



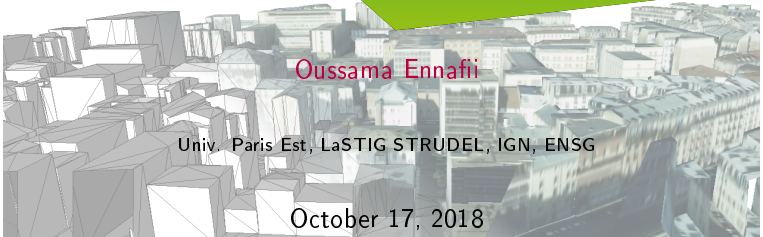
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Semantic 3D building model evaluation

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Introduction

Context: 3D model vs. 3D mesh

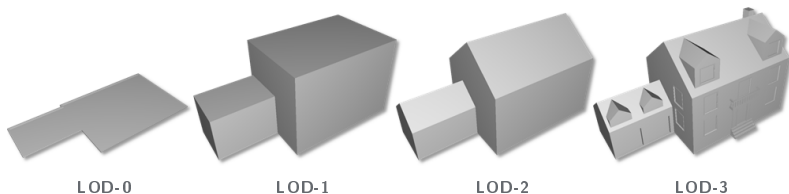
- ▶ 3D urban model \longleftrightarrow polyhedral surface representing a building.

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- ▶ Results seamless but lack generality and often erroneous (Rottensteiner et al., 2014);
→ labourious manual corrections.
- ▶ Urban 3D model semantic diagnostic **not well studied** (Nguatem and Mayer, 2017);

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- ▶ Semantic errors independent from **reconstruction methods** and **urban scenes**.
- ▶ **Transferability**, and hence scalability, of the evaluation method.

Potential use

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- ▶ Urban reconstruction method evaluation;
- ▶ Crowd reconstruction quality assessment.



Methodology

Main ideas behind our approach

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- ▶ Evaluation at building level \implies formulated as a supervised classification problem;
- ▶ Study in a **2.5D overhead (aerial)** modeling setting.

Taxonomy structure

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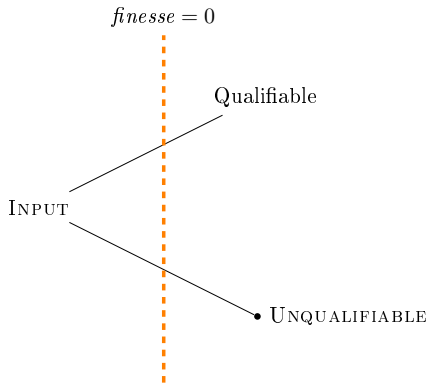
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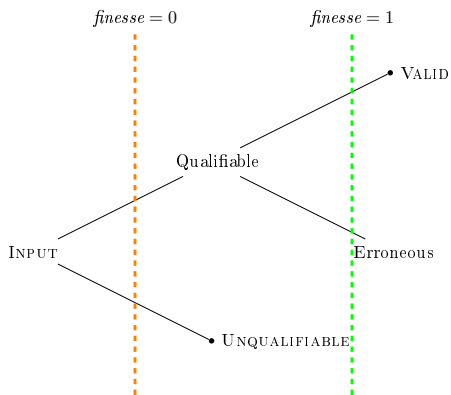
Definition

An error is of maximal *finesse* \Leftrightarrow it corresponds, semantically, to a unitary action required to correct the model. The error is called *atomic*.

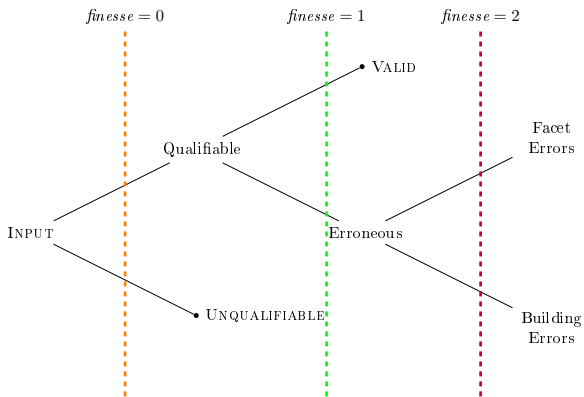
Error taxonomy (*finesse* = 0)



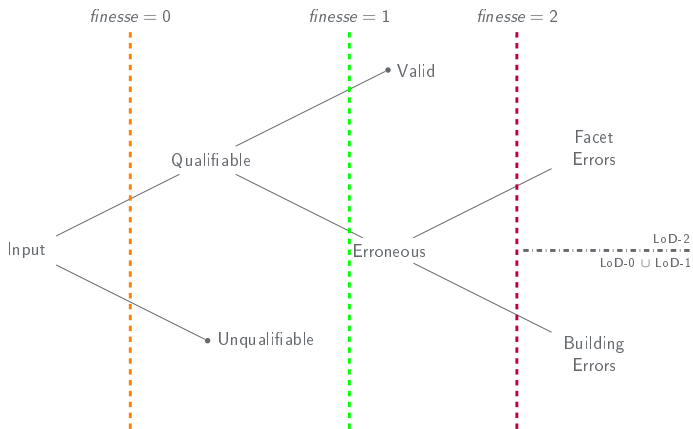
Error taxonomy (*finesse* = 1)



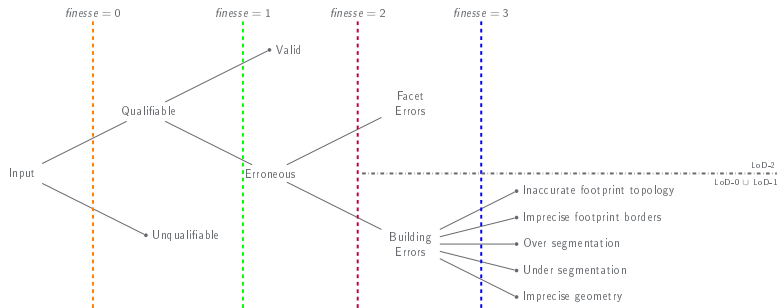
Error taxonomy (*finesse* = 2)



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Error taxonomy (*finesse* = 3)



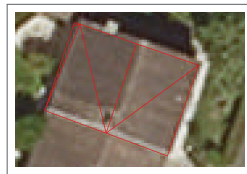
Building *atomic* errors: 2.5D overhead reconstruction case



(a) Under segmentation



(b) Over segmentation

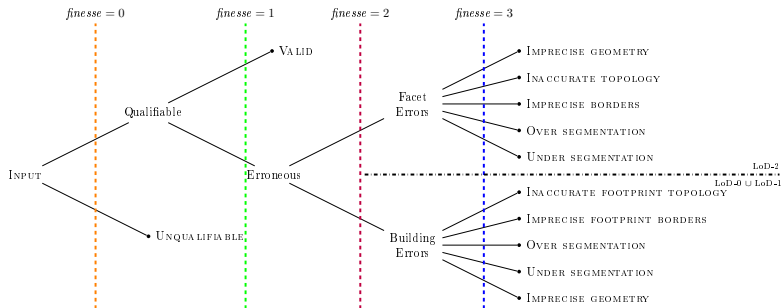


(c) Imprecise border



(d) Inaccurate topology

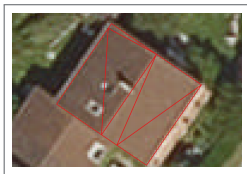
Error taxonomy (*finesse* = 3)



Facet *atomic* errors: 2.5D overhead reconstruction case



(a) Under segmentation



(b) Over segmentation



(c) Imprecise borders

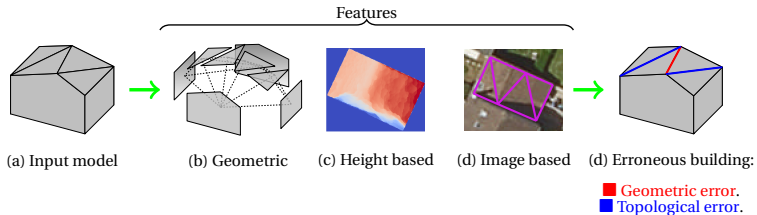


(d) Inaccurate topology

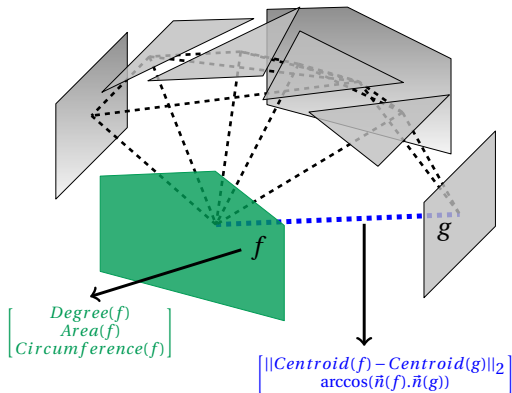


(e) Imprecise geometry

The evaluation pipeline sketch



Geometric features



Height-based features

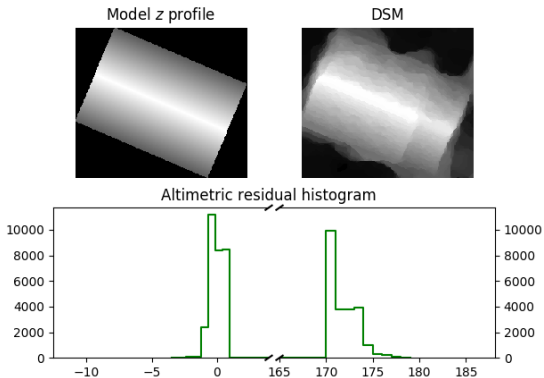
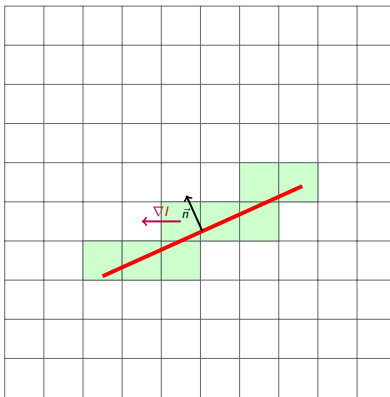


Image-based features



(a) A building projection and the corresponding orthoimage.



(b) For each facet edge, the cosine similarity is computed between its normal and the image gradient, on each intersecting pixel (in green).



Experiments

Results using all features

	Elancourt	Nantes	Paris 13
# samples	2009	748	478

Dataset statistics

Results using all features




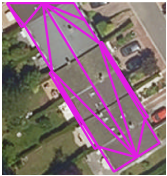
	Elancourt	Nantes	Paris 13
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Dataset statistics

	Elancourt (10-cross val.)		Elancourt → Nantes		Elancourt → Paris 13	
	Recall	Prec.	Recall	Prec.	Recall	Prec.
<i>BOS</i>	90.83	76.14	93.12	42.61	96.53	43.82
<i>BUS</i>	39.32	71.81	8.82	66.67	0	—
<i>BlmB</i>	16.75	68.0	2.02	33.33	0	—
<i>BlmT</i>	11.11	91.67	0.88	100	3.95	50.0
<i>FOS</i>	98.91	98.84	98.33	97.92	97.19	97.58
<i>FUS</i>	1.27	66.67	13.81	63.04	8.36	95.83
<i>FlmB</i>	7.42	100	46.34	65.52	11.80	60.71
<i>FlmT</i>	3.33	100	9.09	100	0	0
<i>FIG</i>	79.02	71.82	94.17	70.70	86.16	88.47

Test results using **Random Forest** (*max depth* = 4 & *#trees* = 1000) trained on Elancourt.

Some failure cases on Elancourt

											
Errors	G.T.	Pred.	Errors	G.T.	Pred.	Errors	G.T.	Pred.	Errors	G.T.	Pred.
<i>BOS</i> Valid	✗ ✓	✓ ✗	<i>BUS</i> <i>FIG</i> <i>FOS</i>	✗ ✓ ✓	✓ ✗ ✗	<i>BOS</i> <i>FUS</i>	✓ ✓	✓ ✗	<i>BOS</i> <i>FOS</i> <i>BUS</i> <i>BImB</i>	✓ ✓ ✓ ✓	✗ ✗ ✗ ✓



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Conclusion

Conclusion & Perspectives

- ▶ **Flexible, robust and hierarchical** taxonomy;
- ▶ **Fast, lightweight and modular** pipeline for model evaluation;
- ▶ Baseline for geometric, image-based and height-based features;

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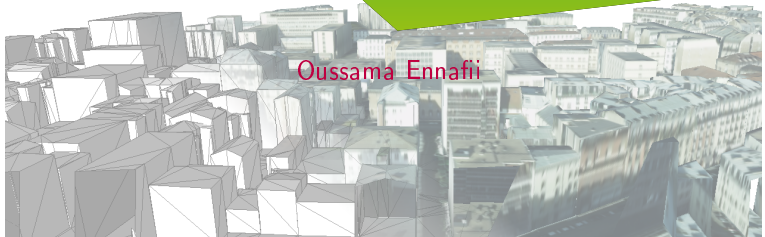
Future work:

- ▶ Dataset augmentation → **Simulate errors** from the taxonomy based on reference data;
- ▶ Extend to richer features → Graph kernels, deep learning.



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Thank you for your
attention!



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