Geometry Images

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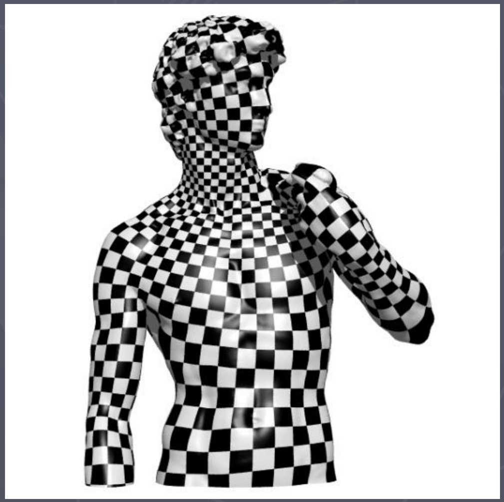
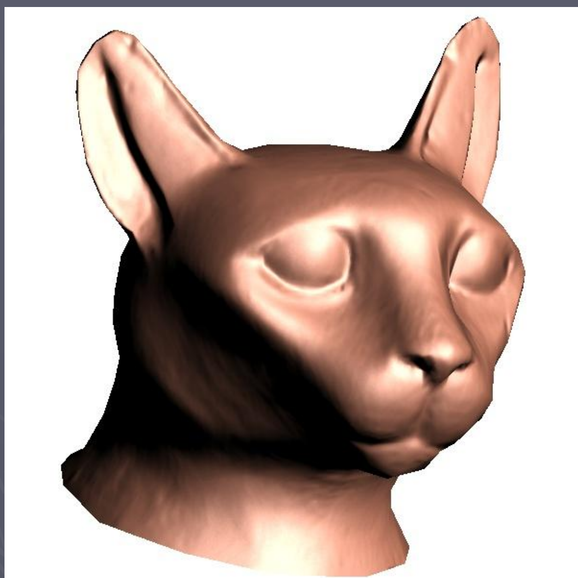


Irregular meshes

Vertex 1 x_1 y_1 z_1
Vertex 2 x_2 y_2 z_2
…

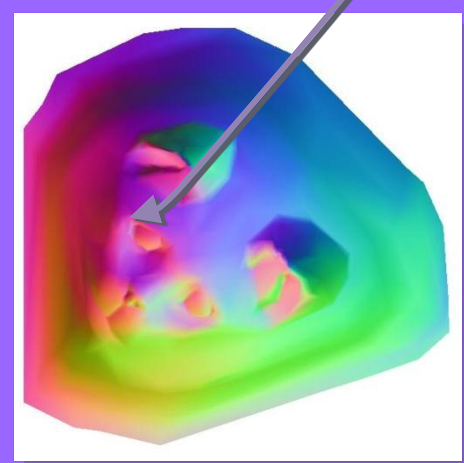
Face 2 1 3
Face 4 2 3
…

Texture mapping



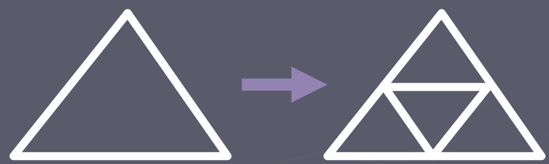
Vertex 1 x_1 y_1 z_1 s_1 t_1
Vertex 2 x_2 y_2 z_2 s_2 t_2
...

Face 2 1 3
Face 4 2 3
...

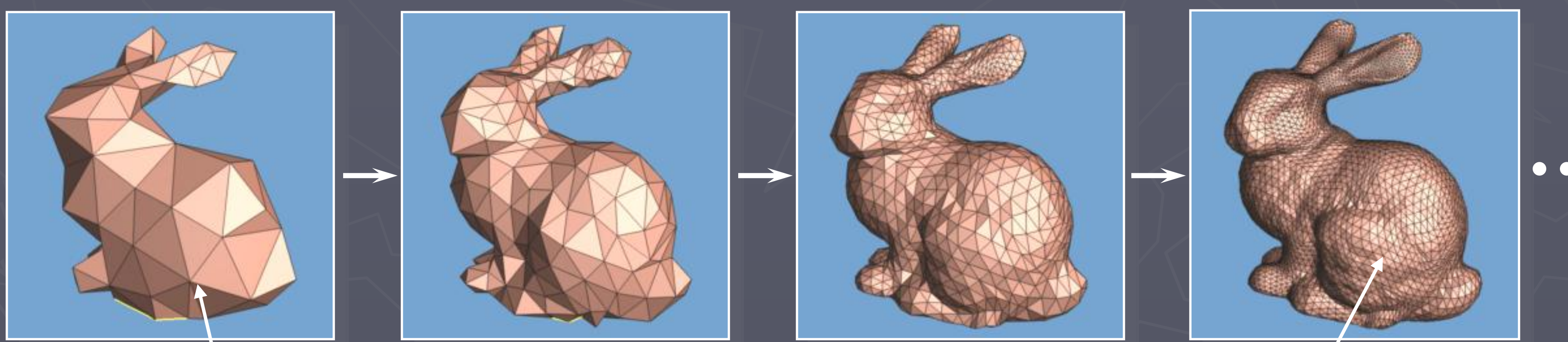


normal map

Remeshing



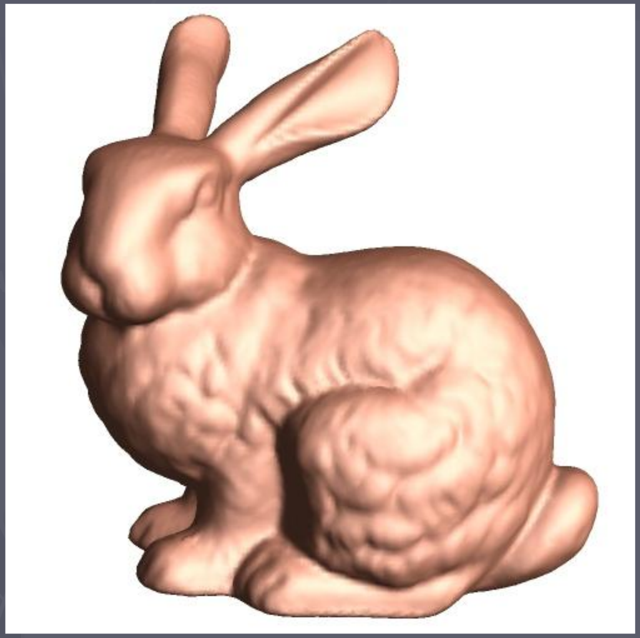
[Eck et al 1995]
[Lee et al 1998]
[Khodakovsky 2000]
[Guskov et al 2000]
…

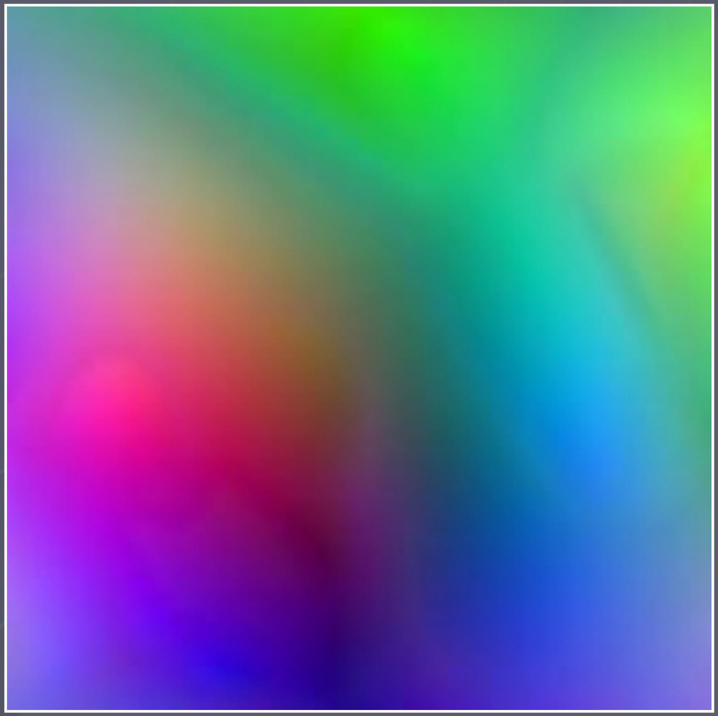


irregular vertex indices

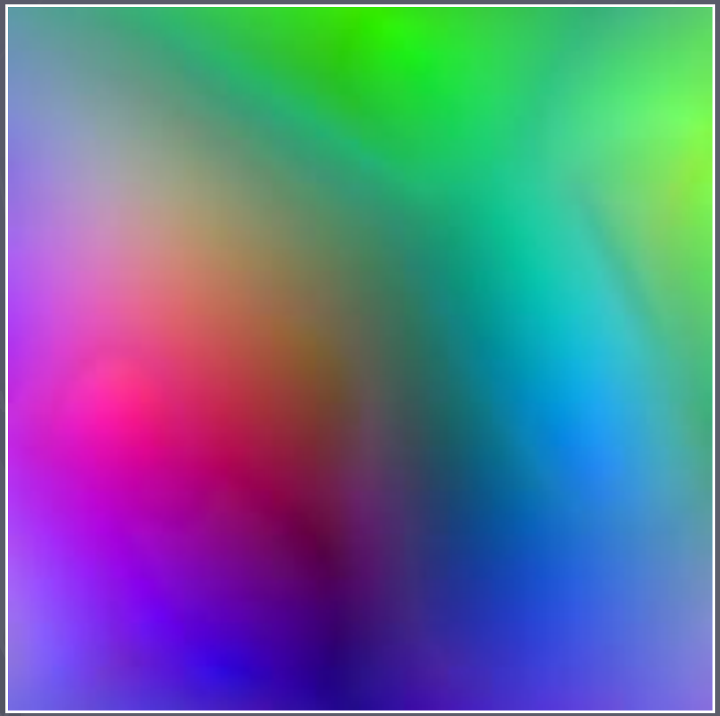
*only **semi**-regular*

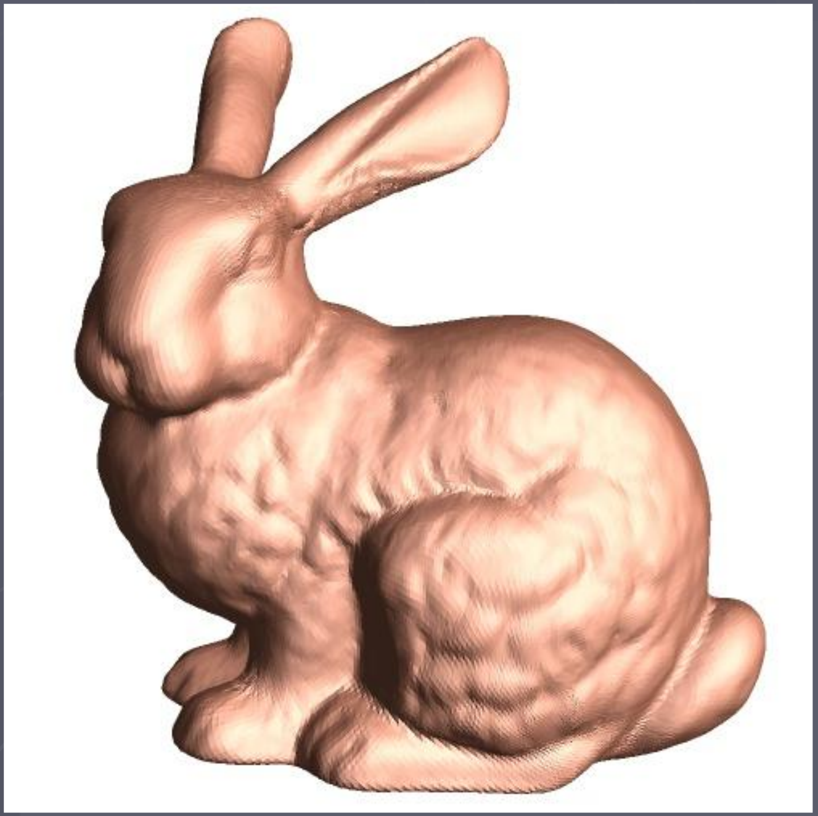
Geometry Image





Geometry Image



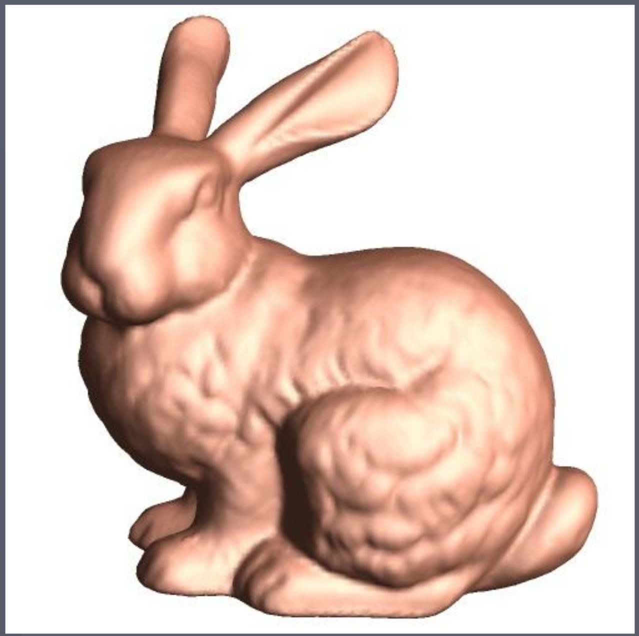


completely regular sampling

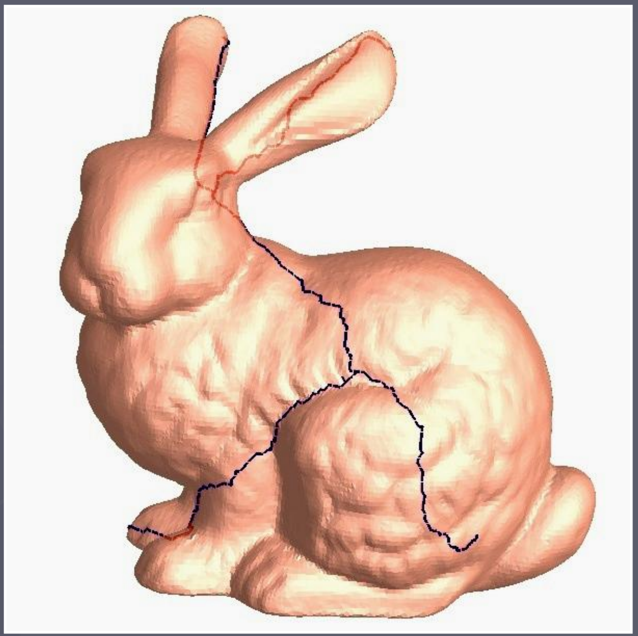
Geometry Image

- Advantages:
  - Other surface attributes, such as normal and colors, are sharing the same domain as the geometry
  - Parameterization itself is implicit - Texture coordinates are absent.

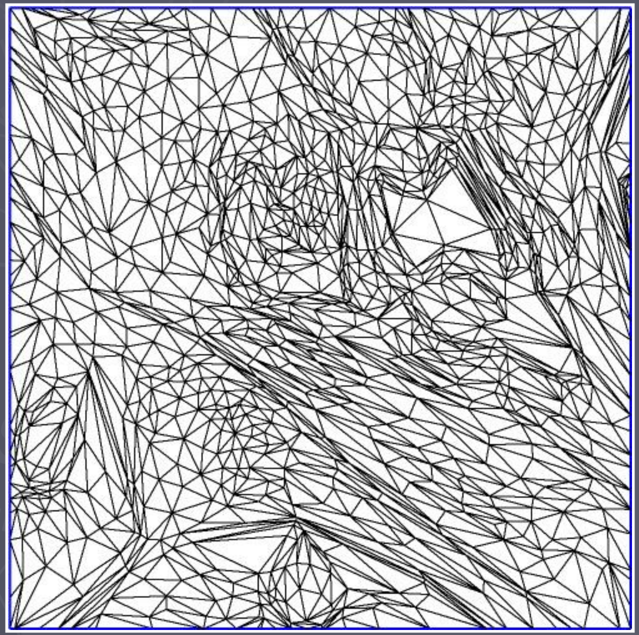
Basic idea



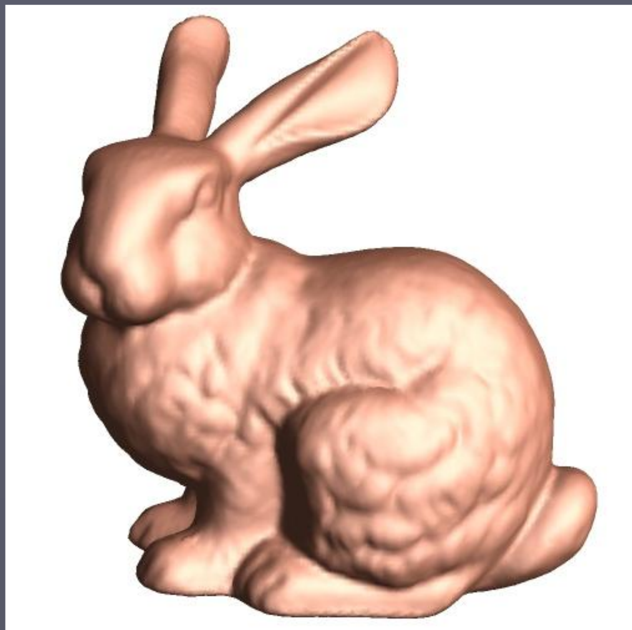
cut



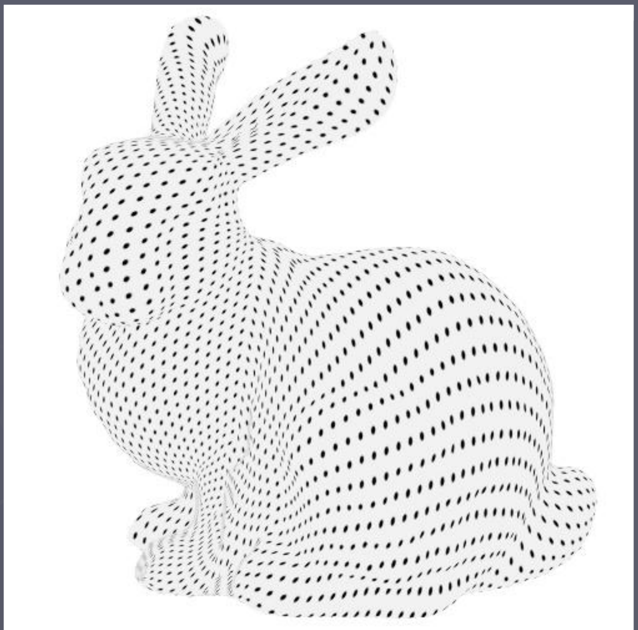
parametrize



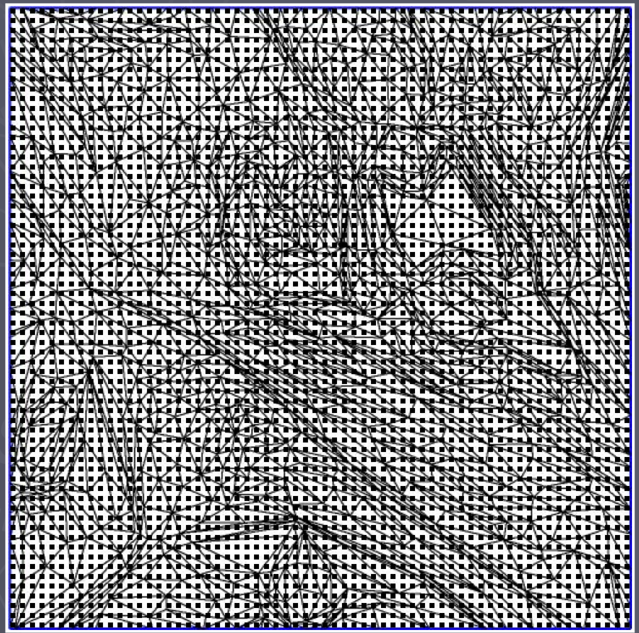
Basic idea



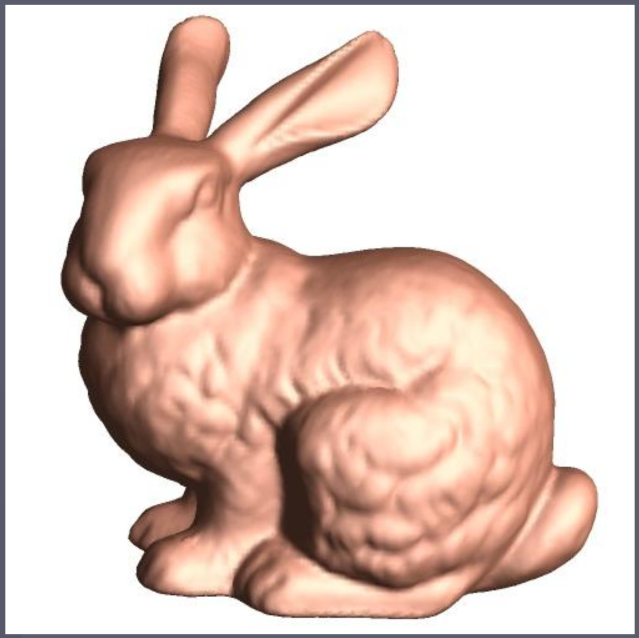
cut



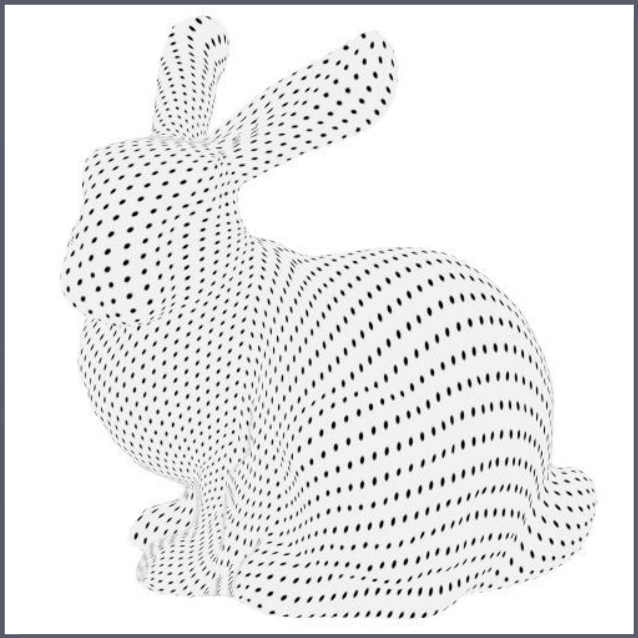
sample



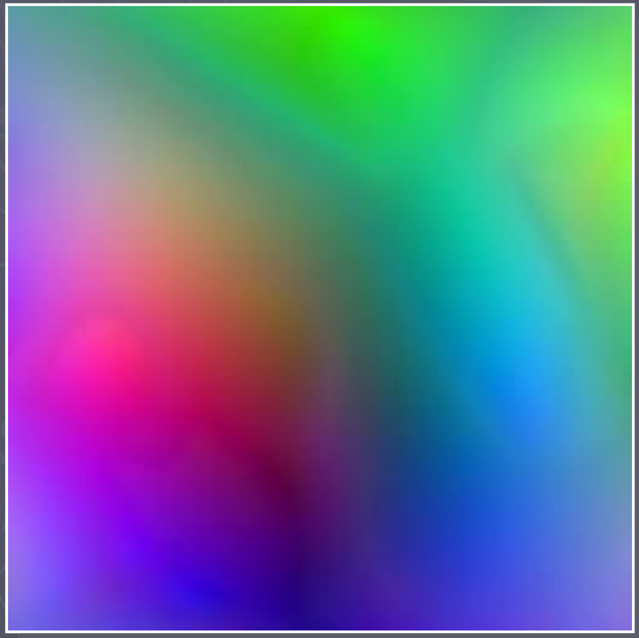
Basic idea



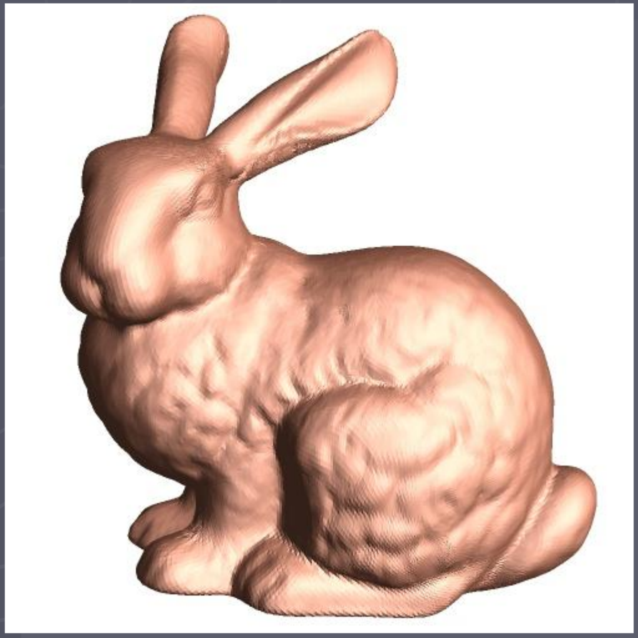
cut



store



render



$[r,g,b] = [x,y,z]$

Creation of Geometry Images Overview

1. Find a good cut ρ
2. Parameterize according to opened cut ρ’

Parameterization

- Assume that we are given a good cut ρ, we do 2 things:

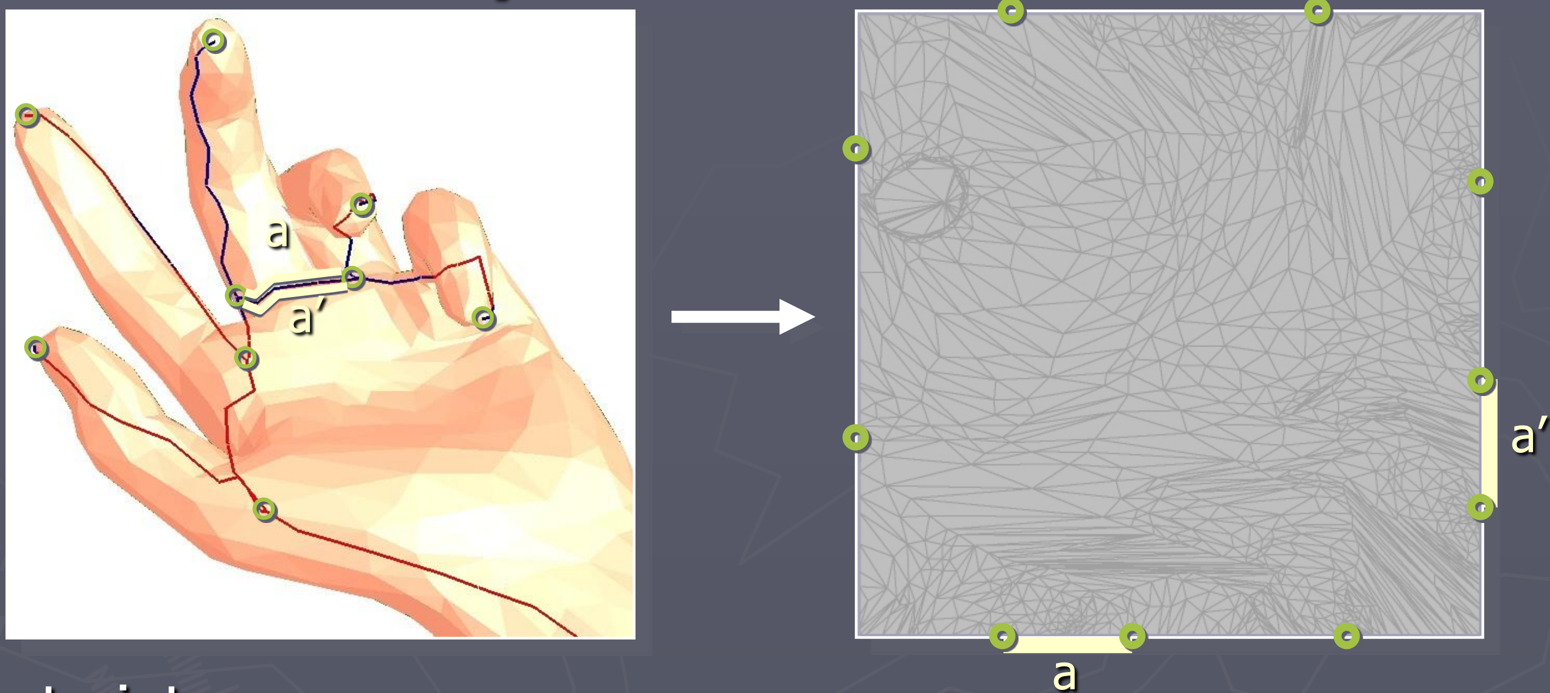
1. Boundary parameterization

   Fix a mapping between the opened cut ρ' and the boundary of the unit square D.

2. Interior parameterization

   Solve for a map of M' onto D that is consistent with these boundary conditions.

Boundary Parameterization



Constraints:

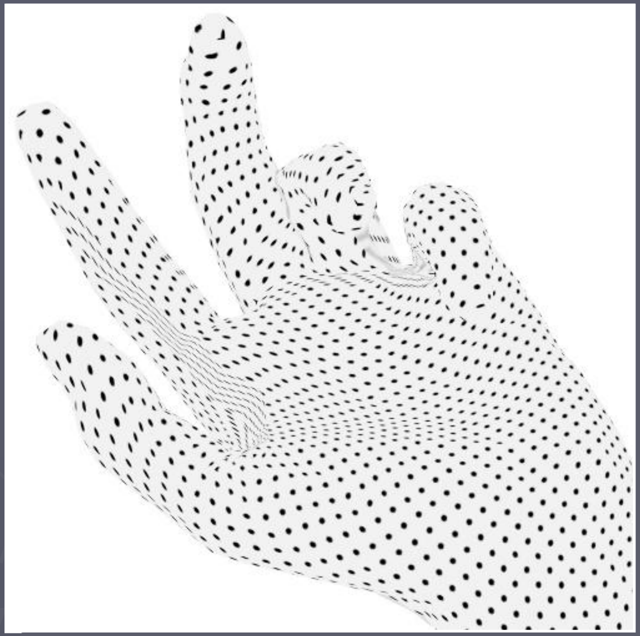
- cut-path mates identical length
- endpoints at grid points

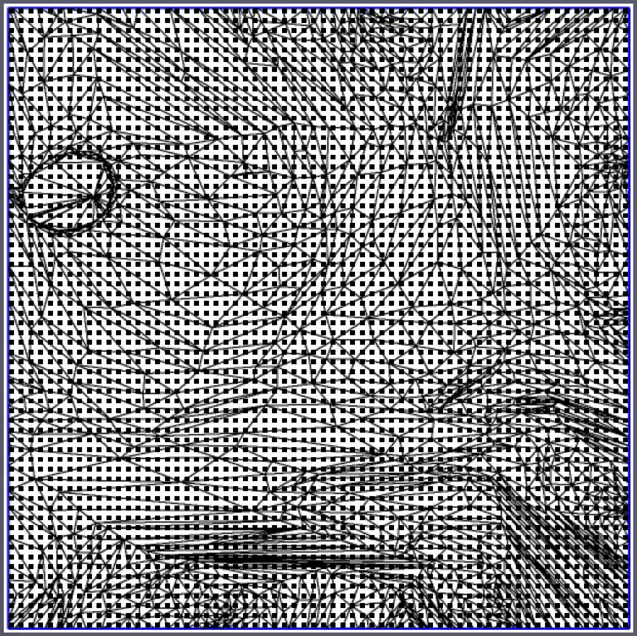
} → no cracks

- No triangle in M’ can have its all vertices mapped to one of the four sides of the square.
- Break any edge that spans one of the four corners of D.

} → Avoid degeneracies

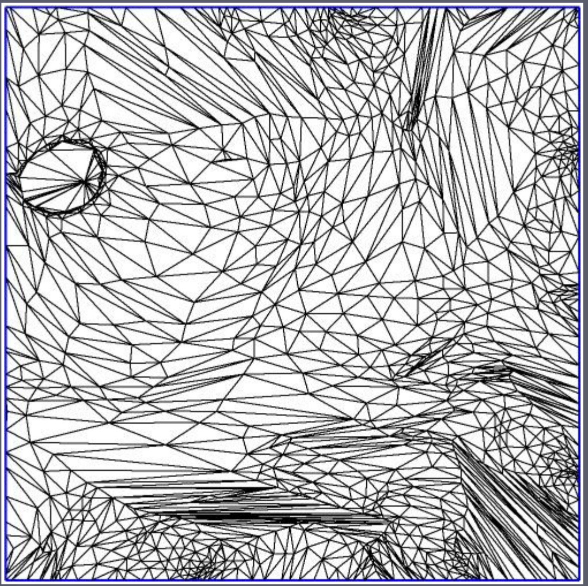
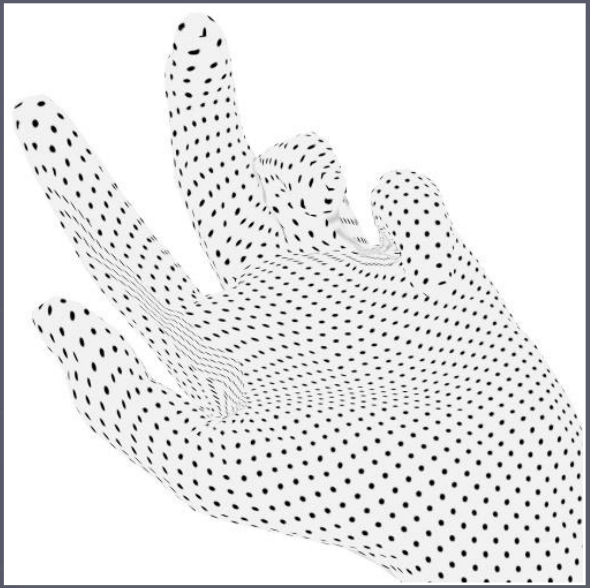
Interior Parameterization





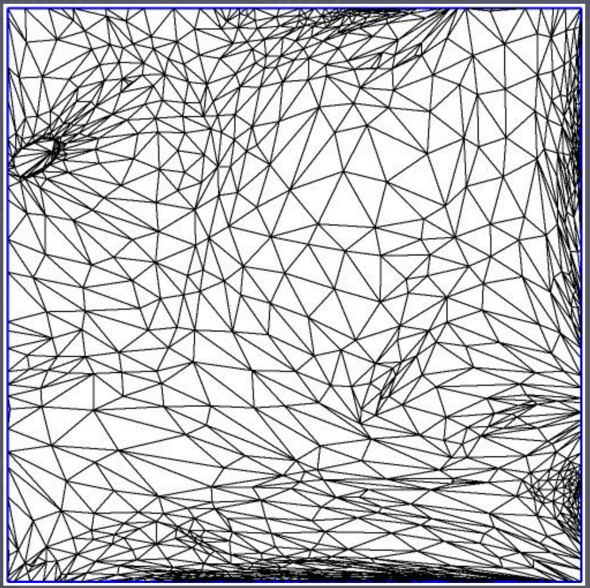
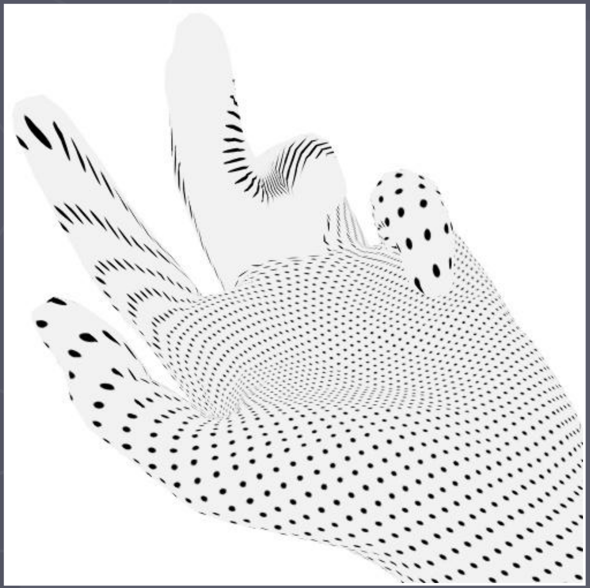
- L2 Geometric-stretch metric [Sander et al 2001]
  - Simplified M' into progressive mesh. [Sander et al 2002]
  - From base mesh, apply vertex splits to successfully refine the mesh.
  - For each inserted vertex, minimize stretch using a local, non-linear optimization algorithm.

Stretch parametrization

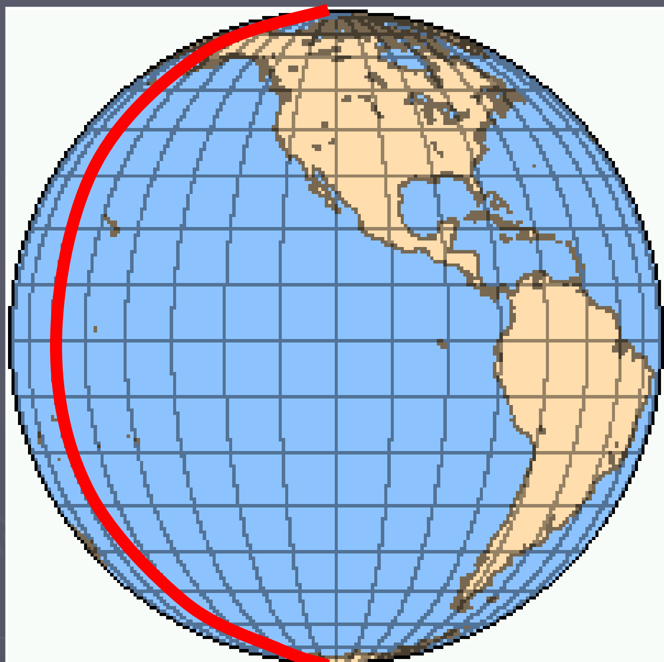




Previous metrics

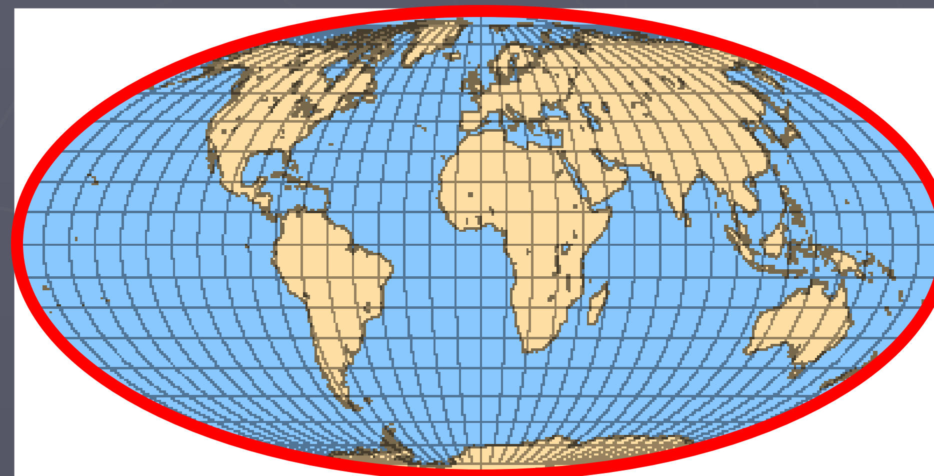
(Floater, harmonic, uniform, …)


Cutting

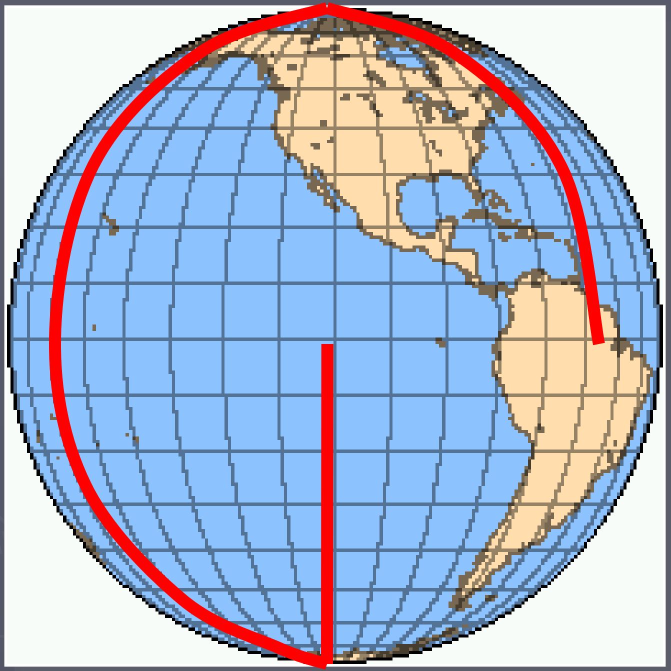


sphere in 3D

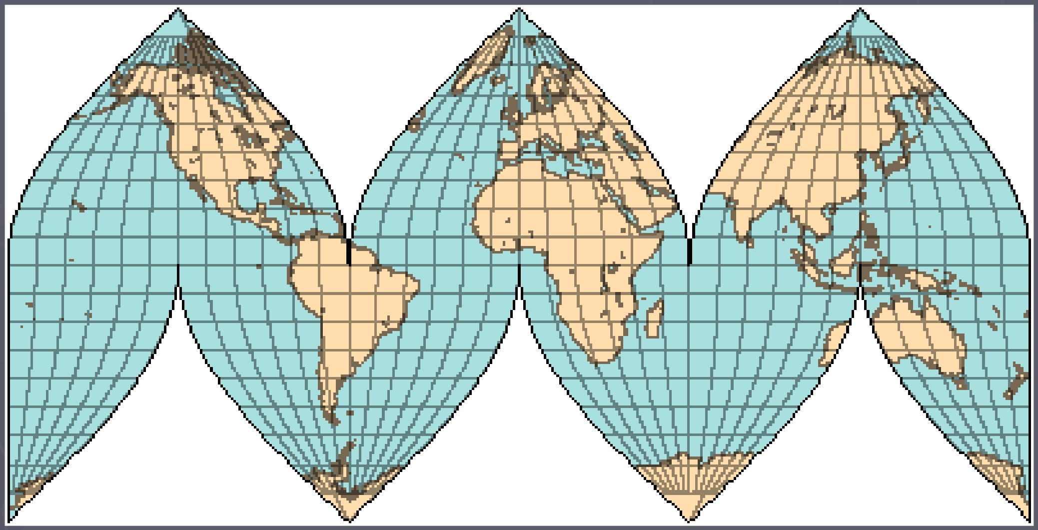


2D surface disk

Cutting



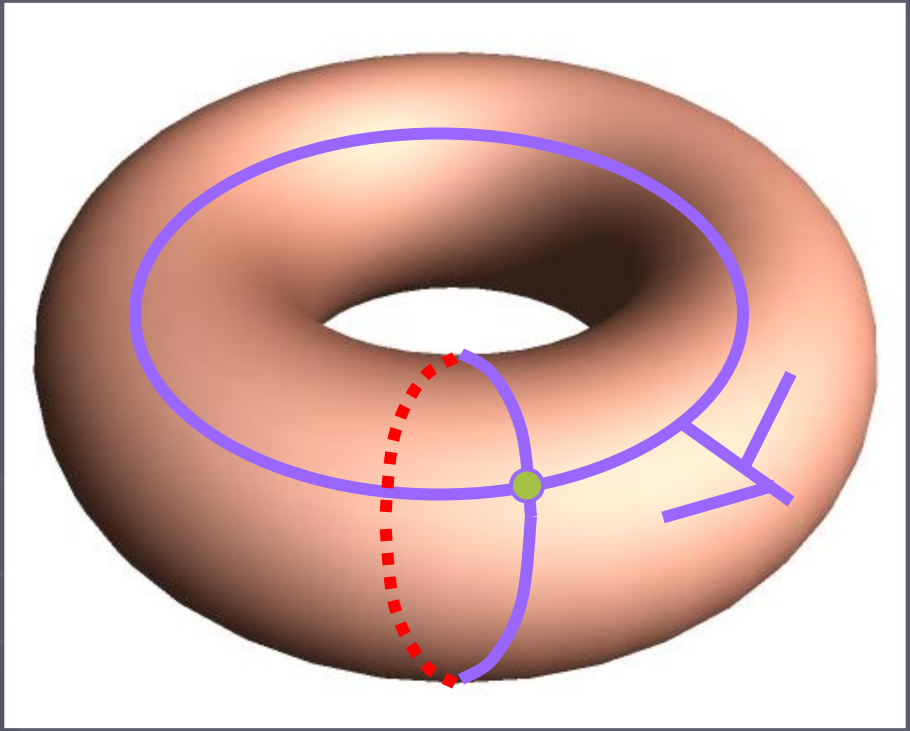
sphere in 3D



2D surface disk

- Genus-0 surface → any tree of edges

Cutting



torus (genus 1)

- Genus-*g* surface → *2g* generator loops *minimum*

Surface cutting algorithm

(1) Find topologically-sufficient cut:

$2g$ loops

[Dey and Schipper 1995]
[Erickson and Har-Peled 2002]

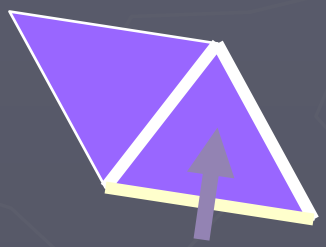
(2) Allow better parametrization:

additional cut paths

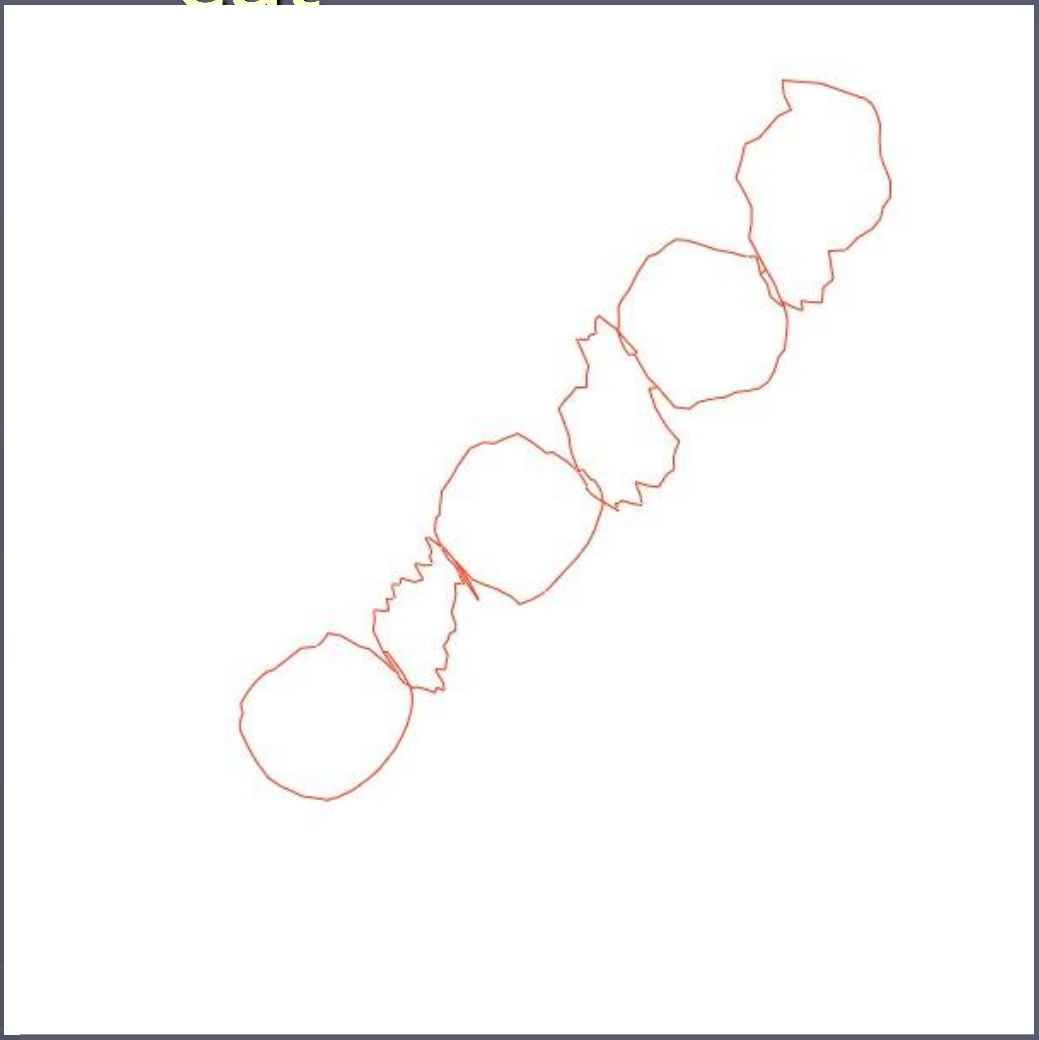
[Sheffer 2002]

Step 1: Find topologically-sufficient cut

(a) retract 2-simplices

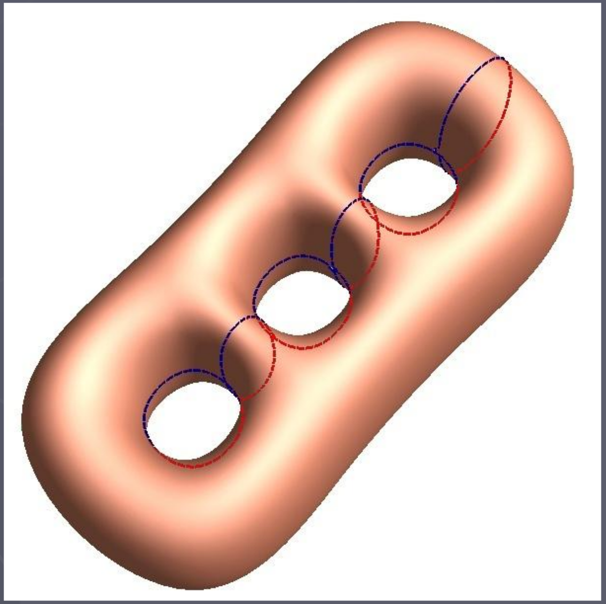


(b) retract 1-simplices



Results of Step 1

genus 6



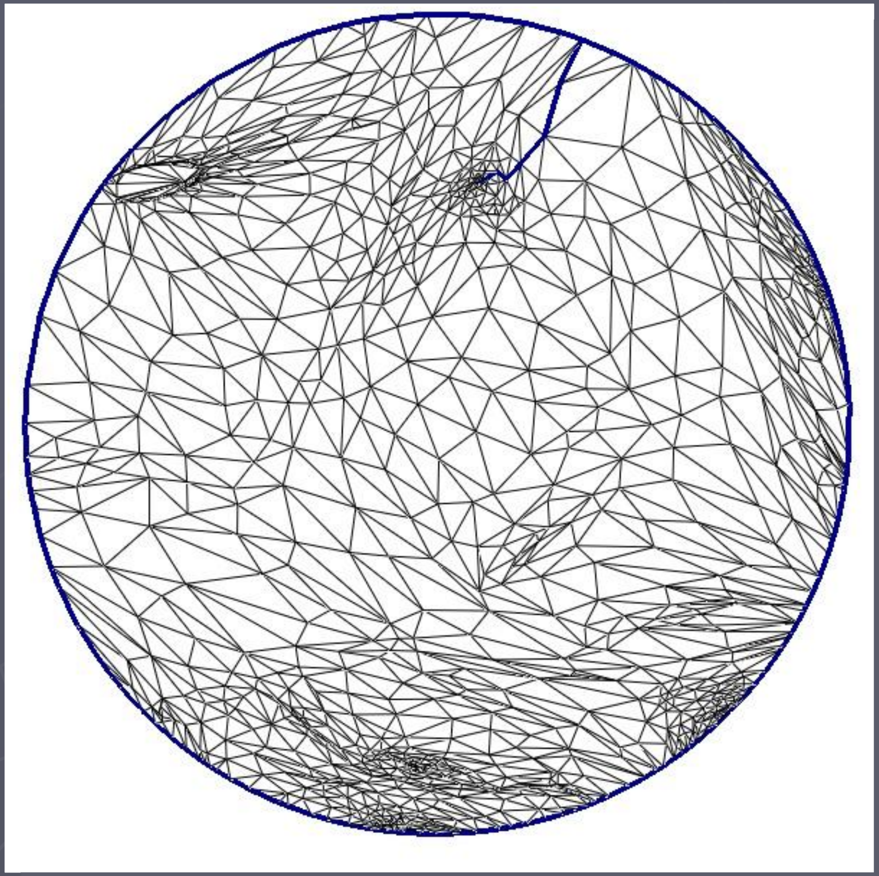
genus 3

genus 0

Step 2: Augment cut

- Make the cut pass through "extrema" (note: not local phenomena).
- Approach: parametrize and look for "bad" areas.

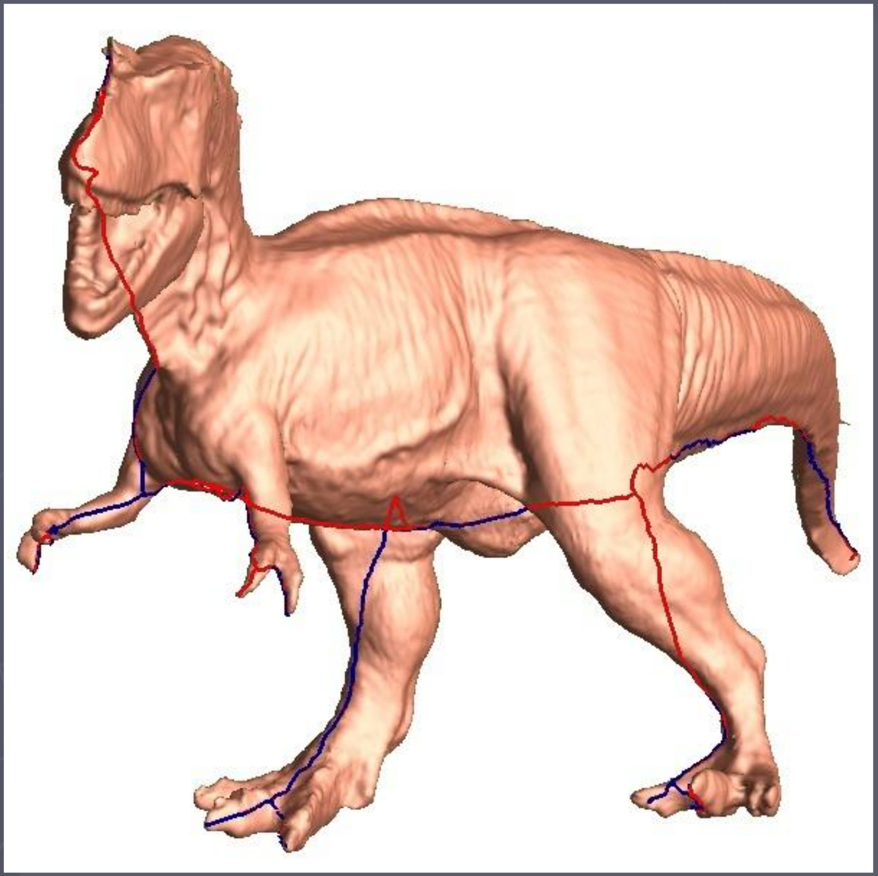
Step 2: Augment cut



…iterate while parametrization improves

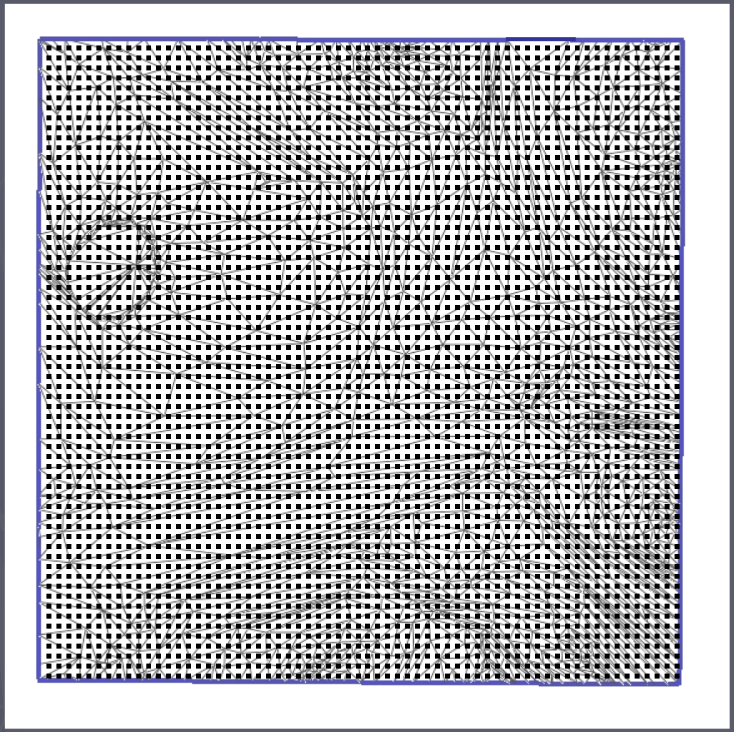
Results of Steps 1 & 2

genus 1



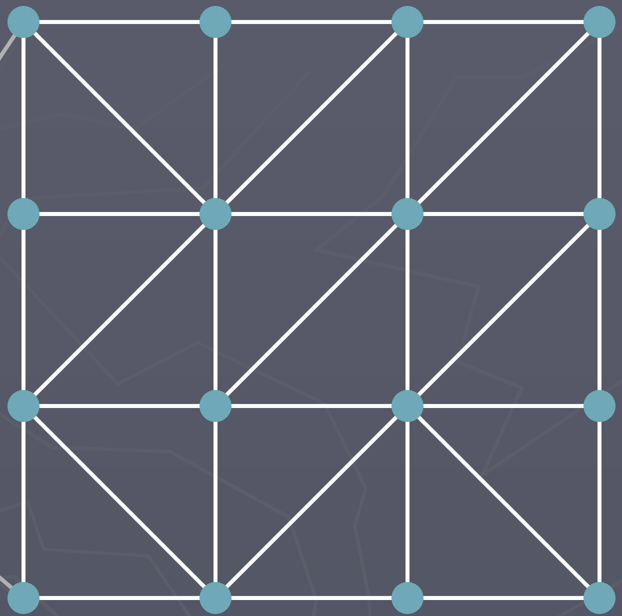
genus 0

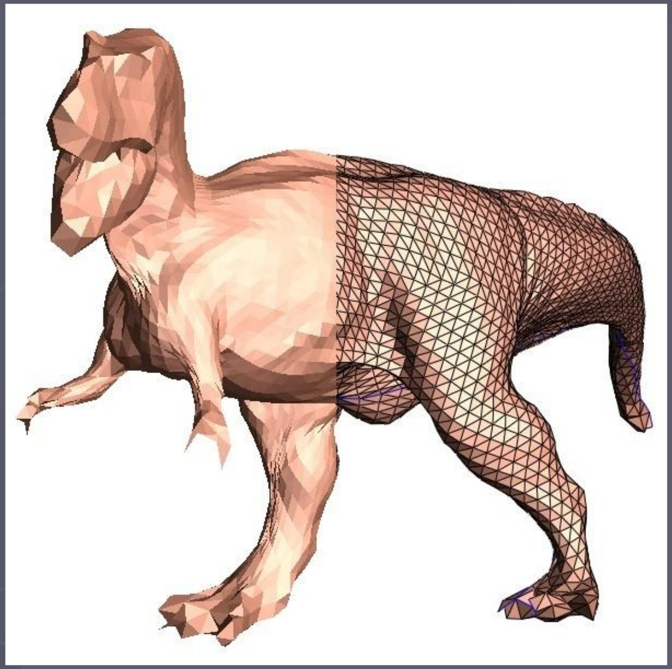
Sample



geometry image

Rendering





(65x65 geometry image)

Rendering with attributes

geometry image 257^2 x 12b/ch

normal-map image 512^2 x 8b/ch

rendering

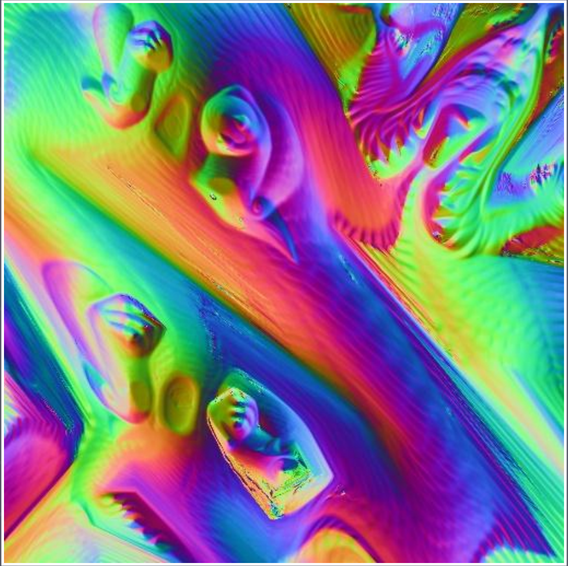
Advantages for hardware rendering

- Regular sampling → no vertex indices.
- Unified parametrization → no texture coordinates.

Summary: compact, regular, no indirection

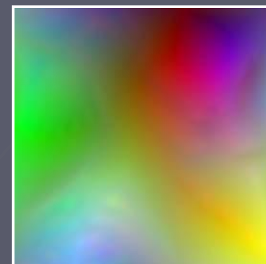
Results

257x257

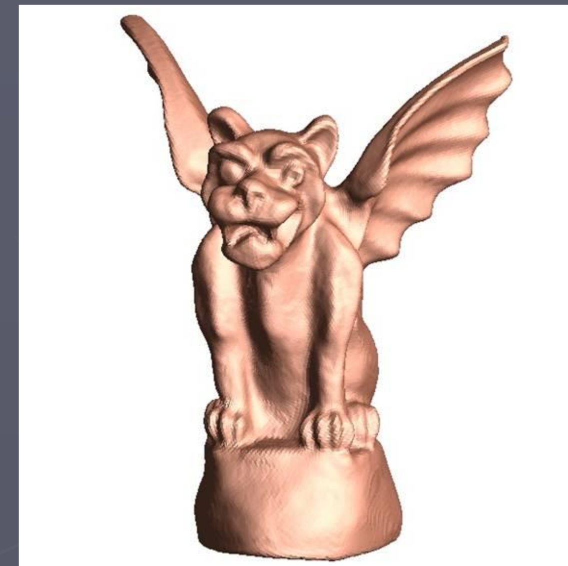


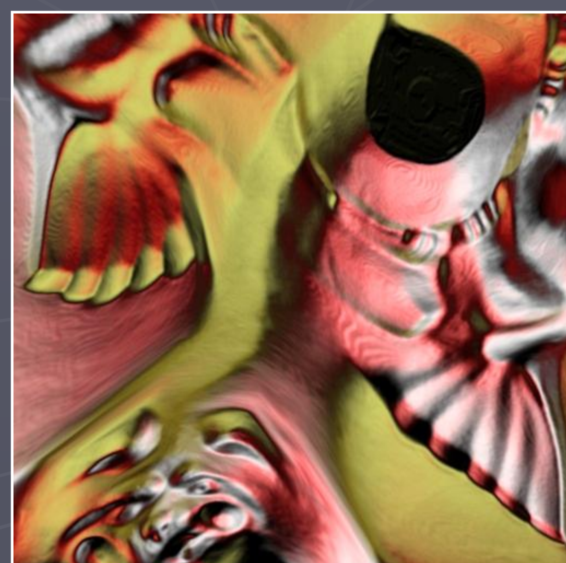
normal-map 512x512

Results

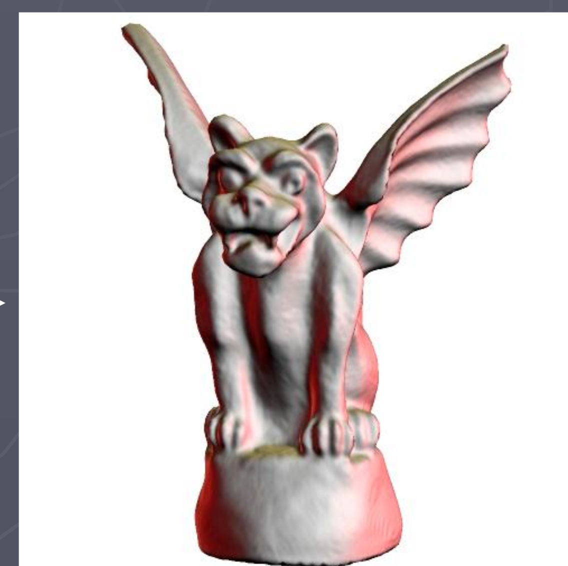


257x257

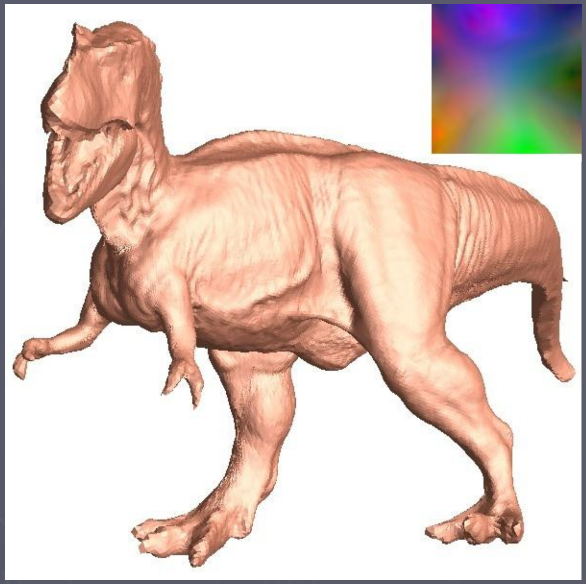




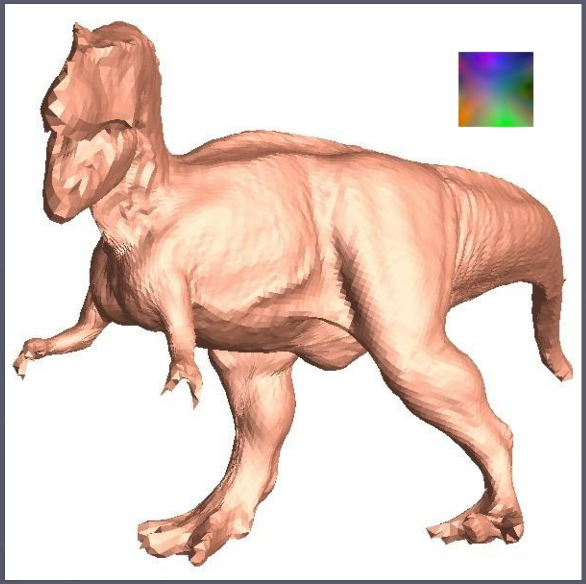
color image 512x512



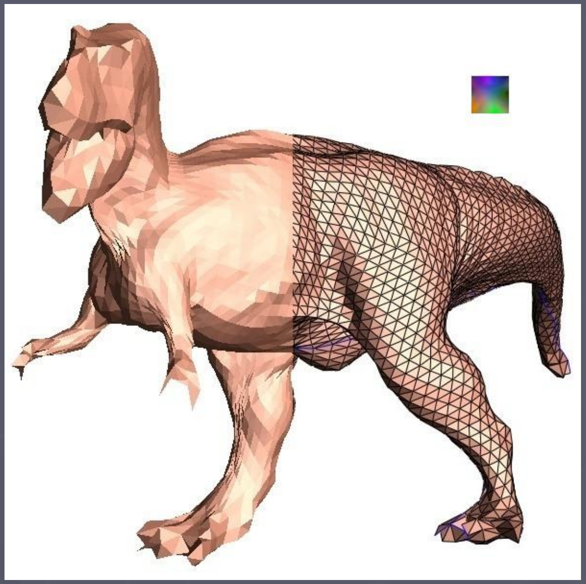
Mip-mapping



257x257

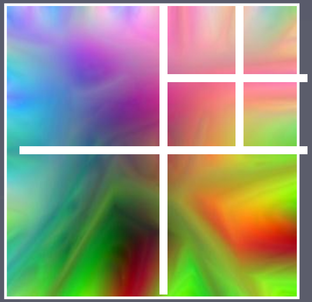


129x129



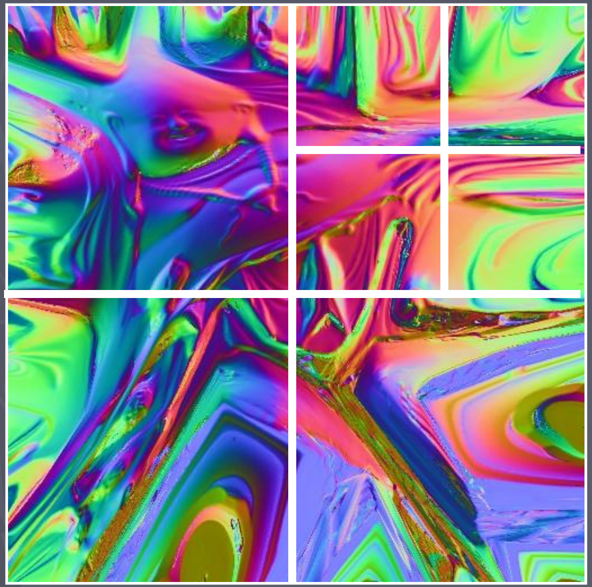
65x65

Hierarchical culling



geometry image

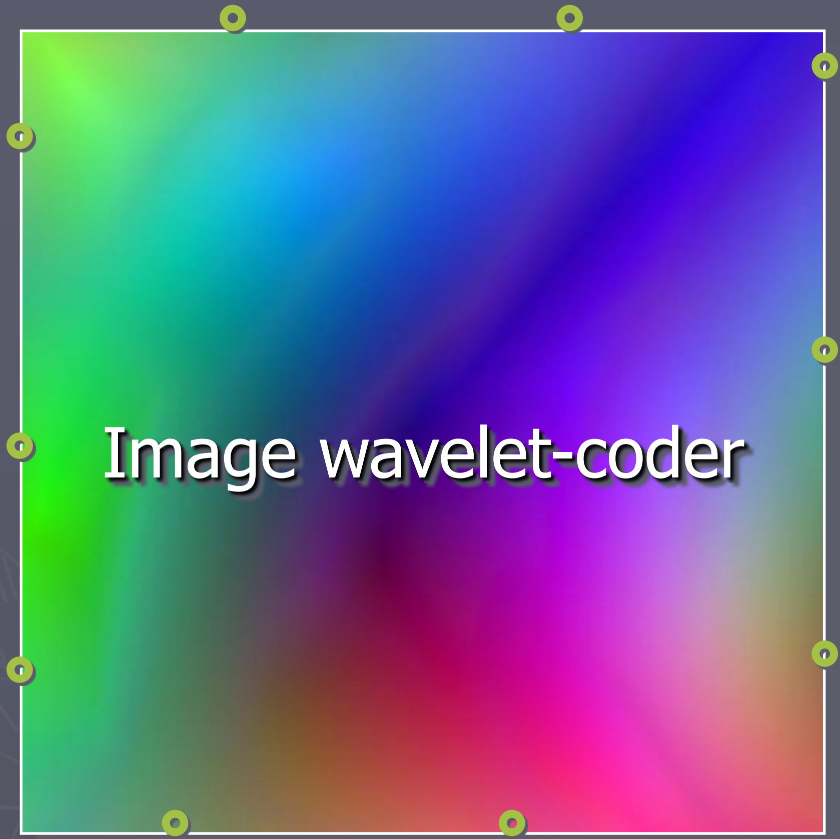
→ view-frustum culling



normal-map image

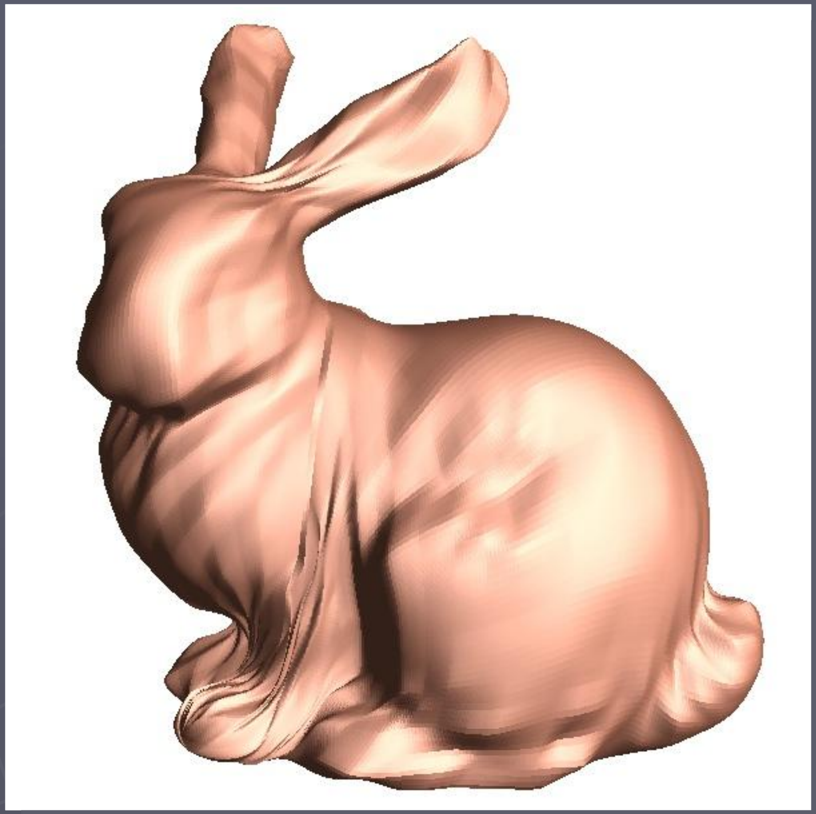
→ backface culling

Compression



295 KB → 1.5 KB

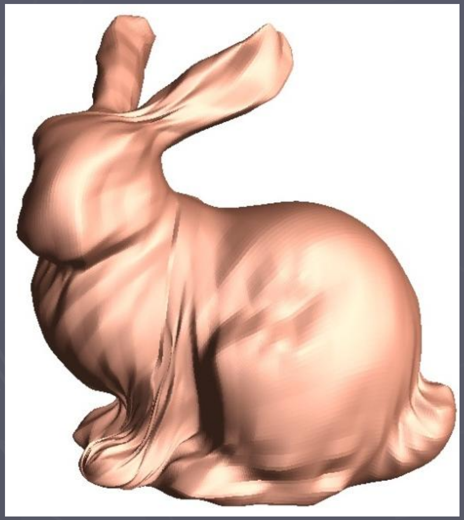
+ topological sideband (12 B)



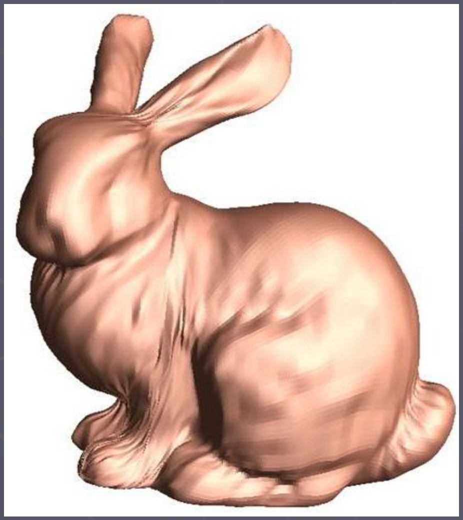
fused cut

Compression results

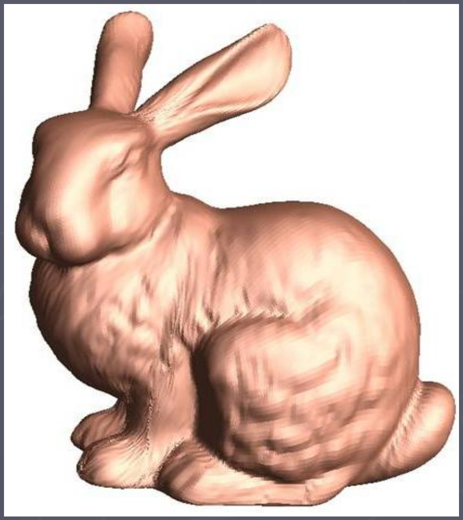
295 KB →



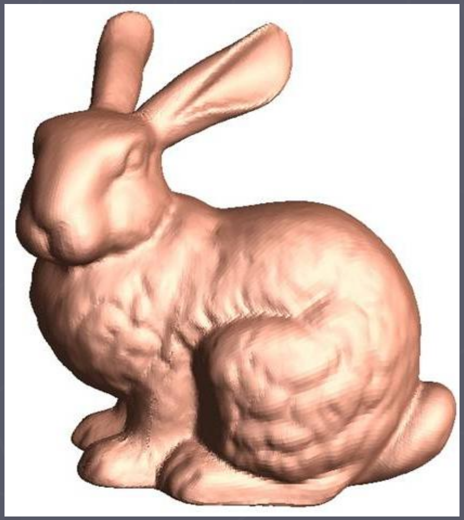
1.5 KB



3 KB

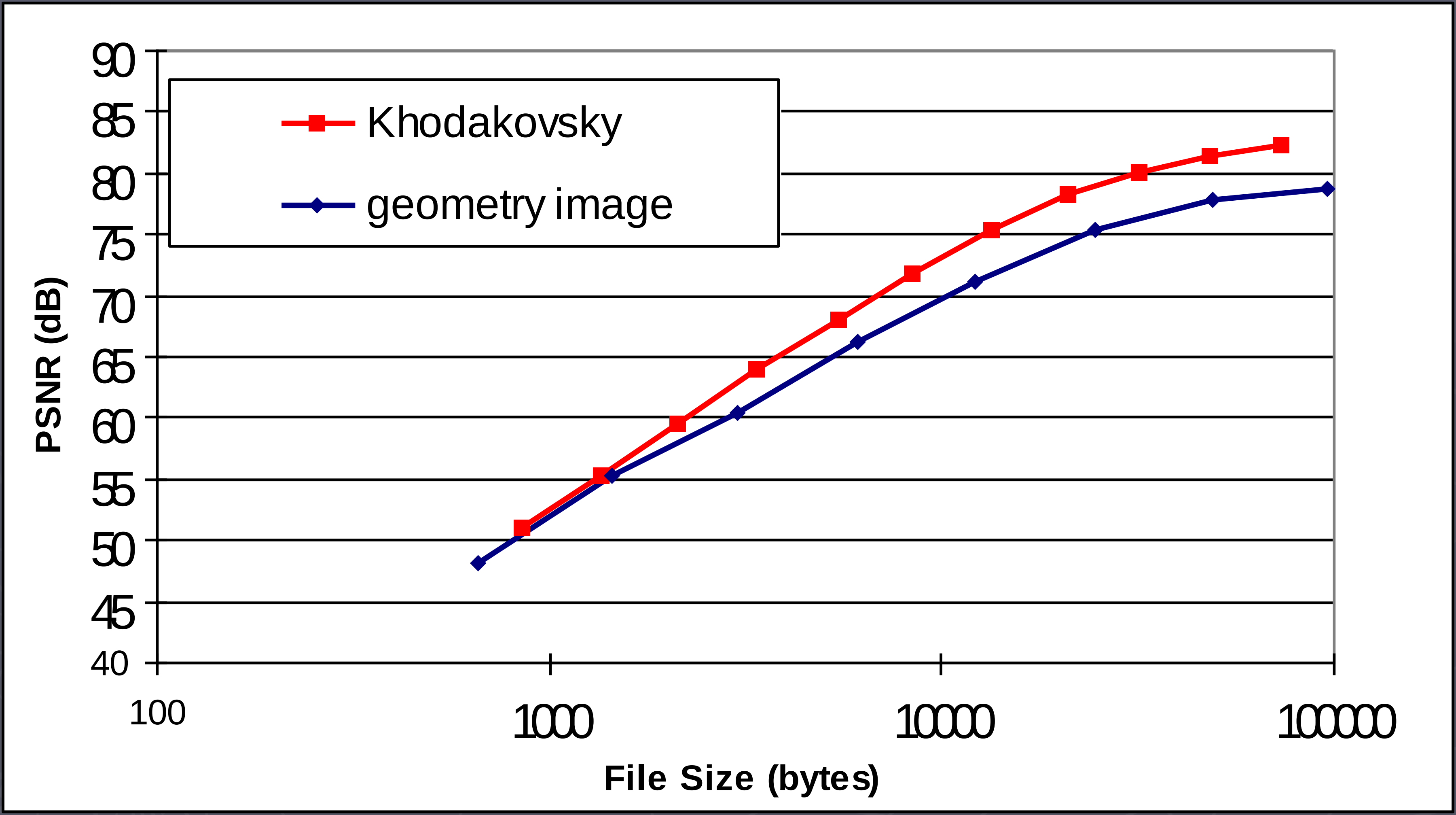


12 KB

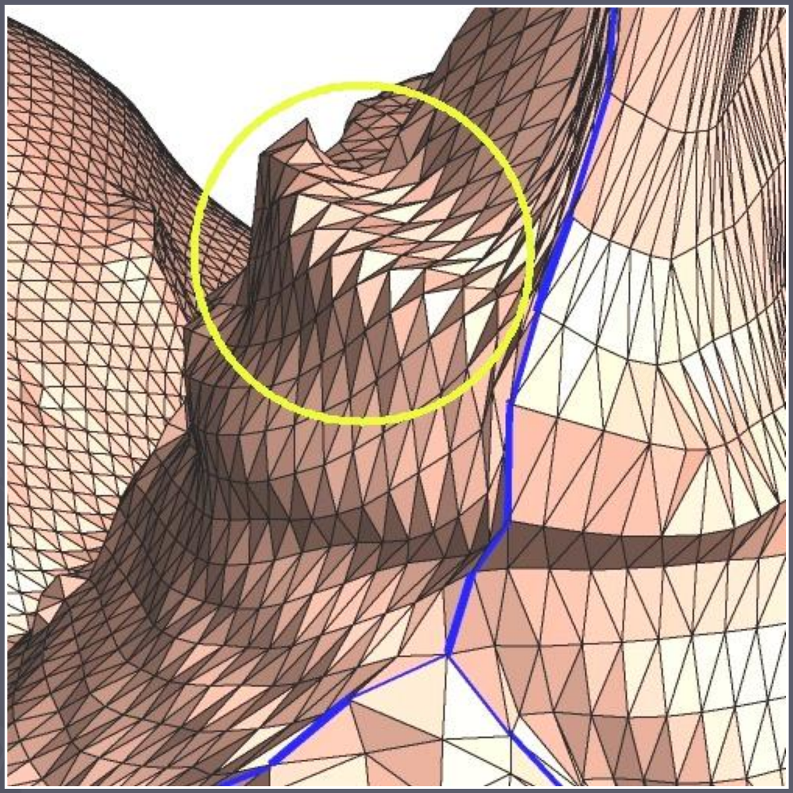


49 KB

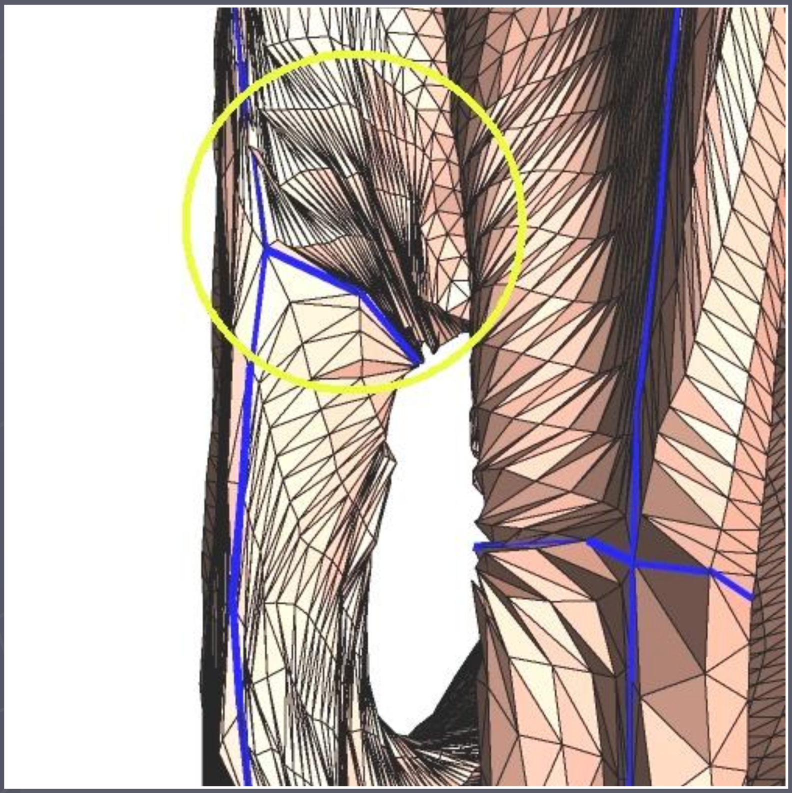
Rate distortion



Some artifacts



aliasing



anisotropic sampling

Summary

- Simple rendering:
  compact, no indirection
- Mipmapped geometry
- Hierarchical culling
- Compressible

Limitations

- Cannot represent non-manifold geometry
- Unwrapping an entire mesh as a single chart can create parameterization with greater distortion and less uniform sampling than can be achieved with multiple local charts.

Future work

- Better cutting algorithms
- Feature-sensitive remeshing
- Tangent-frame compression
- Bilinear and bicubic rendering
- Build hardware