ifp

Universität Stuttgart

The 3D Berlin Project

Martin Kada

Institute for Photogrammetry
University of Stuttgart

ifp

Universität Stuttgart

Project Implementation

- virtualcitySYSTEMS, Dresden
  - Reconstruction of 3D building geometry in LOD 2 from given LIDAR data and ground plans

virtualcitySYSTEMS
The LandXplorer Integration Company

- 3D Geo, Potsdam (now part of Autodesk)
  - Texturing using oblique aerial images

Autodesk

- Starsoda, Berlin
  - Manual modeling of landmarks

Project Consultants

- Potsdam University
  - Hasso-Plattner-Institute
  - Talk of Prof. Döllner on Friday
- University of Bonn
  - Institute for Cartography and Geoinformation
- Technical University of Berlin
  - Department for Geodesy and Geoinformation Science
  - Talk of Prof. Kolbe on Thursday

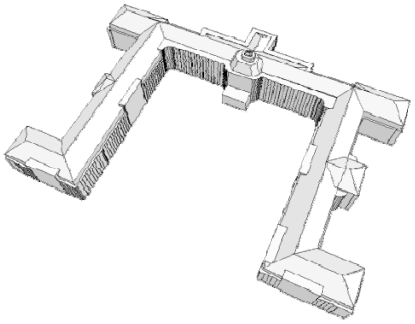
ifp
Universität Stuttgart

What about the ifp?

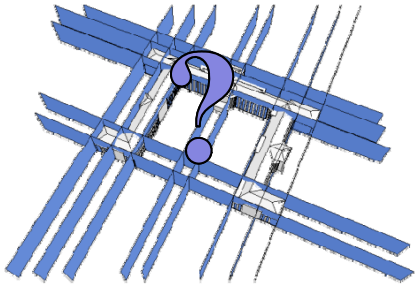
ifp
Universität Stuttgart

Generalization Process

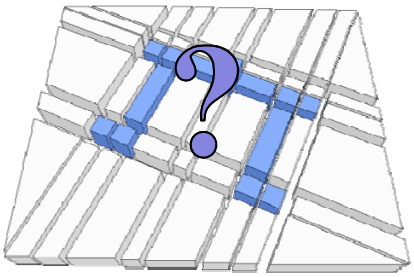
Original model



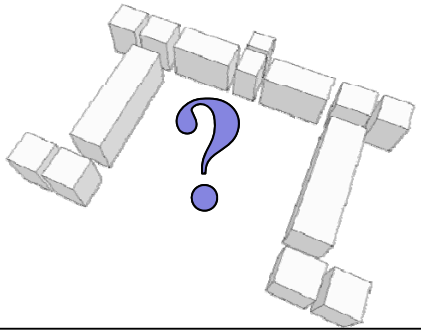
Step 1: Determine decomposition planes



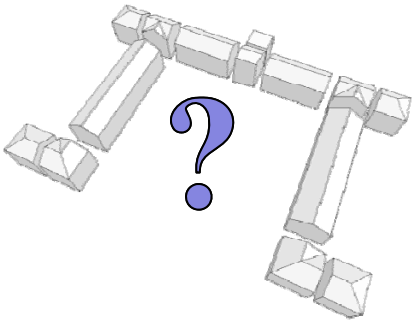
Step 2: Generate …



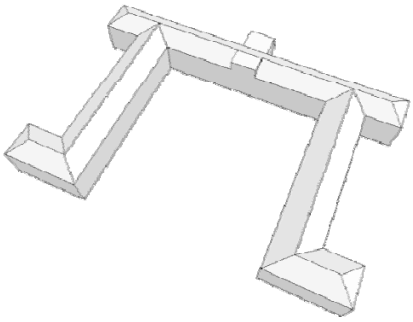
Step 3: … and identify building cells



Step 4: Reconstruct the roof structure



Step 5: Create final 3D building model



Universität Stuttgart

ifp

Requirements

- Input data
  - Ground plans
  - LIDAR points (1-4 pts/m²)
    - given both as regular grid or unstructured point cloud
- Produce valid shapes
  - Strict horizontal eaves and ridge lines
  - Symmetric roof shapes
  - Correct CAD models in LOD 2
- Automatic
  - High automation rate (> 80%)
- Efficient
  - < 1s per building (→ 86,400 buildings per 24h)

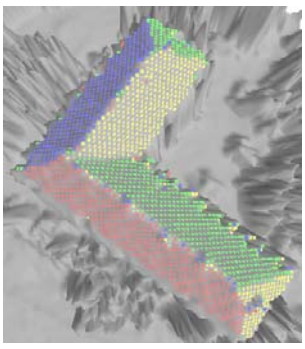
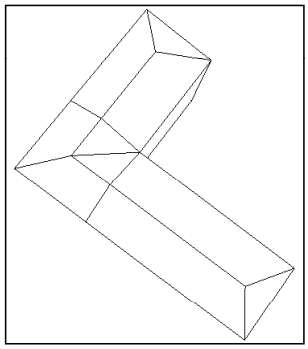
Universität Stuttgart

ifp

Overview of the Reconstruction Approach

- Automatic reconstruction of building geometry in LOD 2 from
  - LIDAR point clouds
  - Ground plans



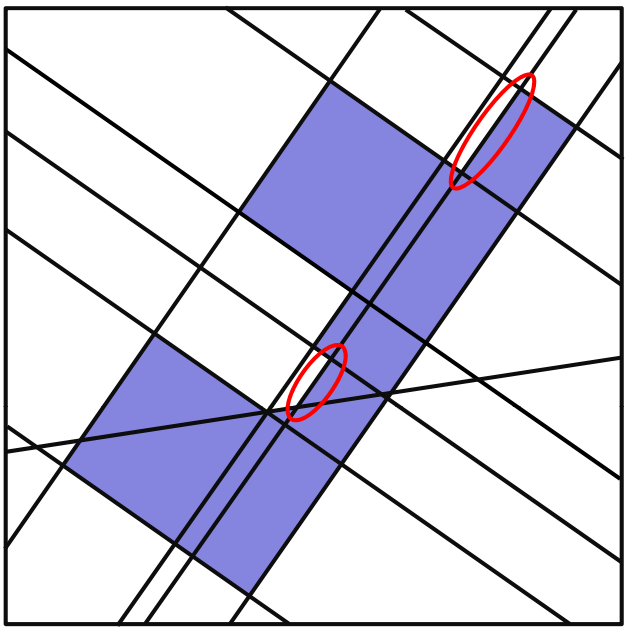
1. Generate a decomposition of the building's footprint into disjoint (mostly quadrangular) cells → Generalization
2. Classify the LIDAR points inside the cells according to the orientation of their locally estimated planes
3. Find for each cell a standard roof shape that best fits the points

Universität Stuttgart

1. Generation of the Cell Decomposition

1. Create decomposition lines from the line segments …
2. … and split the enlarged bounding box of the footprint along these lines
3. Identify the cells with a high overlap with the original footprint

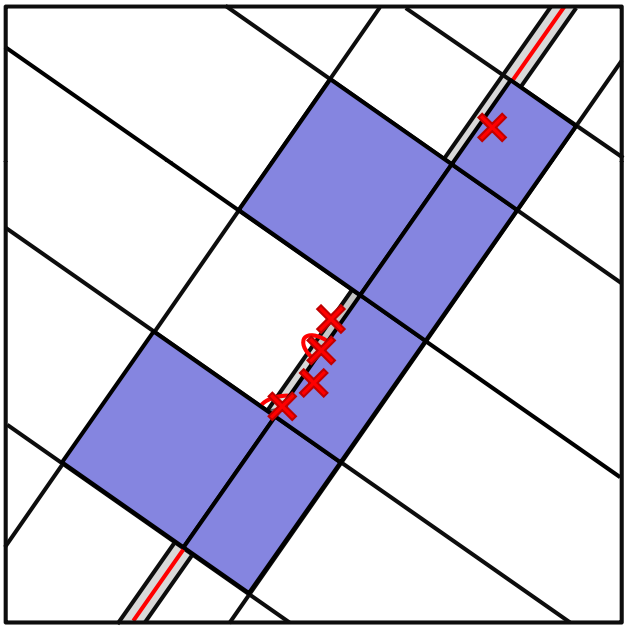
Too many small cells



Universität Stuttgart

1. Generation of the Cell Decomposition

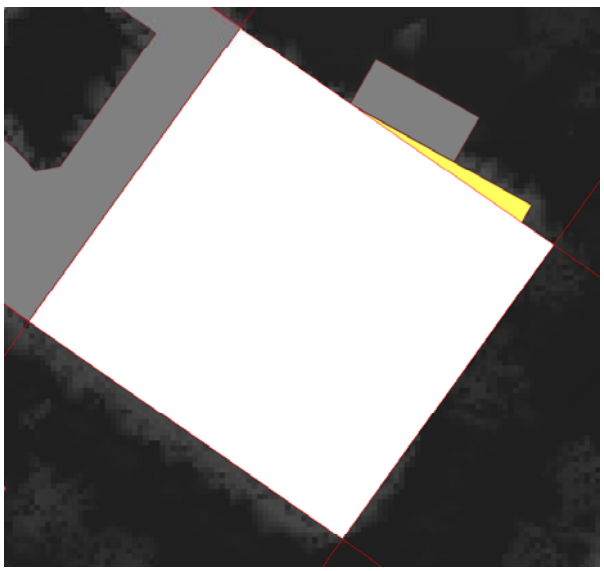
1. Create decomposition lines that approximate the line segments
2. … and split the enlarged bounding box of the footprint along these lines
3. Identify the cells with a high overlap with the original footprint

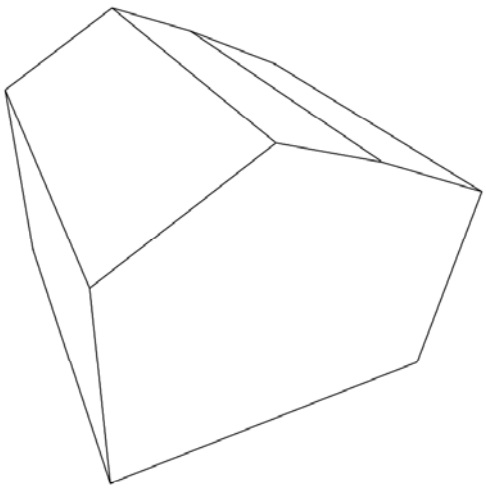


The deviation from the original ground plan is half the generalization distance

1. Generation of the Cell Decomposition

- Decomposition lines are adjusted so that they are perfectly parallel and form right angles

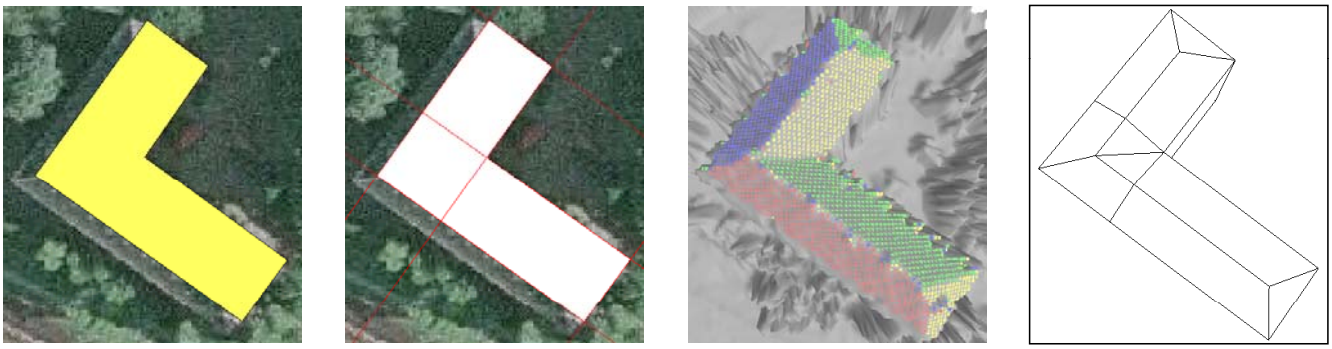




Universität Stuttgart

Overview of the Reconstruction Approach

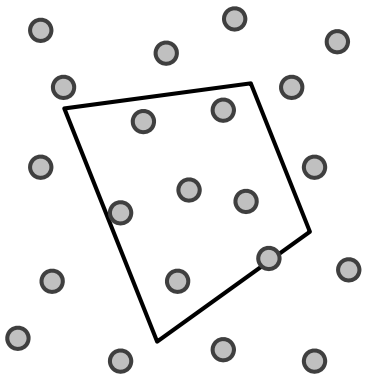
- Automatic reconstruction of building geometry in LOD 2 from
  - LIDAR point clouds
  - Ground plans



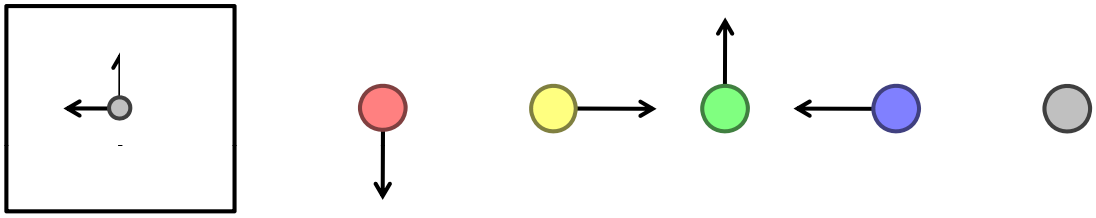
1. Generate a decomposition of the building's footprint into disjoint (mostly quadrangular) cells → Generalization
2. Classify the LIDAR points inside the cells according to the orientation of their locally estimated planes
3. Find for each cell a standard roof shape that best fits the points

2. Classification of Points

- Compute normal direction for each point
  - Estimate a local plane from the point's k-nearest neighbors
  - Points from small features or near break lines are smoothed out

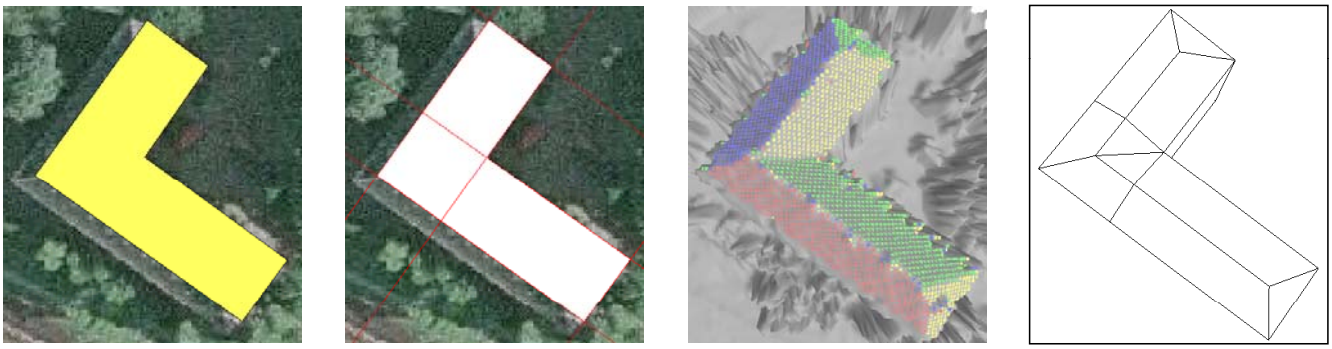


- Classify the points according to border lines of the cell



Overview of the Reconstruction Approach

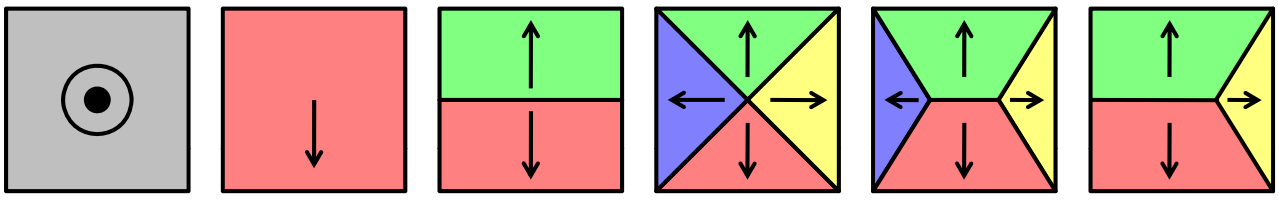
- Automatic reconstruction of building geometry in LOD 2 from
  - LIDAR point clouds
  - Ground plans



1. Generate a decomposition of the building's footprint into disjoint (mostly quadrangular) cells → Generalization
2. Classify the LIDAR points inside the cells according to the orientation of their locally estimated planes
3. Find for each cell a standard roof shape that best fits the points

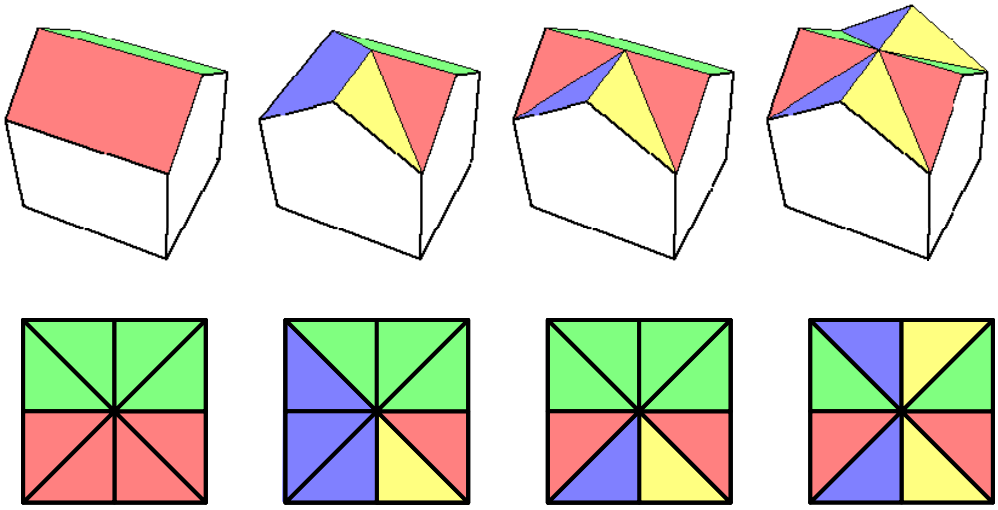
3. Roof Shape Fitting

- Every roof shape can be composed of one or more planar faces
  - When seen from above, it is a 2D decomposition of the roof area
- Test all roof shape against each cell …
  1. Create the 2D roof decomposition of the cell
  2. Assign the LIDAR points to the associated polygon
  3. Count the number of points with the correct slant direction
- Cell gets the roof shape with the highest point count



3. Roof Shape Fitting

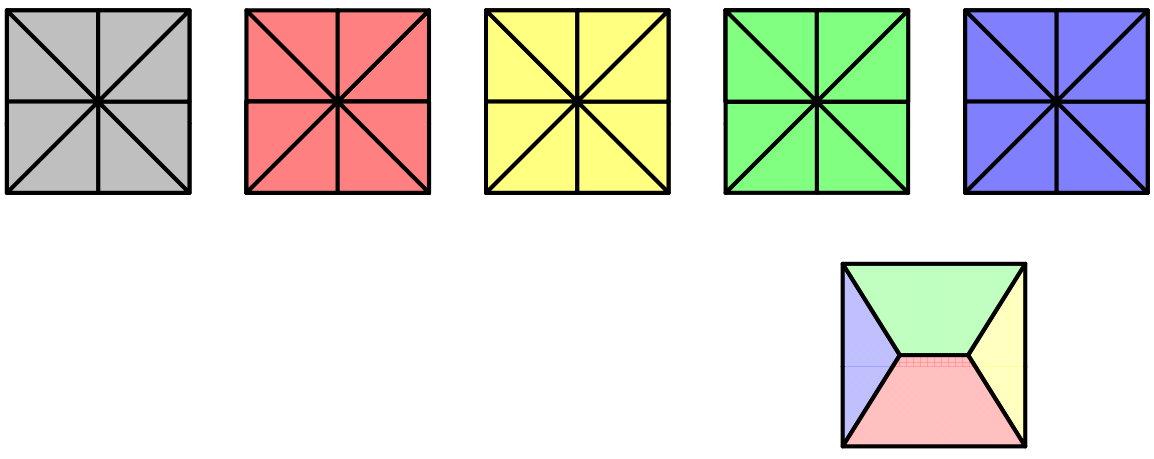
- Every roof shape can be rotated up to 4 times
  - There are many connecting shapes
  - Distributing the LIDAR points to the right roof polygon is very time consuming



Universität Stuttgart

3. Roof Shape Fitting

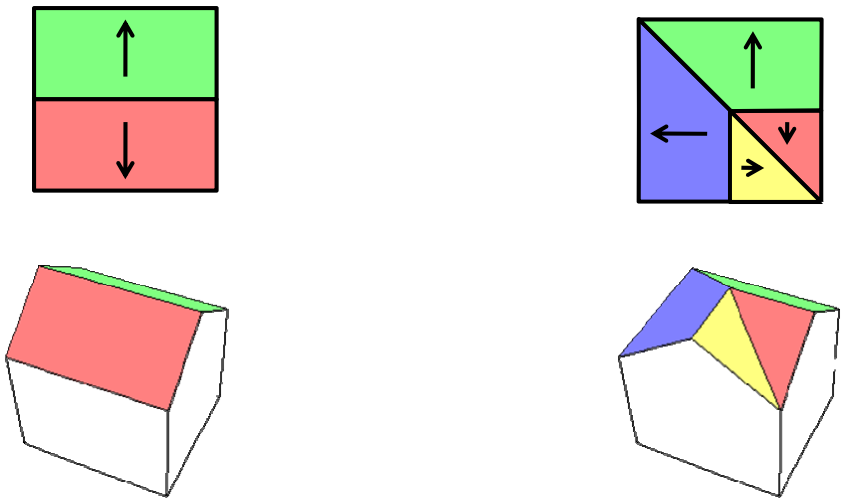
- Optimization (for quadrangular cells)
  - Divide the cell into 8 sections
  - Count for each section the number of points that show
    - upwards, southwards, eastwards, northwards, westwards
  - Reuse the point distribution as much as possible
    - Adding up the right segments



Universität Stuttgart

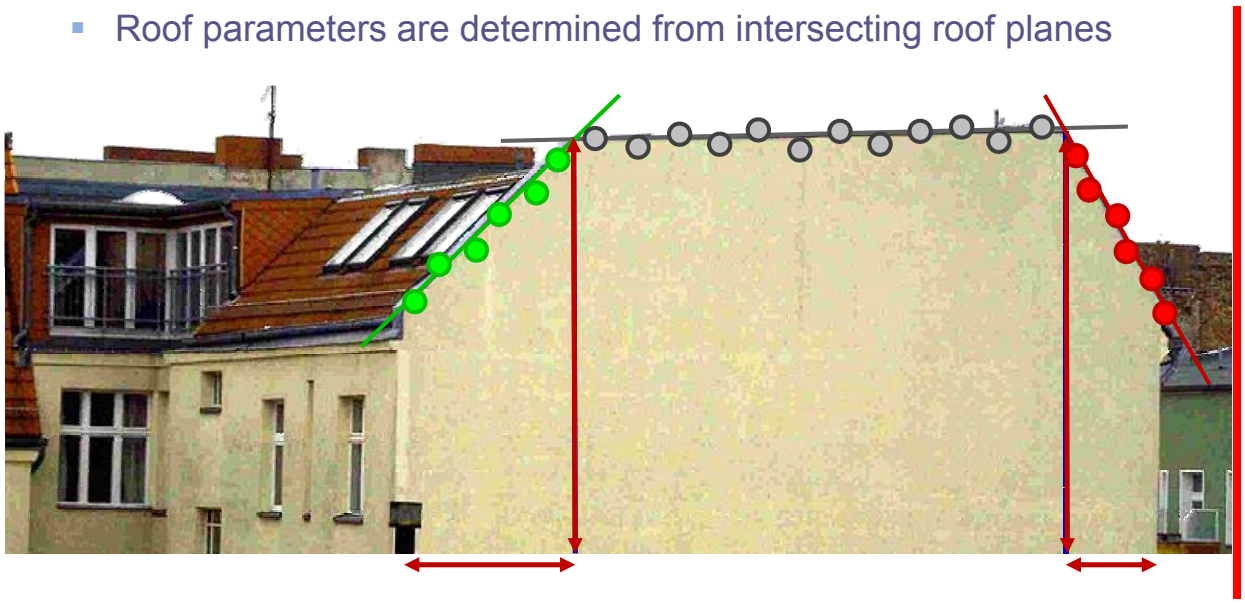
3. Roof Shape Fitting

- The slope of the roof faces is computed by estimating one plane equation from all fitting points
  - Mirror all points to one side (rotation + translation + scaling)

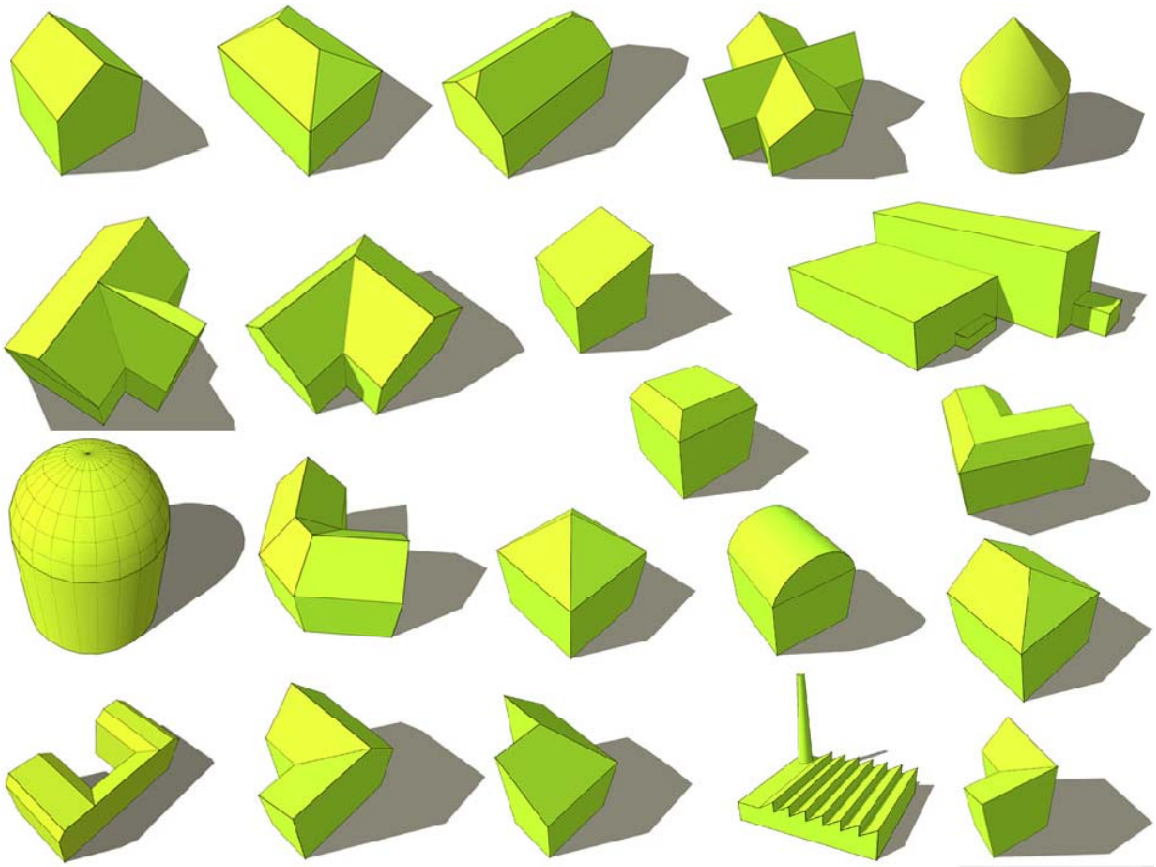


3. Roof Shape Fitting – Berliner Roof

- Very common roof shape for Berlin apartment houses build during the period of promoterism in the 19th century
  - The two break lines are detected by a plane sweep algorithm going from the front to the back side
  - Estimate the three plane parameters from LIDAR points
  - Roof parameters are determined from intersecting roof planes



Examples of Basis Roof Shapes and their Combination to 3D Building Models



Universität Stuttgart

ifp

The 3D Berlin Project

- Eastern districts
  - March 2008 – July 2008
  - 244,000 buildings
- Western districts
  - November 2008 – February 2009
  - 228,000 buildings
- … covering a total area of 857 km²
- Degree of achieved automation
  - 70% – 80% for inner city areas
  - 80% – 85% for residential areas

Universität Stuttgart

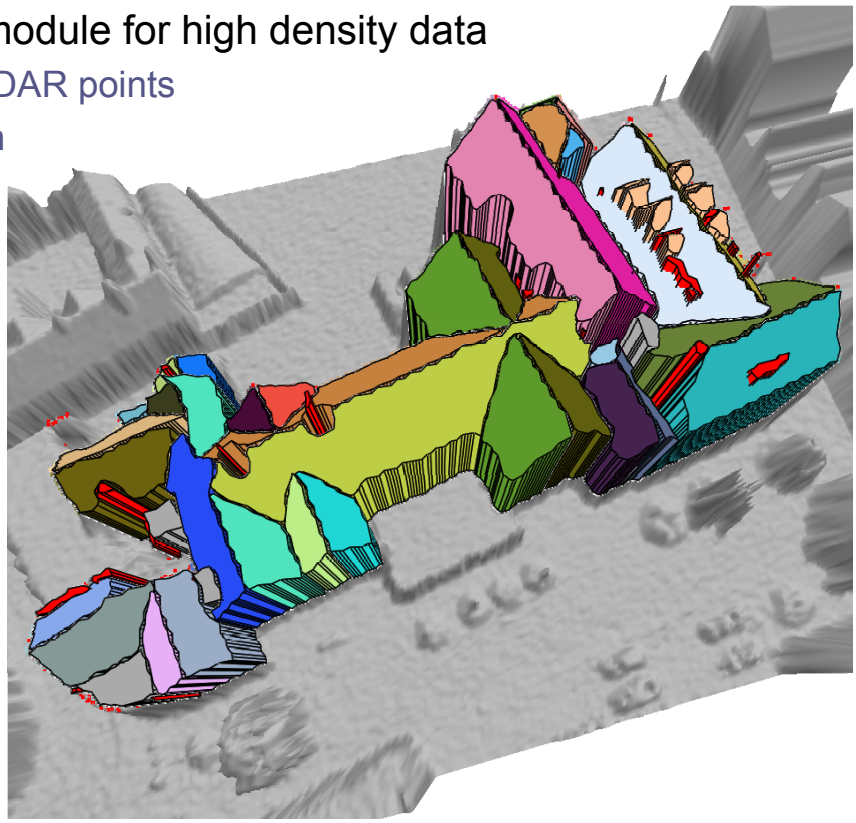
ifp

The 3D Berlin Project

- Approx. 100,000 unique oblique aerial images were used for the texturing of the buildings
- 80 landmarks were modeled by hand
  - 5 buildings can be virtually visited
    - Olympiastadion
    - Sony Center
    - Reichstag
    - DZ Bank
    - Berlin Hauptbahnhof

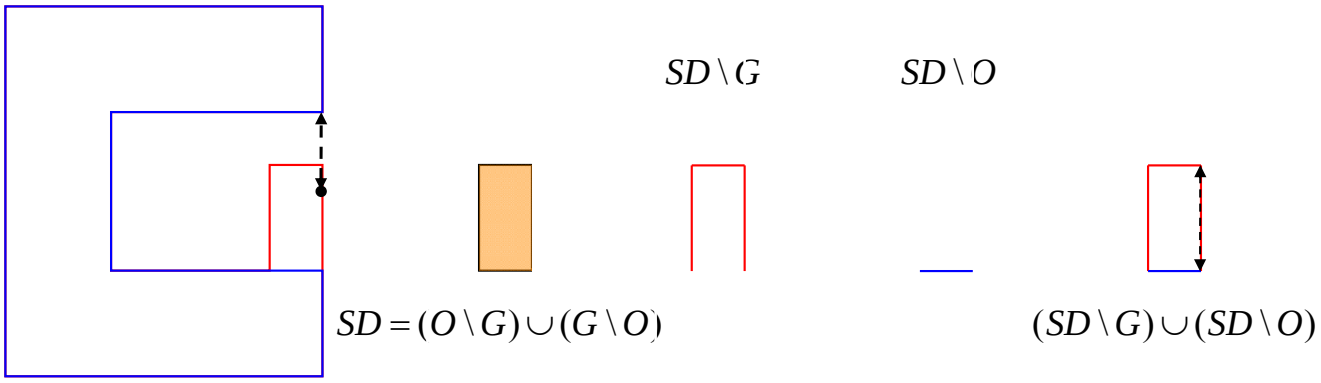
Current Work

- New reconstruction module for high density data
  - Segmentation of LIDAR points
  - Ridge line detection
  - …



Current Work

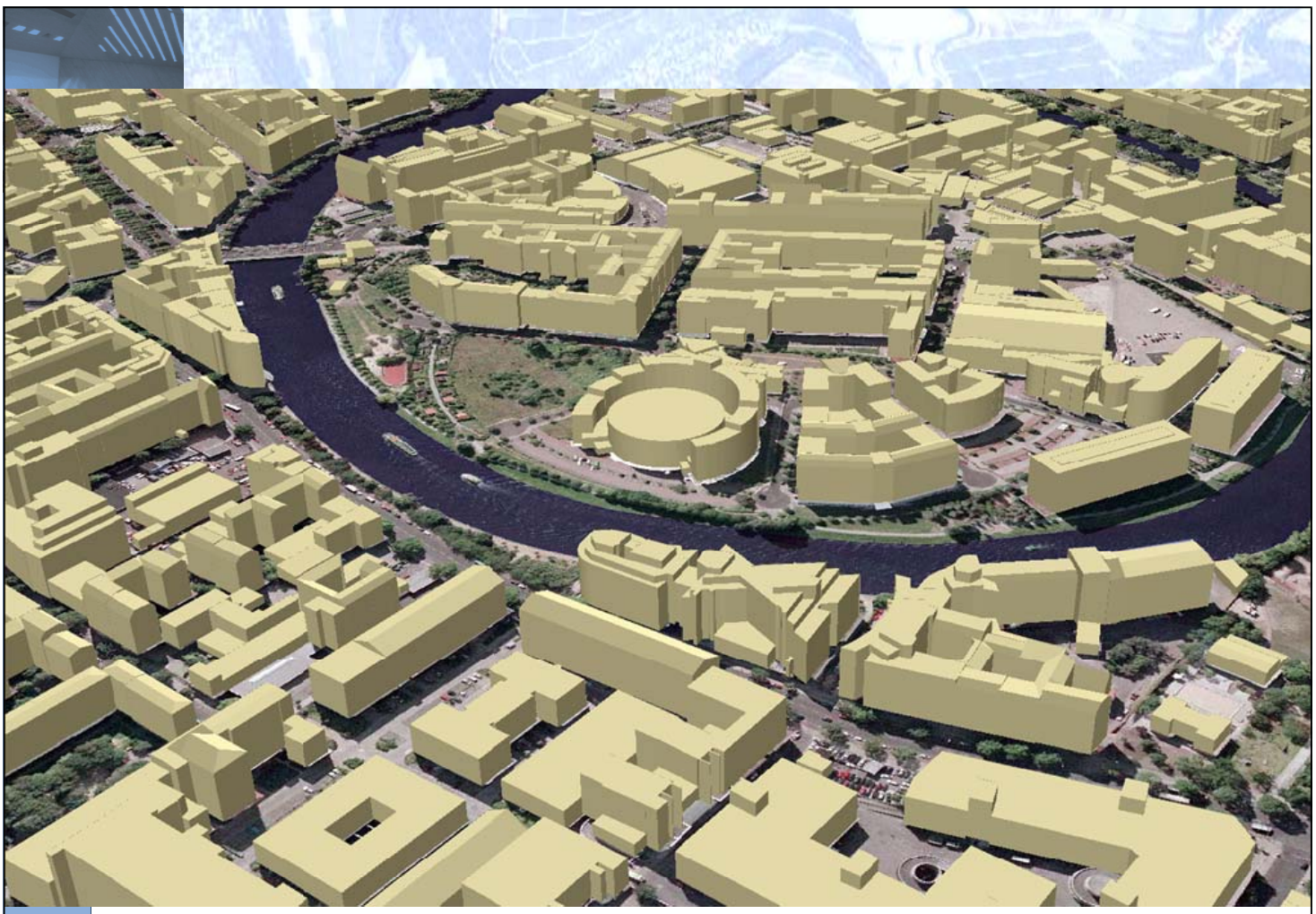
- Quality evaluation of generalized ground plans
  - Maximum deviation between original and generalized ground plan
  - Quality metrics regarding point distances, area differences, trueness of contour lines (Filippovska et al., 2009)



Universität Stuttgart

Uni

Uni



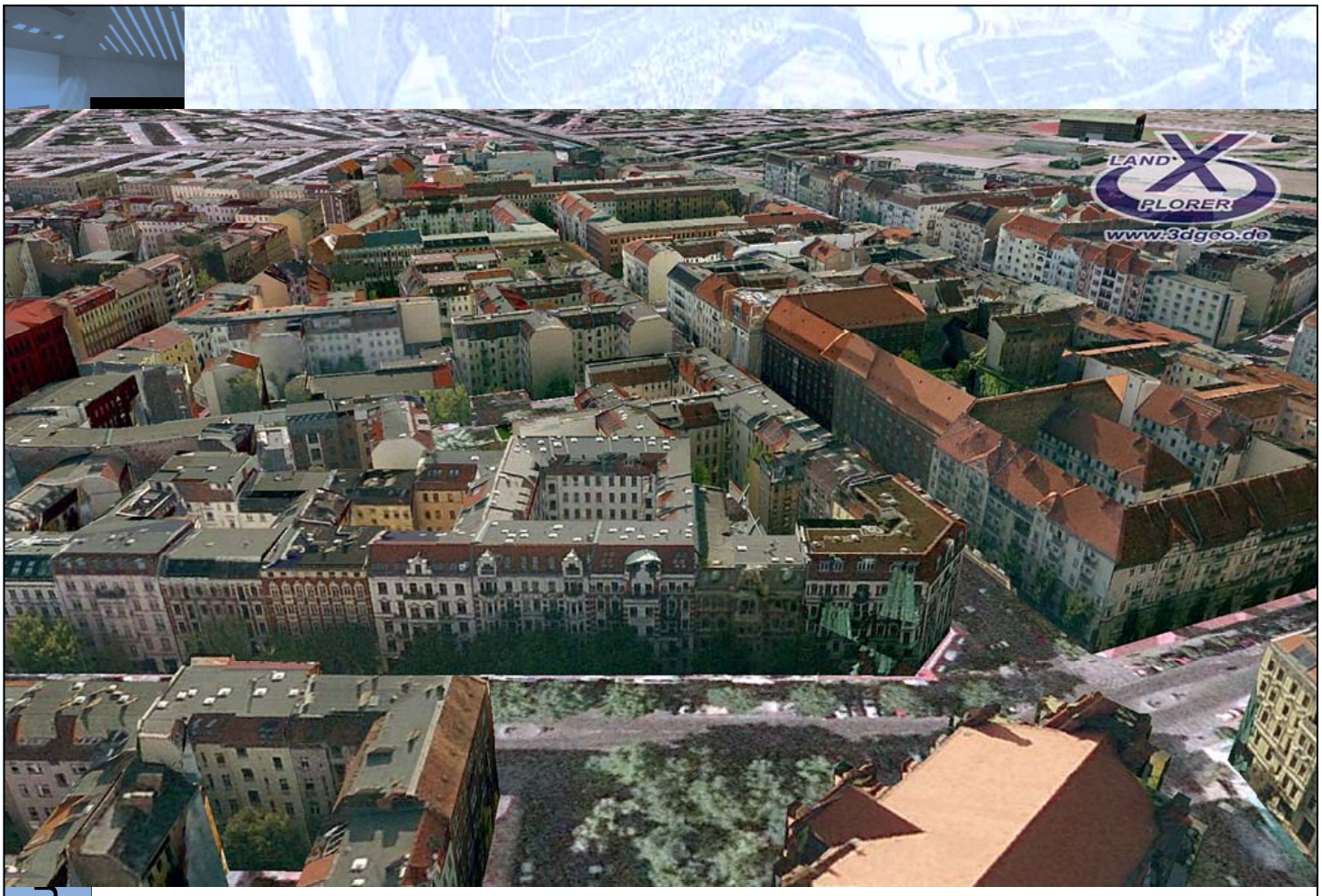

LAND
X
PLORER
www.3dgeo.de


SW CREW


LAND
X
PLORER
www.3dgeo.de


LAND
X
PLORER
www.3dgeo.de


LAND
X
PLORER
www.3dgeo.de


LAND
X
PLORER
www.3dgeo.de