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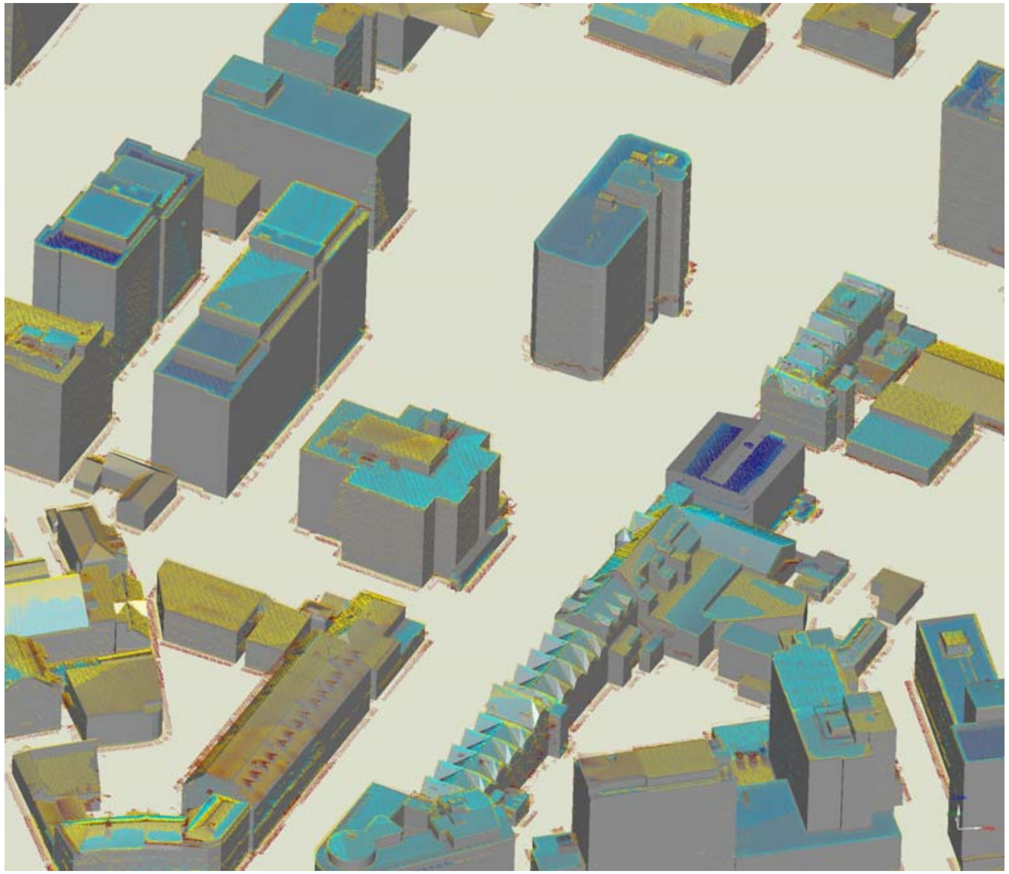

Quality assessment of 3D building data by 3D surface matching

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Introduction – 3D building modeling

• 3D city models are in high demand.

• **Fully automated** methods still cannot satisfy the practical user needs.
This fact led to substantial research on the **semi-automated methods**.
E.g. CyberCity Modeller (Gruen and Wang, 1998).

• While the performance of the methods is improving,
the **quality evaluation of 3D building data** has become an important issue.

Introduction – Quality assessment methods in the literature

- Quality metrics using **pixels** based on 2D projections (Henricsson and Baltsavias, 1997; Ameri, 2000; Suveg and Vosselman, 2002; Boudet et al., 2006),

- Quality metrics using **voxels**, considering buildings as volumetric data (McKeown et al., 2000; Schuster and Weidner, 2003; Meidow and Schuster, 2005),

- **Qualitative and visual** evaluation (Rottensteiner and Schulze, 2003; Durupt, Taillandier, 2006),

- **Error propagation** applied to the stochastic properties of input (road) data (Elberink and Vosselman 2007),

- Detailed reviews in McKeown et al. (2000) and Sargent et al. (2007).

Introduction – objective and goal

• ‘**Quality Assessment of 3D Building Data**’ a cooperative project between
Chair of Photogrammetry and Remote Sensing of **ETH Zurich,**
Research department of **Ordnance Survey**.

• **Goal** is to calculate **metrics** for the **quantitative evaluation** of 3D buildings.

• These **metrics**,
+ correspond to customers’ requirements (of Ordnance Survey),
+ independent of the method of data capture.

Data formats

Input data:
3D building models
provided in CC-Modeler (CyberCity AG, Zurich) **V3D** polygon file format.

Verification (reference) data:
Airborne laser scanning (ALS) point cloud data in **ENZI** ASCII file formats
or
another 3D model given at a higher quality level.

Quality assessment by 3D surface matching

• In fact, 3D building data is in surface form.

• Our proposal to work directly on 3D surface elements (**surfels**). The input model is co-registered to the verification data by **Least Squares 3D surface matching** (**LS3D**, Gruen and Akca, 2005).

• The **LS3D surface matching method**

+ rigorous algorithm for the matching of overlapping 3D surfaces,
+ estimates 3D transformation parameters,
+ min → Sum(Sqr (EuclideanDistance)),
+ using Generalized Gauss-Markoff model,
+ internal quality control,
+ multi-quality & multi-resolution data.

• The LS3D method evaluates the Euclidean distances between the verification and input data sets. **The Euclidean distances** give appropriate metrics for the 3D model quality.

Quality criteria - generated by the LS3D method

• **Reference system accuracy**
Due to production techniques, input & verification reference frames may differ.
LS3D method calculates 7DOF, 6DOF, 3DOF, etc., differences.

• **Positional accuracy**
Each element-to-element correspondence is a 3D Euclidean vector.
Assuming that verification data at a higher quality level,
Euclidean distances are the positional accuracy of the surfels (of input surface).

• **Completeness**
Assuming that verification data complete, accurate and dense,
missing correspondences show the completeness.

Quality assessment strategy

Three procedural steps were followed in the experiments.

Step 1. Computation of initial (spatial) disagreement
Only 3D spatial distances calculated (without any transformation).
This step shows the initial misalignment.

Step 2. Co-registration
Run of the LS3D surface matching with the transformation computation.
Acc. to preliminary tests, only translations (3DOF) between both data sets.
The estimated 3D transformation parameters applied to test data sets.
Thus, the reference system errors isolated from the building's positional errors.

Step 3. Comparison
Again, only 3D spatial distances calculated (without any transformation).
This final step shows the positional accuracy of buildings and completeness.

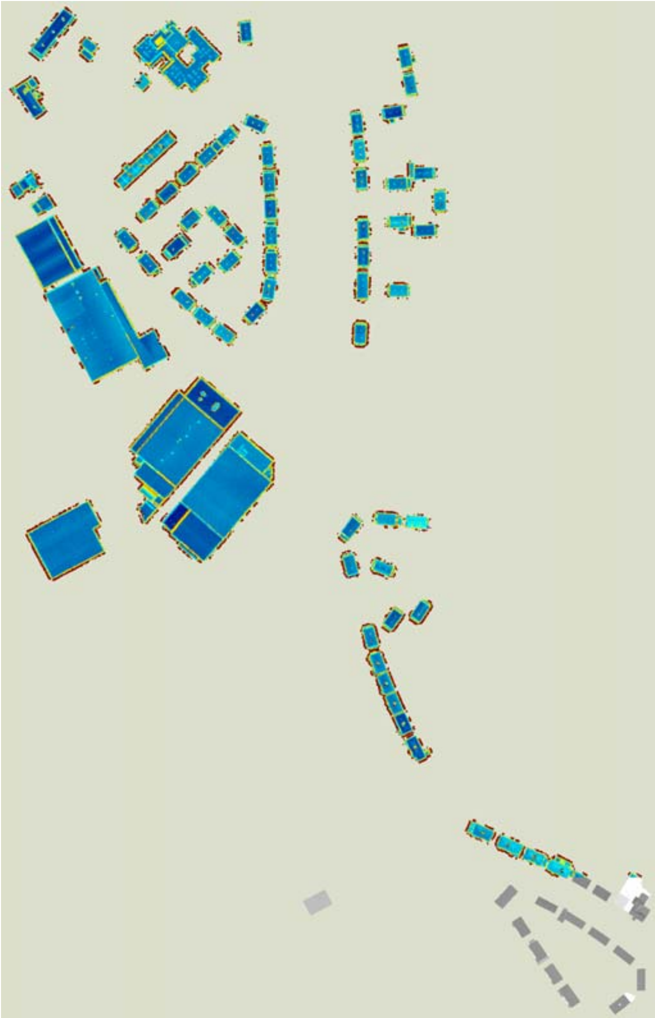
Experimental work – test sites

Two test sites in UK,
- Avonmouth (**AV**)
- Bournemouth test area 2 (**BO2**).

Input data:
- 3D building data,
- generated using CC-Modeler,
- measured through DMC imagery.

Verification data:
- LIDAR point clouds,
- acquired by Airborne 1 Corporation using a Bravo 50K ALTM system carried on a helicopter platform,
- 25 point/m^2 density.

Results of test site AV



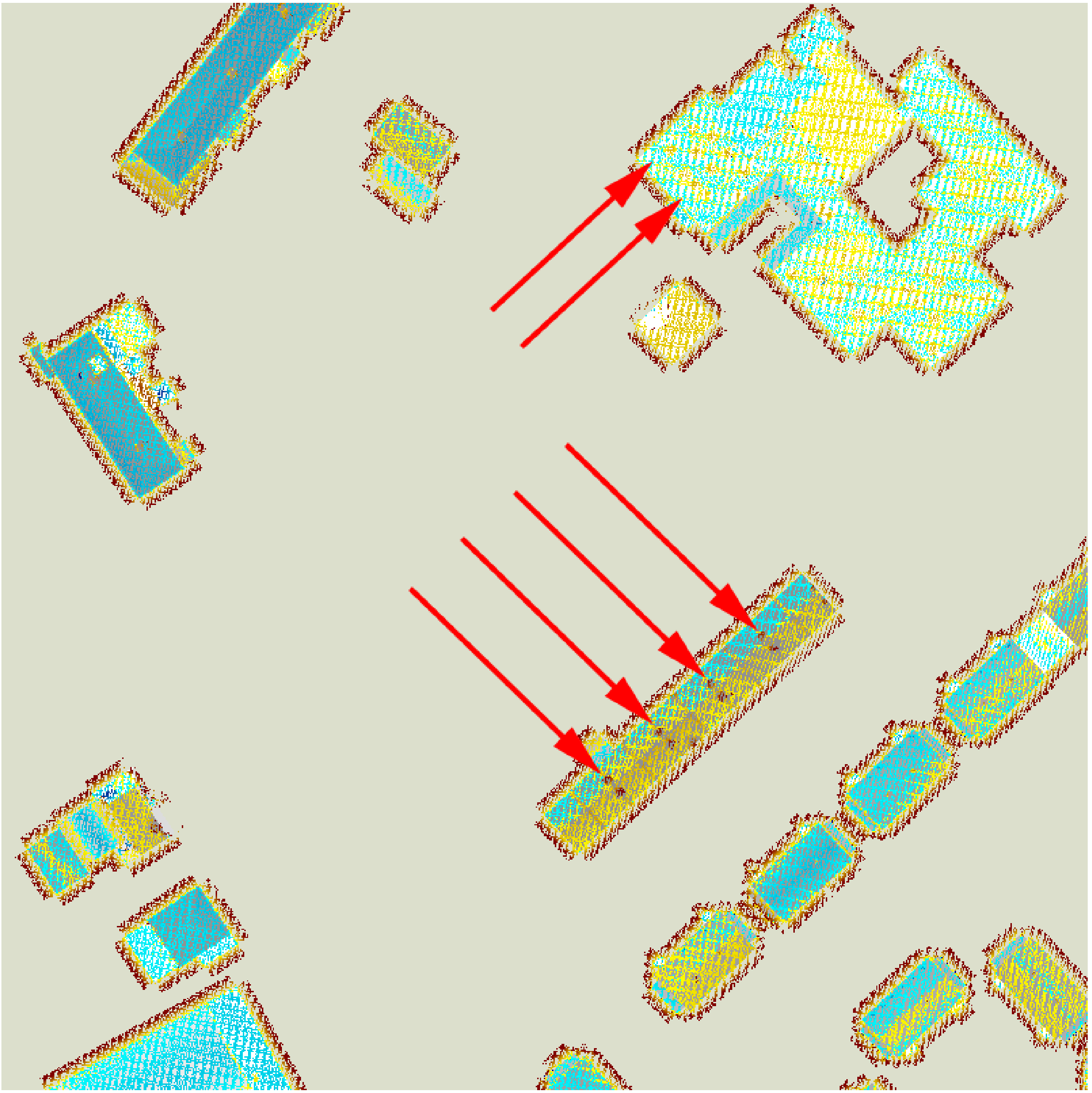
Step 1.
Sigma0^ = ± 0.81 m

Step 2.
Translations (m)
+0.03 (X)
+0.06 (Y)
–0.85 (Z)

Input model V3D is **higher** than the verification LIDAR pointcloud.

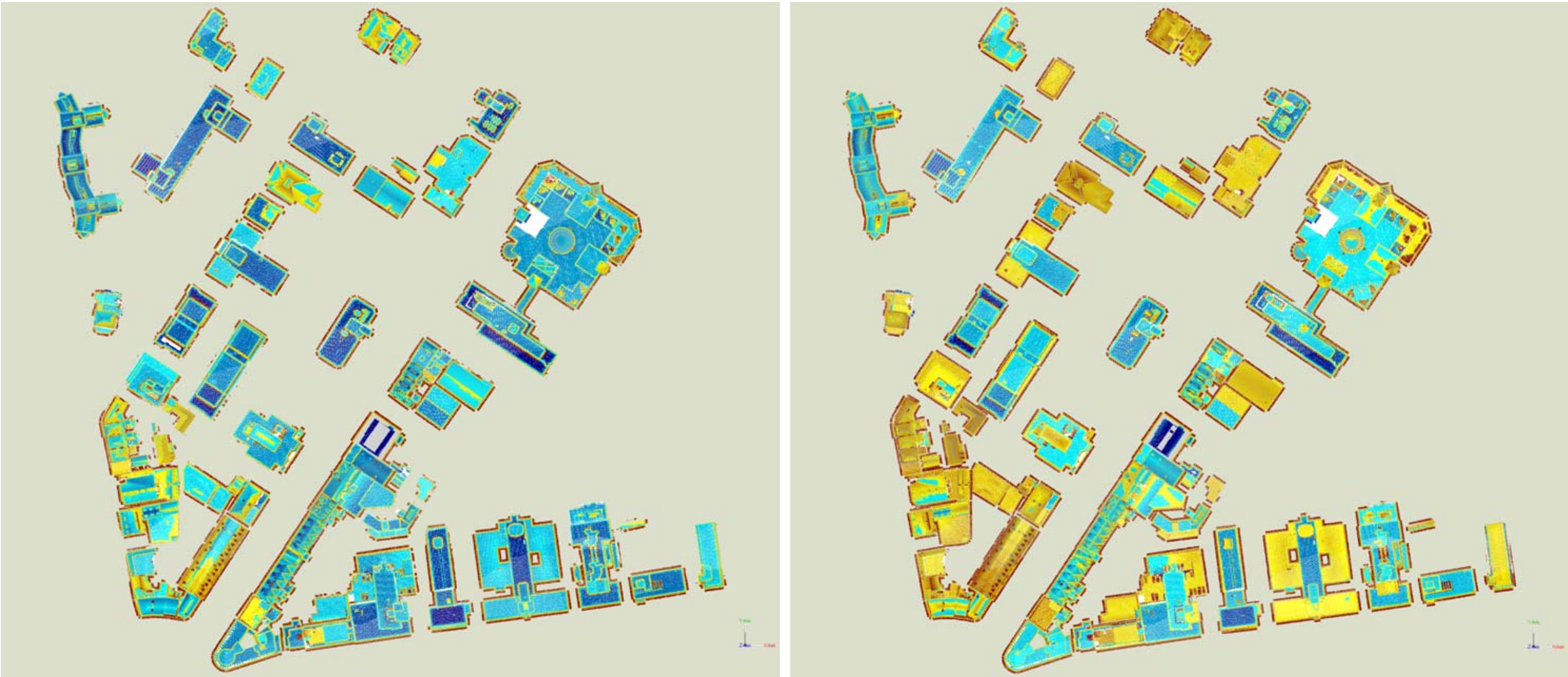
Step 3.
Sigma0^ = ± 0.60 m

Results of test site AV



The red arrows show the missing chimneys and dormers in the V3D input model data.

Results of test site BO2

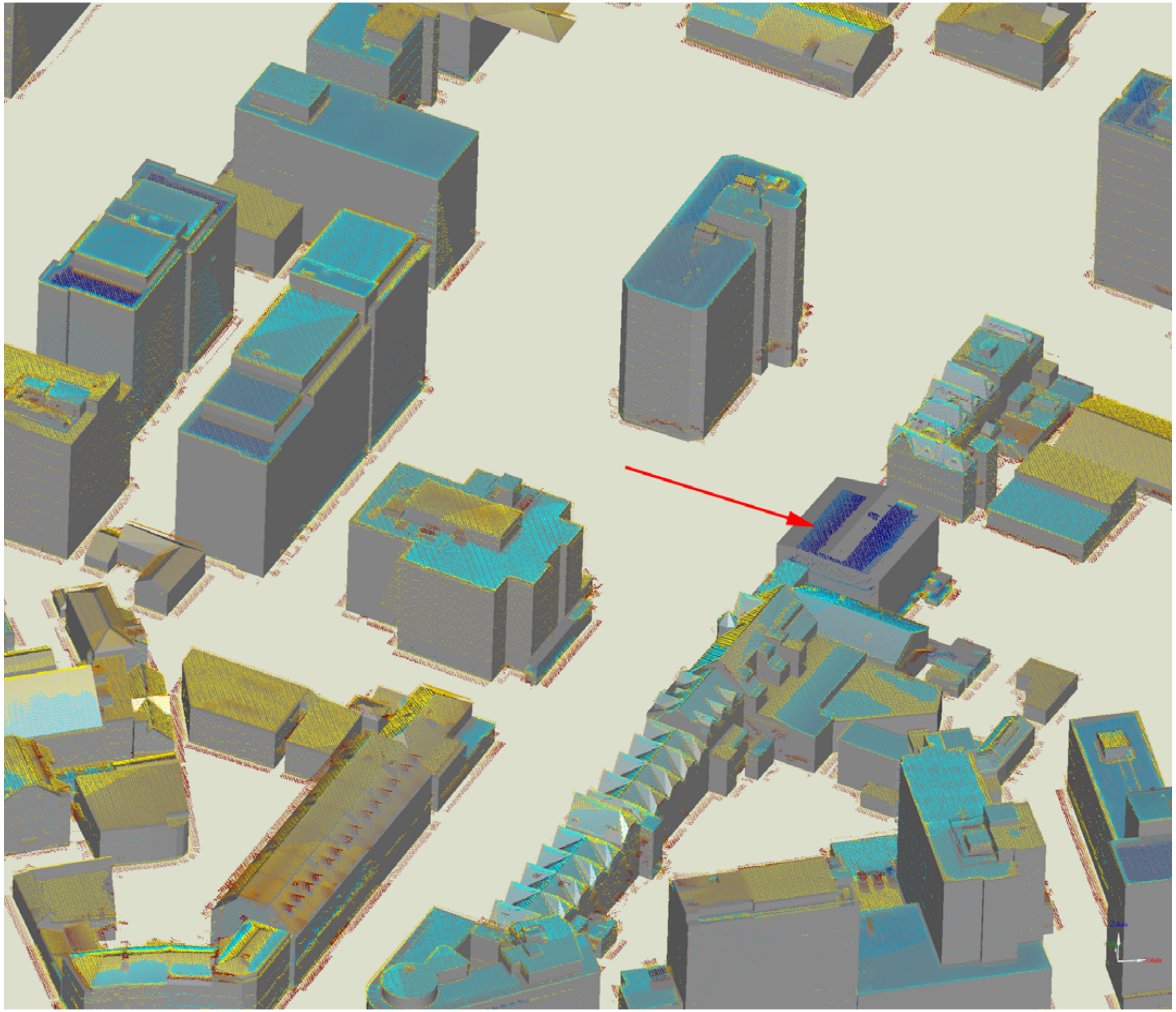


Step 1.
Sigma0^ = ± 0.73 m

Step 2.
Translations (m)
+0.21 (X)
–0.33 (Y)
–0.48 (Z)

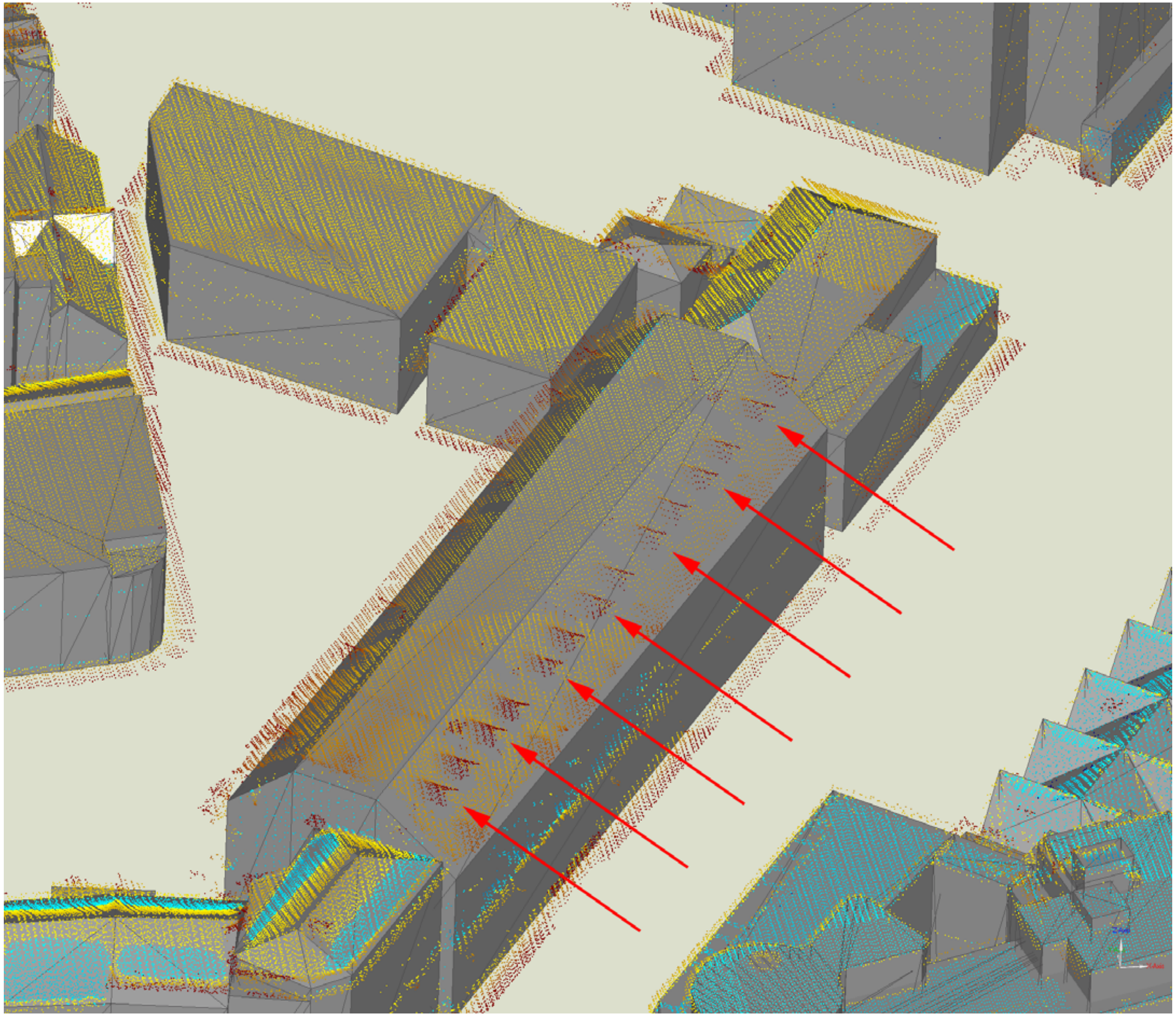
Step 3.
Sigma0^ = ± 0.68 m

Results of test site BO2



The red arrow shows a building which was large differences between the model and the point cloud.

Results of test site BO2



The red arrows show the missing dormers.

Conclusions

• We developed a practical method together with a GUI based C/C++ software.

• Our method can successfully assess the 3D building data in terms of

+ **gross errors** (outliers)

++ completeness

+ **systematic errors**

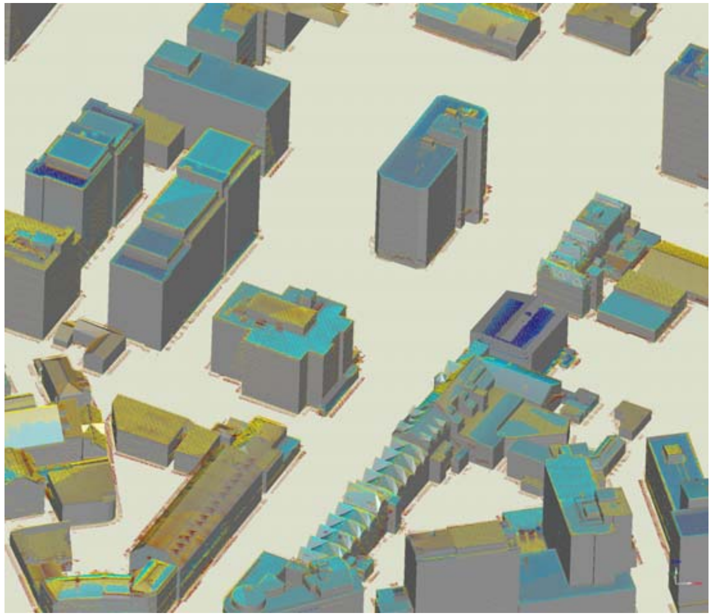
++ errors due to reference system differences

++ systematic measurement errors

+ **random errors** (noise).

Future work

When using the LIDAR point clouds as the verification data, handling of the non-relevant points (points which do not belong to buildings) needs an appropriate strategy.



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