Squaring and Scale-Space based Generalization of 3D Building Data

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Introduction

- Goal:

  Generalization of 3D building models (focus on simplification) using scale-space theory
- Advantage:

  Considers specific characteristics of buildings (right angles)
- Technical Data:
  - Input: VRML-scenes
  - Process: C++, ACIS Geometric Modeler (www.spatial.com)

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Scale-Space based Generalization –

Scale-Spaces

- Linear scale-space $\Rightarrow$ image processing
- Mathematical morphology $\Rightarrow$ used by [Su et al.´95] for generalization of raster data
- Curvature space (diffusion part of reaction-diffusion-space [Kimia et al. ´95]) $\Rightarrow$ elimination of parts with high curvature

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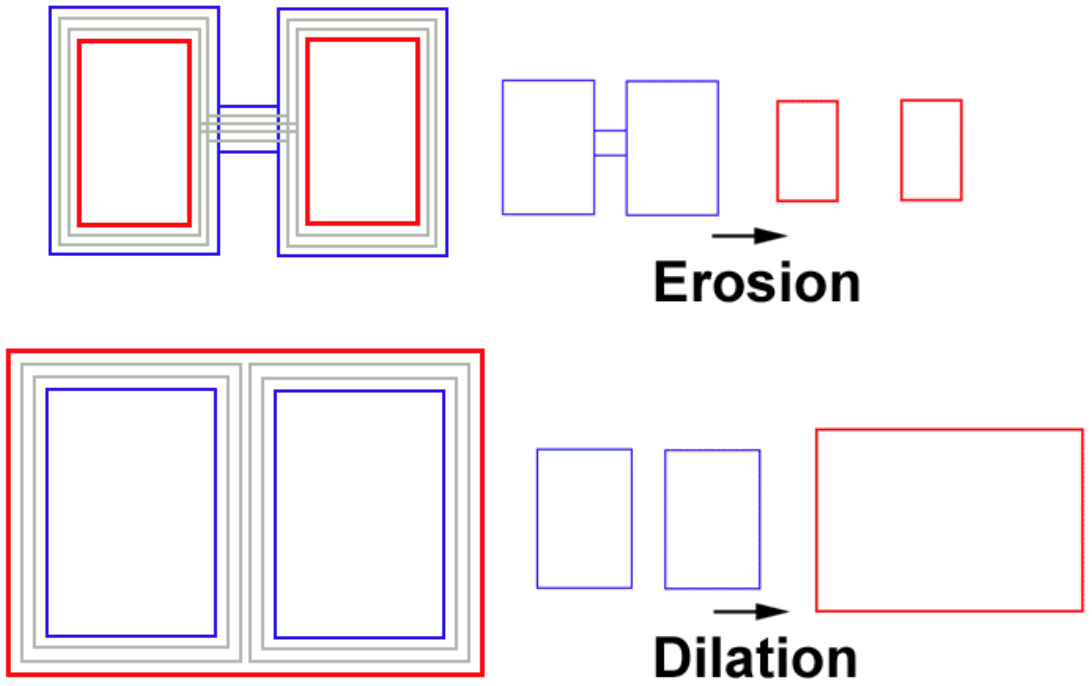
Scale-Space based Generalization –

Mathematical Morphology in 2D

- Mathematical morphology for vector data: Shifting of straight segments inwards or outwards [Mayer´98]

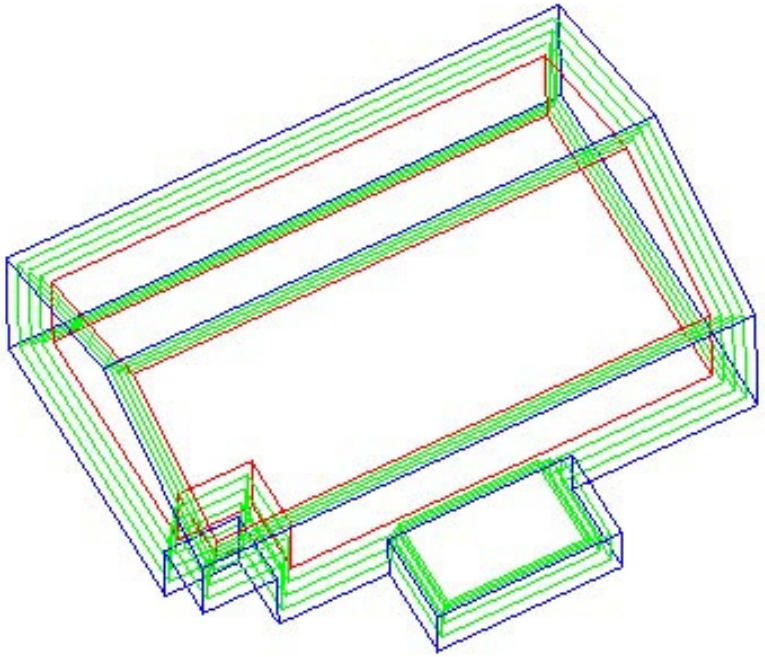


(blue = original, red = result)

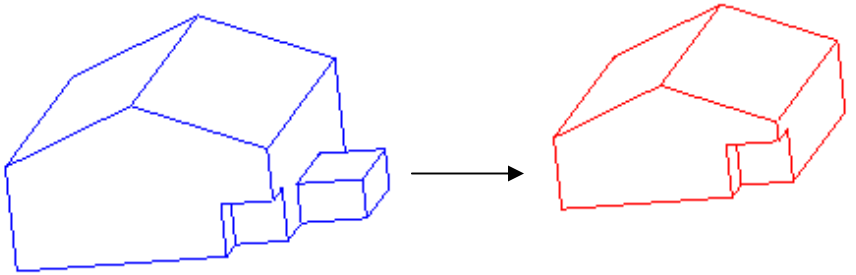
Scale-Space based Generalization –

Mathematical Morphology in 3D

- 3D Erosion / Dilation: Movement of the facets in direction of the normals



Elimination of annex while erosion



(blue = original, red = result)

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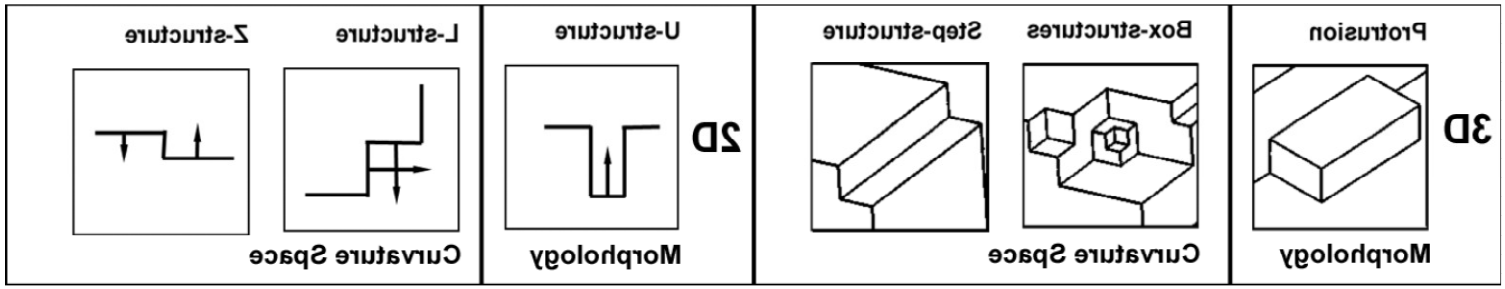
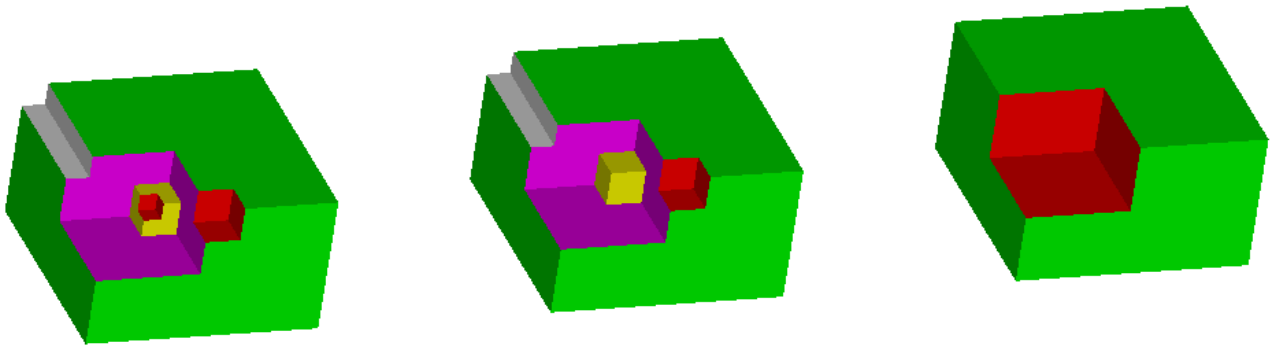
Scale-Space based Generalization –

Curvature Space in 3D

- Shift of specific facets (box- and step-structures)



- Decision, which facets have to be moved in what direction depends on convexity/concavity of local structures [Forberg and Mayer´02]



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Squaring

- Mathematical morphology and curvature space work well mainly for orthogonal structures ⇒ squaring of low inclinations due to incorrect models at least at the beginning of the generalization (preprocessing)

- Squaring of clearly not orthogonal structures (e.g., roofs) at a specific scale (as part of „scale-space based generalization“)

- Squaring of 3D objects not trivial ⇒ main directions have to be taken into account ⇒ differentiation between roof-squaring and wall-squaring

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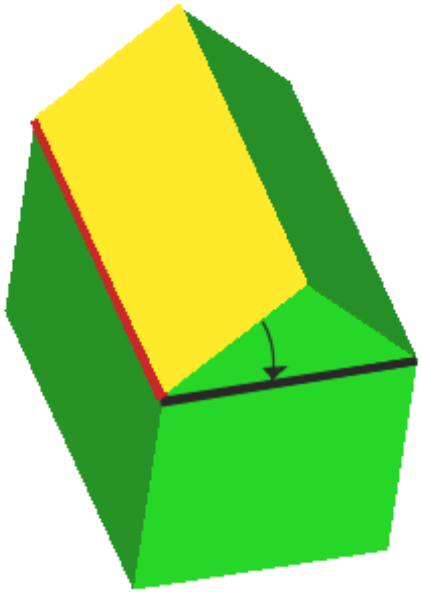
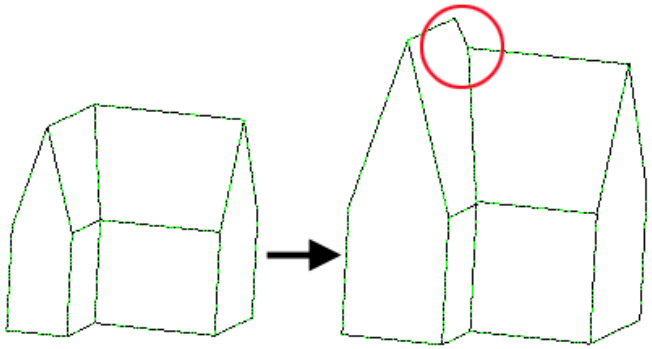
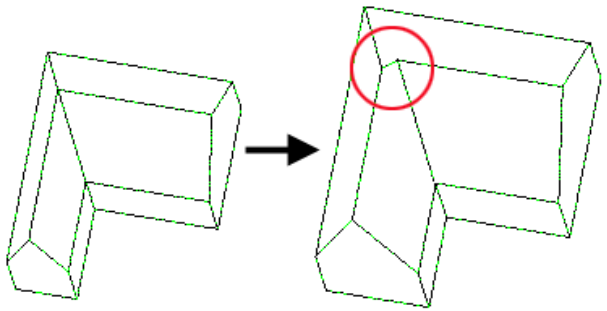
Roof-Squaring

Idea 1: Simultaneous rotation of all roof facets around the eave-lines („Tapering“) until roof-facets become horizontal (small iterative steps) ⇒ problem when having roof-facets with different inclinations







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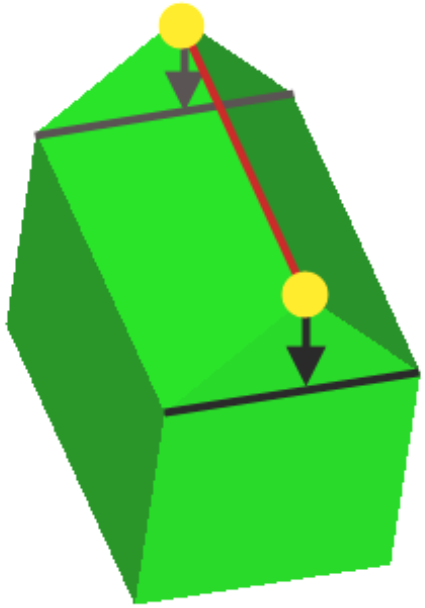
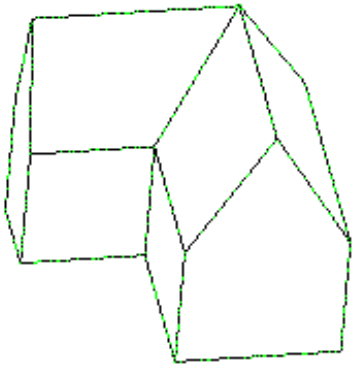
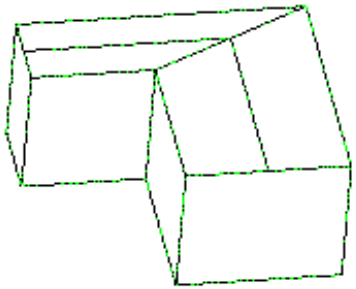
Roof-Squaring

Idea 2: Movement of ridge-line vertices until ridge-line and eave-line have same height ⇒ no problem with different inclinations, but with ACIS (no possibility to automatically change the underlying geometry)







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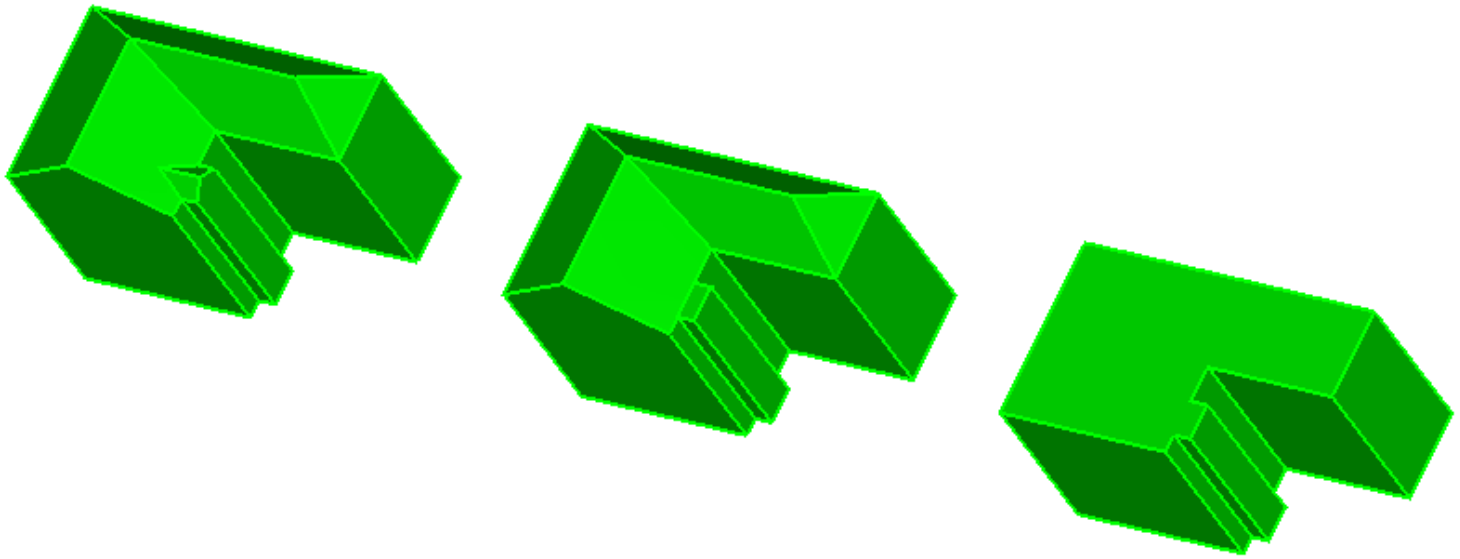
Roof-Squaring

Idea 3: Sequential tapering of individual roof facets, beginning with the smallest one (and excluding triangular facets)



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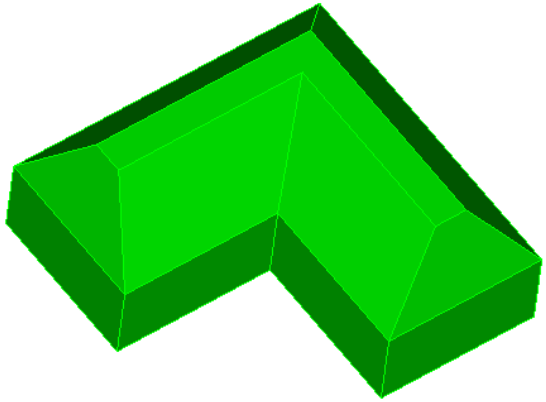
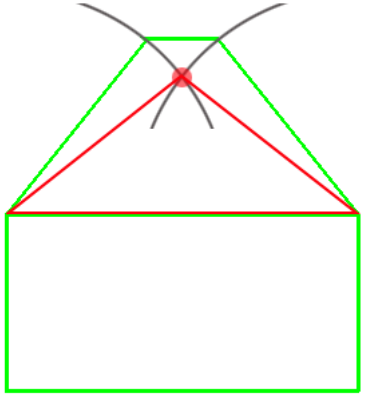
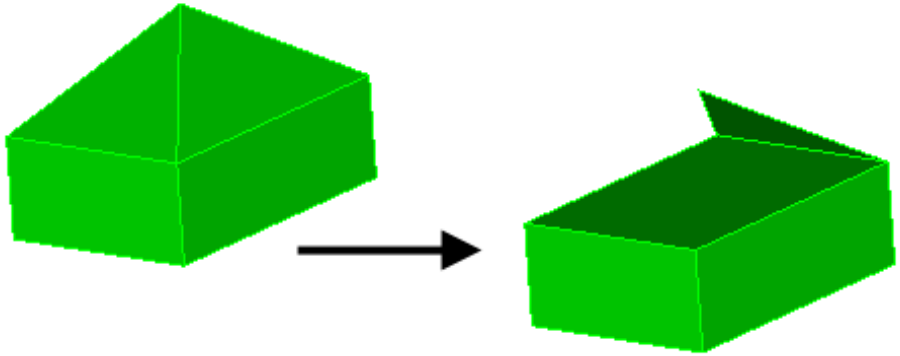
Roof-Squaring –

Problematic roof-structures



Only working with Idea 1 and small iterative steps!





Only triangular facets:
Non-manifold edge created when using idea 3!
But works well with idea 1.

$\Rightarrow$ Solution: Combination of idea 1 and idea 3!

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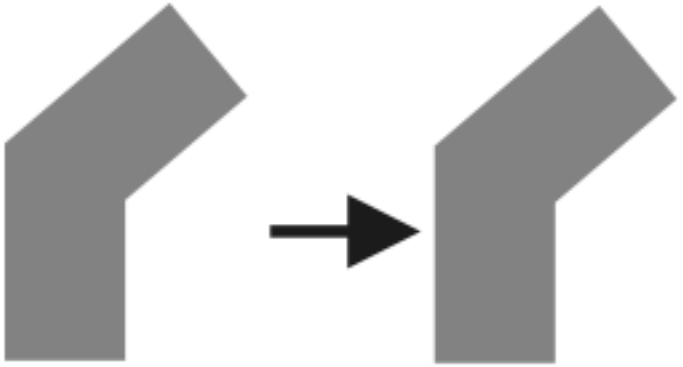
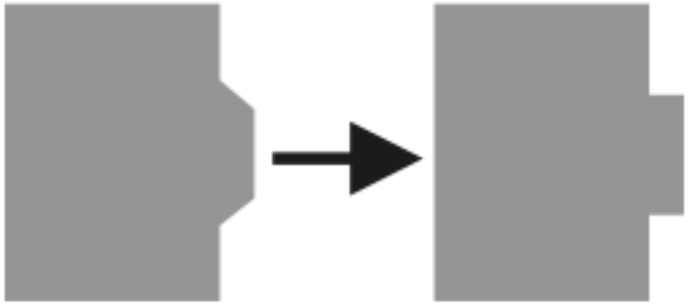
Wall-Squaring

- For large wall-structures strong inclinations can be important characteristics that have to be preserved



- Small deviations from the main directions as well as small, but clearly inclined wall-structures have to be squared before applying mathematical morphology and curvature space



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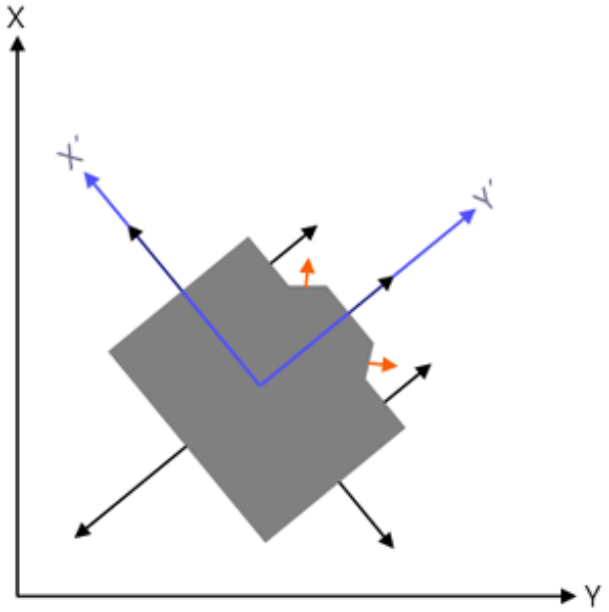
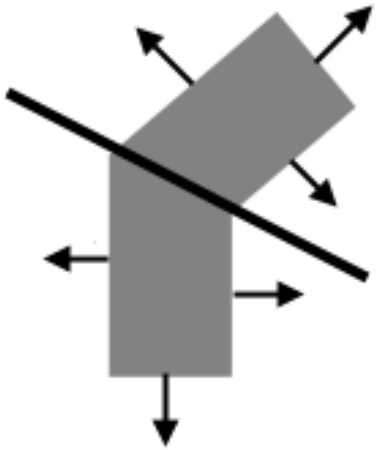
Wall-Squaring

- Determination of inclined wall-facets reducible to 2D problem (squaring of groundplan)
- Main directions and deviating normals have to be determined



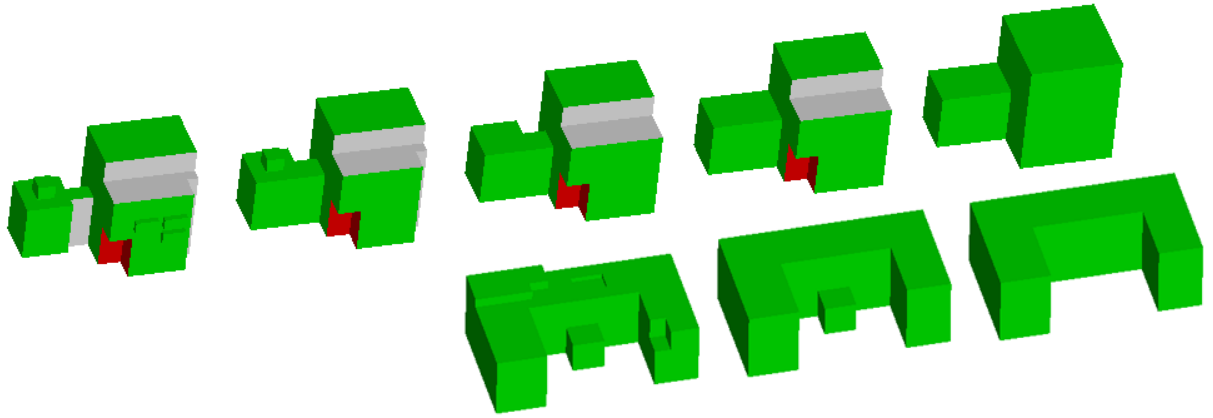
(blue = local coordinate system, black arrows= main directions, red arrows = deviating normals)

Sometimes more than two main directions reasonable

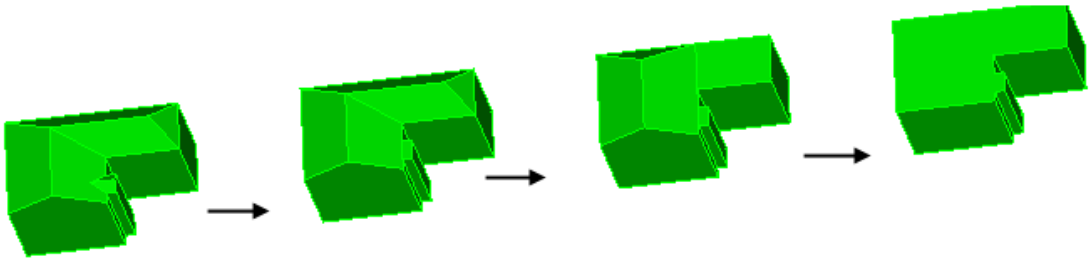


Conclusions

- Status:
  - Mathematical morphology and curvature space work for a set of test buildings



  - First results for roof-squaring, using „Tapering“



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Conclusions

To be done:

- Formal theory for the relation squaring ⇔ scale-space
- Wall-squaring and enhancement of roof-squaring
- Reasonable combination of operations (sequence or one procedure?)
- Semantic characterization of buildings ⇔ Determination of sequence and parameters for the operations