Complexity Reduction Techniques

for large 3D geometries

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Large Scale 3D Mapping for Robots - Meetup

21.July 2015

@RoofUp

Background

- 3D Model generation

Background

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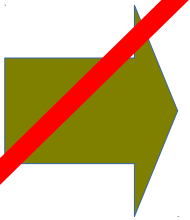
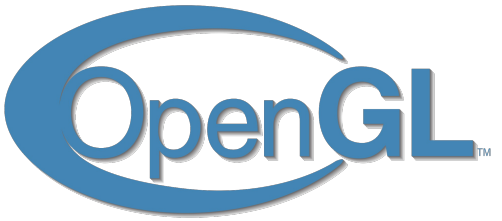




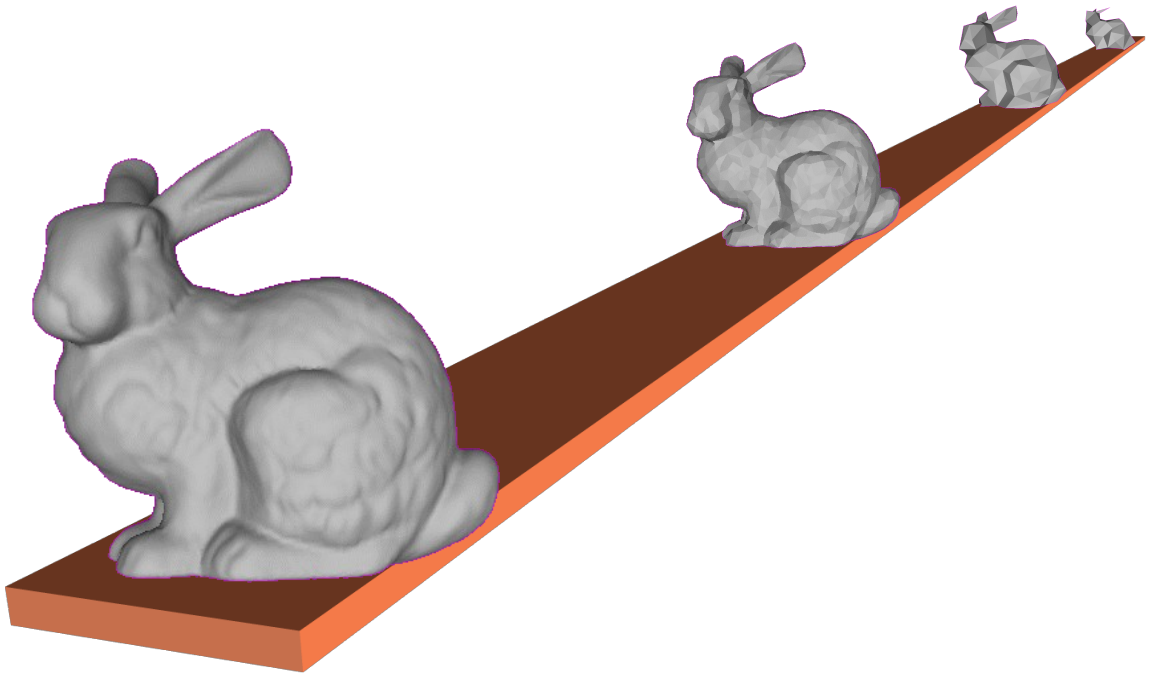
Level Of Details (LOD)

- Create levels of detail (LODs) of objects:

69,451 polys | 2,502 polys | 251 polys | 76 polys

Level Of Details (LOD)

- Distant objects use coarser LODs:



History of LOD Techniques

- Early history: Clark (1976), flight simulators
- Handmade LODs -> automatic LODs

Discrete LOD -1

Traditional LOD in a nutshell:

- Create LODs for each object separately in a preprocess
- At run-time, pick each object's LOD according to the object's distance (or similar criterion)
- Since LODs are created offline at fixed resolutions, we call this **discrete LOD**

Discrete LOD -2- Manual Mesh Simplification

1. Simplify mesh

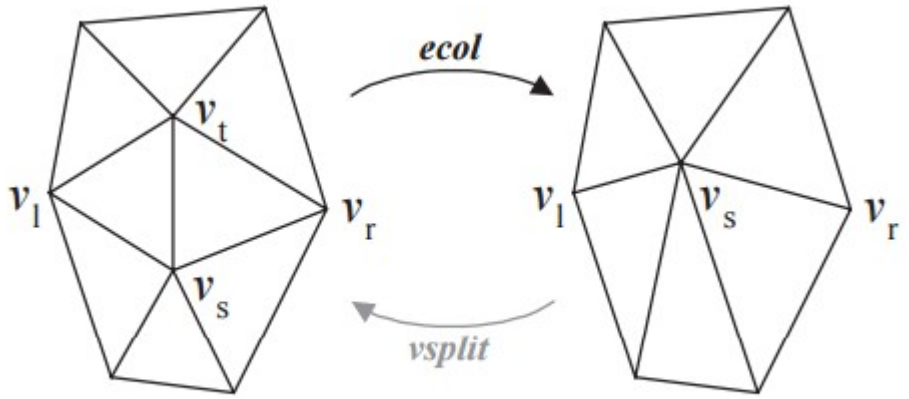


Figure 1: Illustration of the edge collapse transformation.

But: How to control the **approximation accuracy**?

Discrete LOD -3- Manual Mesh Simplification

1. Simplify mesh

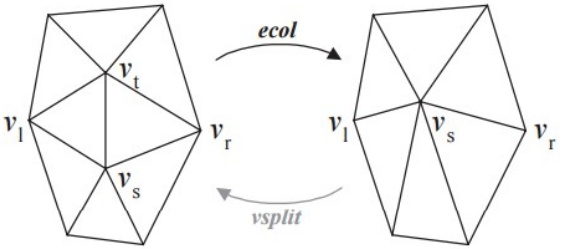


Figure 1: Illustration of the edge collapse transformation.

We will say that a pair $(\mathbf{v}_1, \mathbf{v}_2)$ is a *valid* pair for contraction if either:

1. $(\mathbf{v}_1, \mathbf{v}_2)$ is an edge, *or*
2. $\|\mathbf{v}_1 - \mathbf{v}_2\| < t$, where t is a threshold parameter

Michael Garland and Pail S. Heckbert, *Surface Simplification Using Quadric Error Metrics*, In ACM Computer Graphics, 1997

Discrete LOD -3- Manual Mesh Simplification

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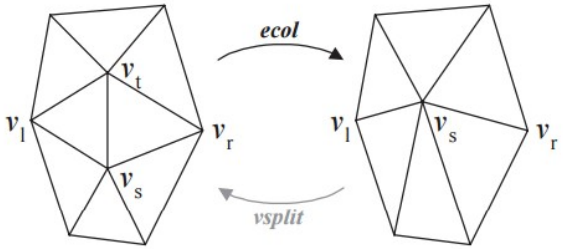


Figure 1: Illustration of the edge collapse transformation.

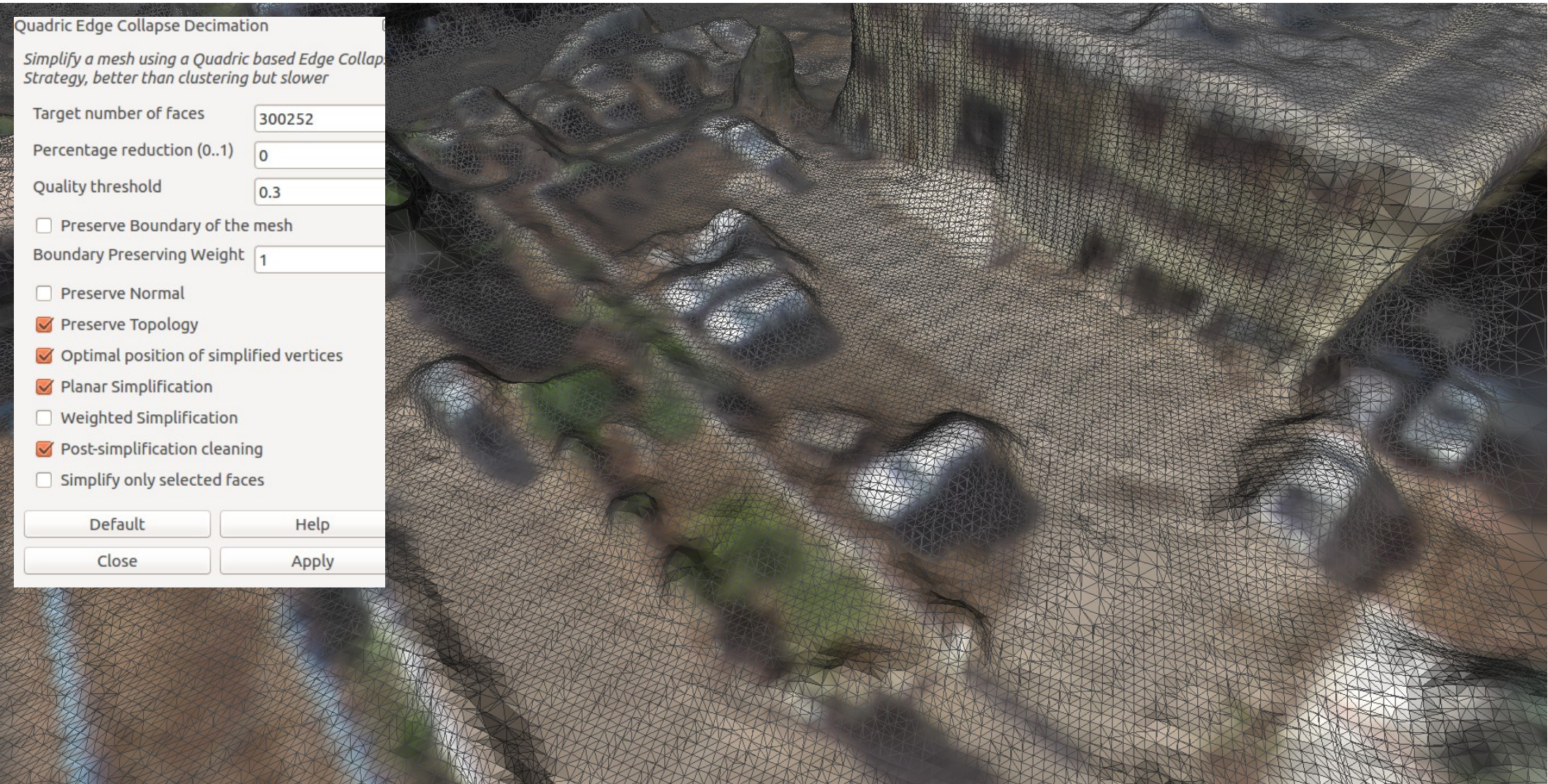
$$\bar{\mathbf{v}} = \begin{bmatrix} q_{11} & q_{12} & q_{13} & q_{14} \\ q_{12} & q_{22} & q_{23} & q_{24} \\ q_{13} & q_{23} & q_{33} & q_{34} \\ 0 & 0 & 0 & 1 \end{bmatrix}^{-1} \begin{bmatrix} 0 \\ 0 \\ 0 \\ 1 \end{bmatrix}$$

V: New position of the vertex after simplification
Q: 4x4 matrix measuring the “edgyness”.
Precomputed for each vertex.

Michael Garland and Pail S. Heckbert, *Surface Simplification Using Quadric Error Metrics*, In ACM Computer Graphics, 1997

Discrete LOD -3- Manual Mesh Simplification

1. Simplify mesh (in MeshLab)



Discrete LOD -3- Manual Mesh Simplification

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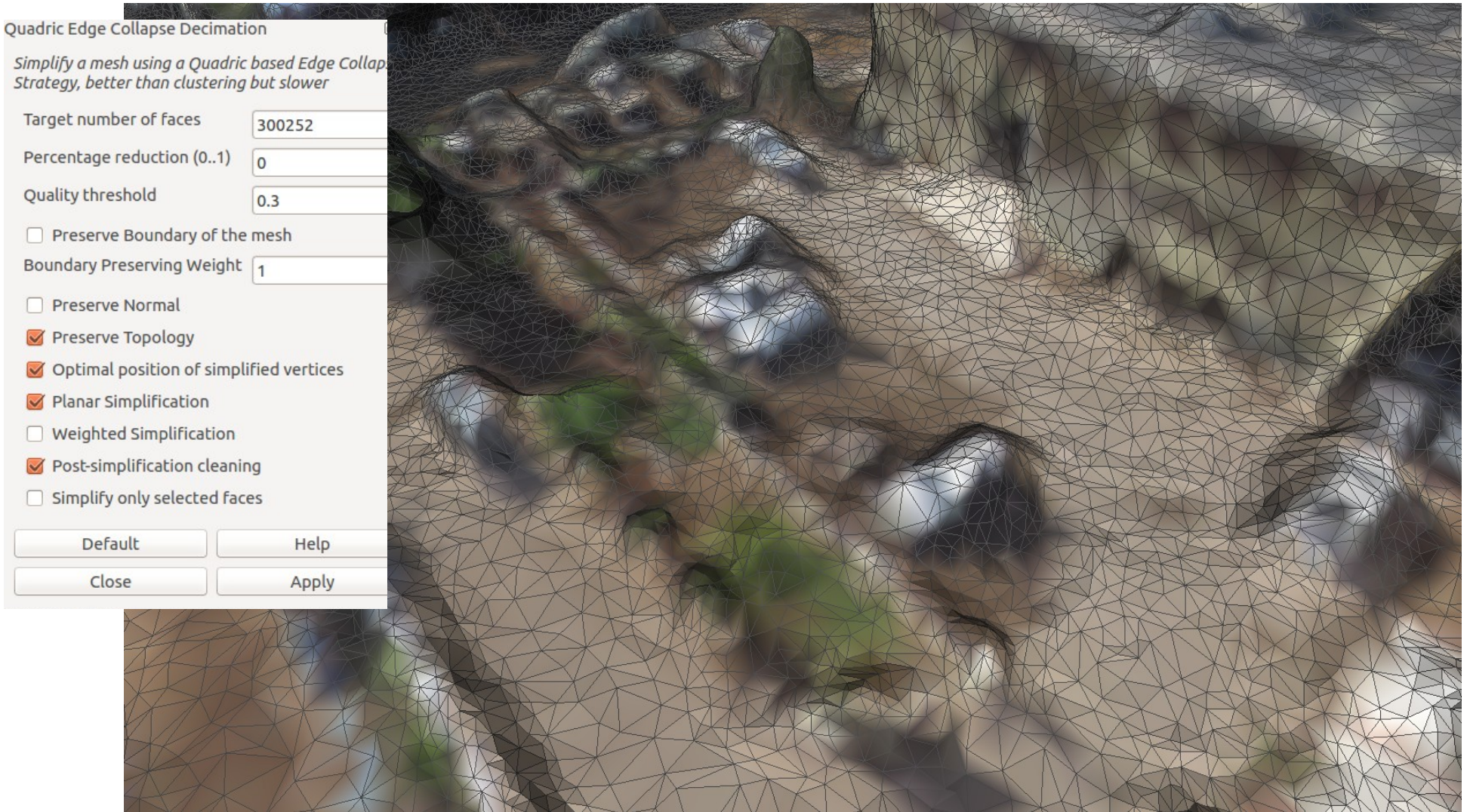

Discrete LOD -3- Manual Mesh Simplification

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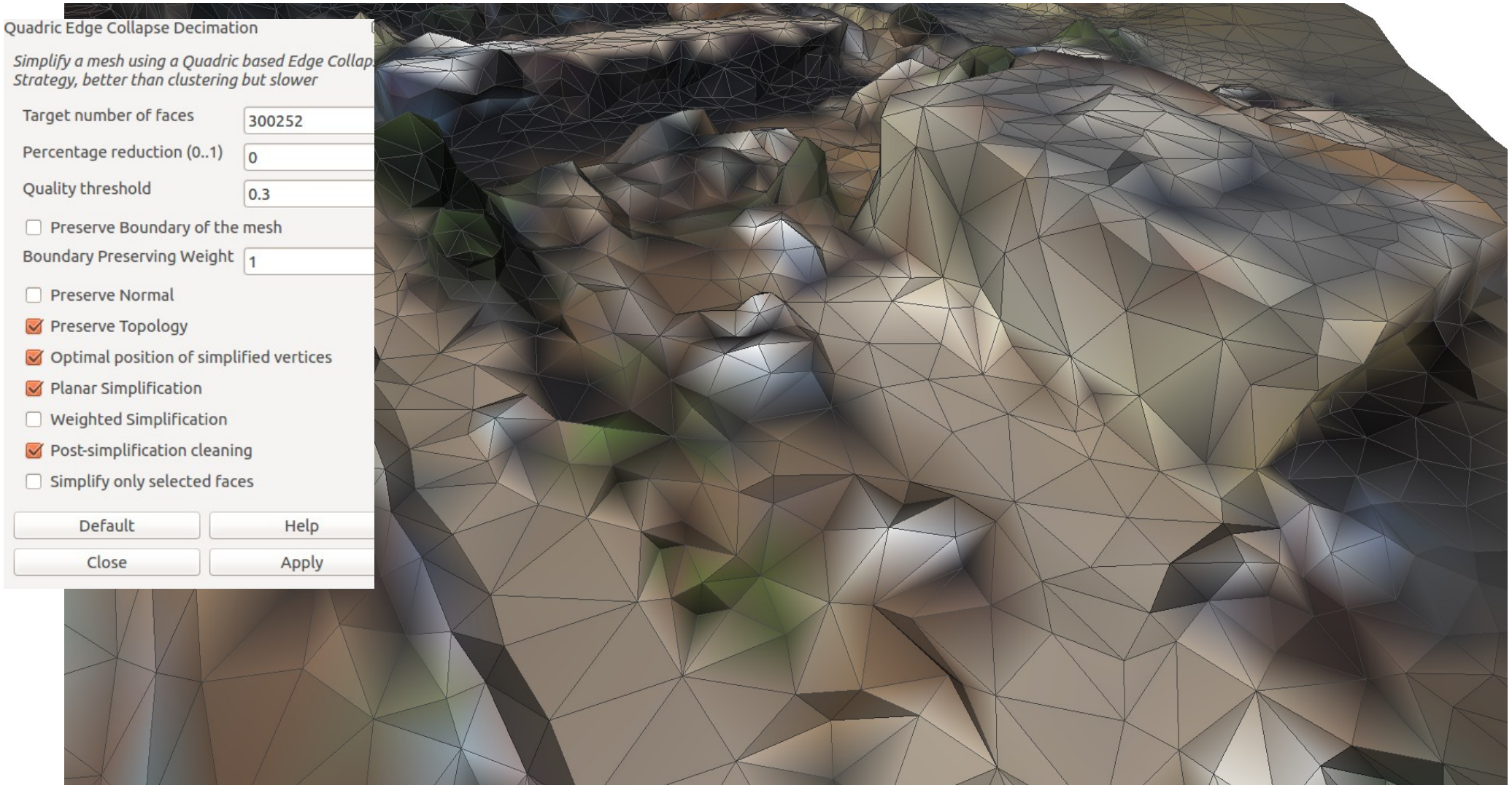
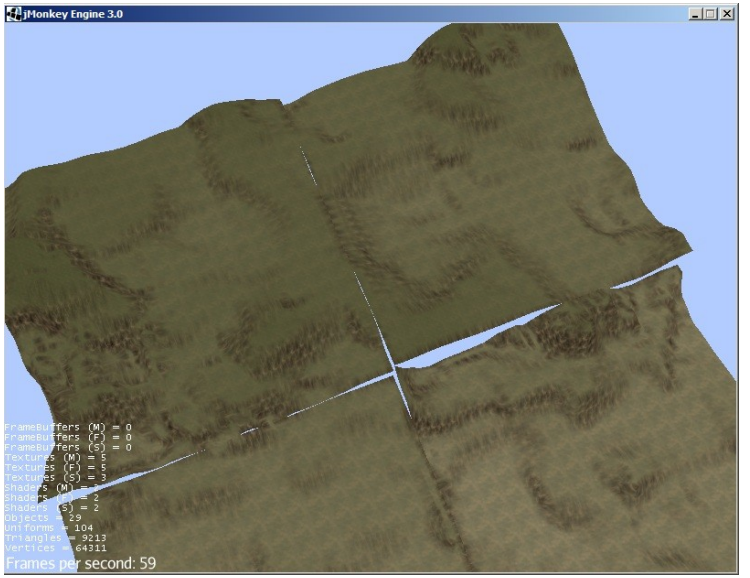


Discrete LOD -3- Manual Mesh Simplification

Issues:

- Terrain flyovers
- Super-Detailed scans
- Massive CAD Models



Continuous LOD

http://x3dom.org/pop/

(a) **17% triangles, low-resolution texture**

(b) **86% triangles, low-resolution texture**

(c) **86% triangles, high-resolution texture**

(d) **100% triangles, high-resolution texture**

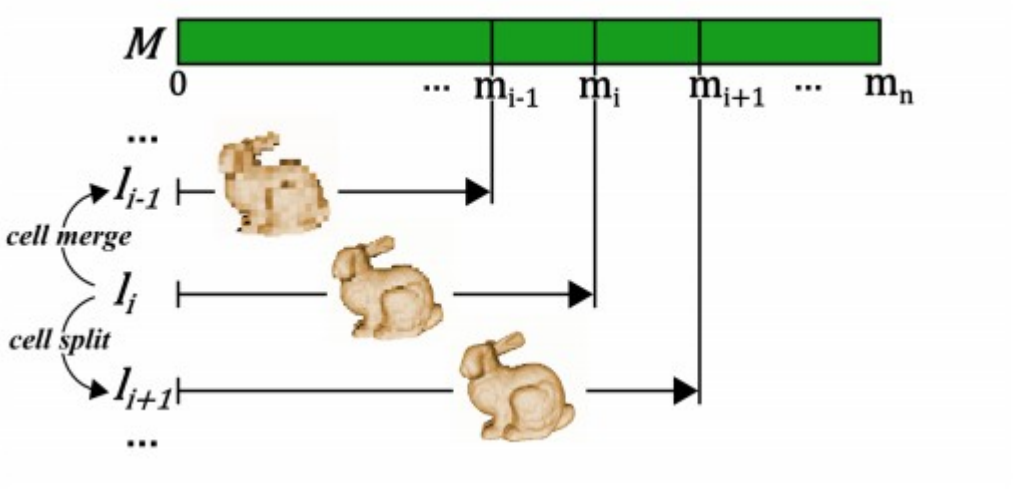
(a) **4 bit, 5.5% triangles**

(b) **5 bit, 16% triangles**

(c) **6 bit, 36% triangles**

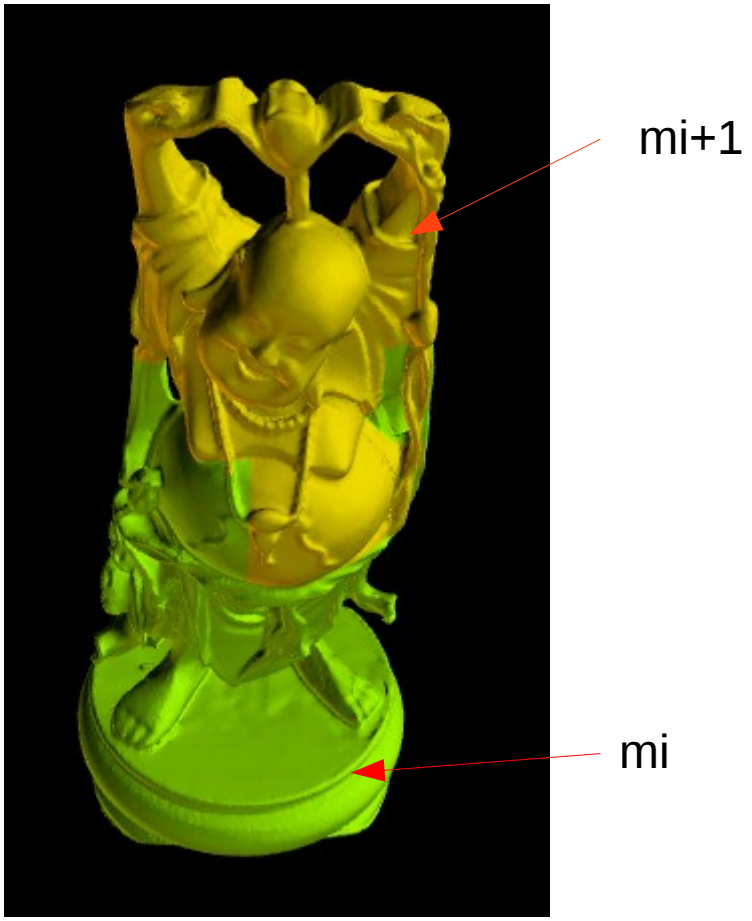
(d) **16 bit, 100% triangles**

Continuous LOD



(b) POP Buffer

Figure 3: *The POP buffer in GPU memory, compared to the approach of Sander and Mitchell. Their method stores several LOD representations in disjoint subsections of a mesh data buffer M. In contrast, our approach reorders mesh data in such a way that the m_i elements of each buffer are fully contained within the m_{i+1} elements of the succeeding buffer.*



http://x3dom.org/pop/

Practically?

- 1. Have a look at http://www.x3dom.org/examples/
- 2. Convert your model to an optimized x3d file

  http://doc.x3dom.org/tutorials/models/aopt/index.html
- 3. Write a short HTML page

```
<html >
        <head>
    <link rel="stylesheet" type="text/css" href="x3dom/x3dom.css" />
                <script type="text/javascript" src="x3dom/x3dom.js"></script>
        </head>
<body>
<x3d xmlns="http://www.x3dom.org/x3dom" showStat="false" showLog="false" x="0px" y="0px" width="400px" heigh
  <scene>
    <inline DEF='MODEL' url='data/your_model.x3d' mapDEFToID='true' nameSpaceName='model'></inline>
  </scene>
</x3d>
</body>
</html>
```

X3dom Demo

- video

Thanks for coming!

- Papers and explanations about the concepts will be uploaded to github.com/*ls3dmfr*