

Plane Based Free Stationing for Building Models

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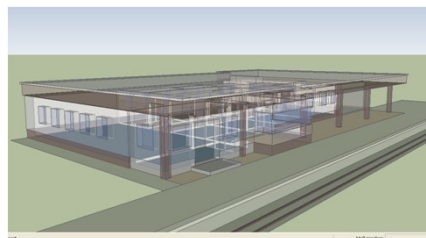
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Introduction

Chair of Geodesy and Adjustment Theory



- ▶ Motivation
- ▶ Plane based building model
- ▶ Plane detection in point clouds
- ▶ Plane based free stationing
 - Transformation parameter
 - Corresponding planes
- ▶ Geometrical adaption
- ▶ Conclusions

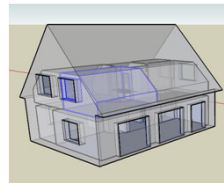


Motivation



3D Building Models are used to

- ▶ Construct buildings
 - all entities are designed
 - Geometry is errorless given
- ▶ Manage existing buildings
 - Current description
 - Model geometry should be based on real measurements
- ▶ Planning of modifications or interior decoration
 - The model geometry has to be sufficient comparing to given tolerance values

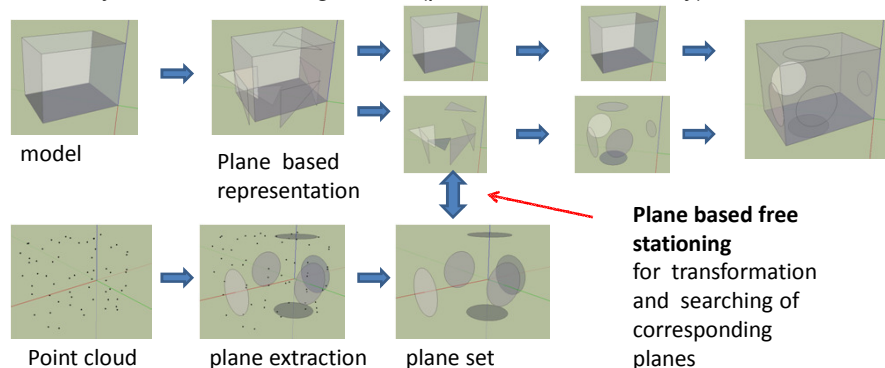


Motivation



Searched :

- ▶ Method to update the model geometry
- ▶ Quality control of building model (precision and reliability)

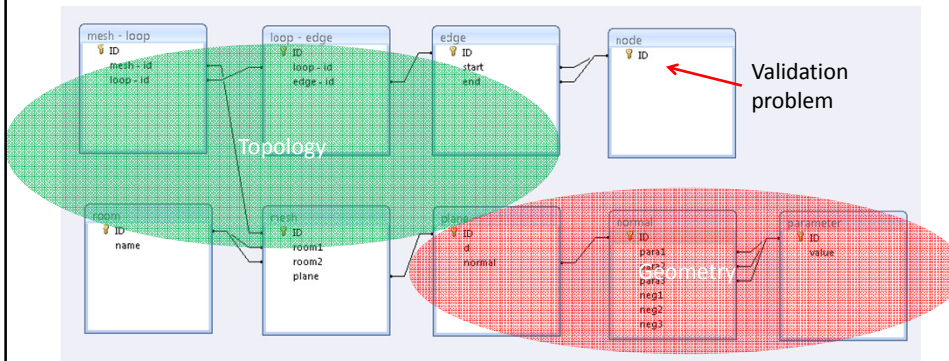


Plane based Building Model

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Plane based representation



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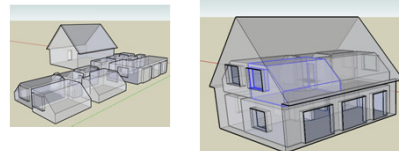
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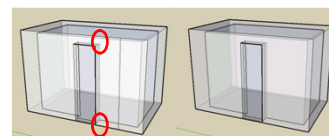
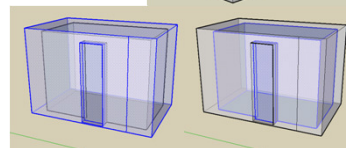
Building representations based on

- ▶ Solids (civil engineering)
- ▶ Divided spaces (surveying)



Validation in steps:

- ▶ Step 1: Separate validation
 - Closed spaces or solids
 - Aggregation of related entities to solve the Euler formula $v-e+f+2h-r=2$ (vertices v , edges e , faces f , holes h , inner loops r)
- ▶ Step 2: Joined validation
 - Nodes intersect by more than 2 planes
 - Independent plane normal's more than 2



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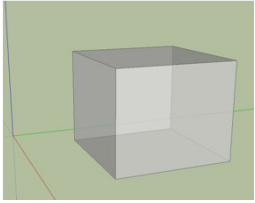
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XML-file of a cuboid



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Model of a cuboid

Nodes	Edges
Edges	Mesh
Mesh	Plane
Plane	Normal Vector
Normal Vector	Parameter

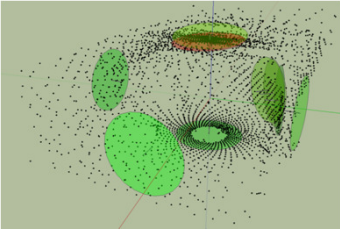
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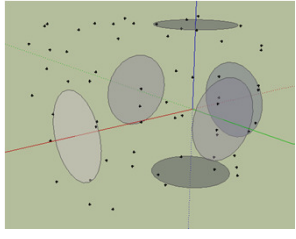
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Automated feature extraction in point clouds

- ▶ Relationship between points and planes is given (total station)
- ▶ Neighborhood of the points is given (laser scanning)
- ▶ without assumptions or advance information





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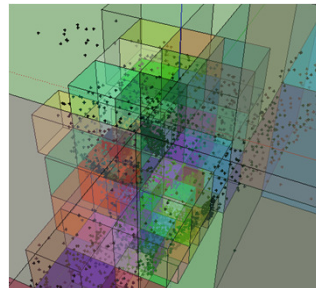
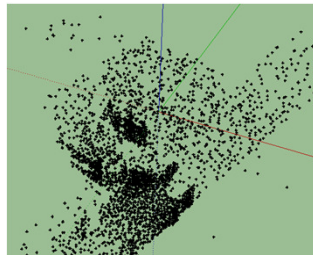
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Step 1: Segmentation (adjacent point groups)

- ▶ Storing the points in a kd-tree
- ▶ Create a space index with respect to a fixed number of points (cubed subspace)



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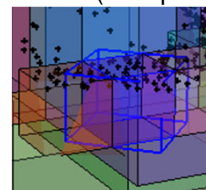
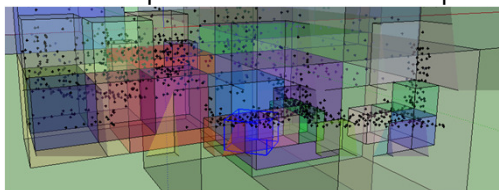
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Step 2: Determination of planes

- Using Random Sample Consensus (RANSAC) paradigm
 - To extract multiple instances
 - Number of useful tries l depends on the failure rate f and the number of planes k . ($l = \ln(1/p) * k^2$)
- 1. After l tries the best represented plane parameter are chosen
- 2. Adjustment (gives the parameter and stochastic information)
- 3. The assigned points were canceled for the next detection
- The procedure will run until k planes were extracted (subspace)



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Plane Detection

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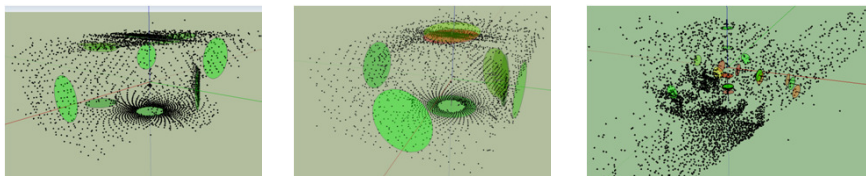


Step 3: Merging the local planes to a global plane set

- ▶ Use the F-Test to detect identical planes
- ▶ Using the index structure of the subspaces

At the end of the feature extraction

- A planes set is given
- Stochastic information is accessible for all planes in the plane set



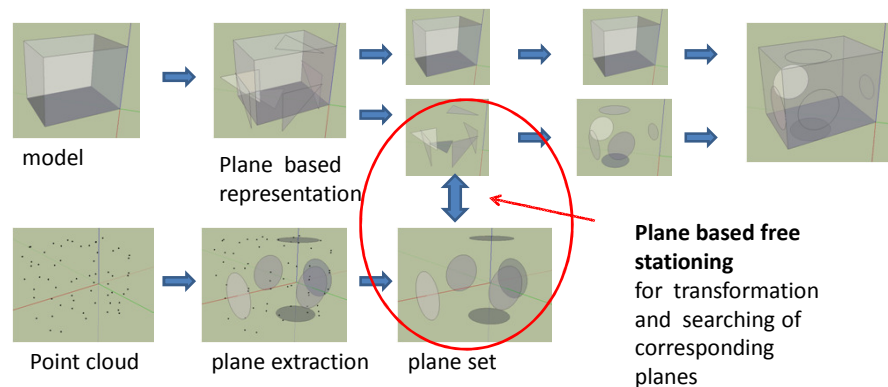
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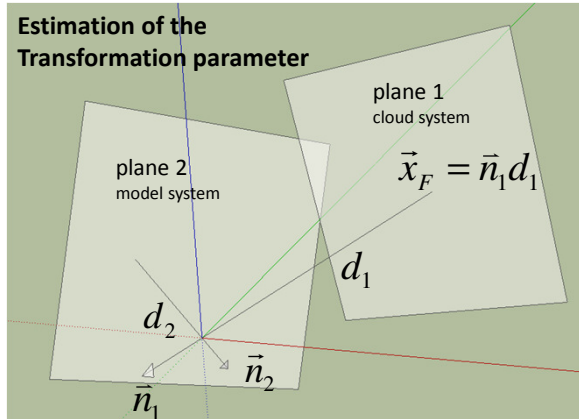
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Estimation of the Transformation parameter



$$\vec{n}_2 = R\vec{n}_1$$

$$\vec{x}_{plane2} = R\vec{x}_F + \vec{t}$$

$$0 = \vec{n}_2 \cdot \vec{x}_{plane2} - d_2$$

$$0 = \vec{n}_2 (R\vec{x}_F + \vec{t}) - d_2$$

$$0 = \vec{n}_2 (R\vec{n}_1 d_1 + \vec{t}) - d_2$$

$$0 = \vec{n}_2 (\vec{n}_2 d_1 + \vec{t}) - d_2$$

$$0 = d_1 + \vec{n}_2 \vec{t} - d_2$$

$$0 = \vec{n}_2 \cdot \vec{x}_{plane2} - d_2 \quad 0 = \vec{n}_1 \cdot \vec{x}_{plane1} - d_1$$

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Semi-automatic matching of corresponding planes

1. Manual assignment of more than two corresponding planes
2. Calculation of the transformation parameter between the model system and the point cloud system
3. Transformation of the plane set into the model system to find more candidates for corresponding planes
4. Testing the candidates and extending the plane based model
5. Rerun step 1 – 4 until no more identical planes were found

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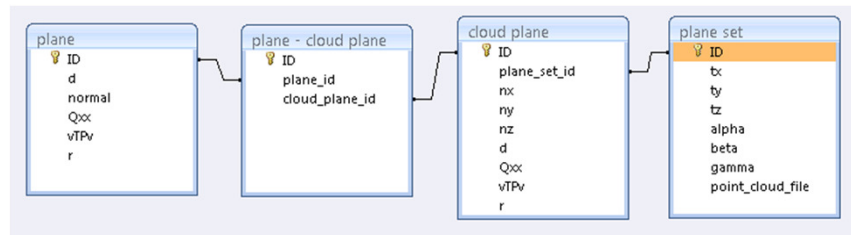
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The plane based building model and its upgrad with respect to the corresponding planes

- ▶ Each cloud plane is attributed with it transformation to the model
- ▶ For each plane it stochastic information is accessible
- ▶ Plan assignments are stored in a entity relationship model



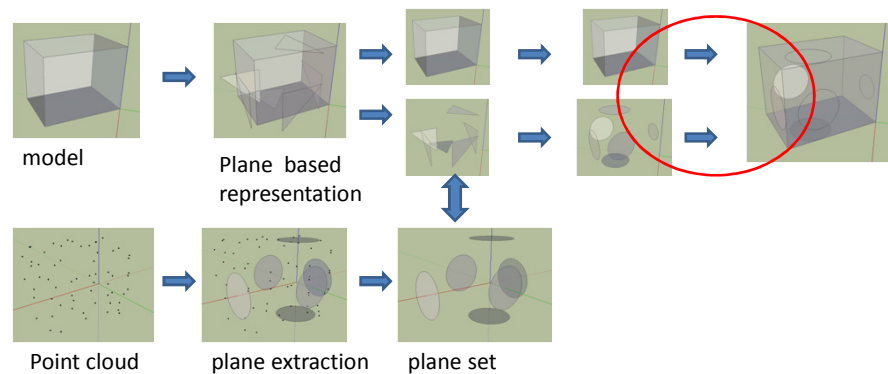
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Geometrical adaption

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Thanks for your attention!

