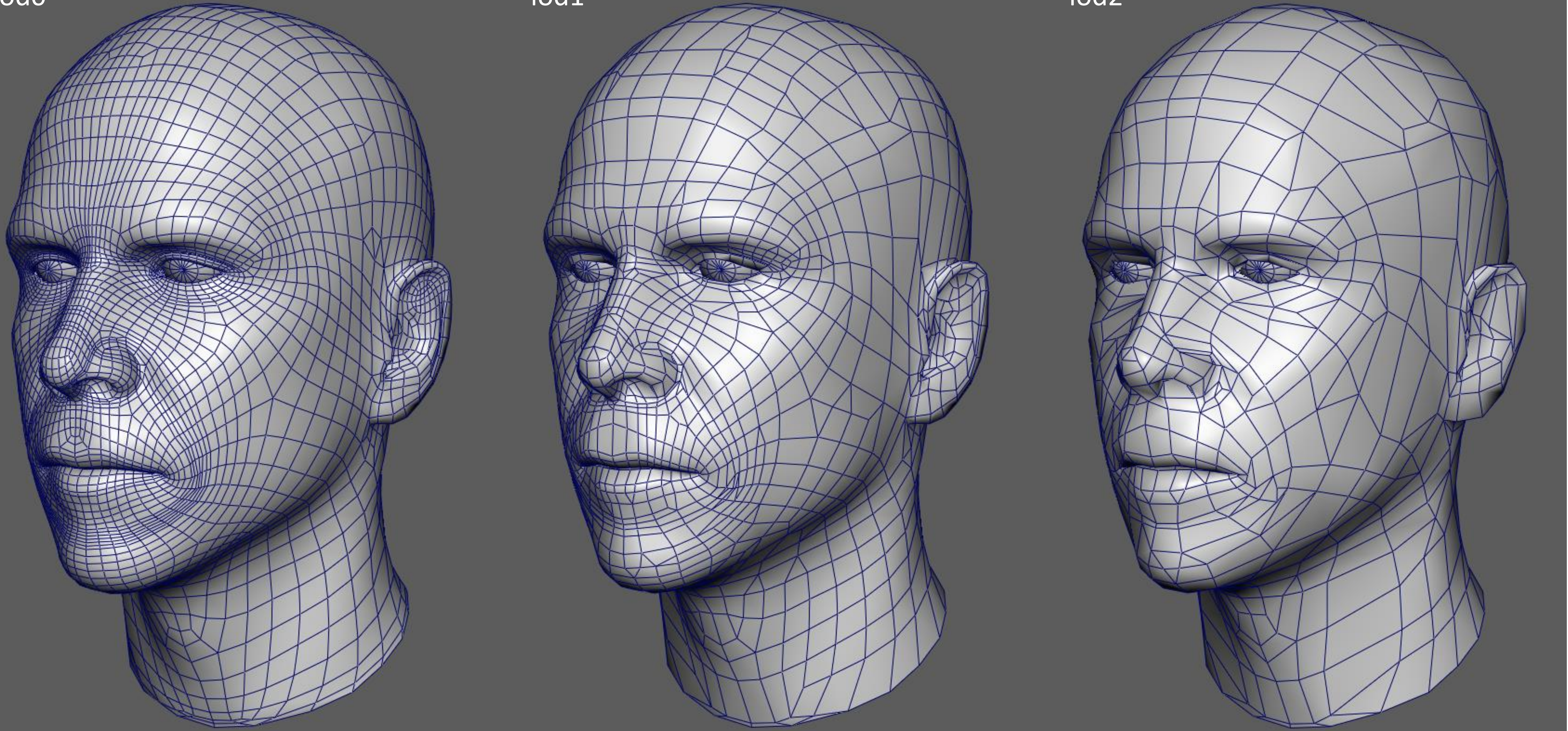
New edge causes existing islands to merge



Merging of islands in the wild



Incremental update of nearby collapse candidates



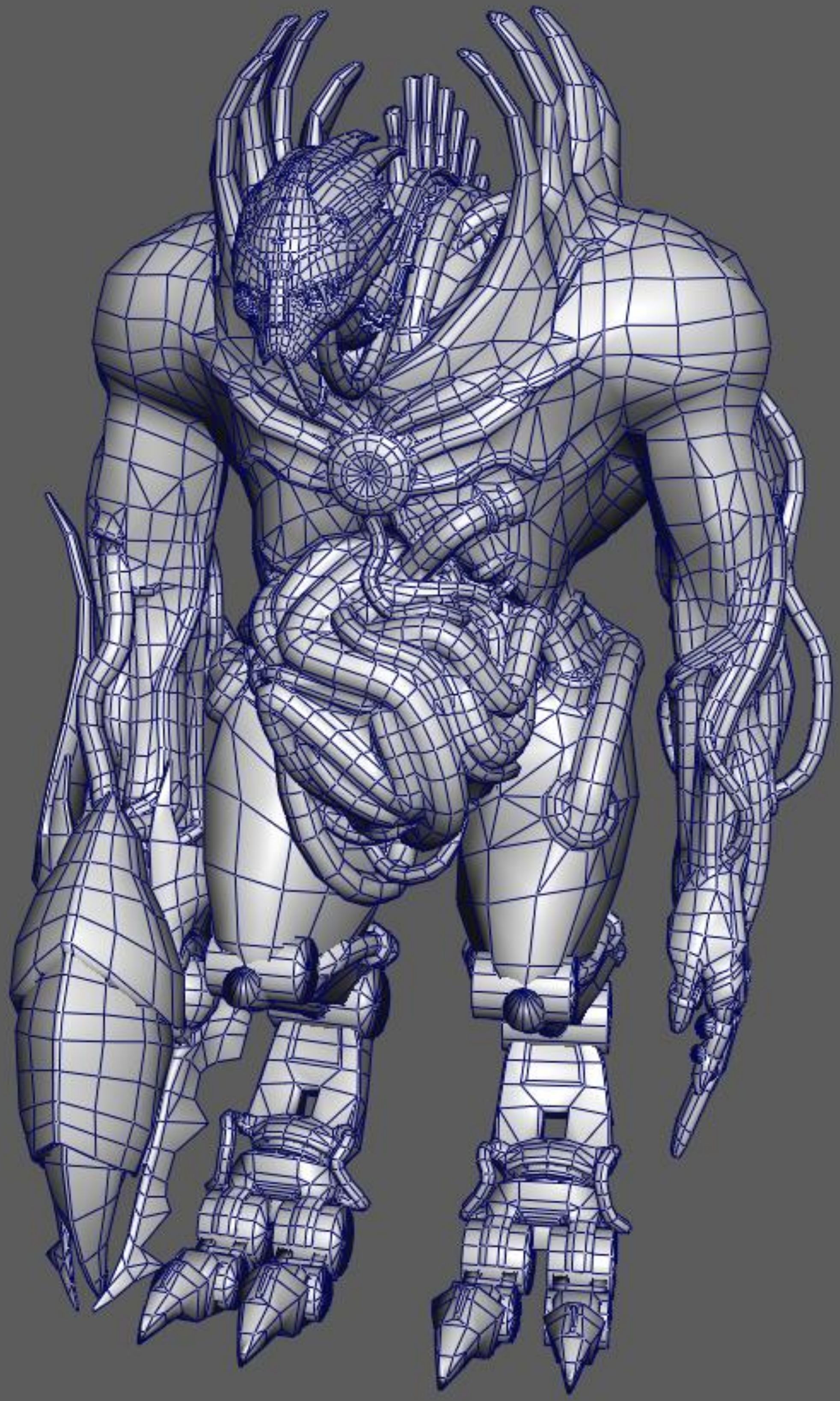
lod0

lod1

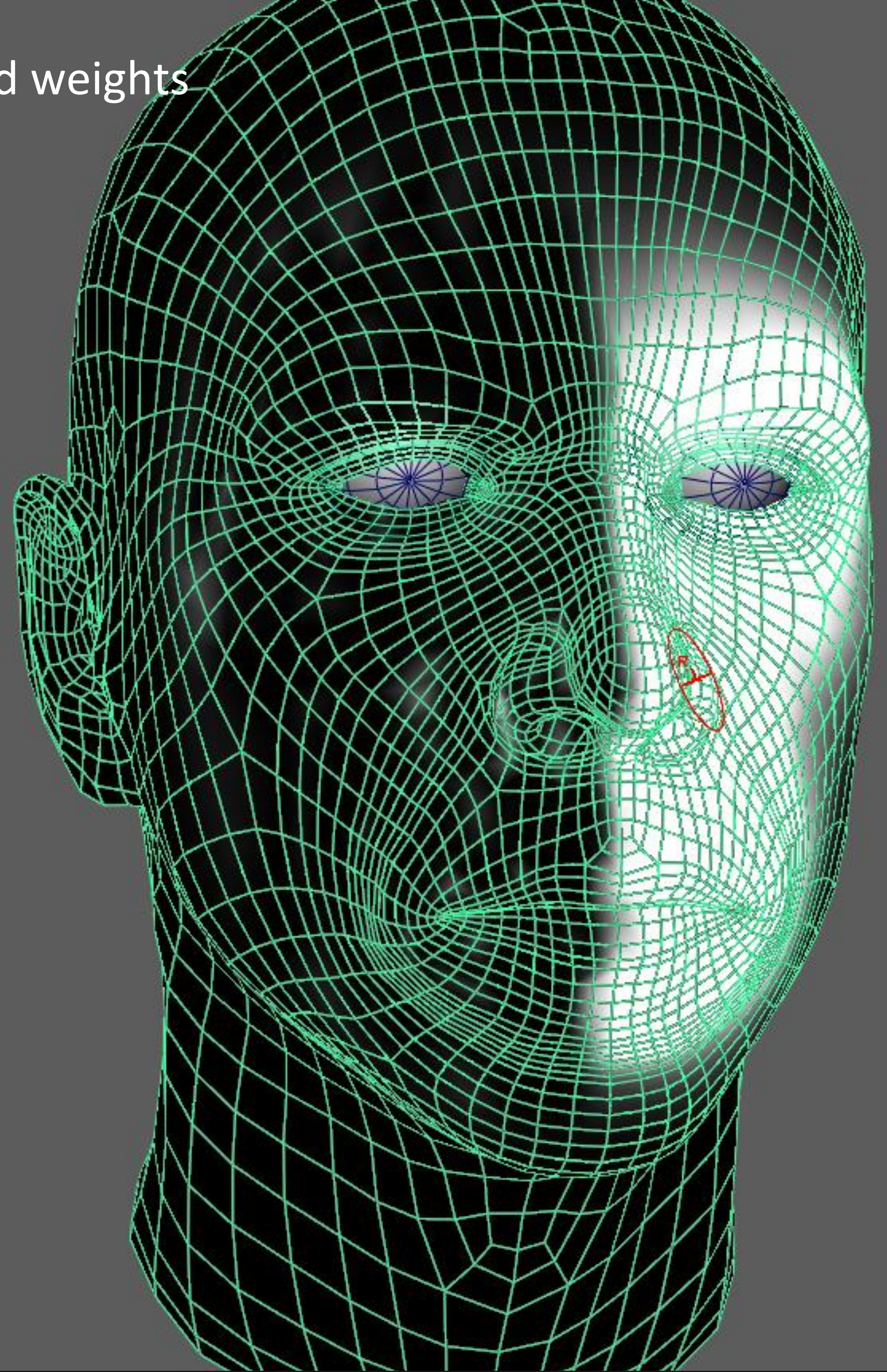
lod2

Results with sub-polychord collapse

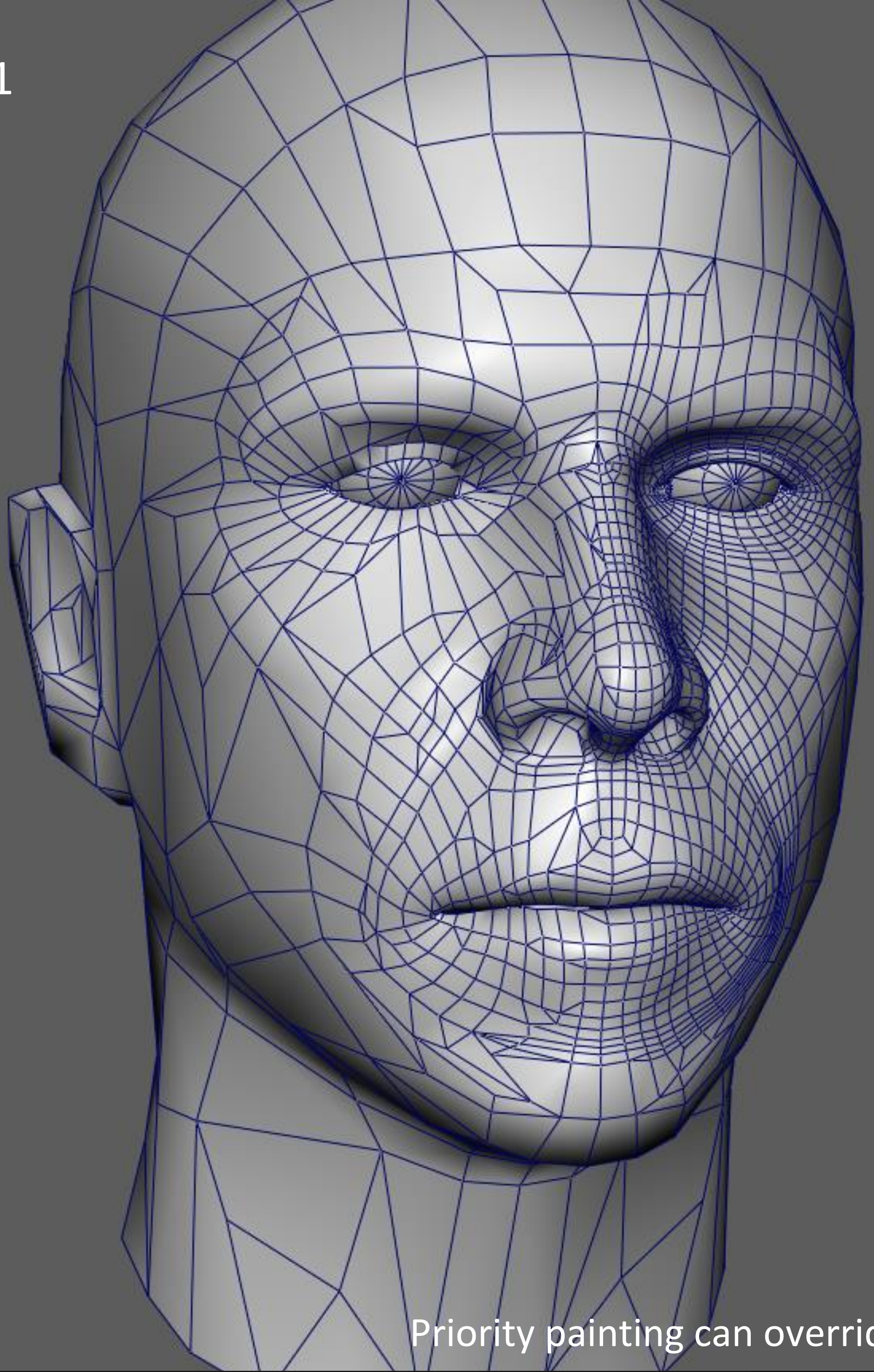
Symmetry



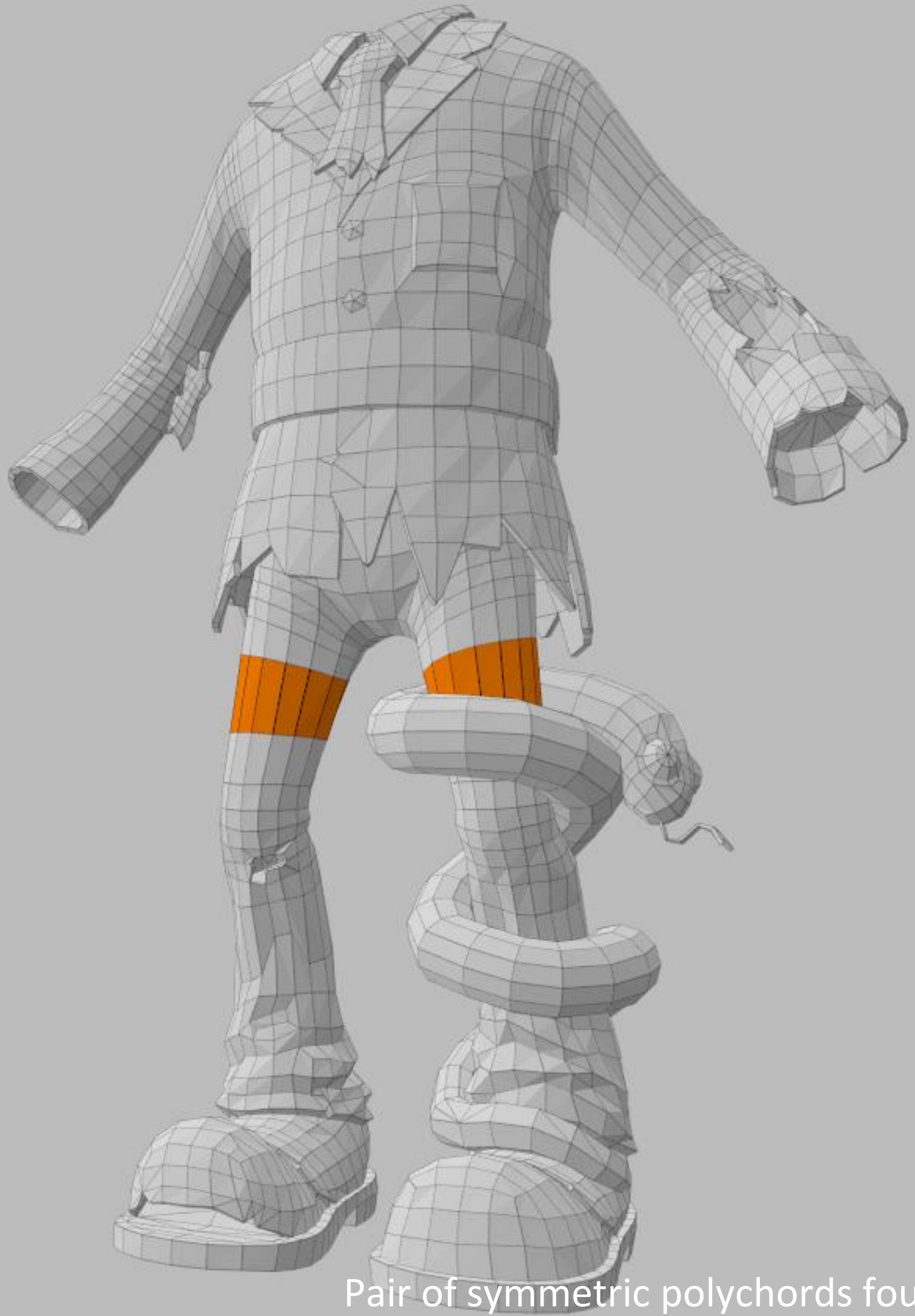
painted weights



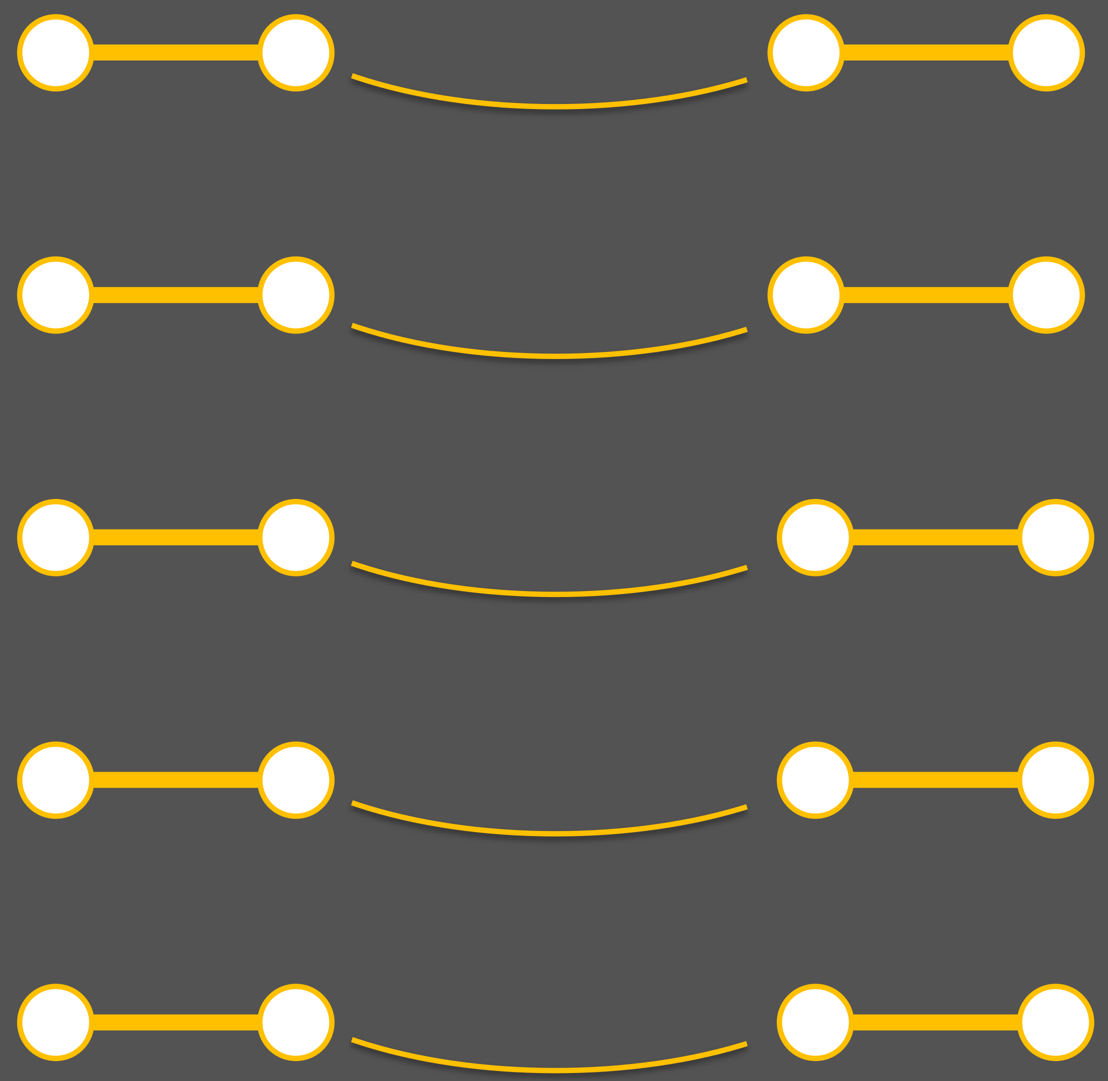
lod1



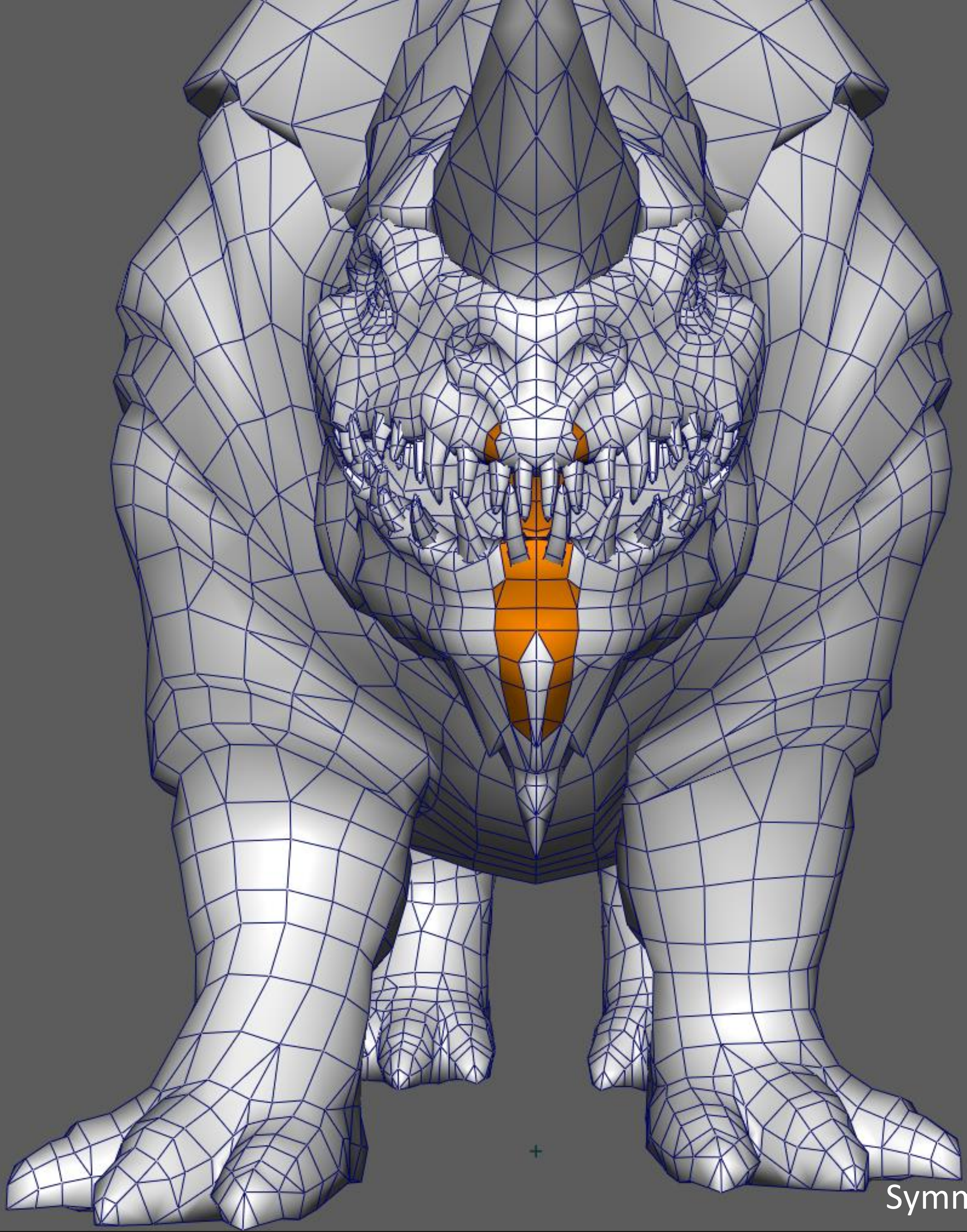
Priority painting can override symmetry



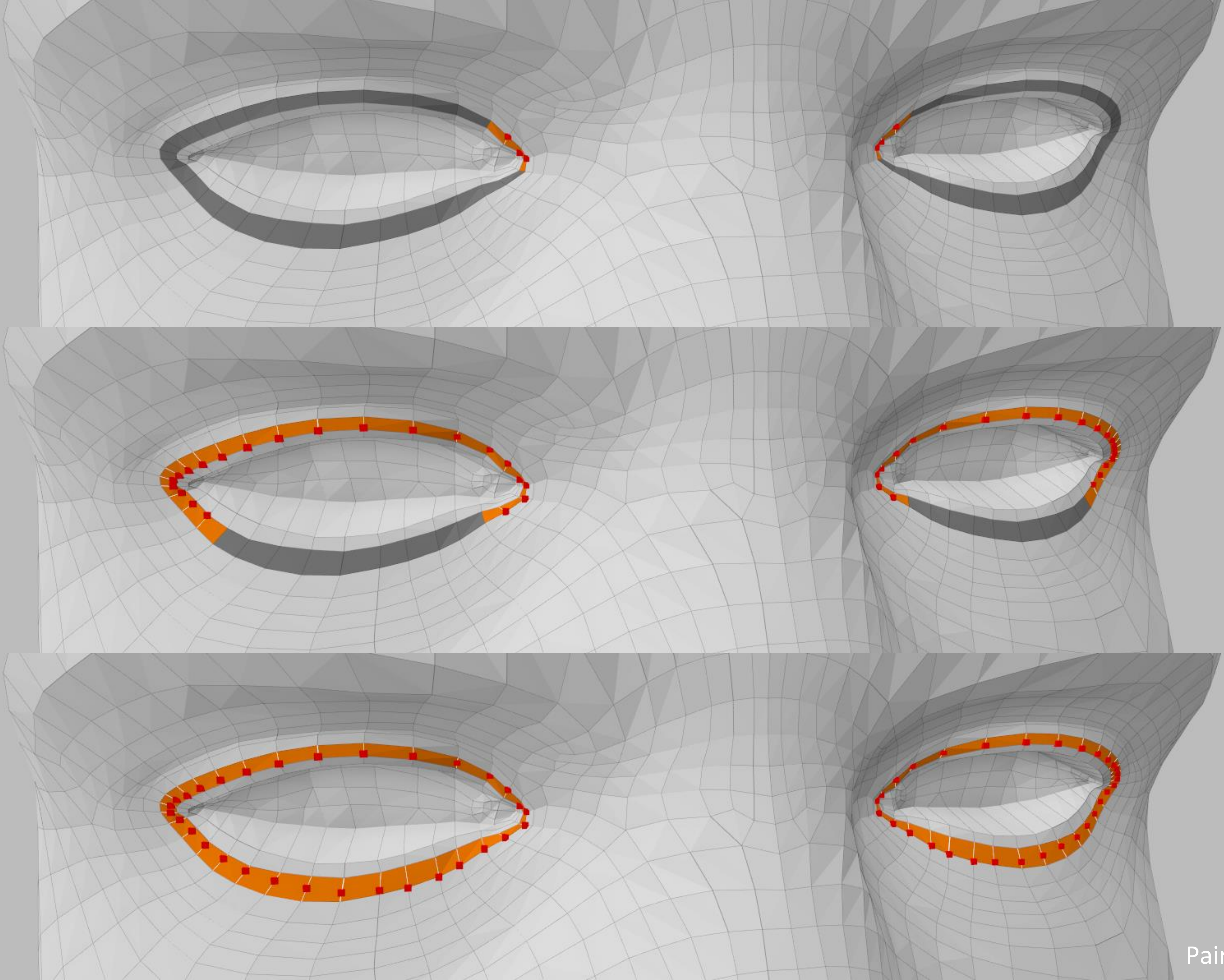
Pair of symmetric polychords found by symmetry identification



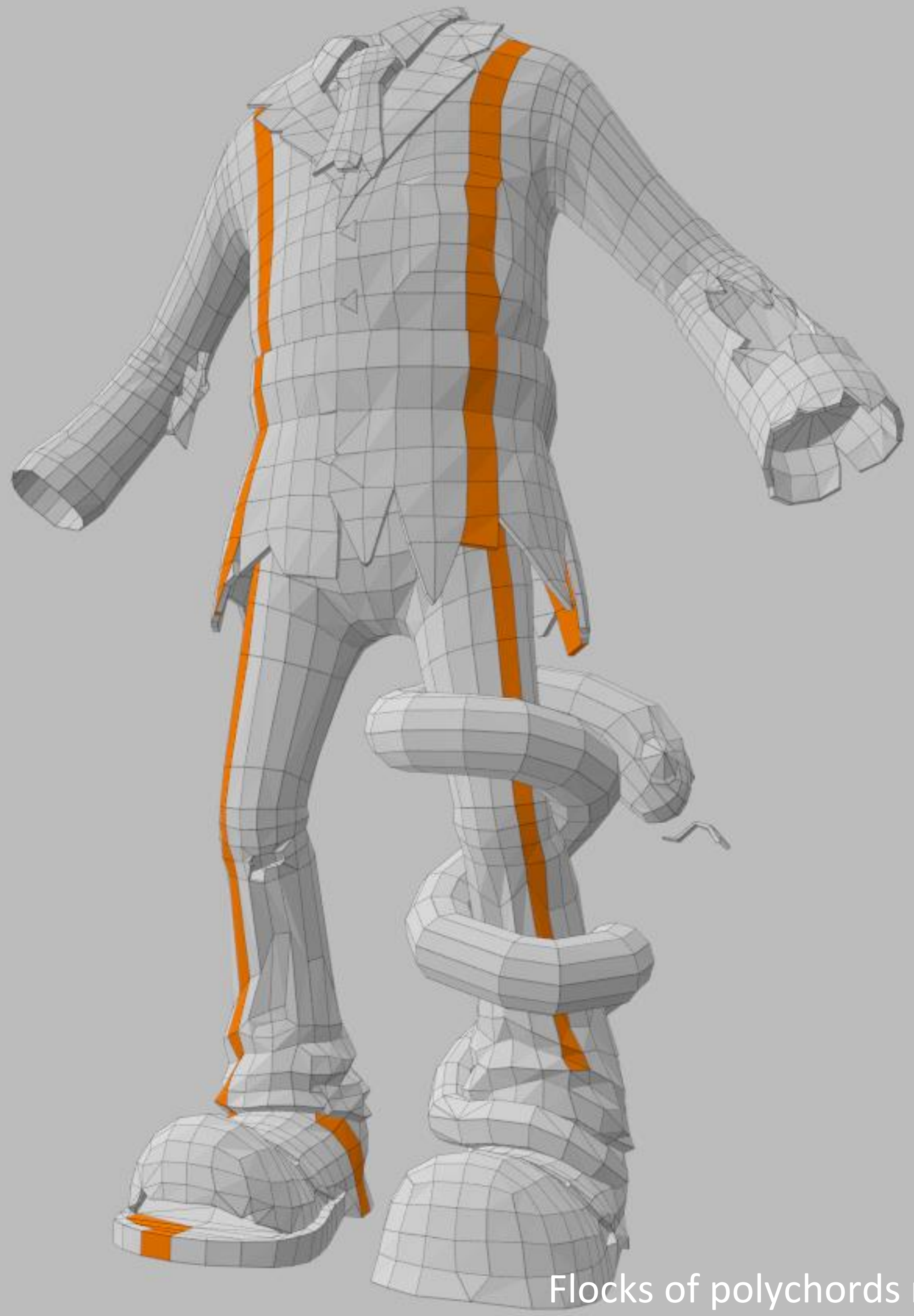
Result of symmetry identification is a per-edge symmetry map



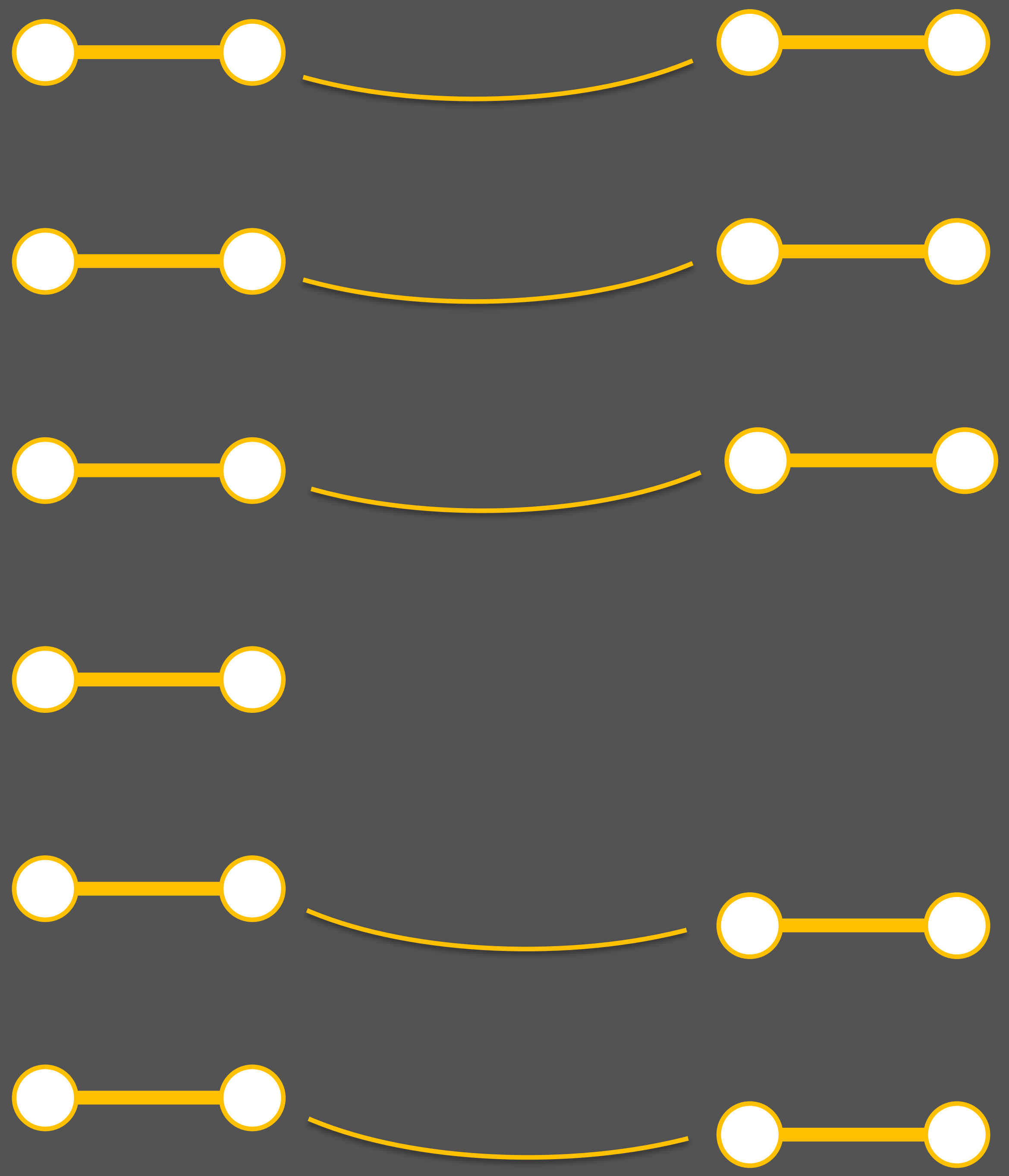
Symmetric polychords should be collapsed atomically



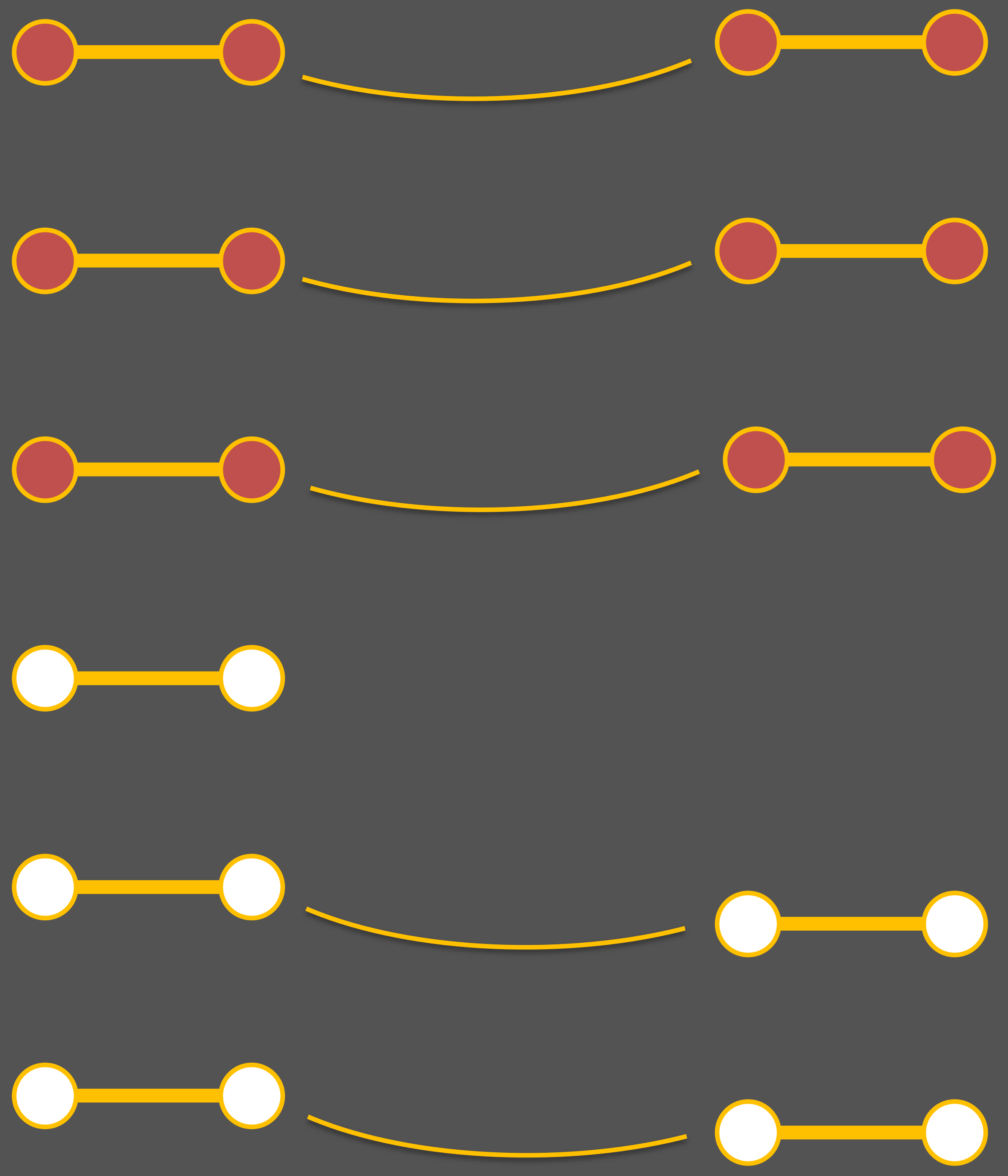
Pair-wise sub-polychord search



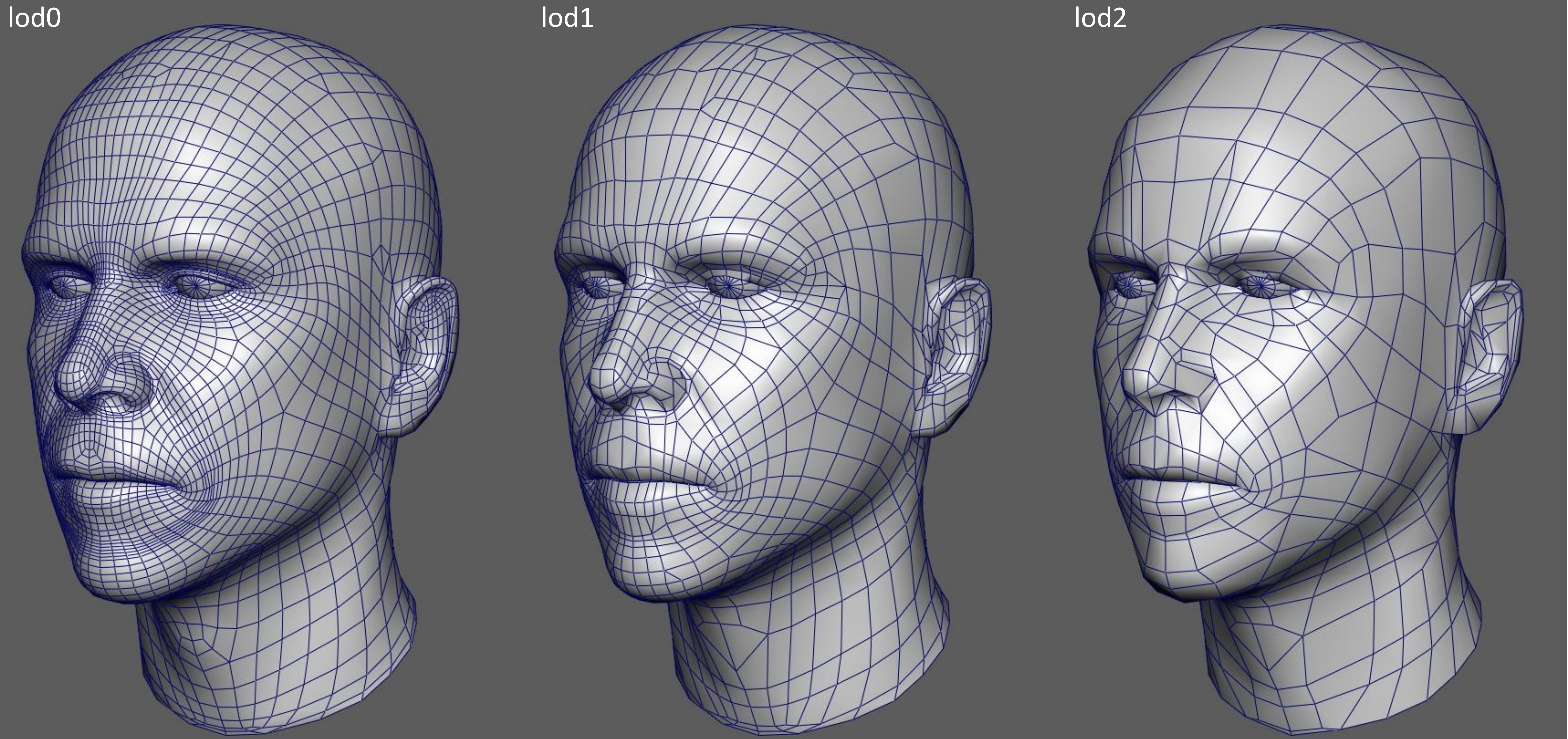
Flocks of polychords related by per-edge symmetry



Flock of three polychords related by edge symmetries

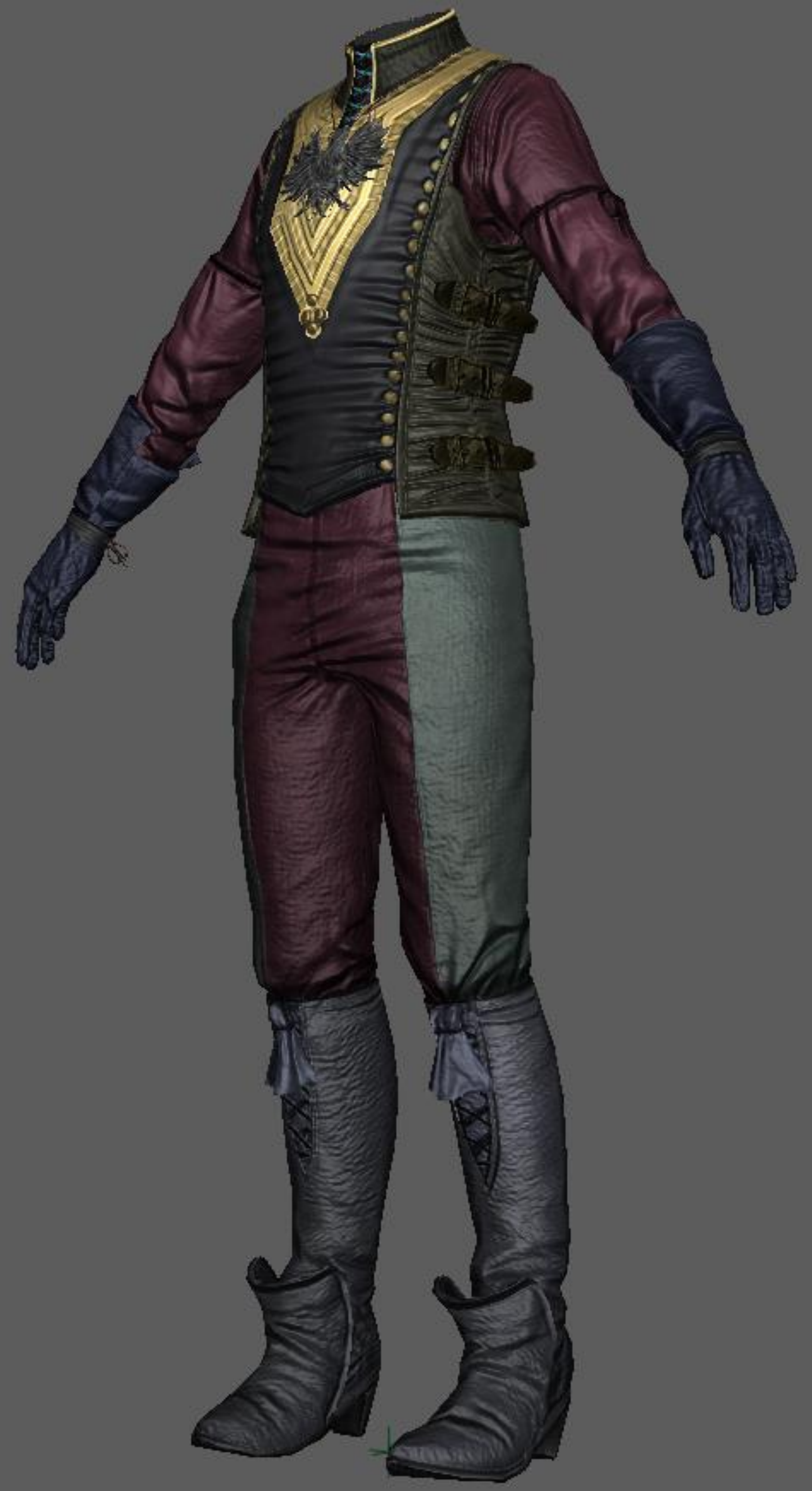


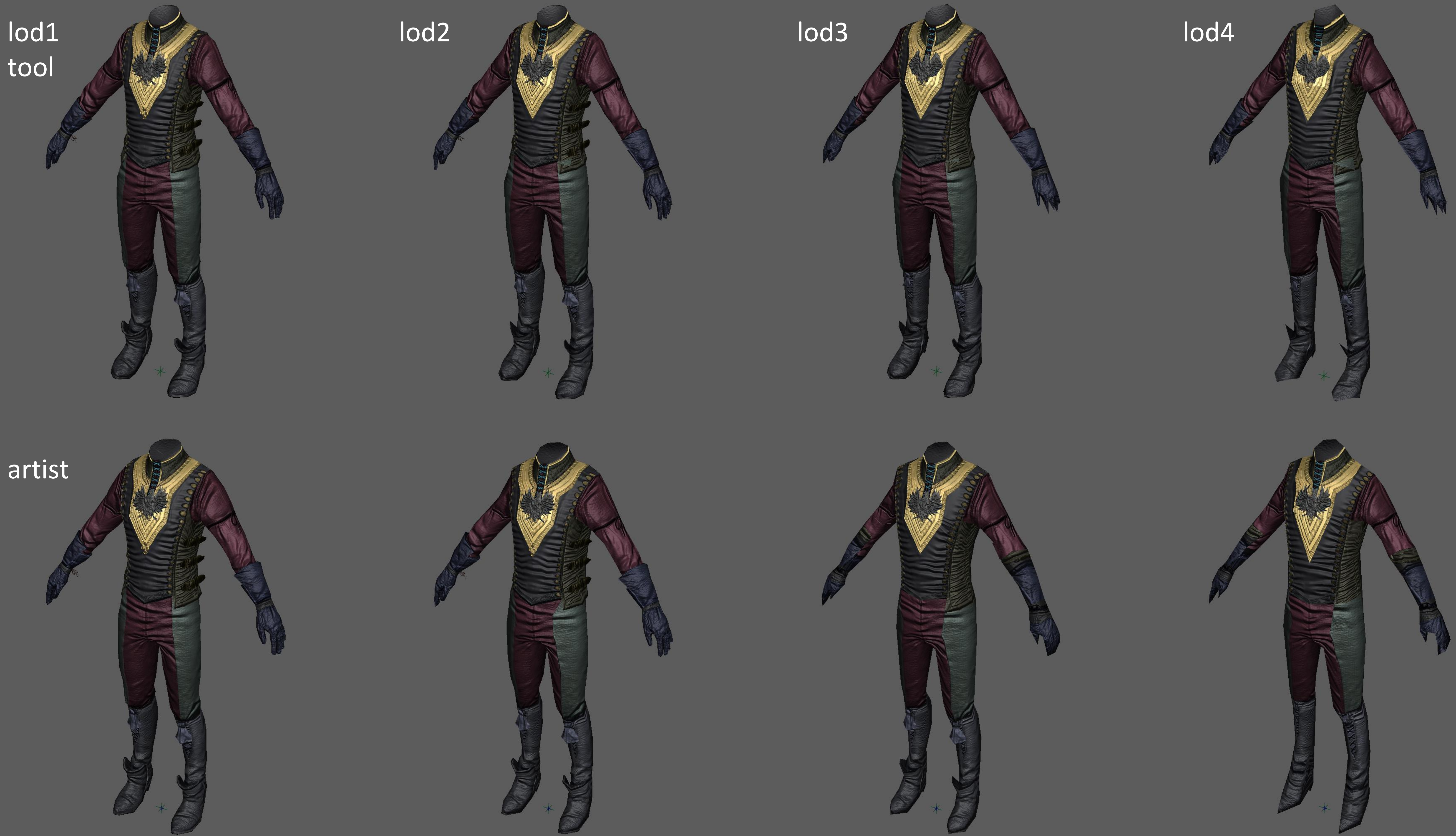
Identified polychord pair



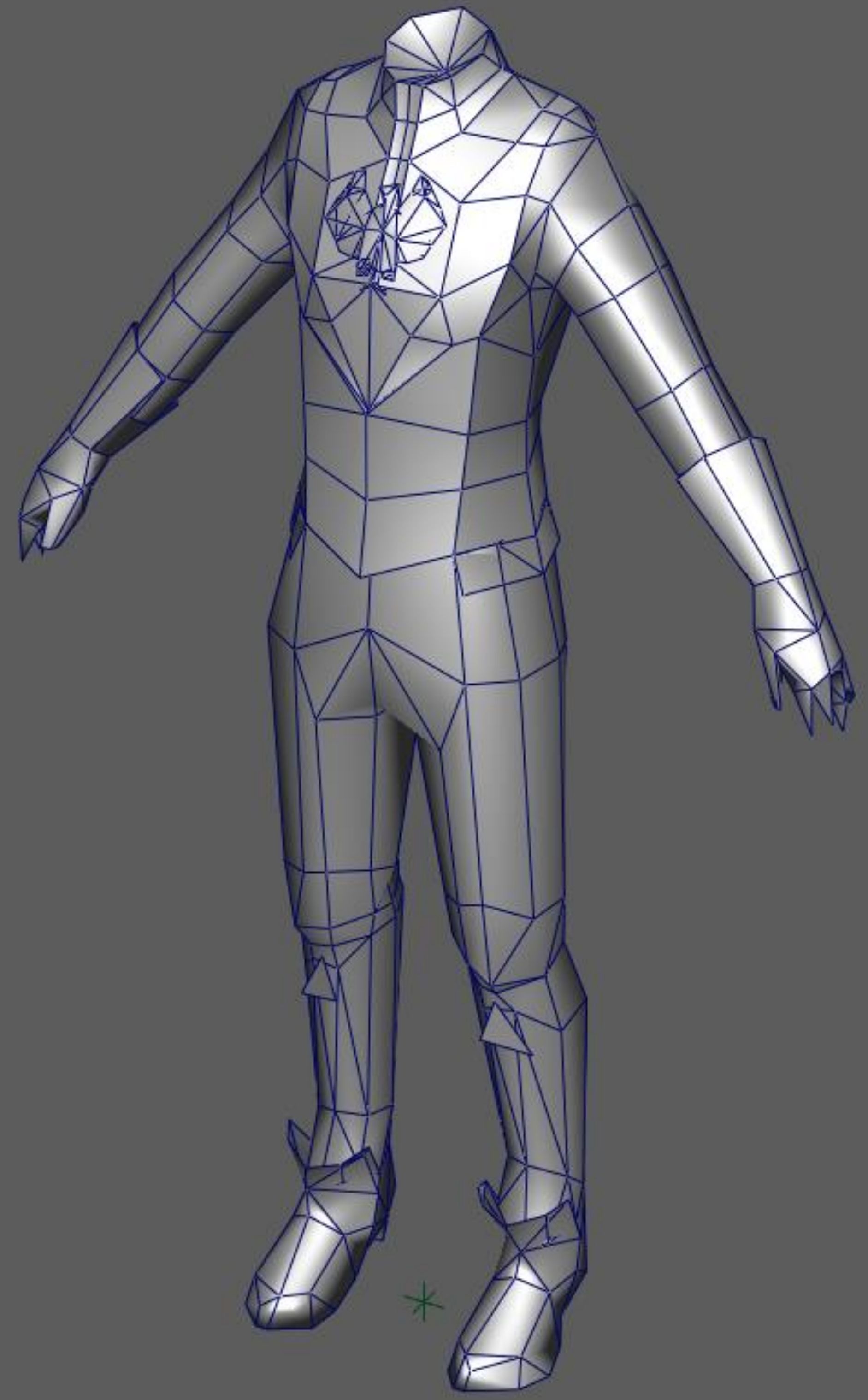
Results with symmetric sub-polychord collapse

Results

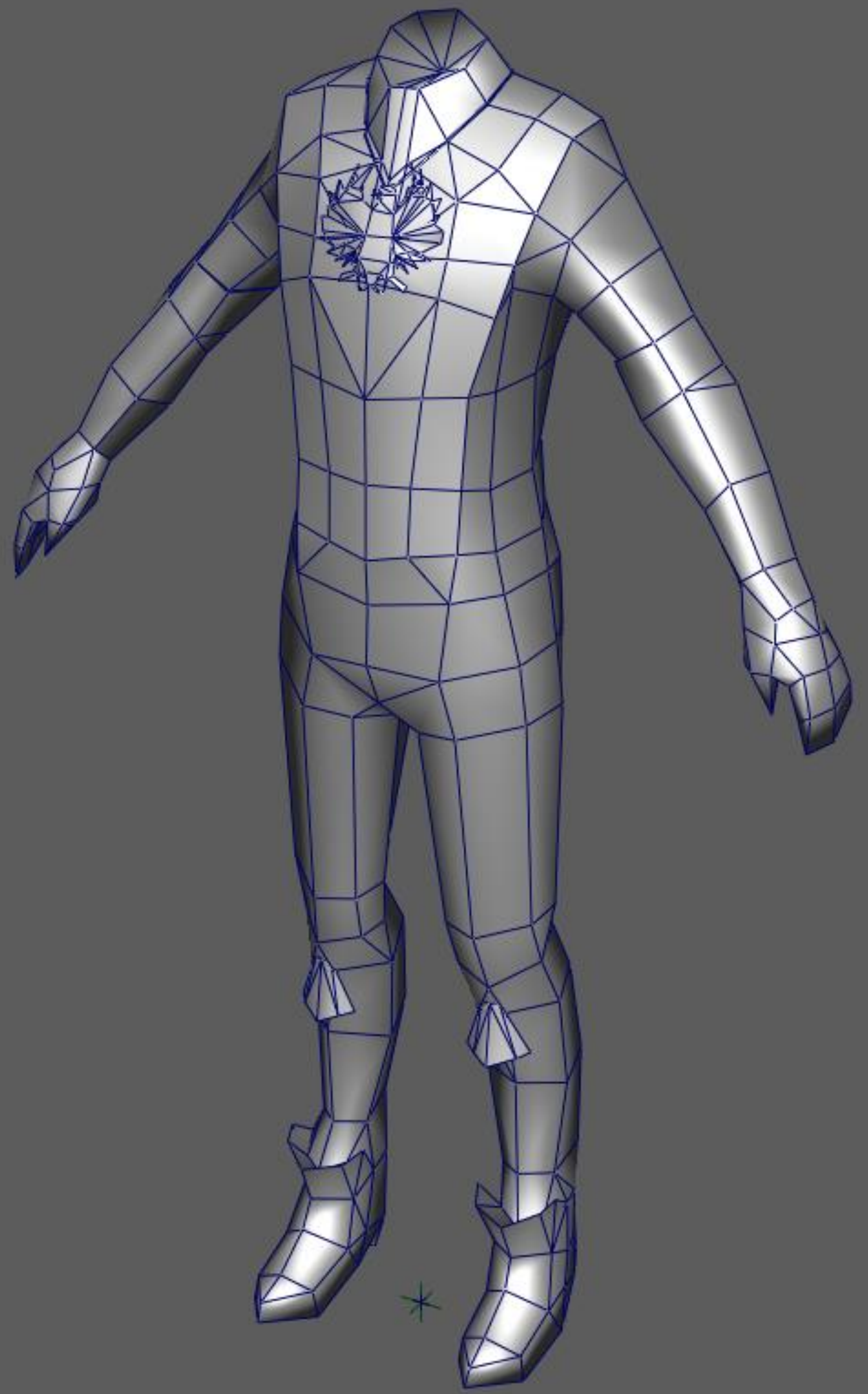



lod1
tool
lod2
lod3
lod4
artist

lod3
tool



lod3
artist



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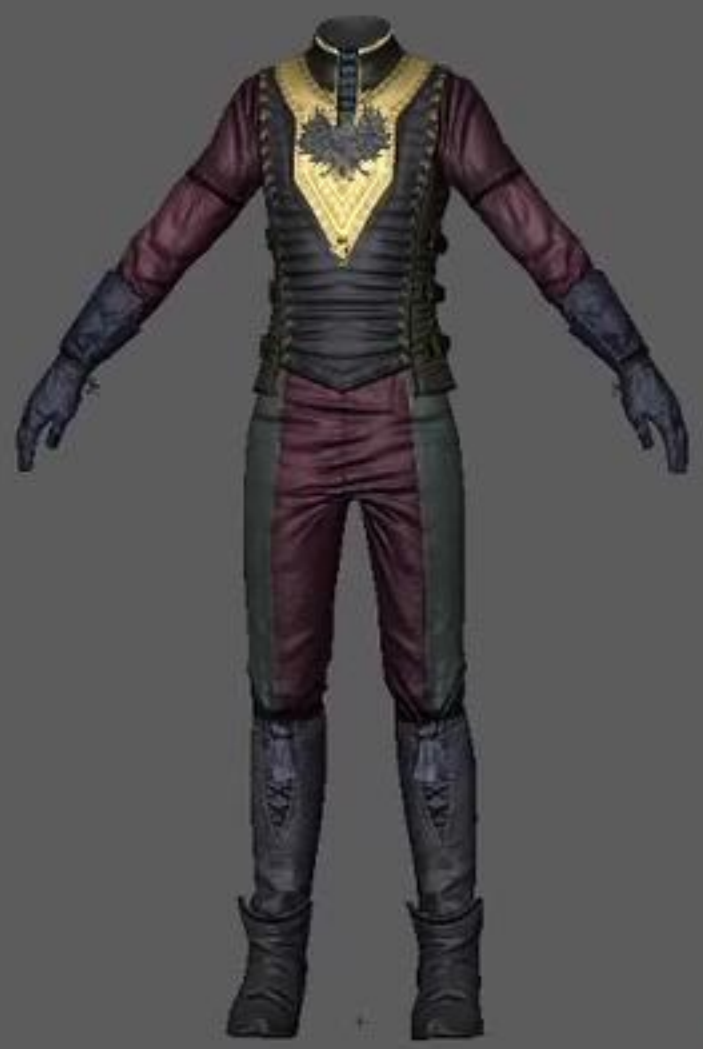

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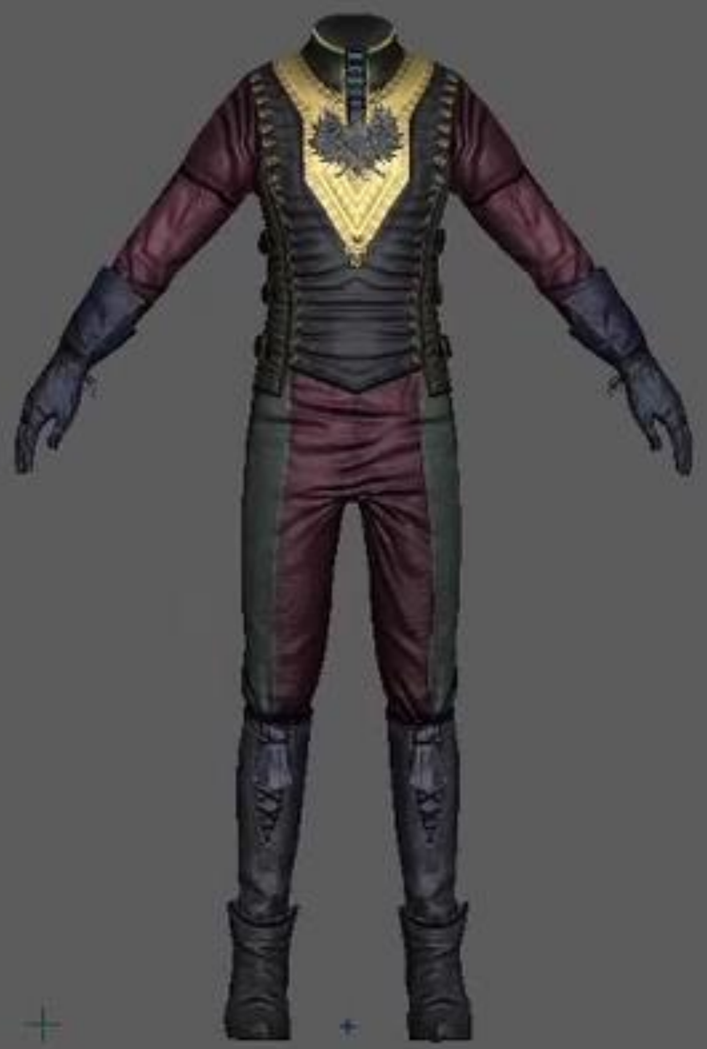
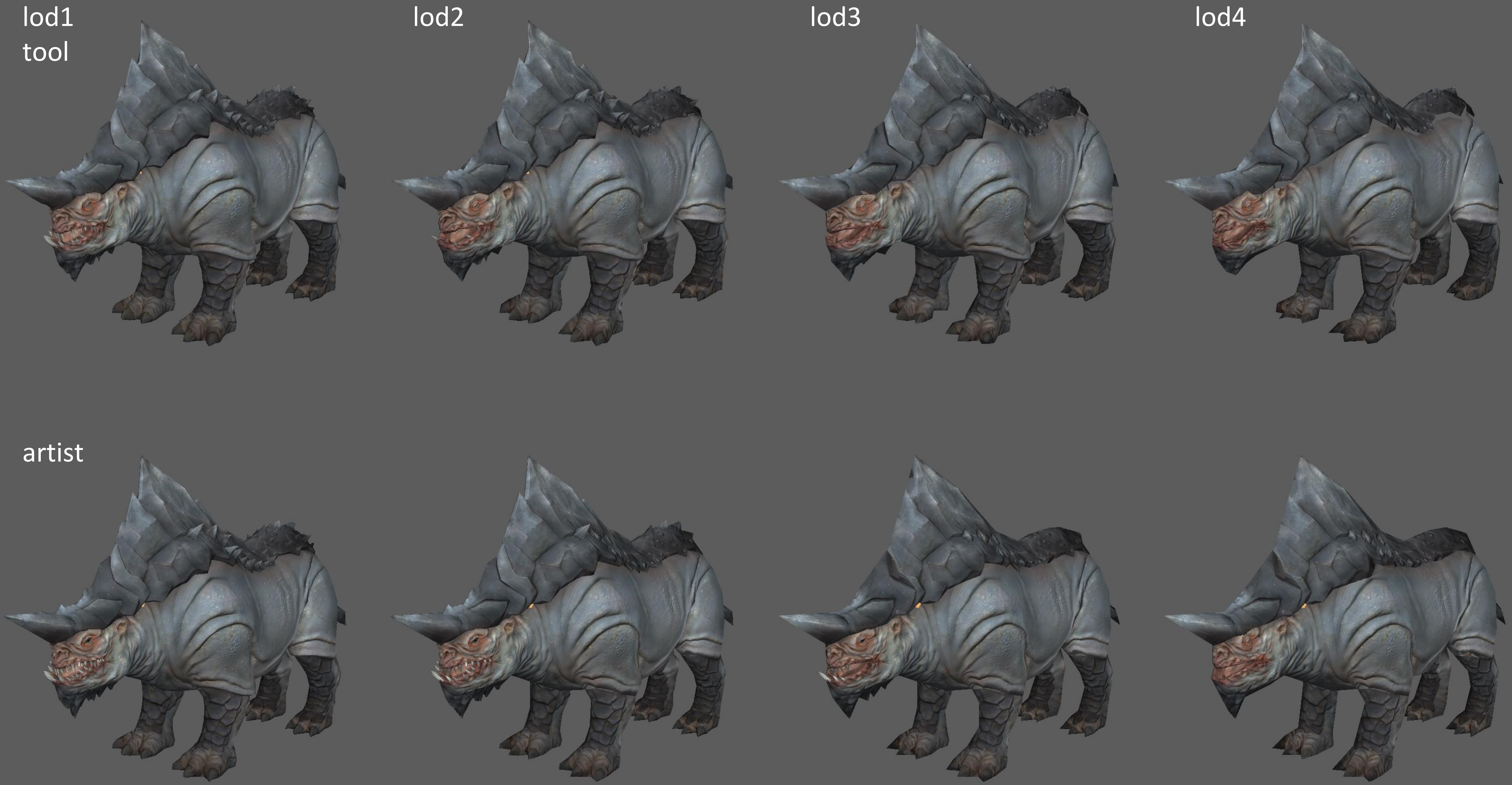
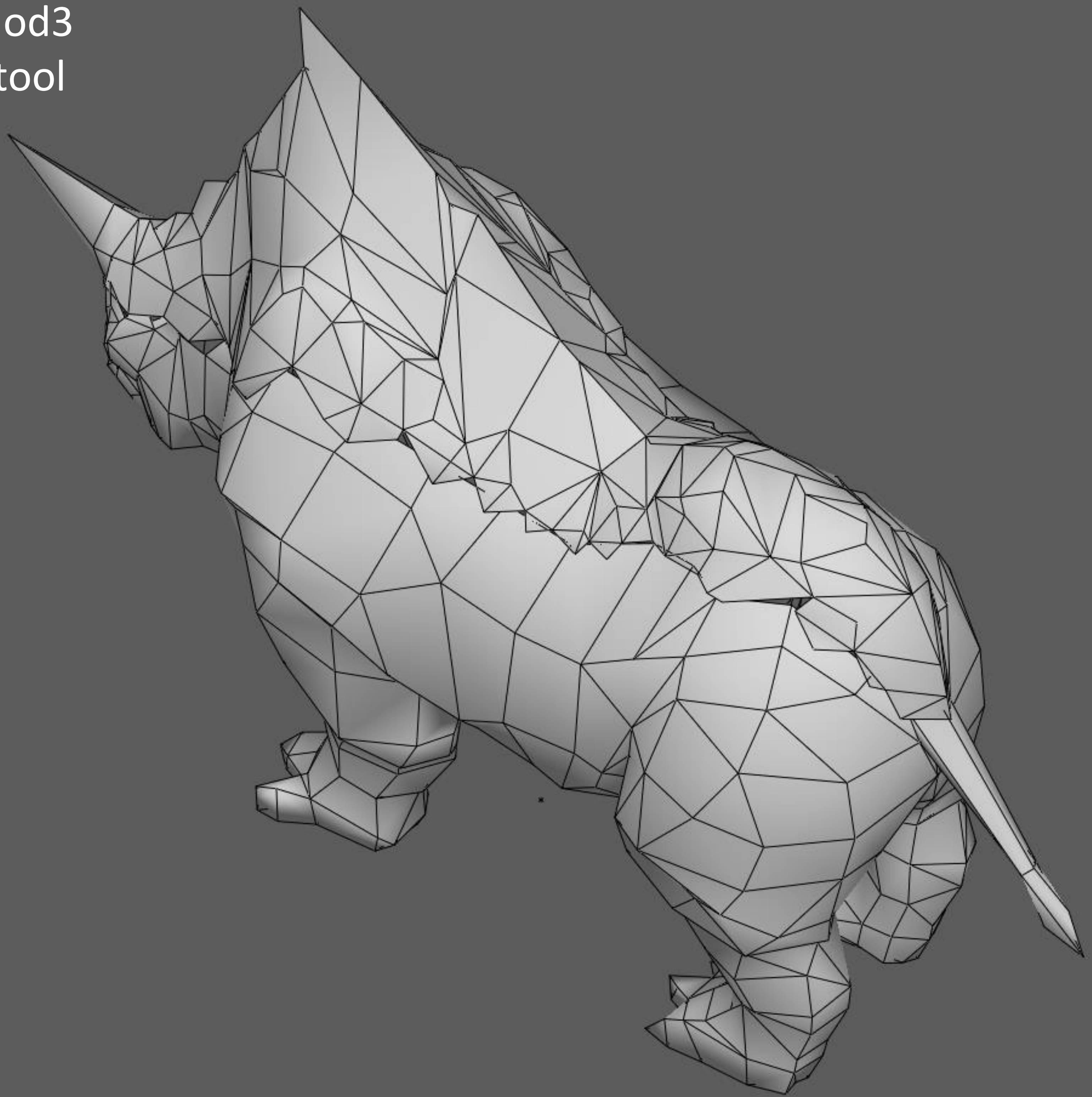



lod1
tool
lod2
lod3
lod4
artist



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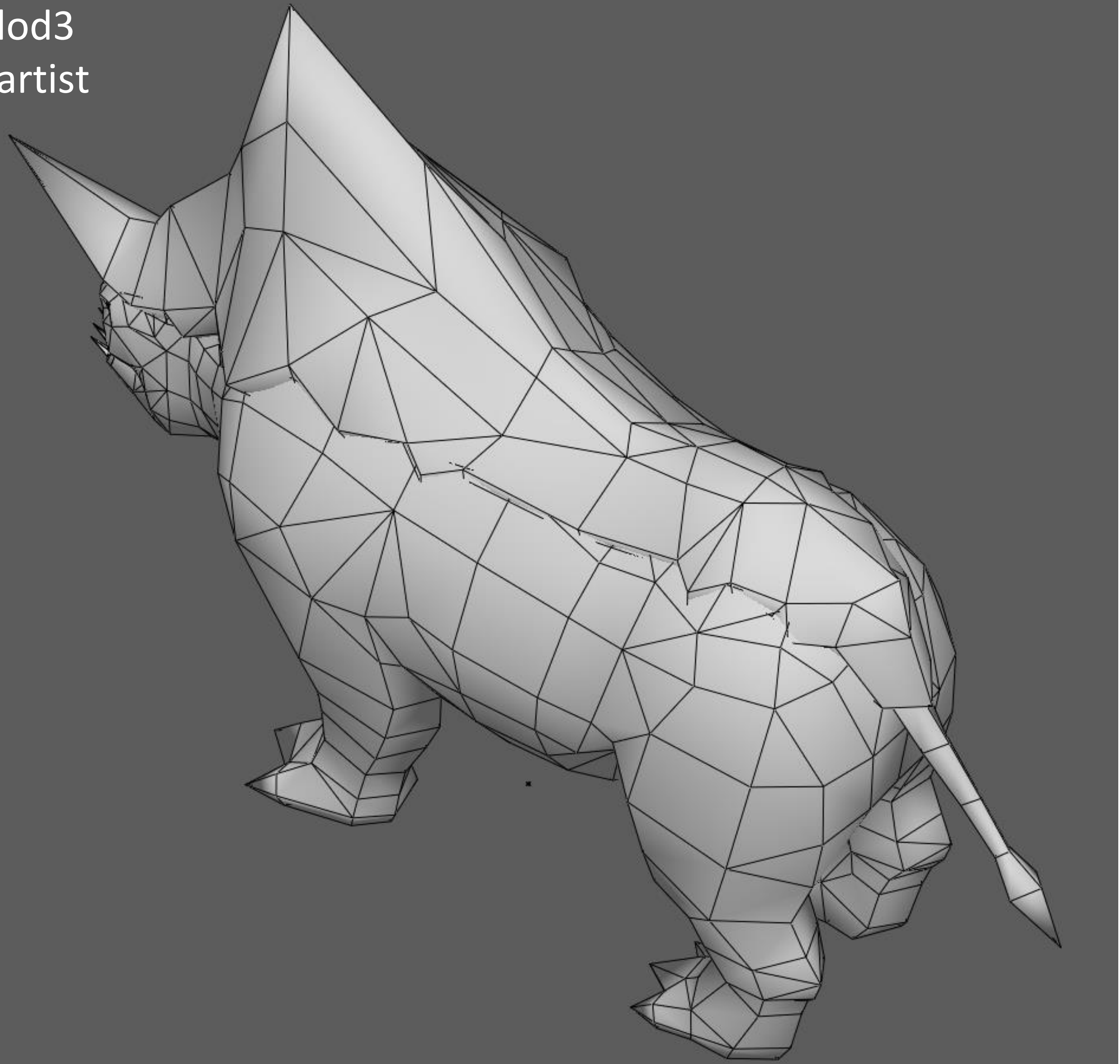
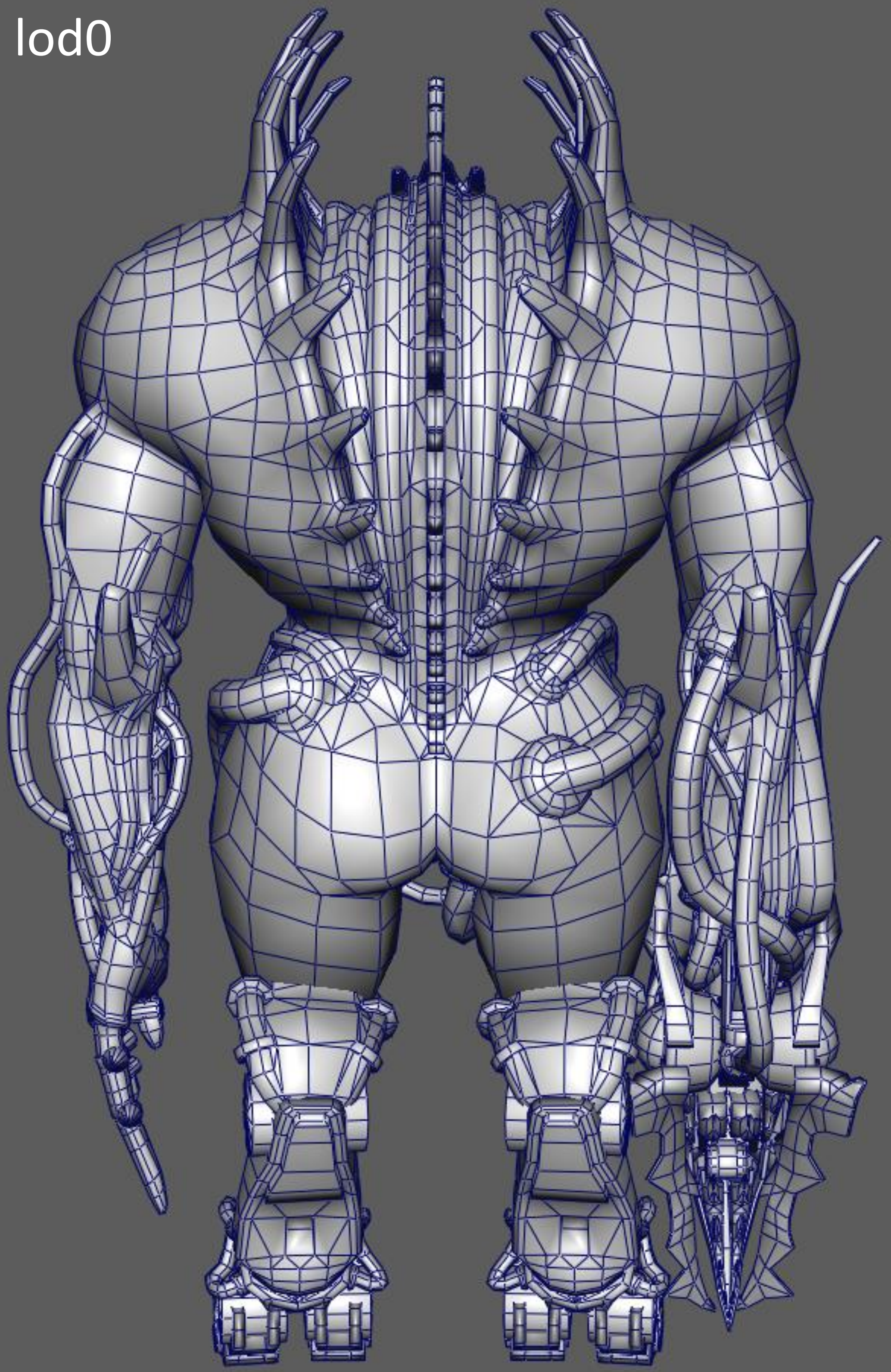
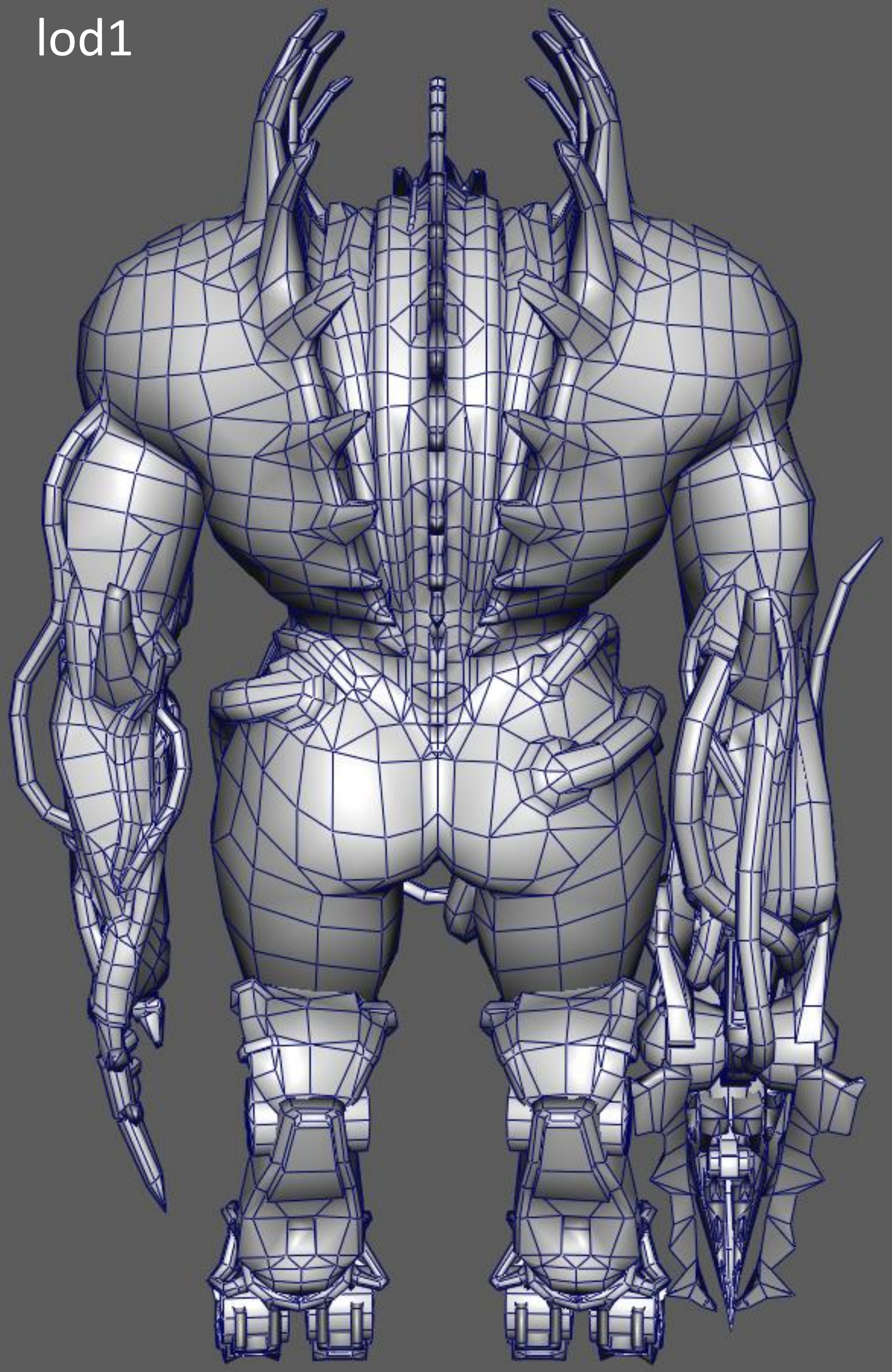


lod3
artist

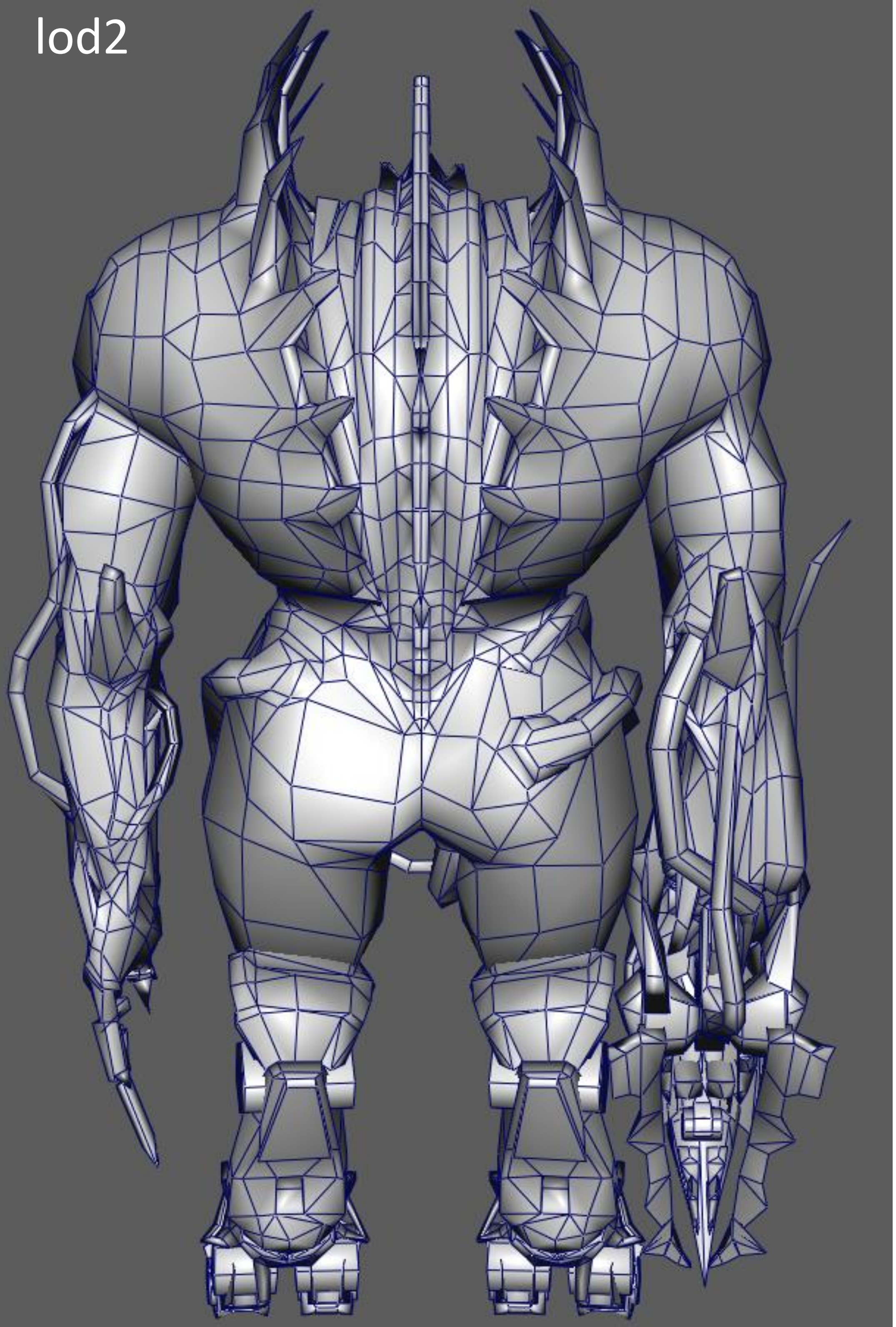
lod0



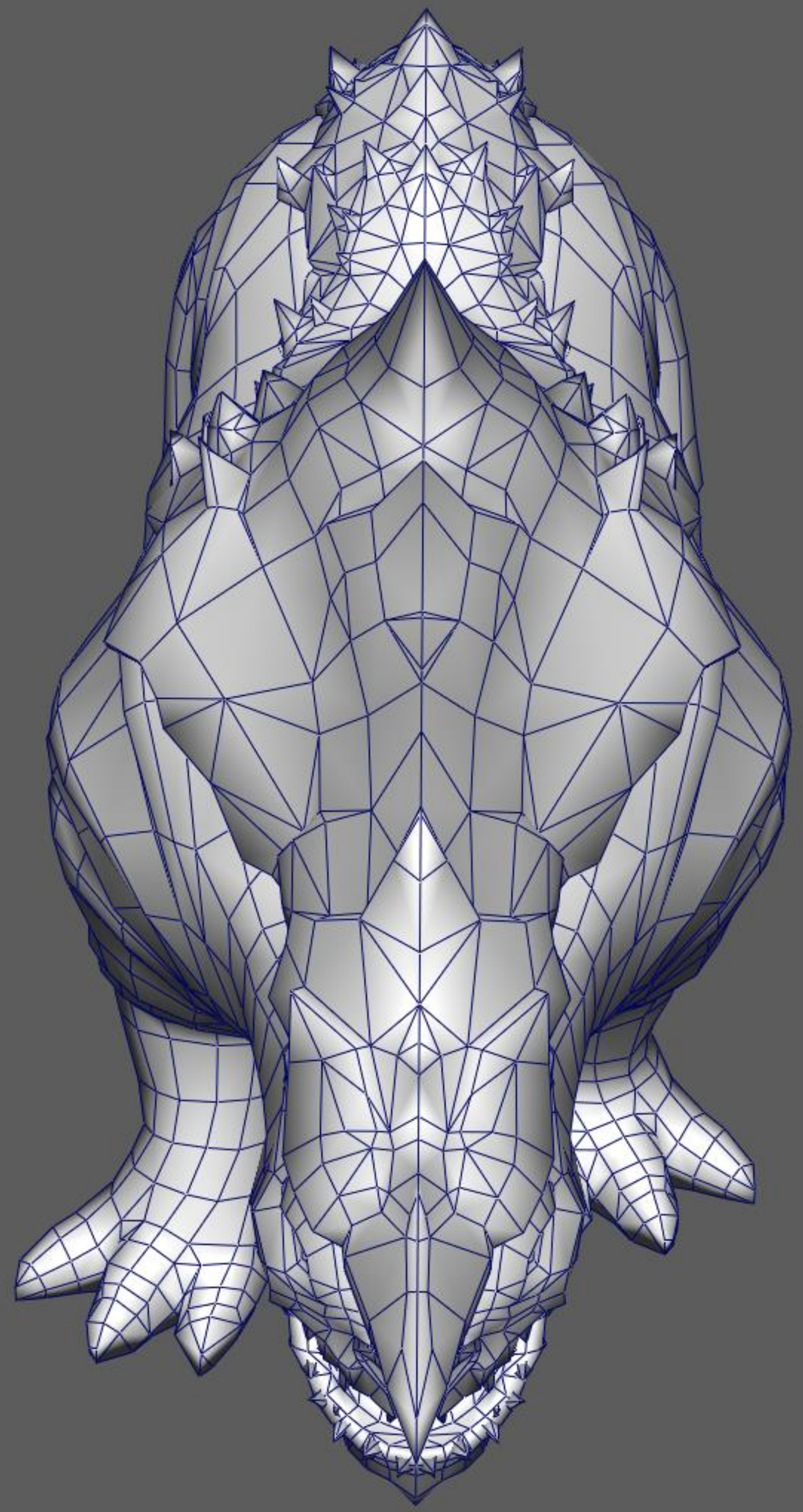
lod1



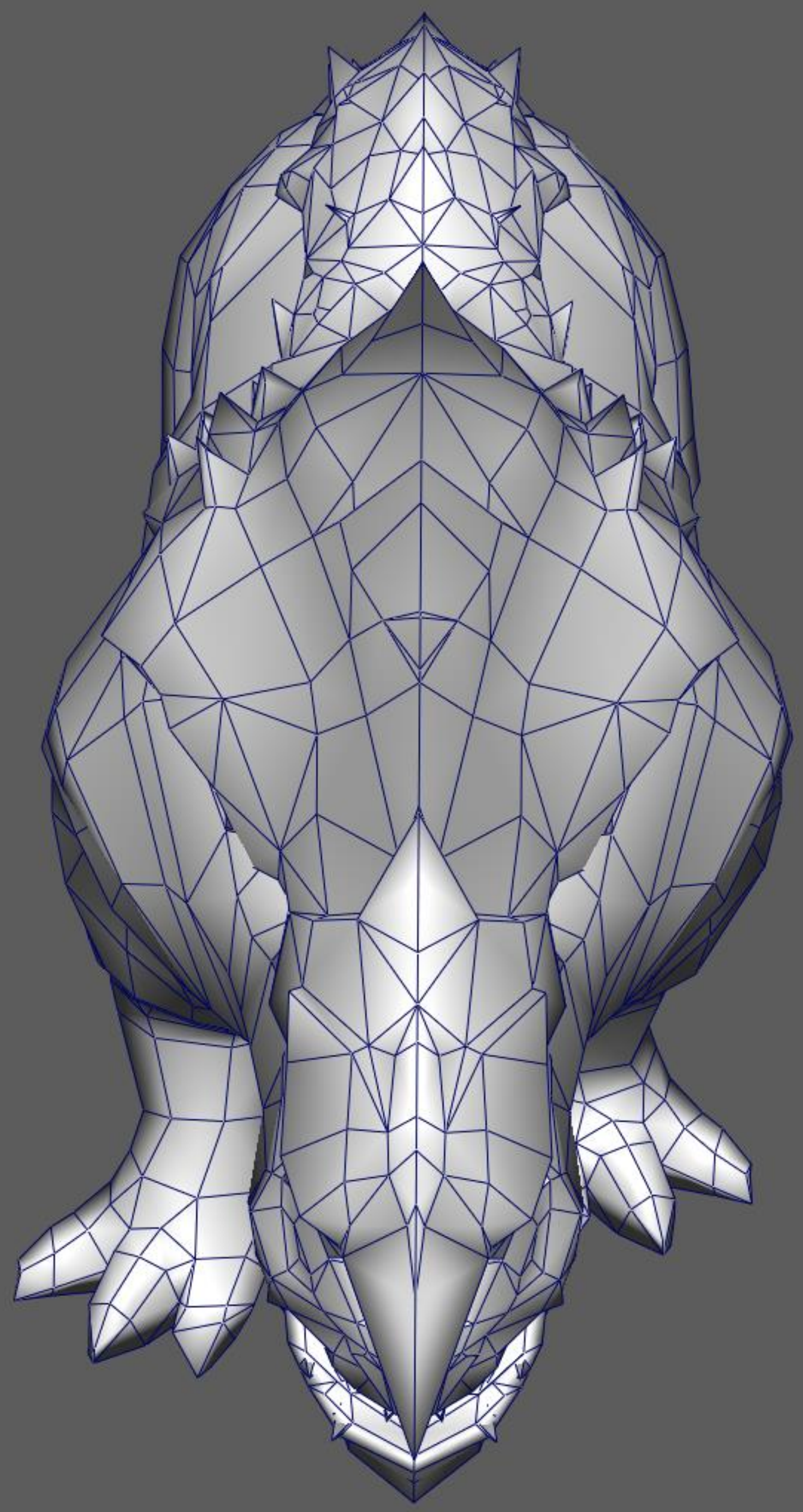
lod2

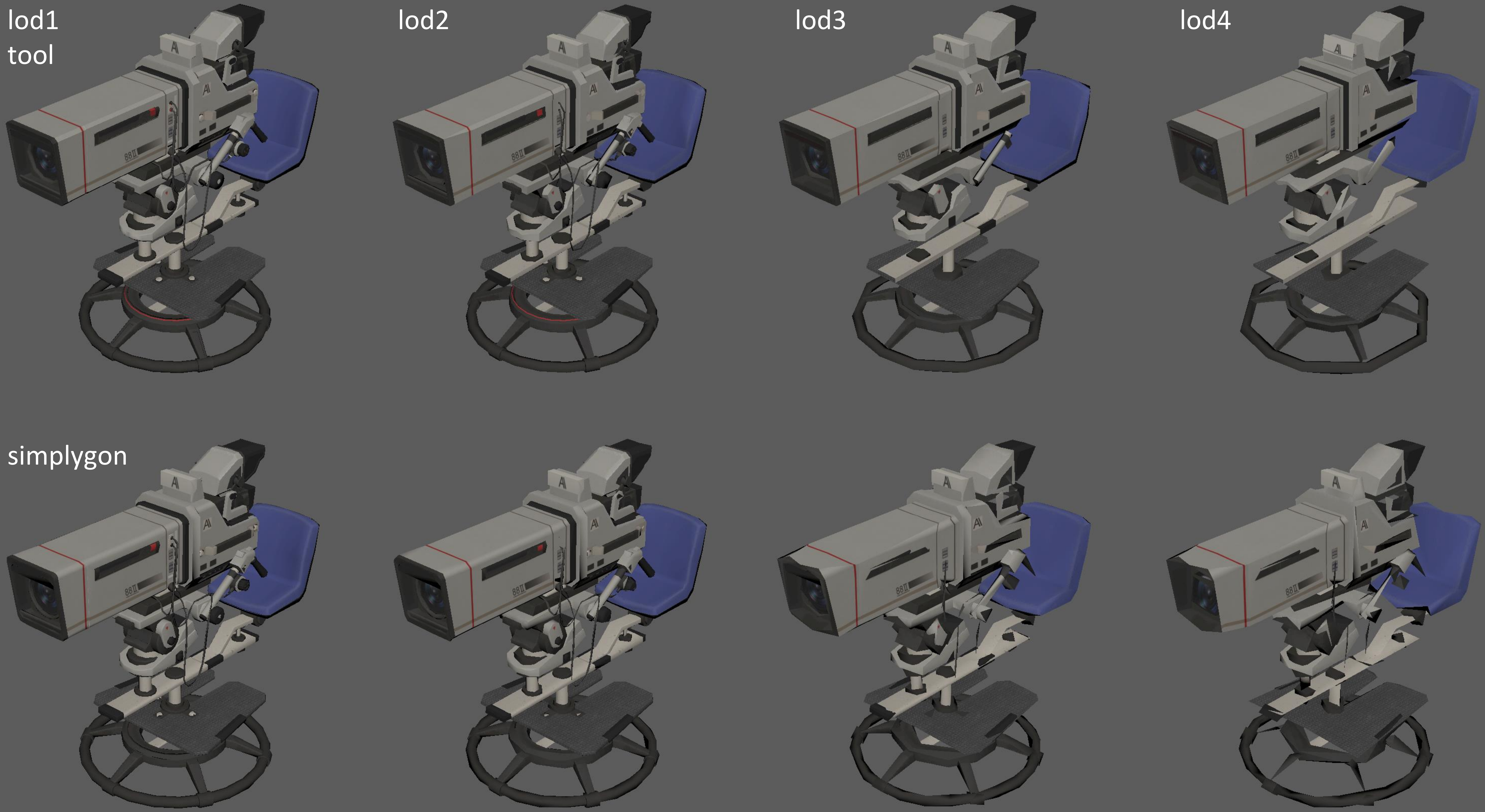


lod0

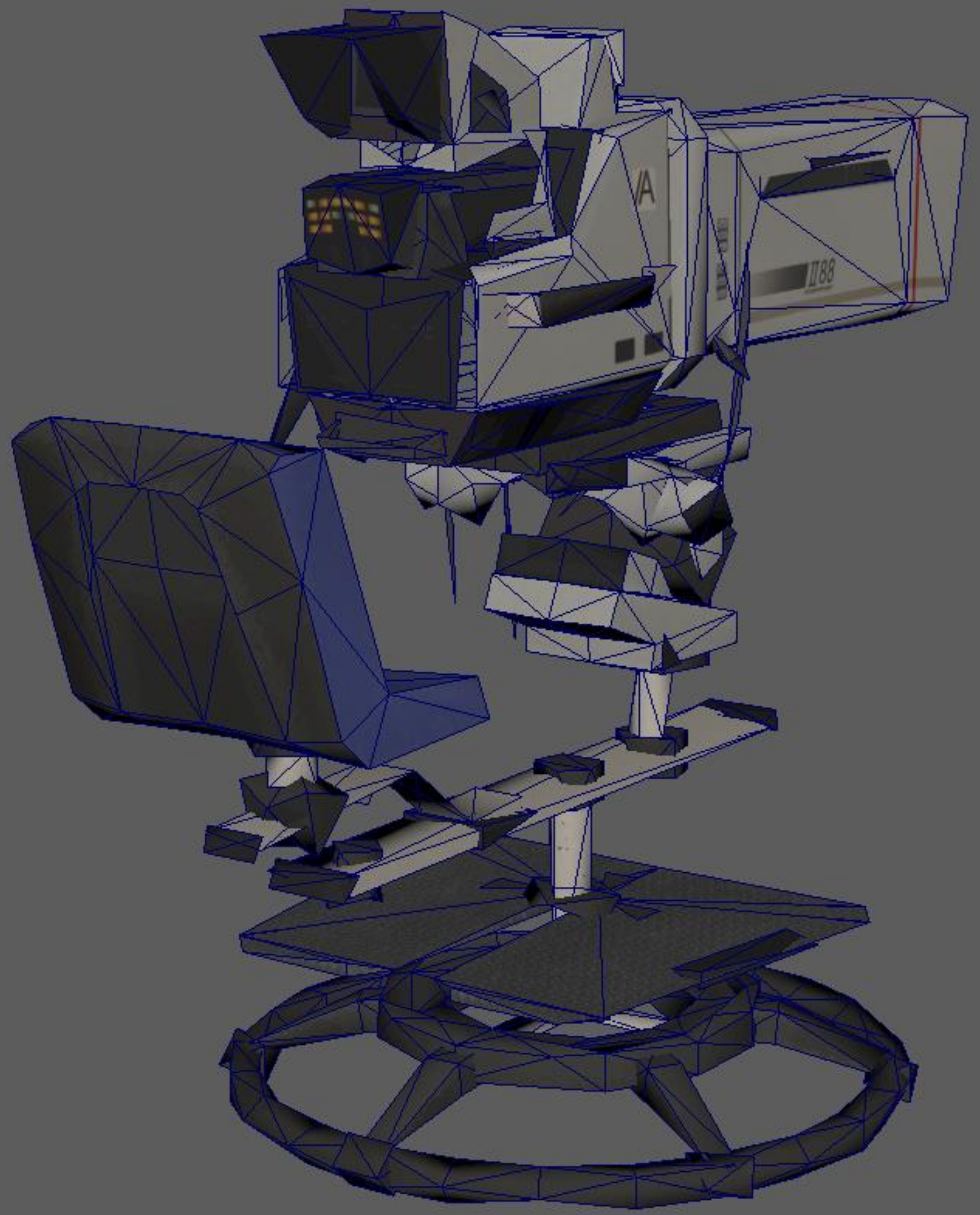


lod1

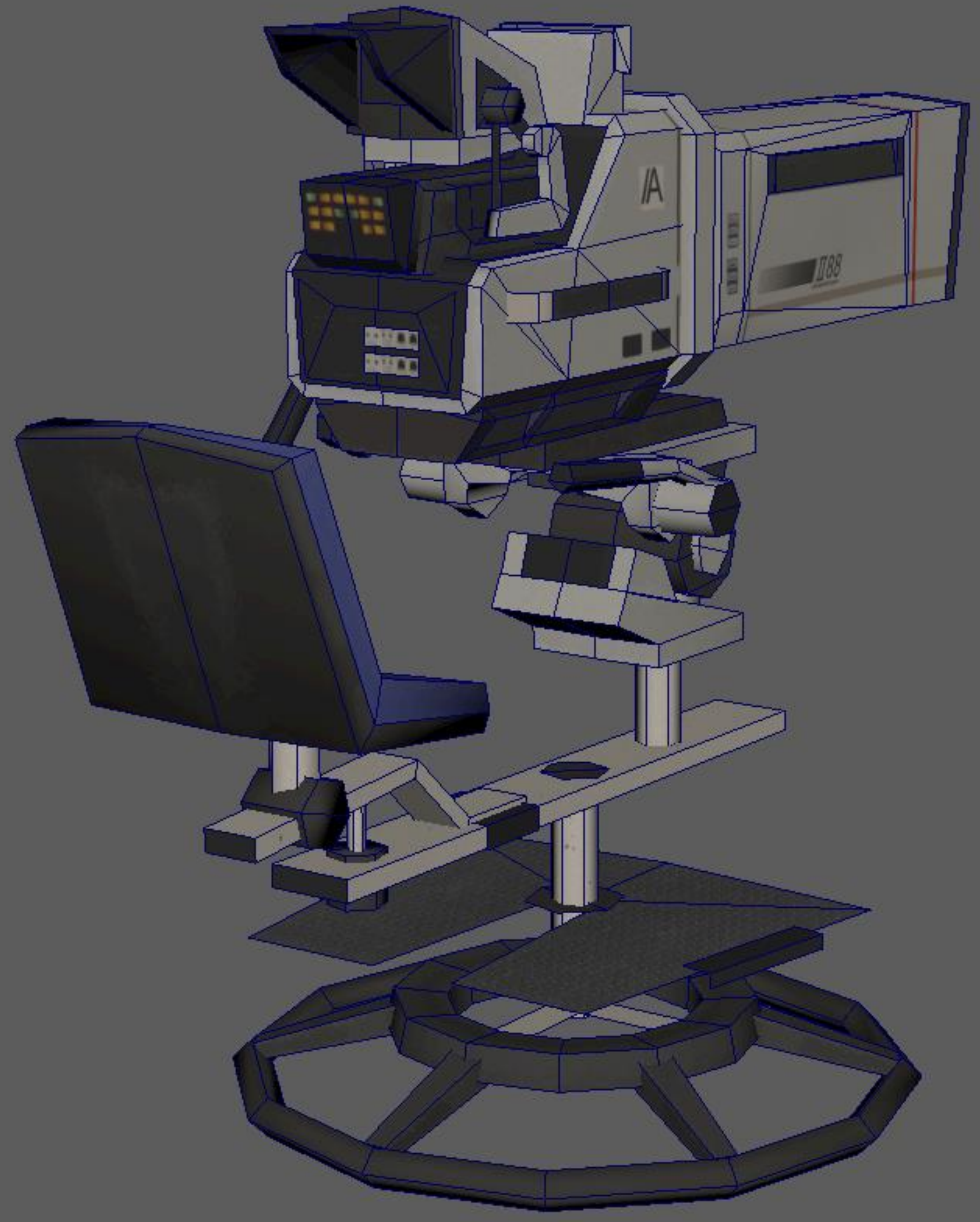



lod1
tool
lod2
lod3
lod4
simplygon

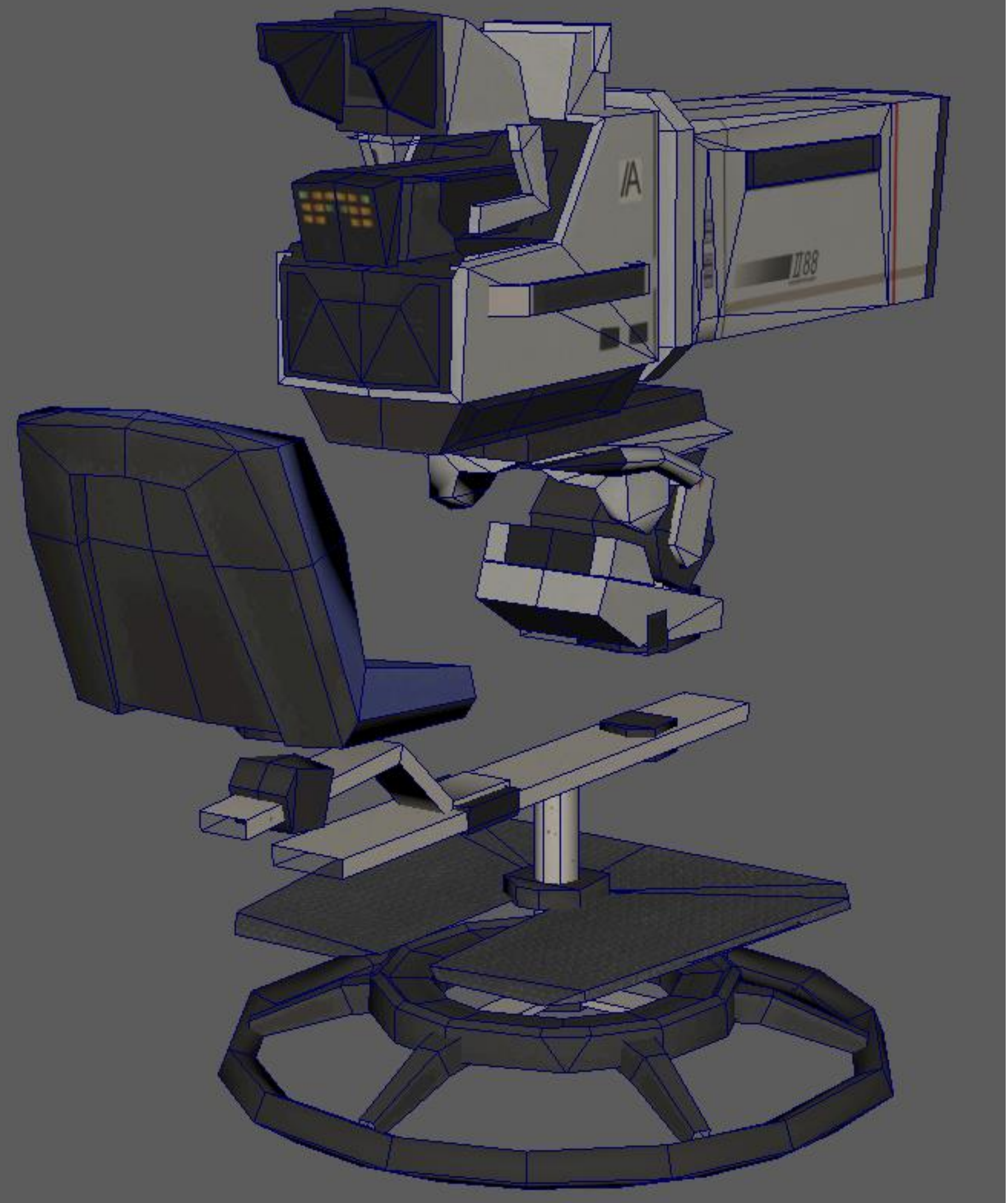
lod3
simplygon



lod3
tool



lod3
artist



The end

Thanks for watching