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A Contribution to 3D Generalization

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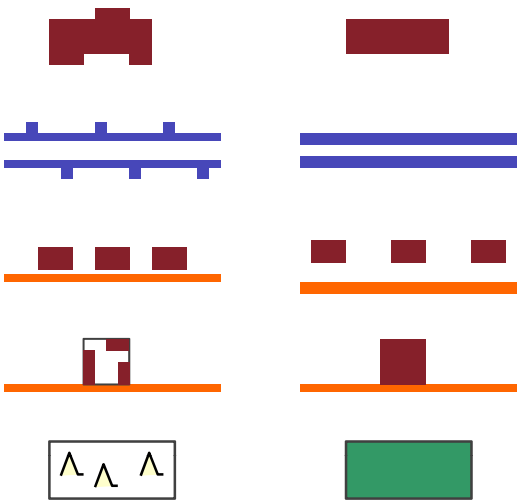
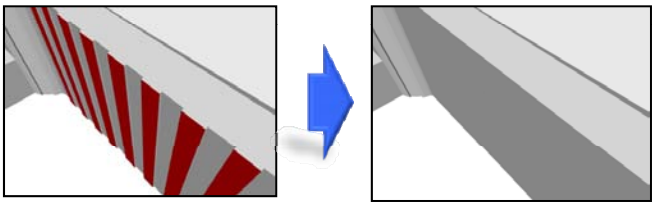
Generalization

- Cartographic Generalization is the transformation of a spatial situation so that it is easier to perceive
- Cartographic Operators (Hake et al., 2002)
  - Simplification
  - Enhancement
  - Displacement
  - Aggregation
  - Classification
  - ...

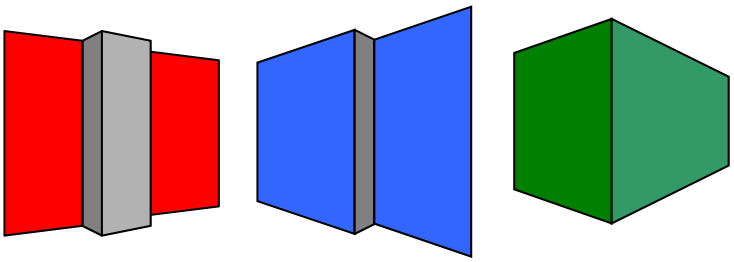


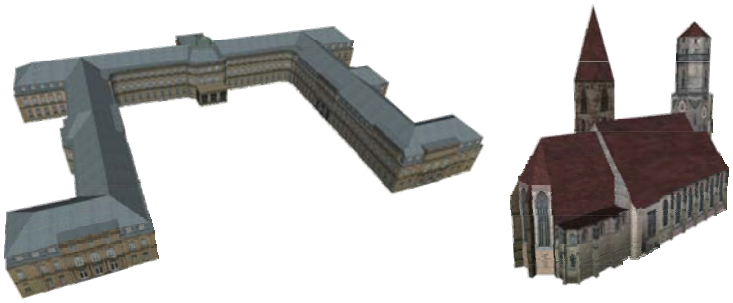
Generalization of 3D Building Models



- Eliminate unimportant details
  - extrusions, intrusions, etc.

- Maintain geometric relations
  - coplanar, parallel and right-angled facade faces





- Preserve object specific appearance
  - global shape
  - important elements

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Applications for Simplified 3D Building Models

- Real-Time and Web-Based Visualizations
  - reduction of the geometric complexity and the number of facade images (textures) to accelerate network transmission and rendering (traditional LOD concept)

- Location-Based and Context-Aware Applications
  - processing of (spatial) situations for the presentation on mobile devices

- Expressive Rendering Techniques
  - determination of characteristic edges of building models for sketch-like drawings

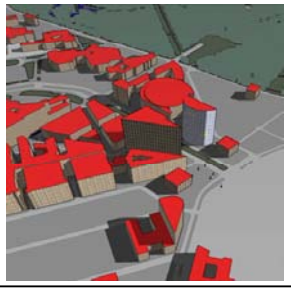

Image from Buchholz et al. 2005
Real-Time Non-Photorealistic Rendering of 3D City Models

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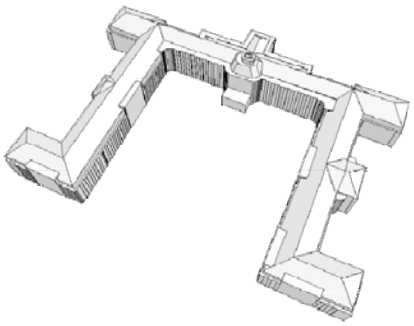
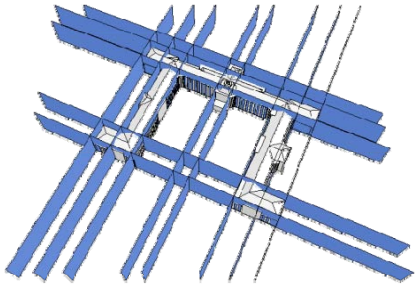
Overview of the Generalization Process

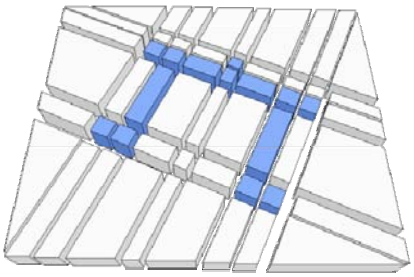
original model



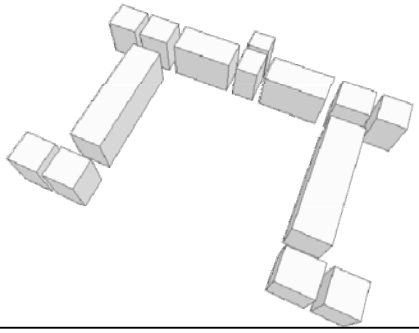
Step 1: determine dominant facade planes



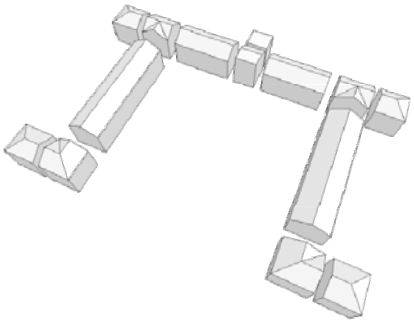
Step 2: generate …



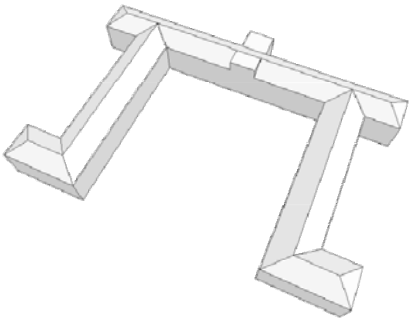
Step 3: … and identify building cells



Step 4: reconstruct roof structure



Step 5: create final 3D building model



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Step 1: Determine Dominant Facade Planes

- **Wanted:** Partition $P = \{ P_1, P_2, \ldots, P_m \}$ of $M = \{ F_1, F_2, \ldots, F_n \}$

$$P_i := (E, F_P, F_{NP})$$

$$E := \{A, B, C, D_{\min}, D_{\max} \mid$$

$$A^2 + B^2 + C^2 = 1 \vee$$

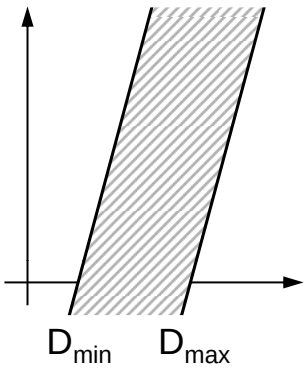
$$\forall p \in F_P \cup F_{NP} :$$

$$Ap_x + Bp_y + Cp_z \geq D_{\min} \vee$$

$$Ap_x + Bp_y + Cp_z \leq D_{\max} \vee$$

$$D_{\max} - D_{\min} < \varepsilon_{dist} \quad \vee$$

$$\forall \vec{n} \in F_P : \arccos\left(\frac{\vec{n} \cdot \begin{pmatrix} A \\ B \\ C \end{pmatrix}}{\sqrt{\vec{n}^2}\sqrt{(A^2 + B^2 + C^2)}}\right) < \varepsilon_{angle} \}$$



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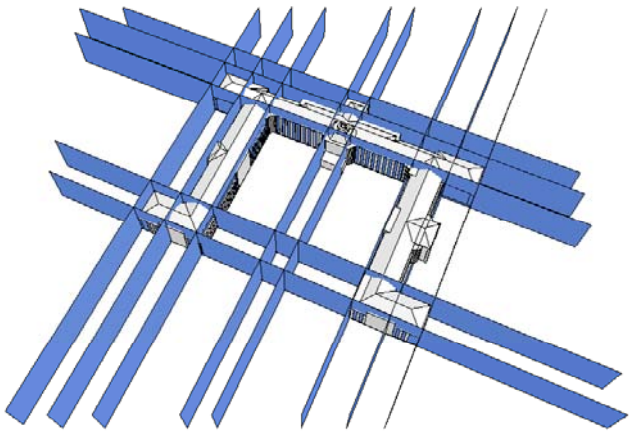
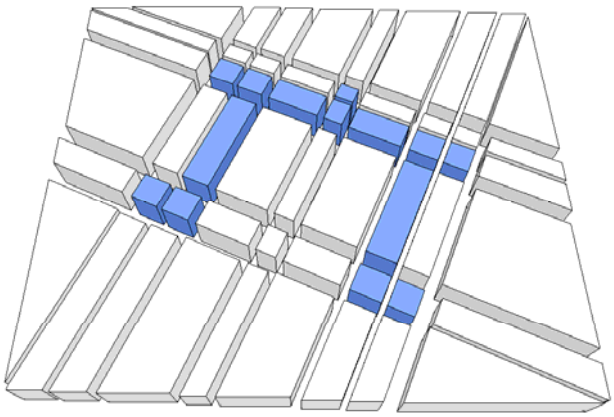
Step 2: Generate 2.5D Decomposition

- Decomposition of the (infinite) space along the averaged plane equations of the m dominant planes P_1 bis P_m

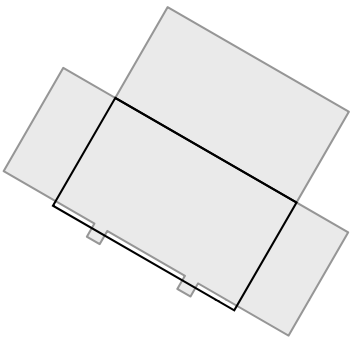
$$D = \forall p_i \in f_j \in F_P : \frac{\sum Area(f_j)(Ap_{i_x} + Bp_{i_y} + Cp_{i_z})}{\sum Area(f_j)}$$

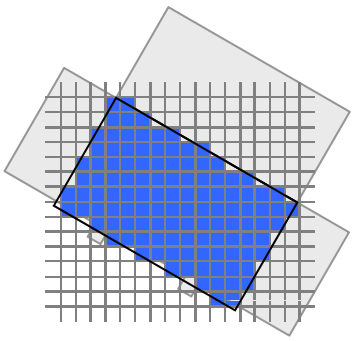




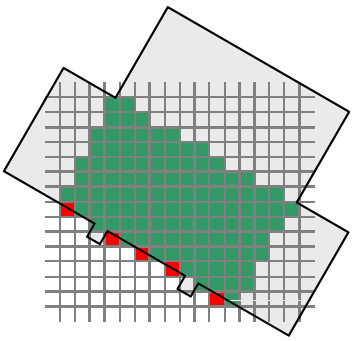
Step 3: Identify Building Cells

- Overlap of cells and ground plan polygon
  - subdivide testing area in equally sized samples
  - cells with high overlap → building cells





$\blacksquare \subseteq C$



$\blacksquare \subseteq C \cap G$

$\blacksquare \subseteq C \setminus G$

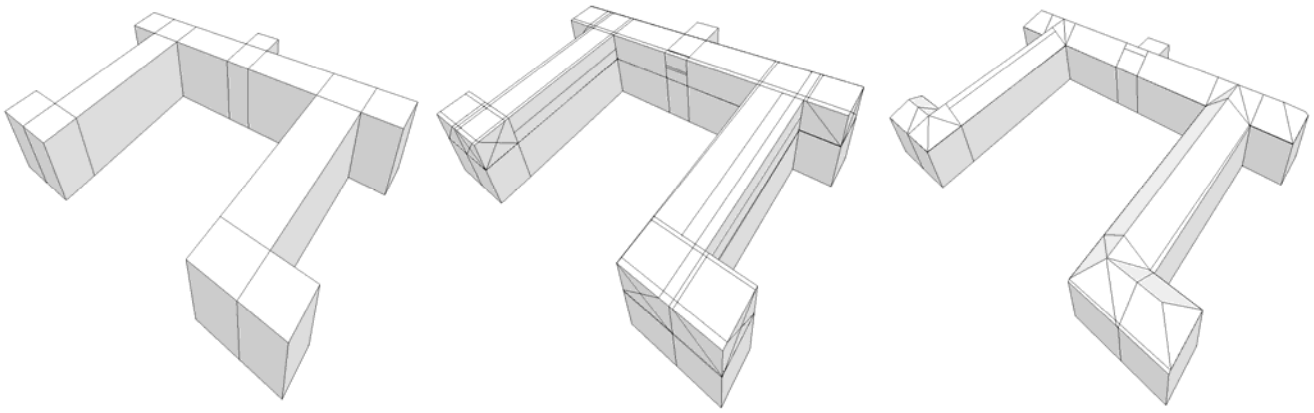
$$Overlap = \frac{C \cap G}{C} = \frac{\sum \blacksquare}{\sum \blacksquare}$$

Step 4: Reconstruct Roof Structure

- Analogues approach as 2D ground plan decomposition
  - determine (global) dominant planes from roof polygons
  - generate 3D cell decomposition
    - locally for each ground plan cell

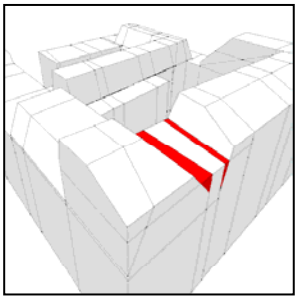
$$\exists f \in F_P : f \cap C \neq \varnothing$$

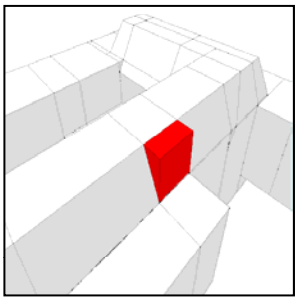
  - identify building cells

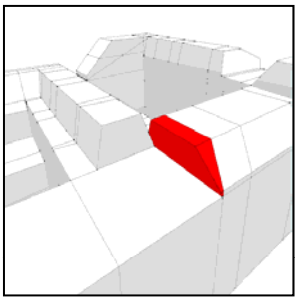


Step 4: Reconstruct Roof Structure

- Hole filling
  - area borders positive building cells > 50%

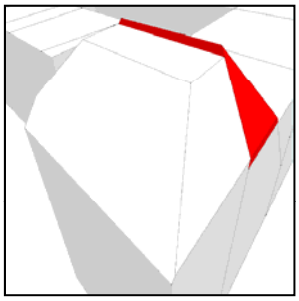


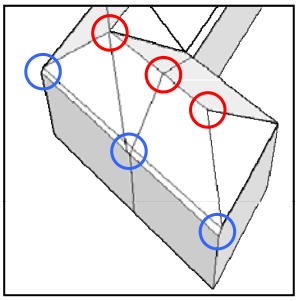




- Removal of distracting roof cells
  - flat roof cells on sloped faces
  - overhangs

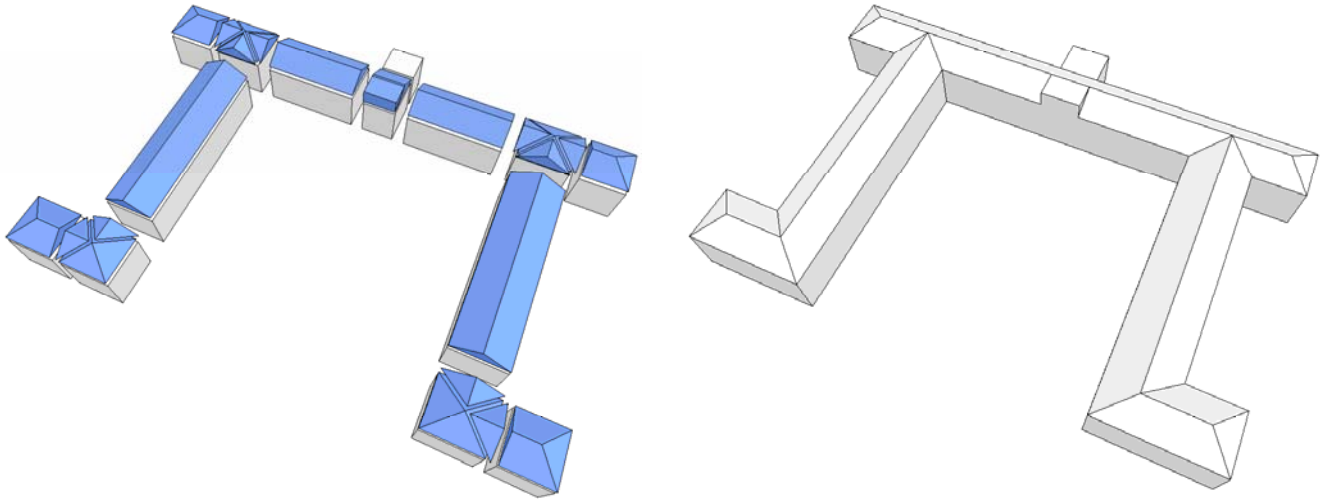
- Contraction of roof vertices
  - towards ground plan vertices as well as on middle of edge and cell points
  - adjustment to uniform height





Step 5: Create Final 3D Building Model

- 3D building cells are „glued together“



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