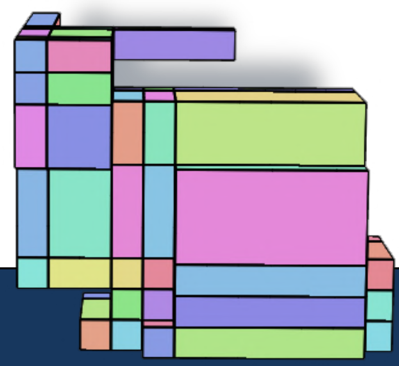
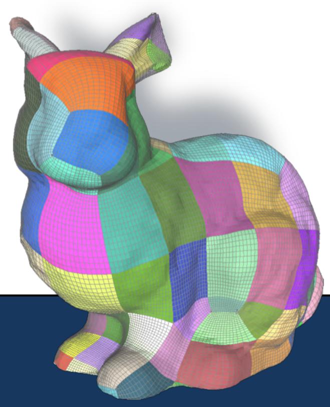
University of Cagliari
Department of Mathematics and Computer Science

PolyCubes Optimization

Generating Coarse Quad-Layouts via Smart Polycube Quantization





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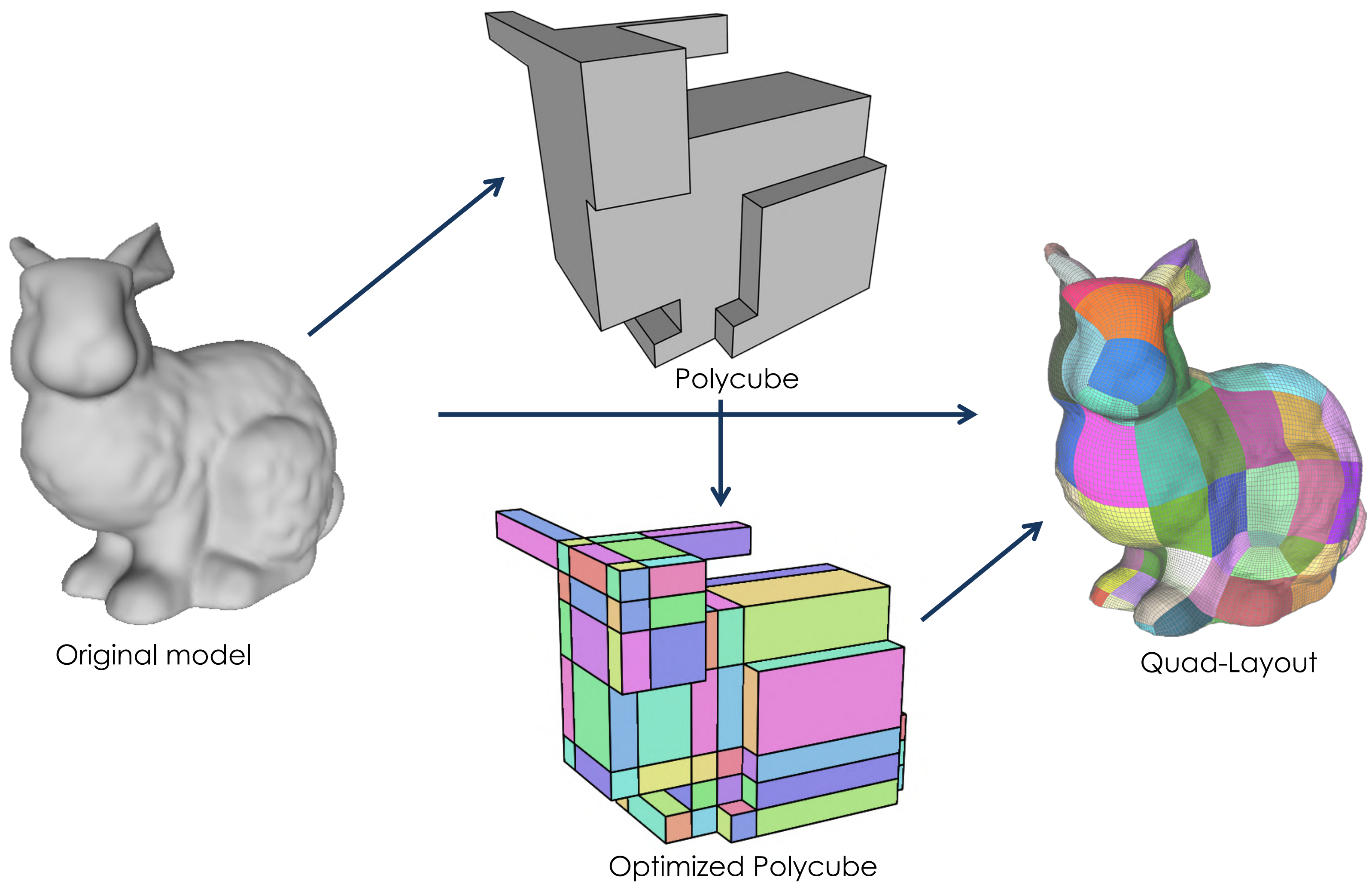
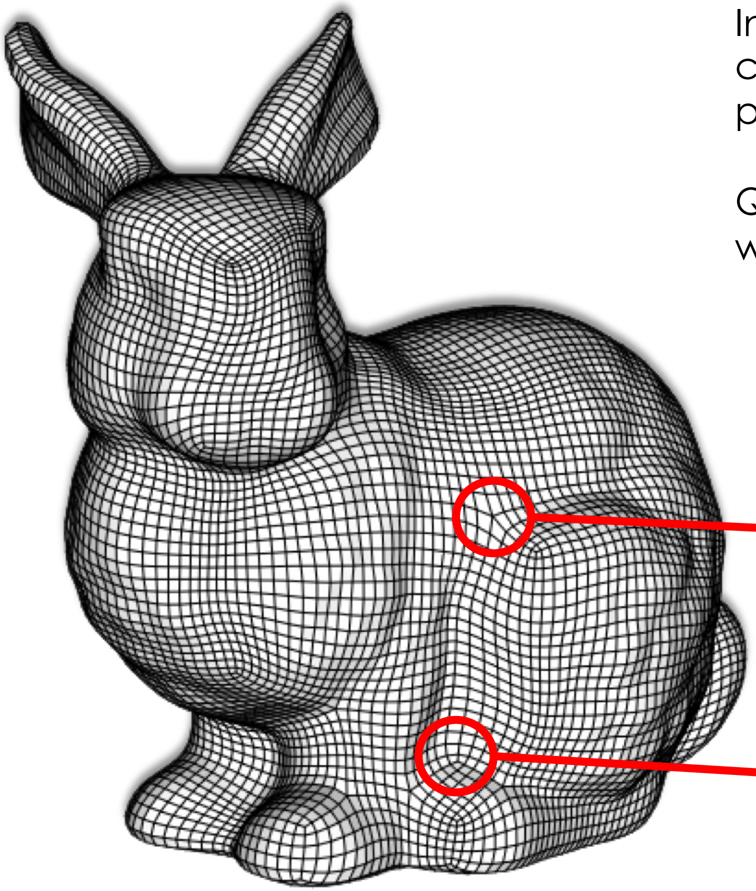
M.Sc. Candidate
Gianmarco Cherchi

Goal



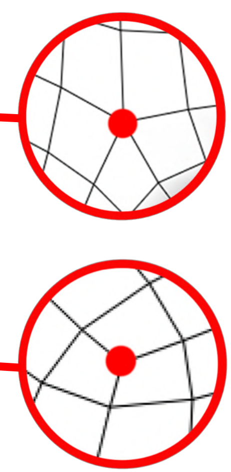
Quad-mesh



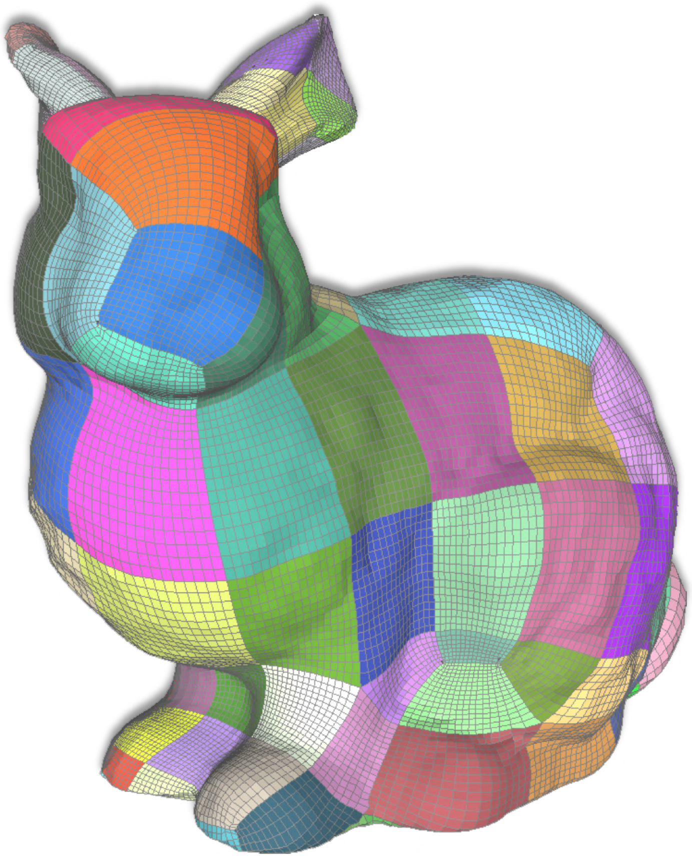
In 3D Computer Graphics a *Polygon-Mesh* is a collection of vertices, edges and faces of a polyhedral object.

Quad-meshes are a type of polygonal meshes in which faces are quadrilateral.

Singularities



Quad-Layout

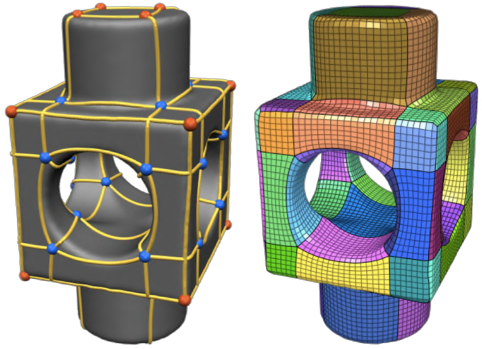


The mesh domain subdivision called *Quad-Layout* is obtained by connecting the mesh singularities through chart boundaries.

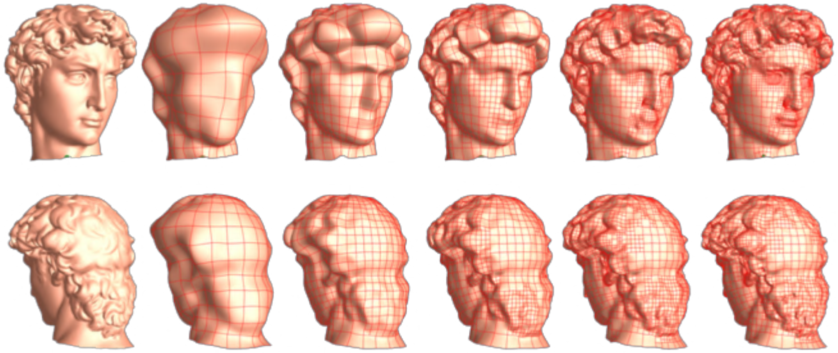
Having a good quality quad-layout is very important for many applications .

Quad-Layout

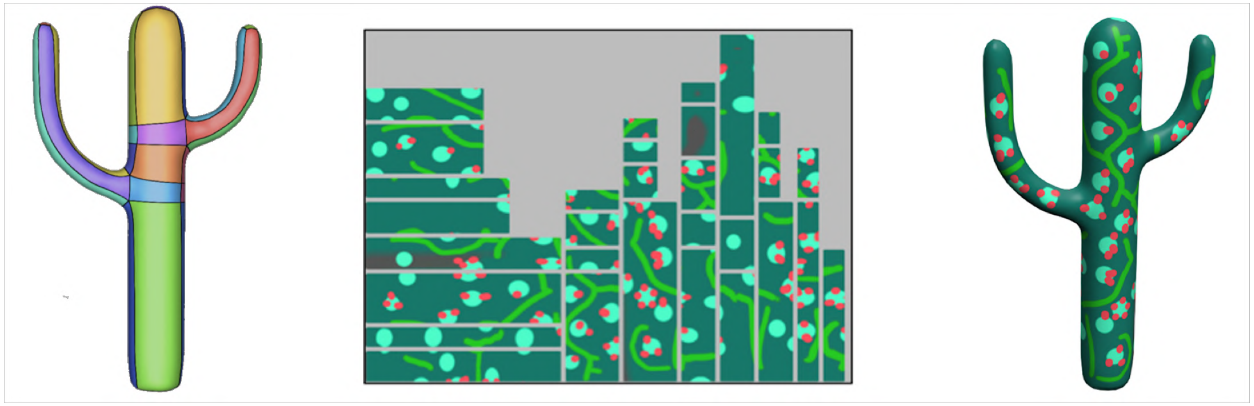
Semi-structured Quad (re)meshing



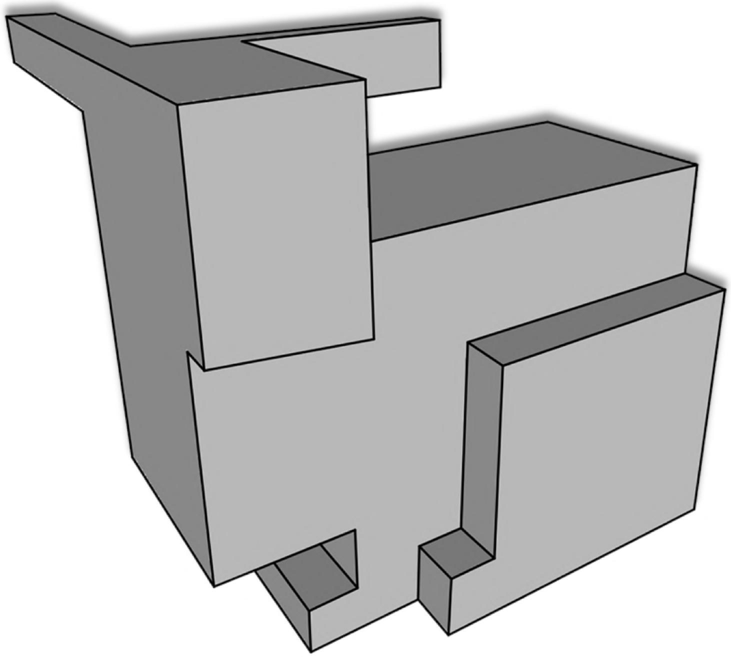
High-order meshing



Texturing



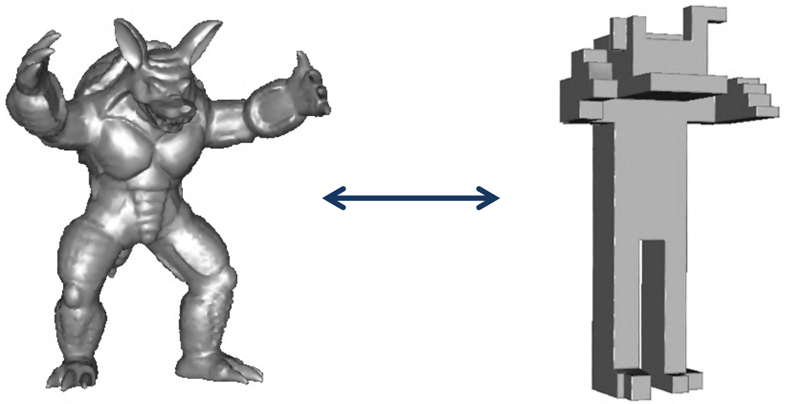
PolyCube



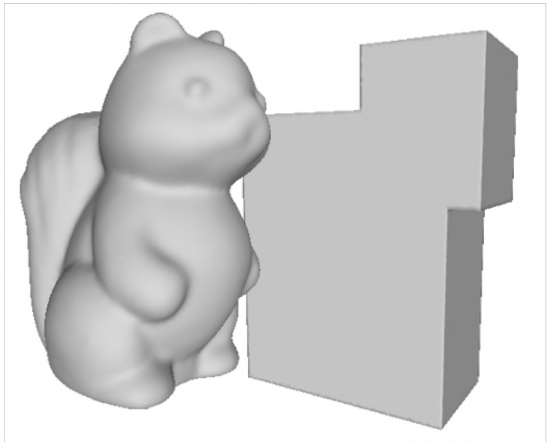
PolyCubes are orthogonal polyhedra made up of:

- axis-aligned faces
- only 90° dihedral angles
- planar faces.

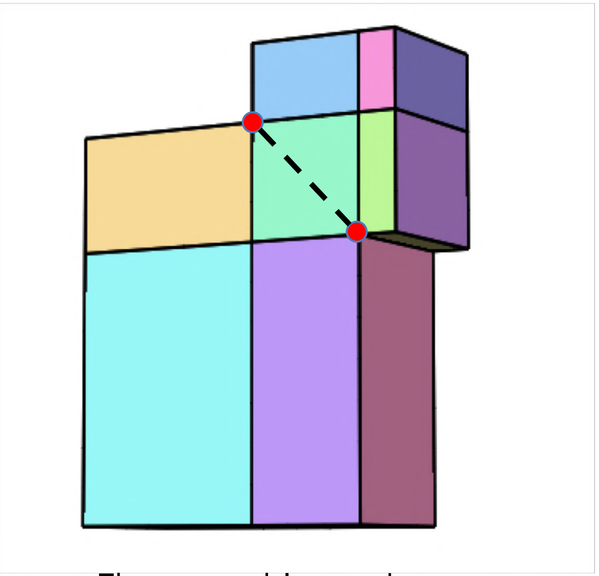
The most important property of a polycube is the ability to represent the original shape in a simple way.



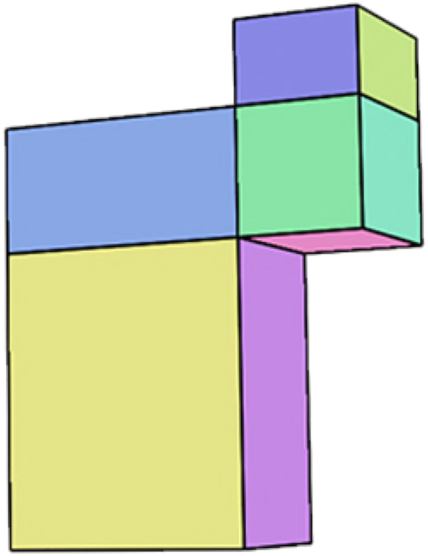
The pipeline



The original model
and
its polycube



The quad-layout
in the original
polycube



The quad-layout
in the **optimized**
polycube

A Possible Solution

The principle on which our approach is based is:

"***to align polycube corners to remove the largest number of misalignments***"

↓

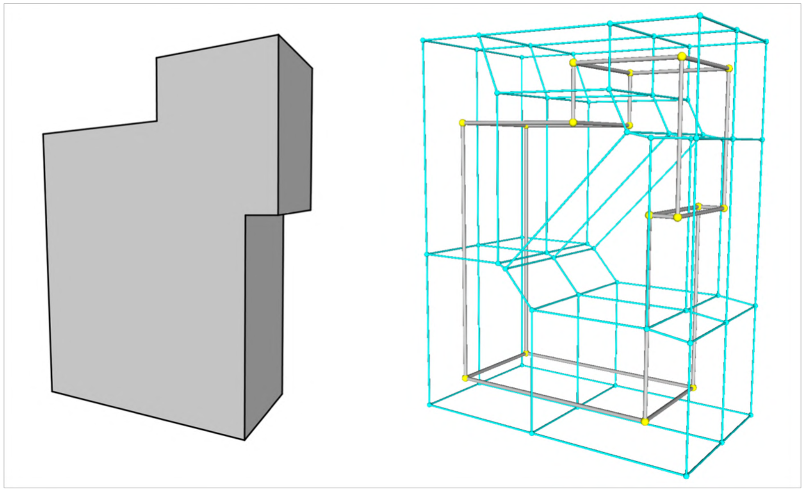
Mathematical Model

The Mathematical Model – Objective Function

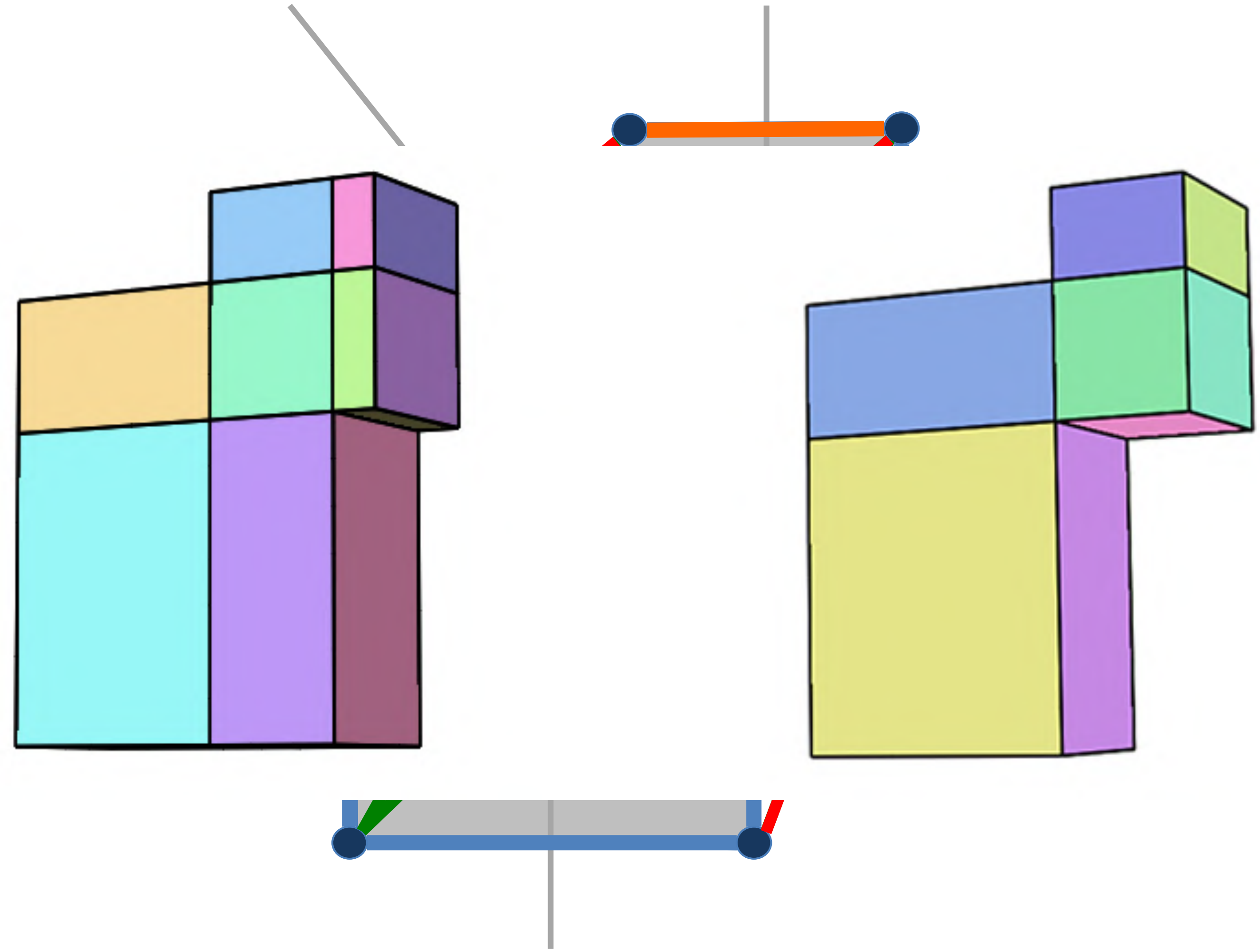
$$min\ e = \alpha \cdot E_{shape} + \beta \cdot E_{align}$$

$$E_{shape} = \sum_{i \in V} \left[(x_i - \tilde{x}_i)^2 + (y_i - \tilde{y}_i)^2 + (z_i - \tilde{z}_i)^2 \right]$$

$$E_{align} = \sum_{(i,j) \in A_x} (x_i - x_j)^2 + \sum_{(i,j) \in A_y} (y_i - y_j)^2 + \sum_{(i,j) \in A_z} (z_i - z_j)^2$$

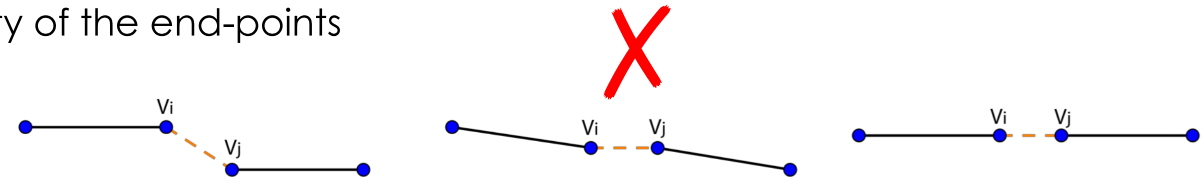


The Mathematical Model – Objective Function

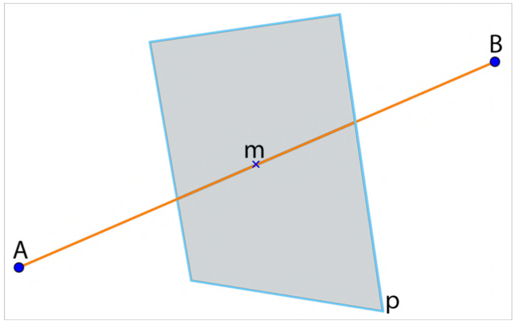


The Mathematical Model – Constraints

- Collinearity of the end-points



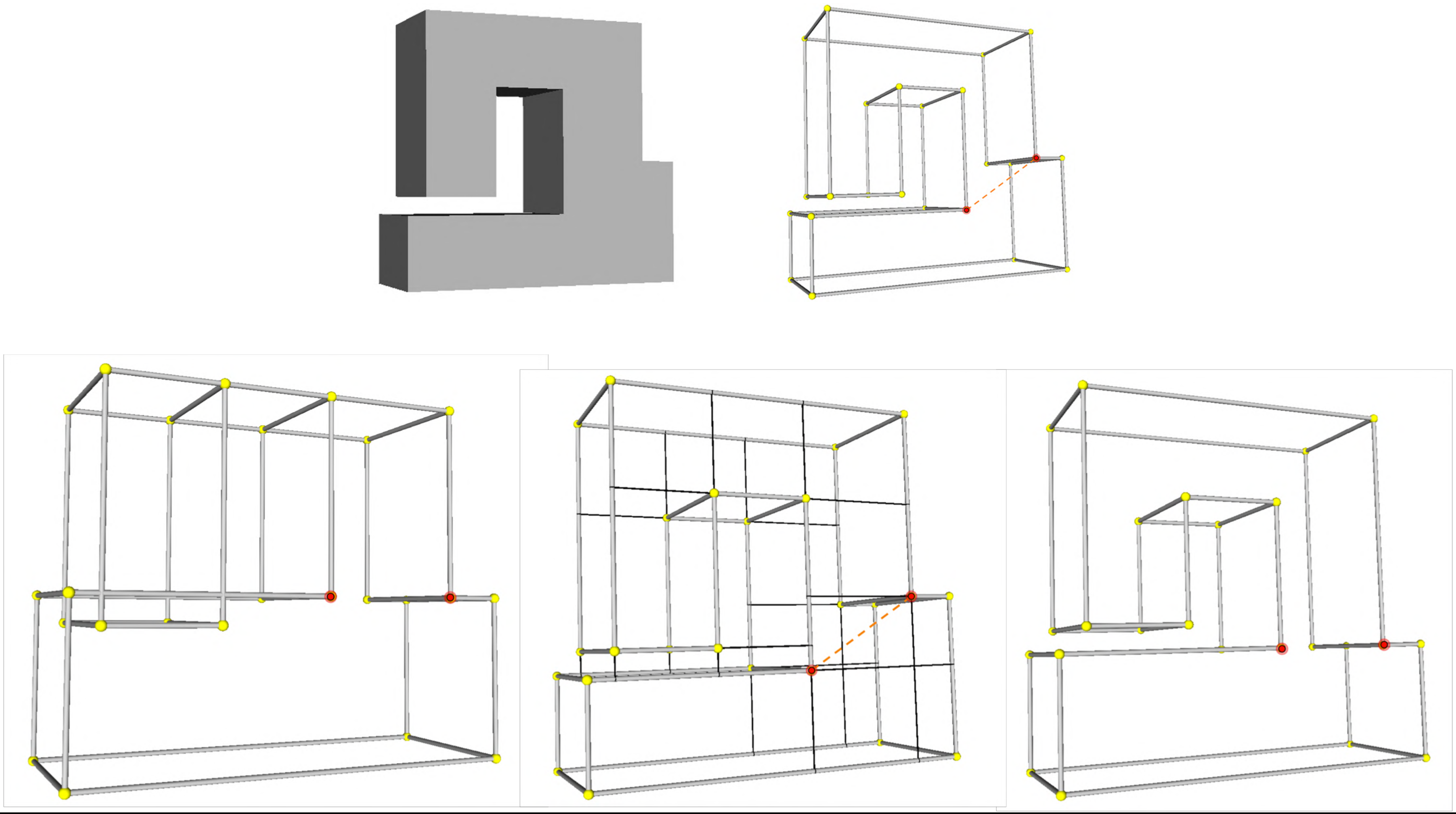
- Keep vertices in their half-spaces



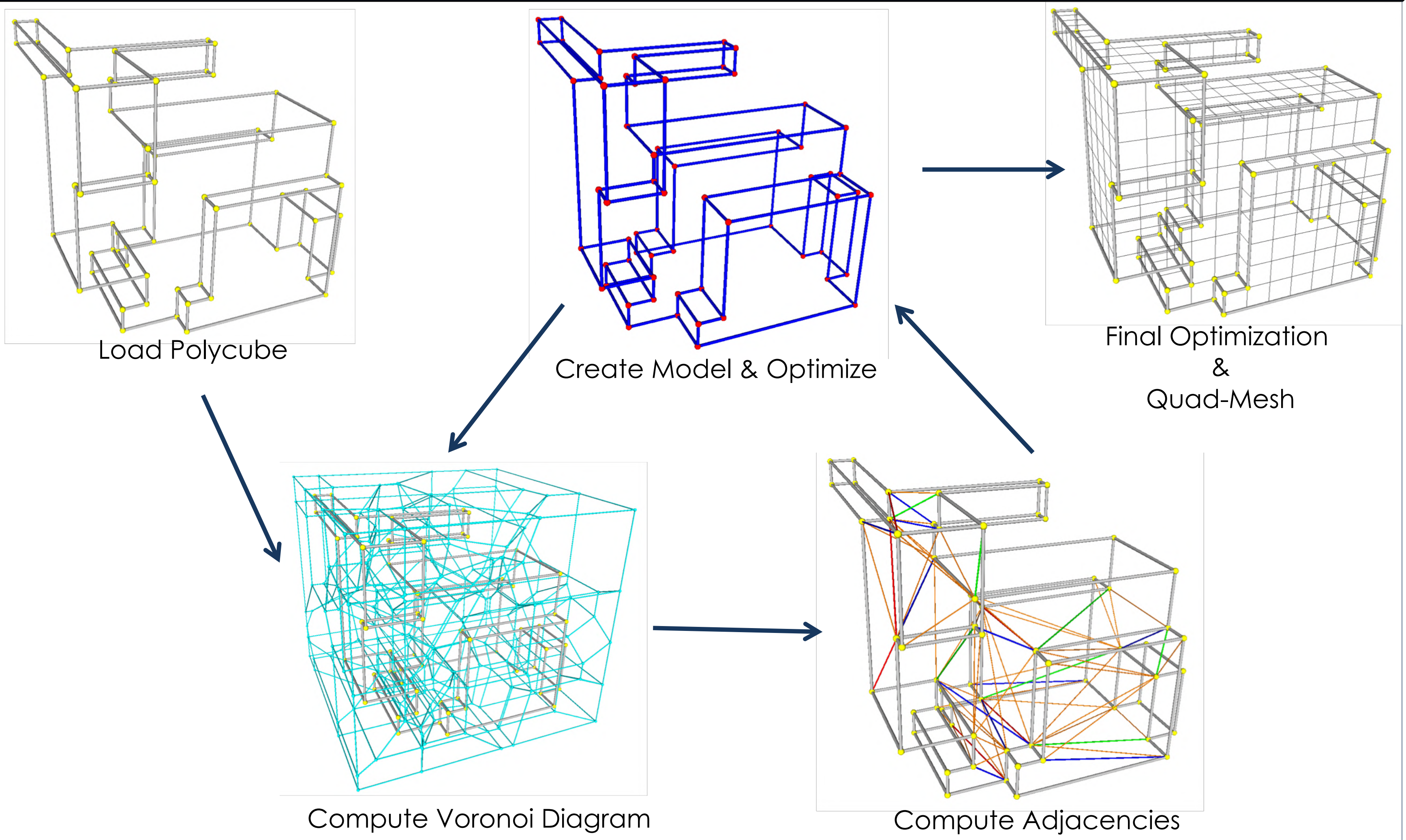
- Minimum length of edges
- Integer coordinates
- Preserve already aligned vertices
- Avoid shape collapse

The Mathematical Model – Constraints

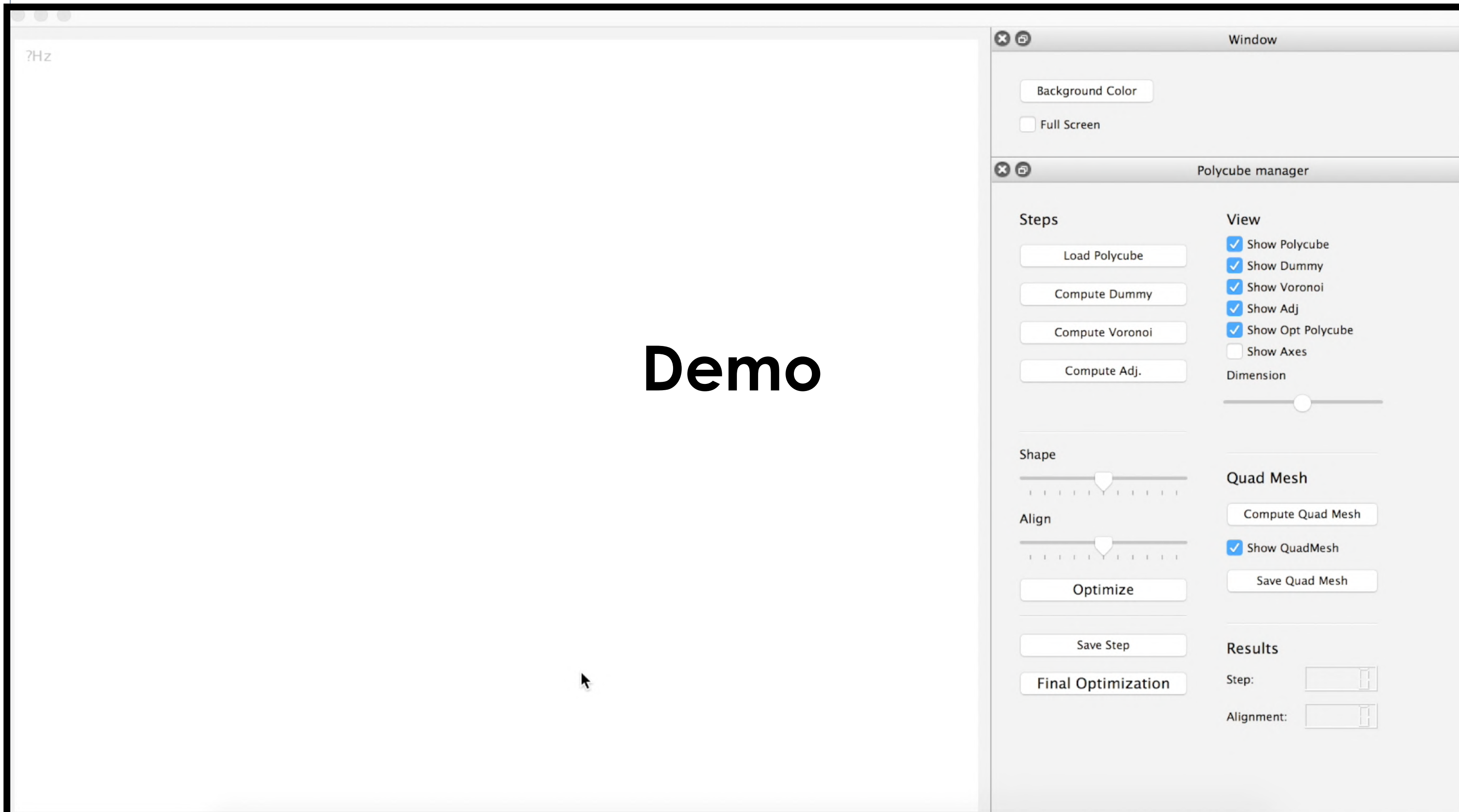
Dummy vertices and edges



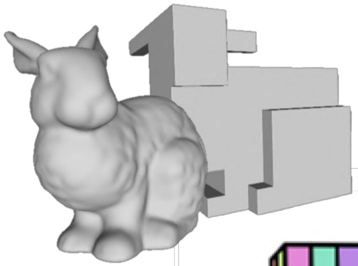
The Algorithm

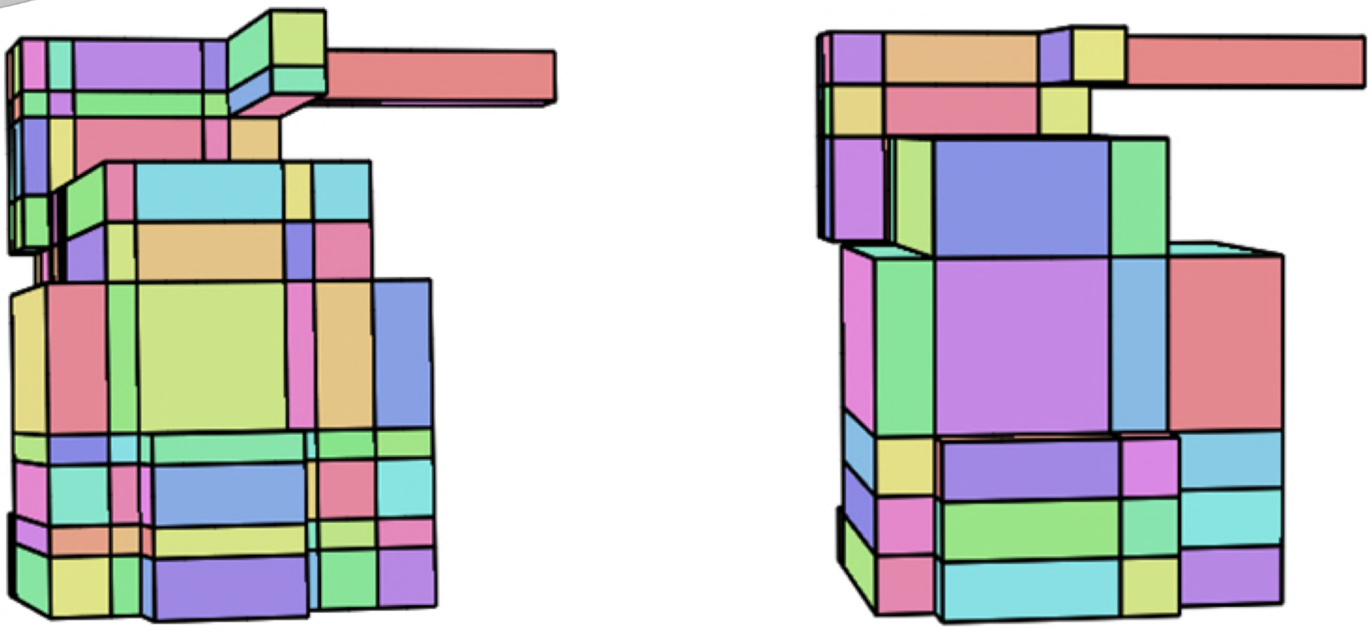


The Interactive Tool



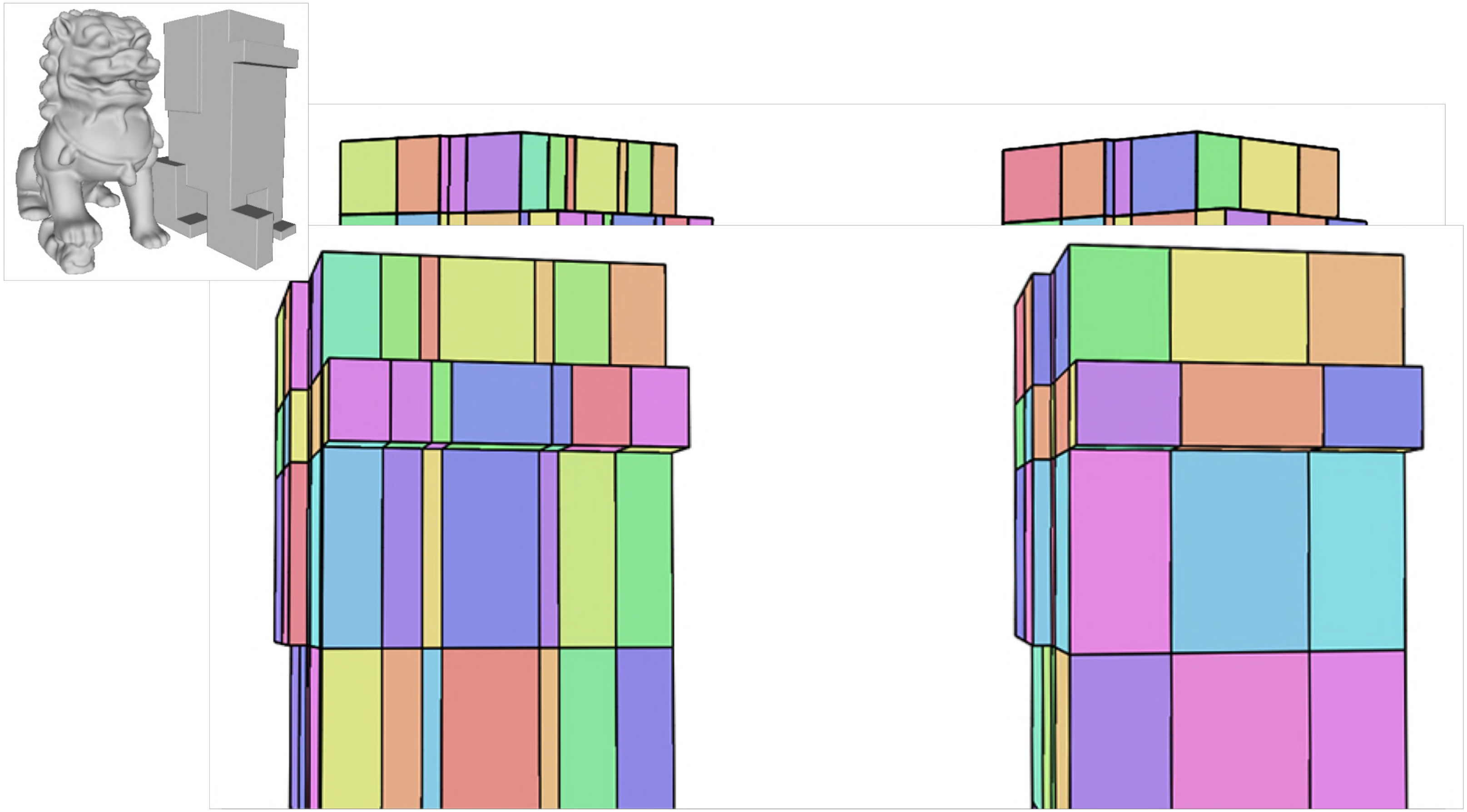
Results - Bunny





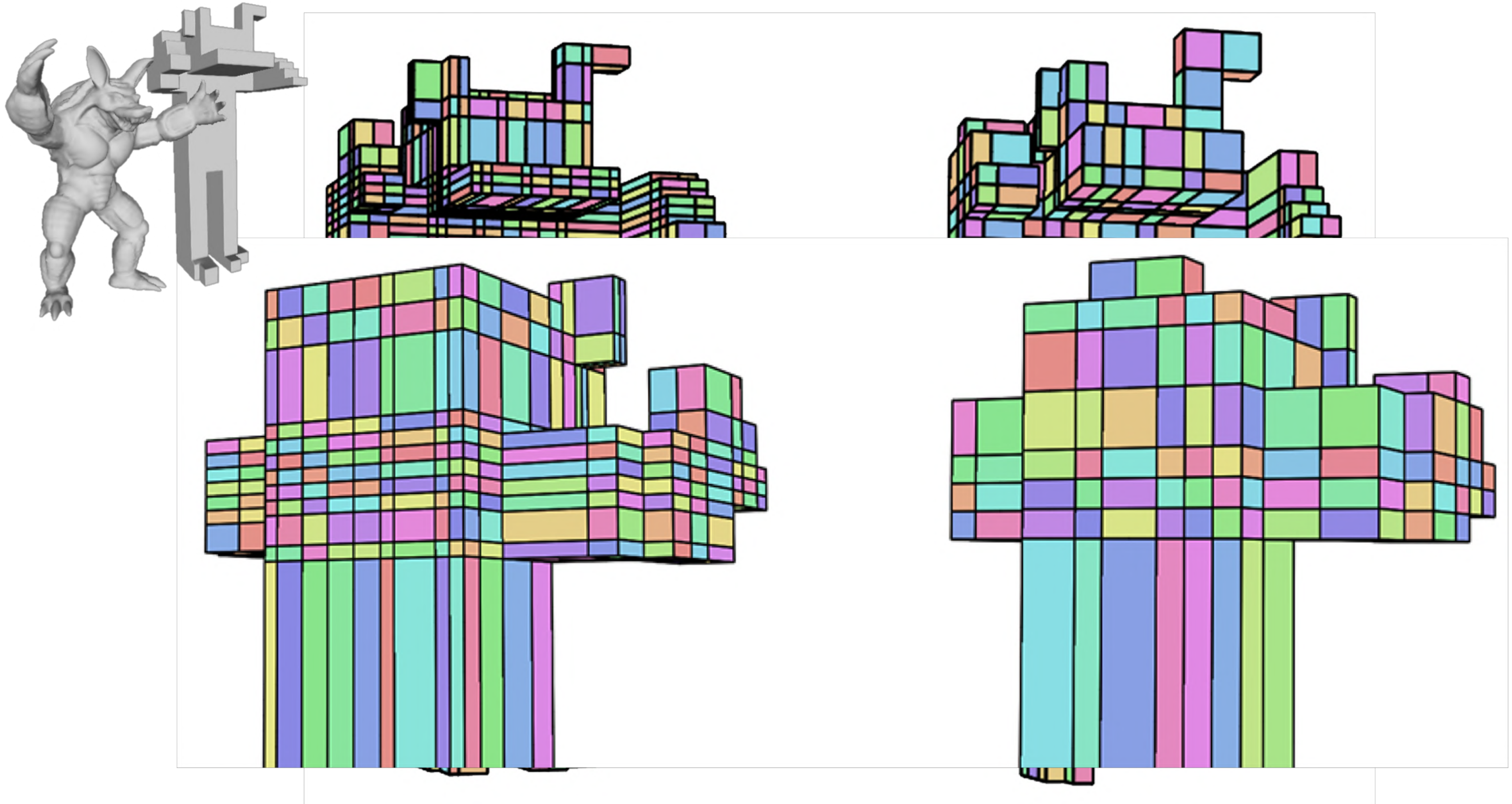
Num. quads: 310 ⟶ 156 (49.68 % of reduction) 0.24 sec

Results - Dragon



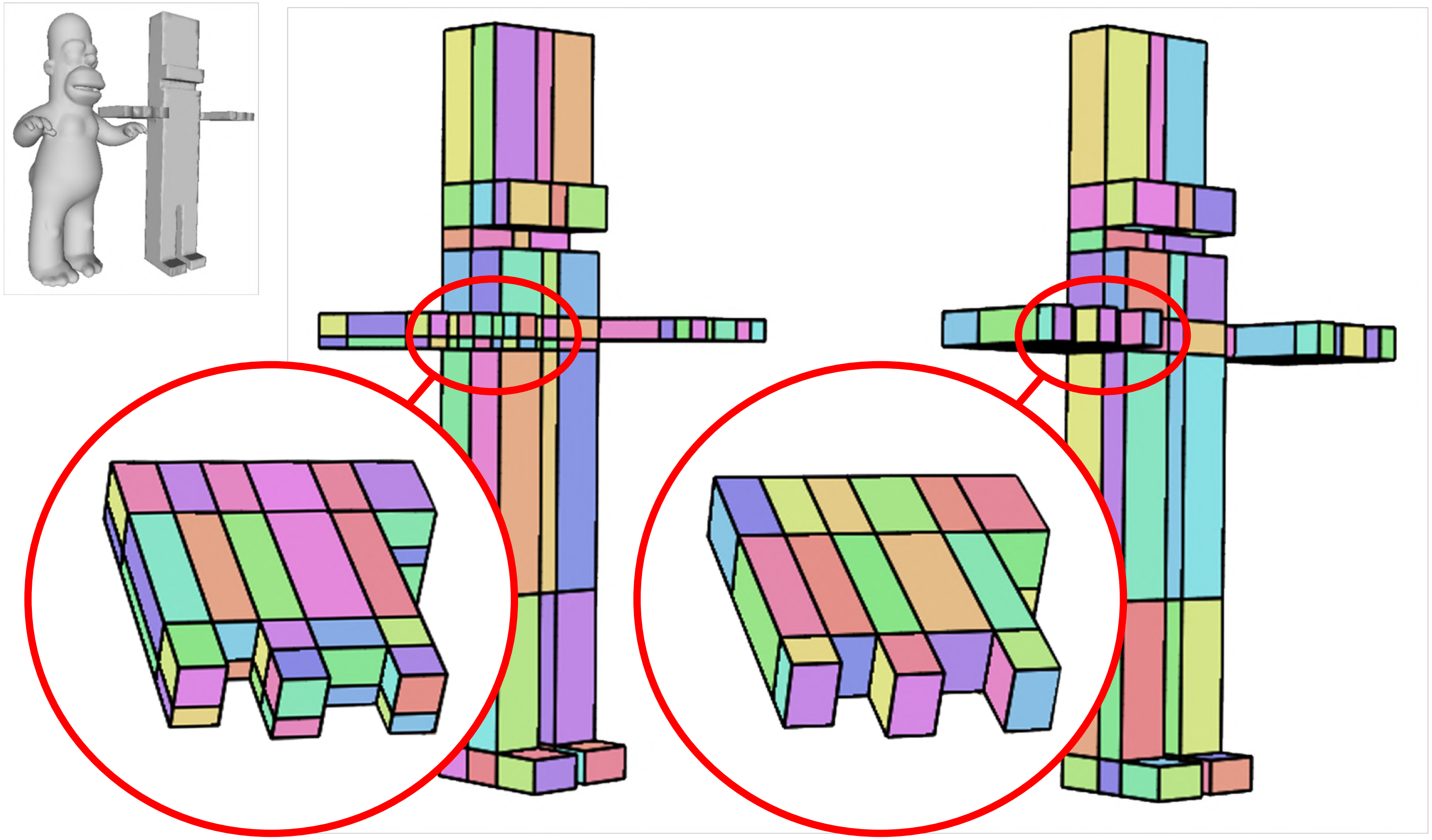
Num. quads: 396 ⟶ 210 (46.97 % of reduction) 0.49 sec

Results - Armadillo



Num. quads: 952 ⟶ 438 (54.00 % of reduction) 2.36 sec

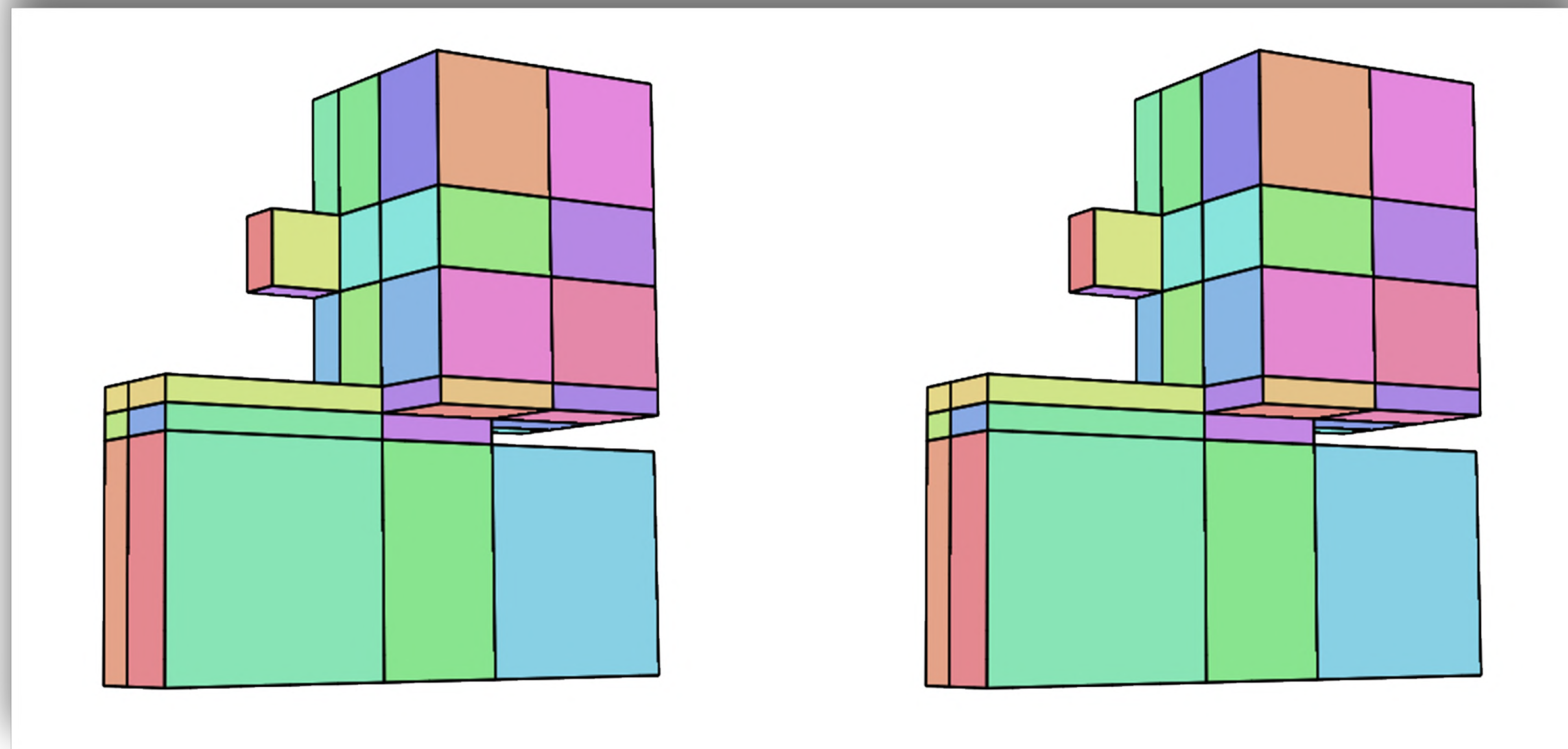
Results - Homer



Num. quads: 260 ⟶ 202 (22.31 % of reduction) 14.75 sec

Conclusions

- Our approach generates an optimized polycube that can be transformed in an **optimized quad-layout**.

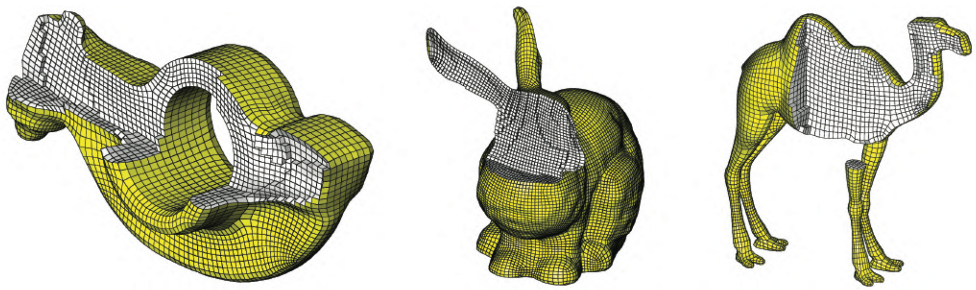


Percentage of reduction of the quads' number

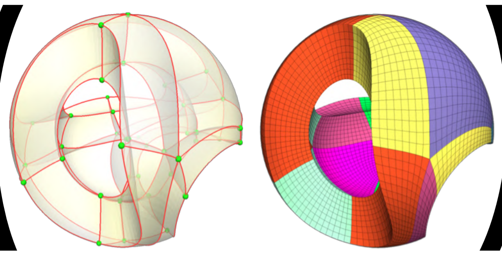
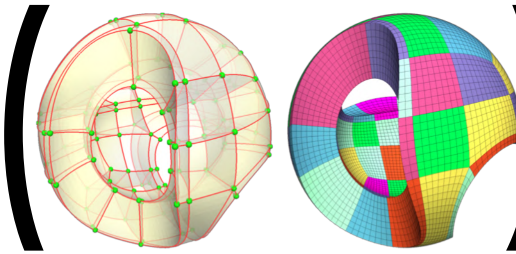
Total time (in second)

Future Work

We would like to test our algorithm (with the appropriate changes) in the **hex-meshing** field.



Use optimized polycube for hex-mesh generation.

Q () > Q ()

Q = quality of the hex-layout

Thanks!