



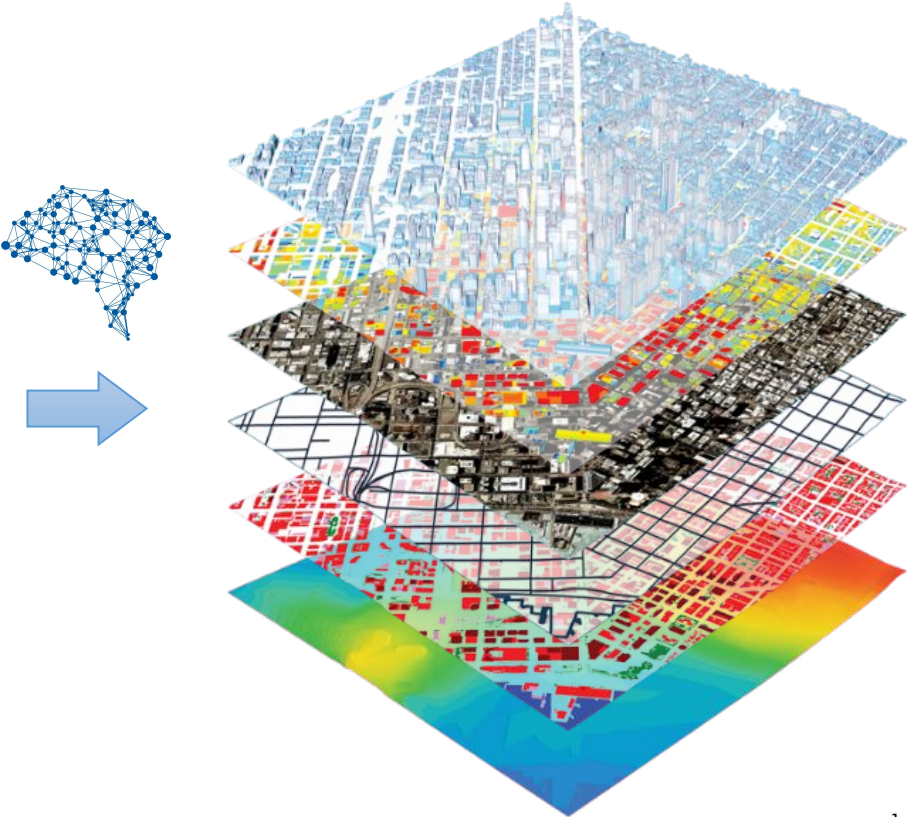
SimpliCity: Reconstructing Buildings As Simple Regularized 3D Models

Jean-Philippe Bauchet¹, Raphael Sulzer^{1, 2}, Florent Lafarge², Yuliya Tarabalka¹
¹ LuxCarta Technology, ² Centre Inria d'Université Côte d'Azur

Mapping **your** world in 3D



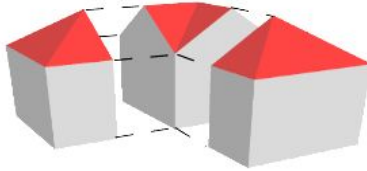
Maxar WorldView images



- How to generate lightweight building models from airborne Lidar point clouds?

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- Objectives:
 - Fidelity
 - ✓ Provide accurate geodata
 - Simplicity
 - ✓ Regular and simple polygons
 - Efficiency
 - ✓ Ability to process large-scale areas, anywhere in the world
 - Geometric guarantees
 - ✓ Watertightness, orientable meshes...

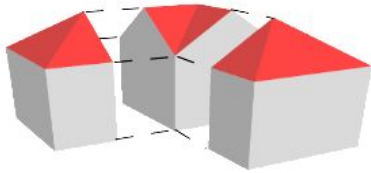
Model-driven reconstruction



[Lafarge '10], [Verma '06], [Xiong '14]

...

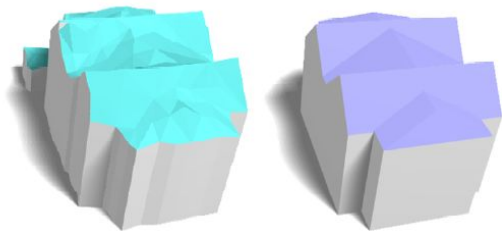
Model-driven reconstruction



[Lafarge '10], [Verma '06], [Xiong '14]

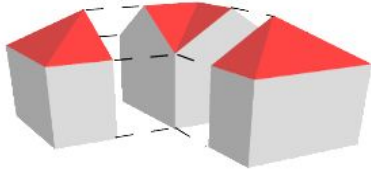
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Mesh simplification



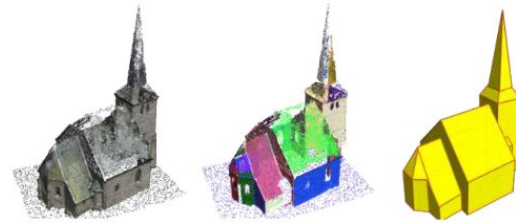
[Zhou '12], [Salinas '15], [Bouzas '20] ...

Model-driven reconstruction



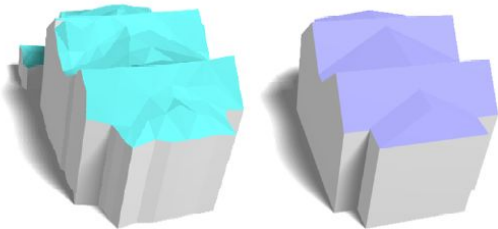
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...

Shape assembling pipelines



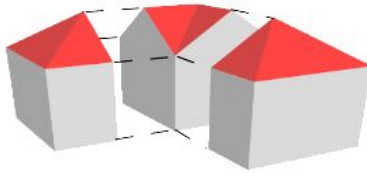
[Nan '17], [Bauchet '20],
[Peters '22], [Huang '22] ...

Mesh simplification



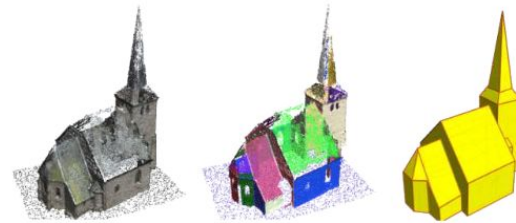
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Model-driven reconstruction



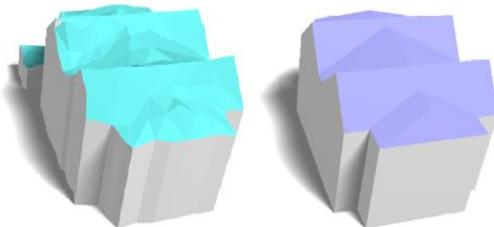
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Shape assembling pipelines



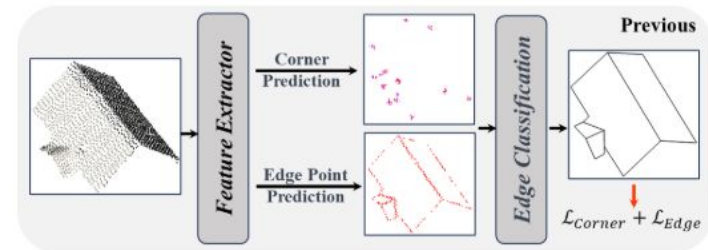
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Mesh simplification



[Zhou '12], [Salinas '15], [Bouzas '20] ...

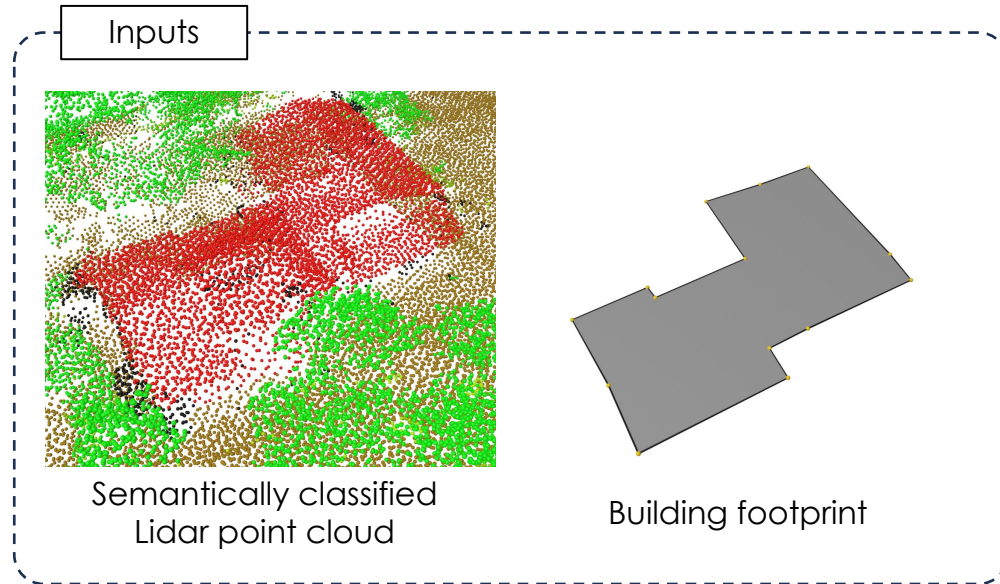
Neural methods



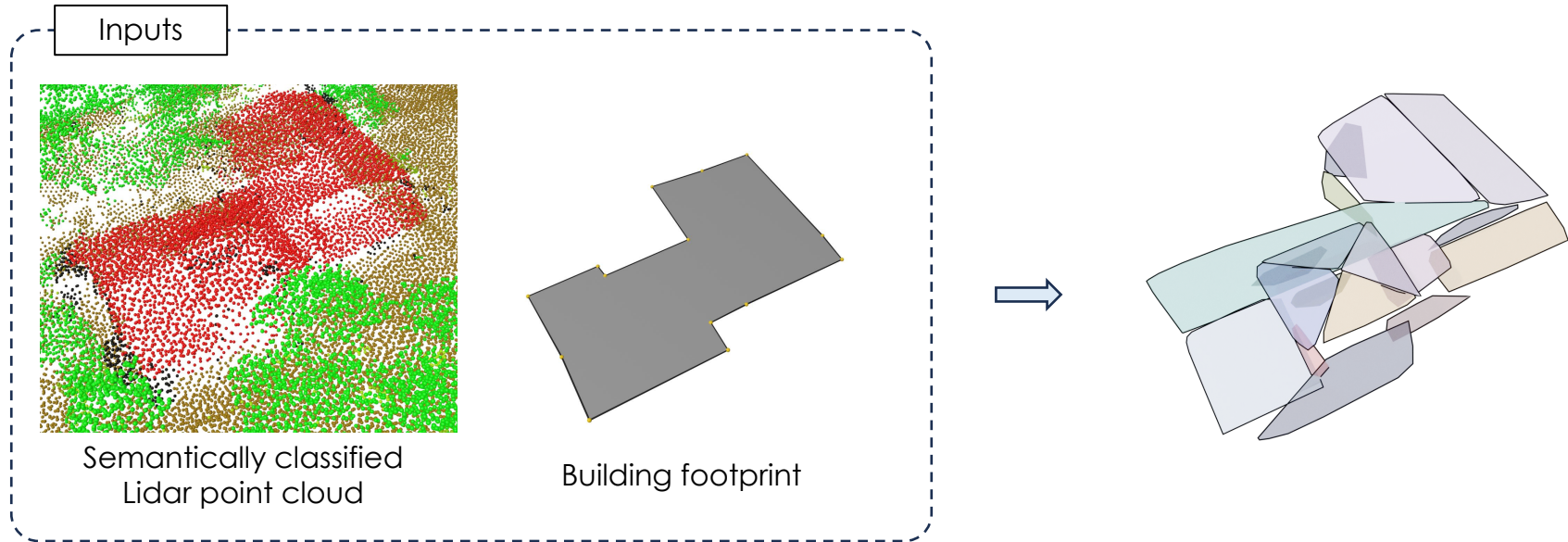
[Chen '22], [Huang '23], [Liu '24] ...

- Our contributions are twofold:
 - A planimetric arrangement that generates concise, watertight building models from Lidar data, based on a 2.5D-view dependent representation
 - A regularization procedure that simplifies the produced models, while enforcing geometric regularization and preserving geometric guarantees

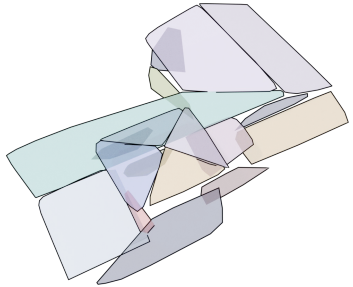
1) Plane detection



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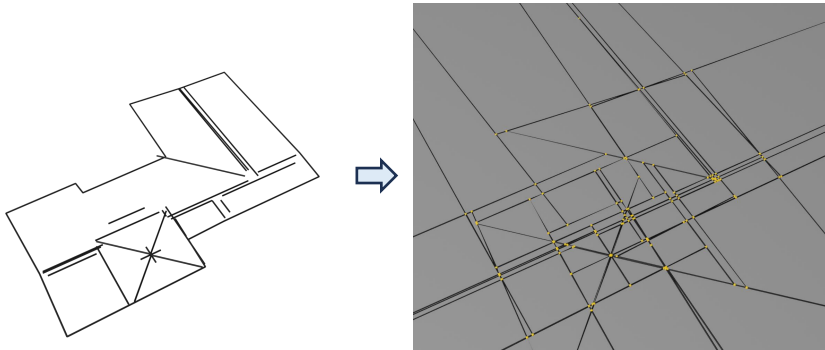


2) Construction of a polygonal partition



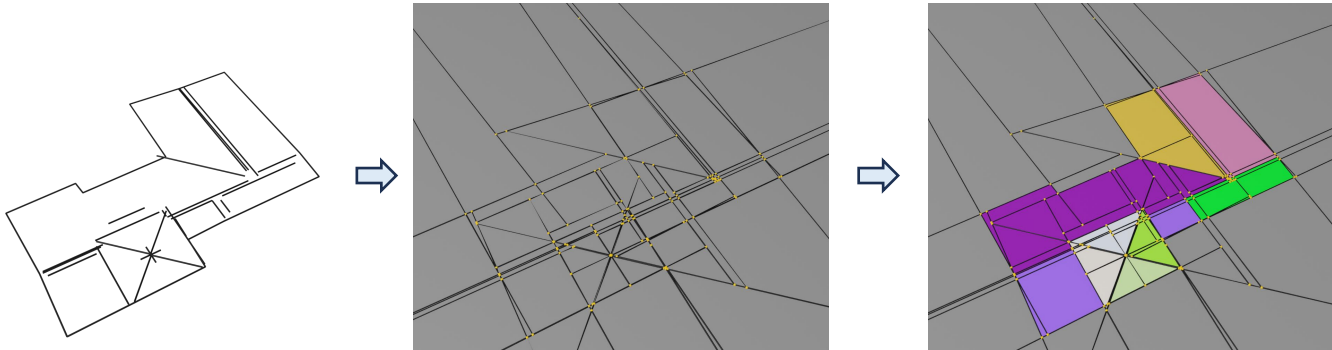
2) Construction of a polygonal partition

- A kinetic framework [Bauchet '18] produces a 2D decomposition of the space into convex cells. It is initialized with a set of 2D line-segments, composed of:
 - 3D line-segments, projected on the horizontal plane (plane-plane intersections, height discontinuities in the point cloud)
 - Building footprint's line-segments



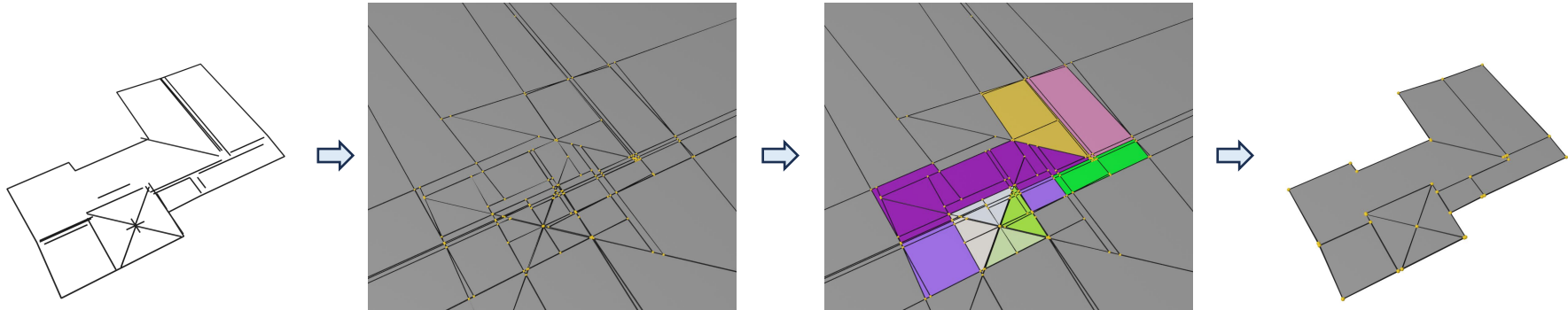
2) Construction of a polygonal partition

- Plane labels are assigned to the cells of the 2D partition by energy minimization (Potts model with a complexity term)

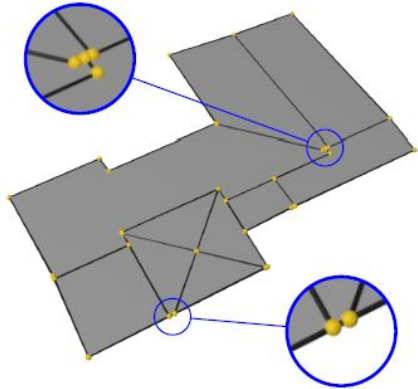


2) Construction of a polygonal partition

- Roof structure is obtained by grouping polygonal cells with same plane label

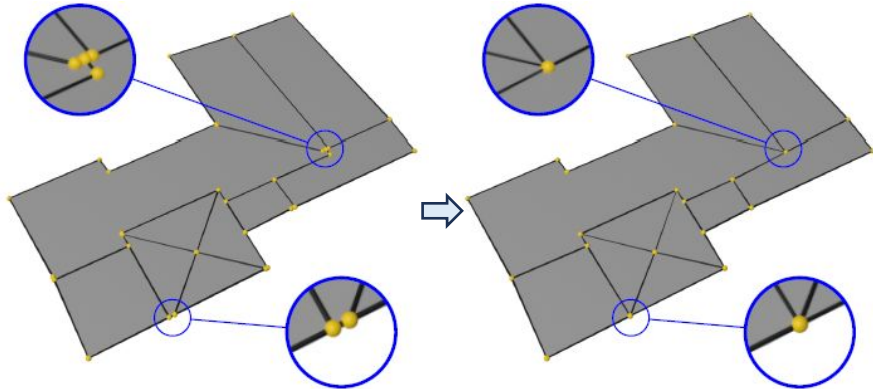


3) Regularization of 2D polygonal partitions



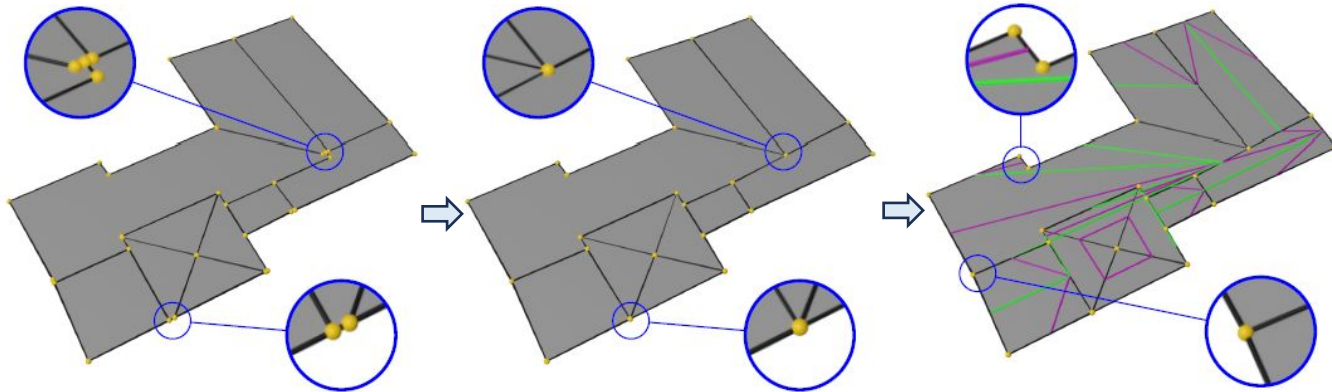
3) Regularization of 2D polygonal partitions

- Vertex simplification



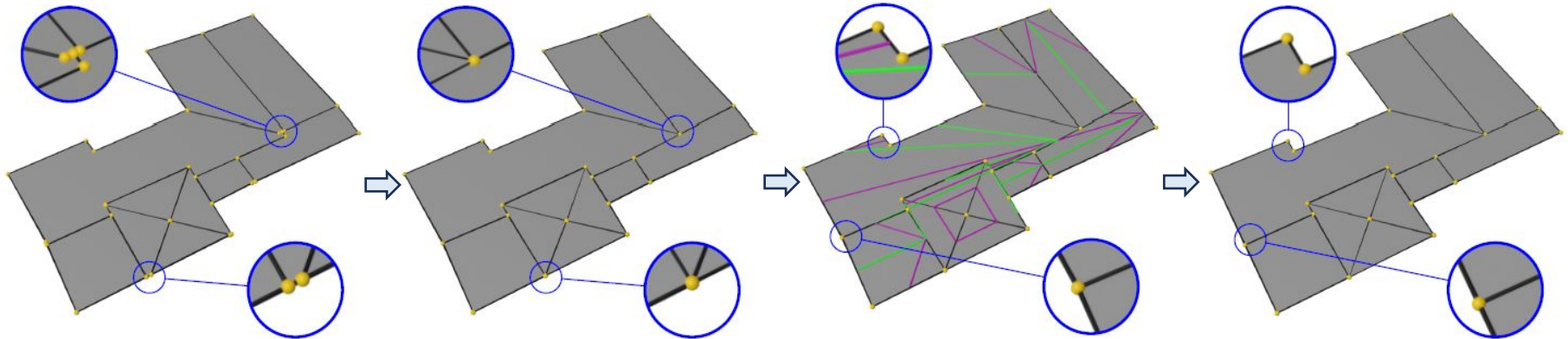
3) Regularization of 2D polygonal partitions

- Pairs of near-parallel and near-orthogonal edges in the partition are detected

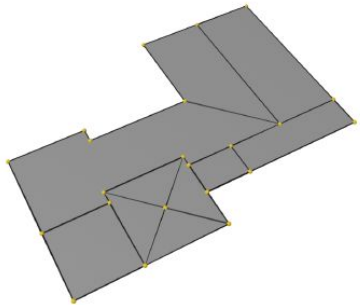


3) Regularization of 2D polygonal partitions

- Coordinates of 2D vertices at the end of near-collinear or near-orthogonal edges are optimized globally via energy minimization

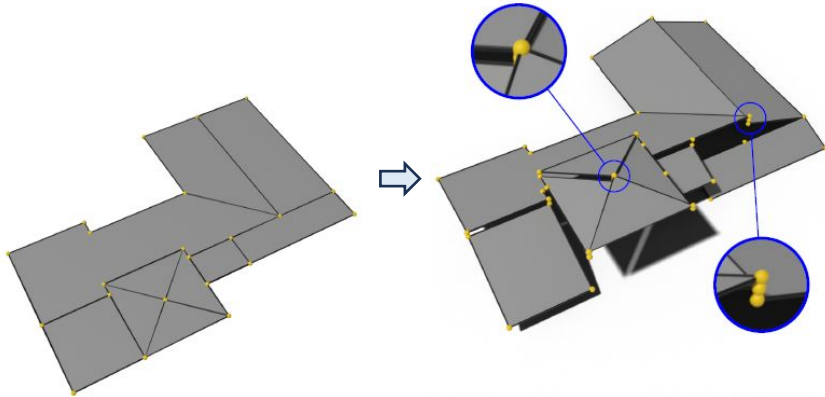


4) Extrusion



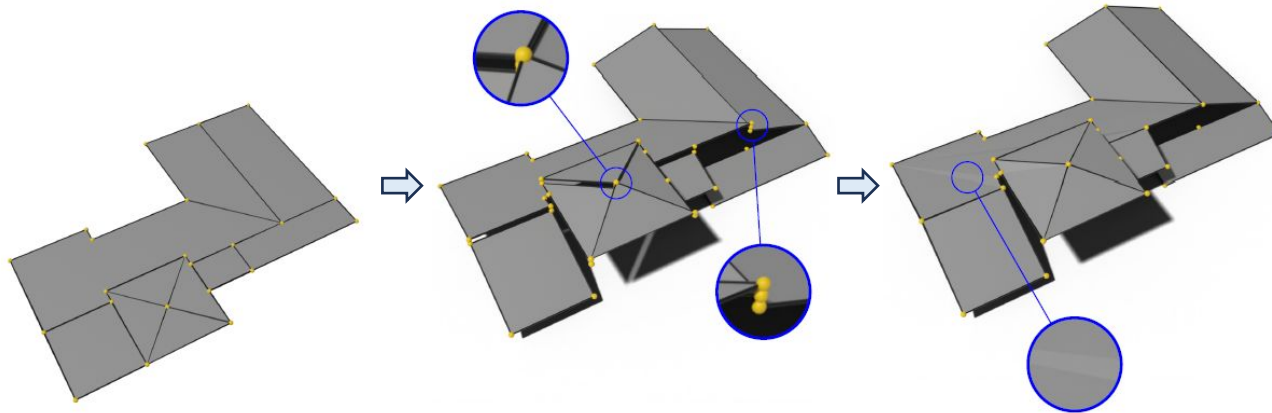
4) Extrusion

- Construction of 3D vertices for each roof section



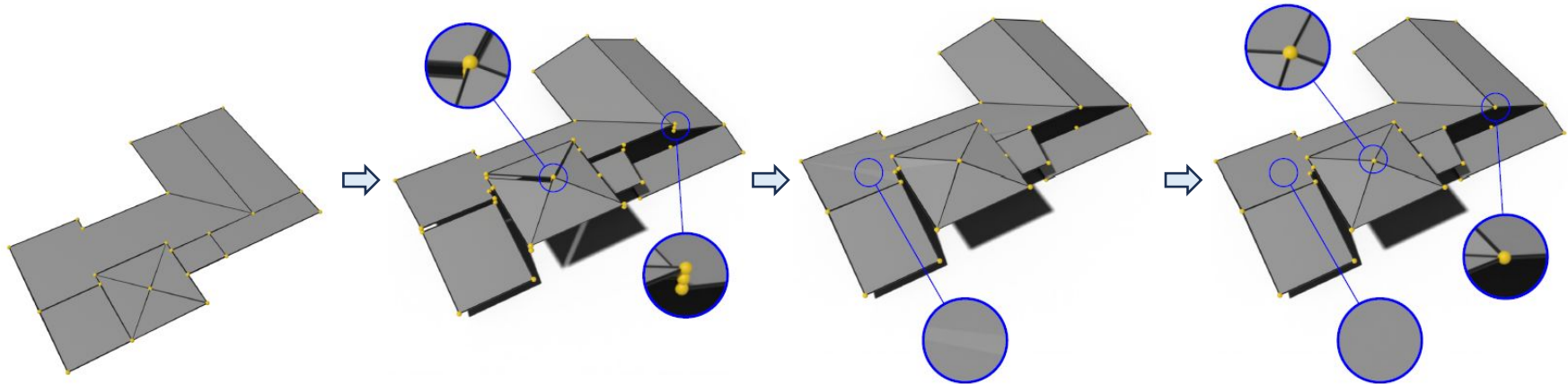
4) Extrusion

- Vertex simplification along the vertical axis



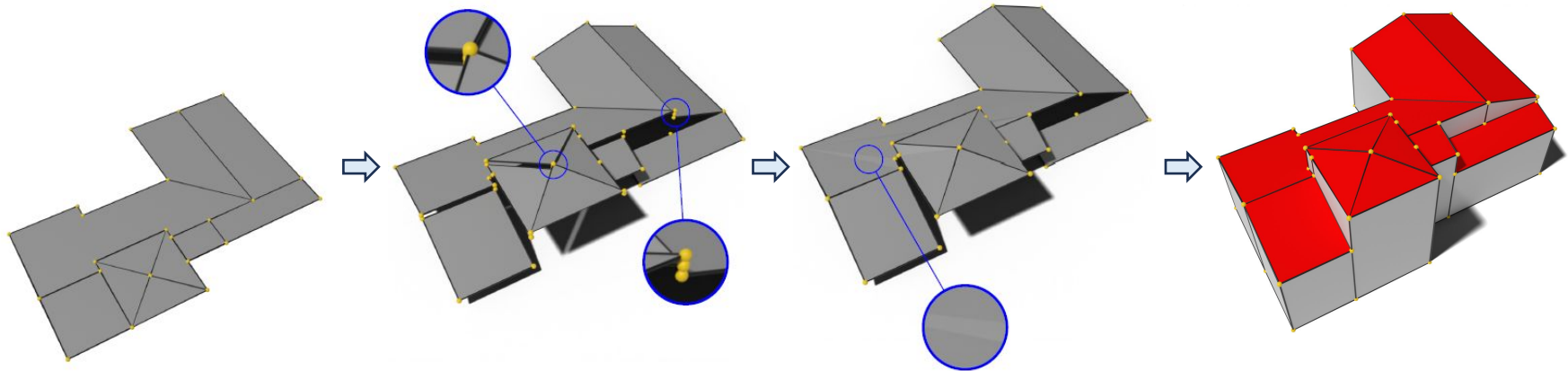
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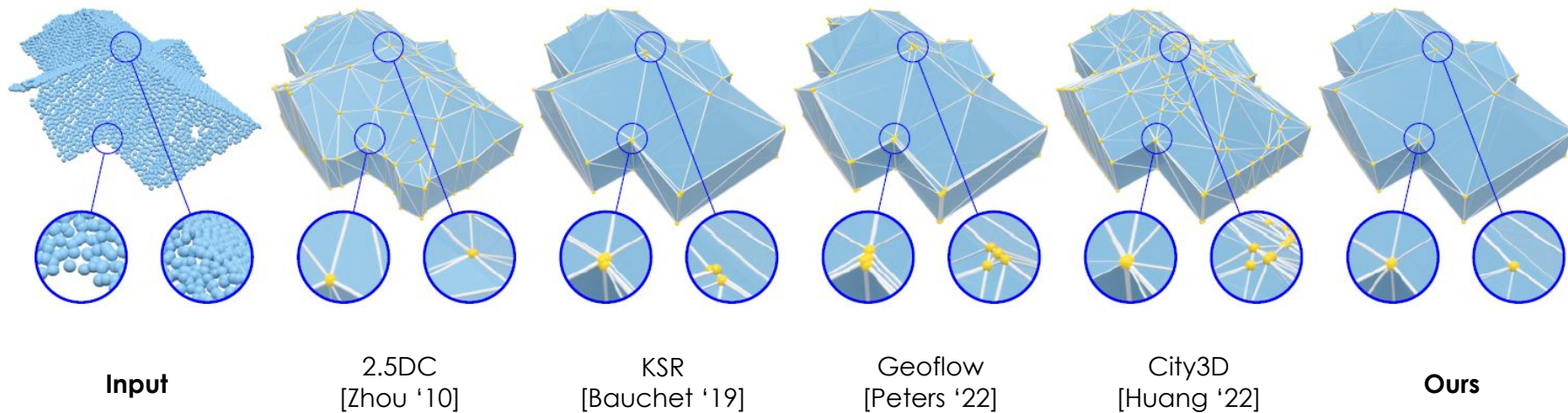
- z-coordinates of the vertices are adjusted by global optimization
 - ✓ Planarity constraints ensure valid geometric models

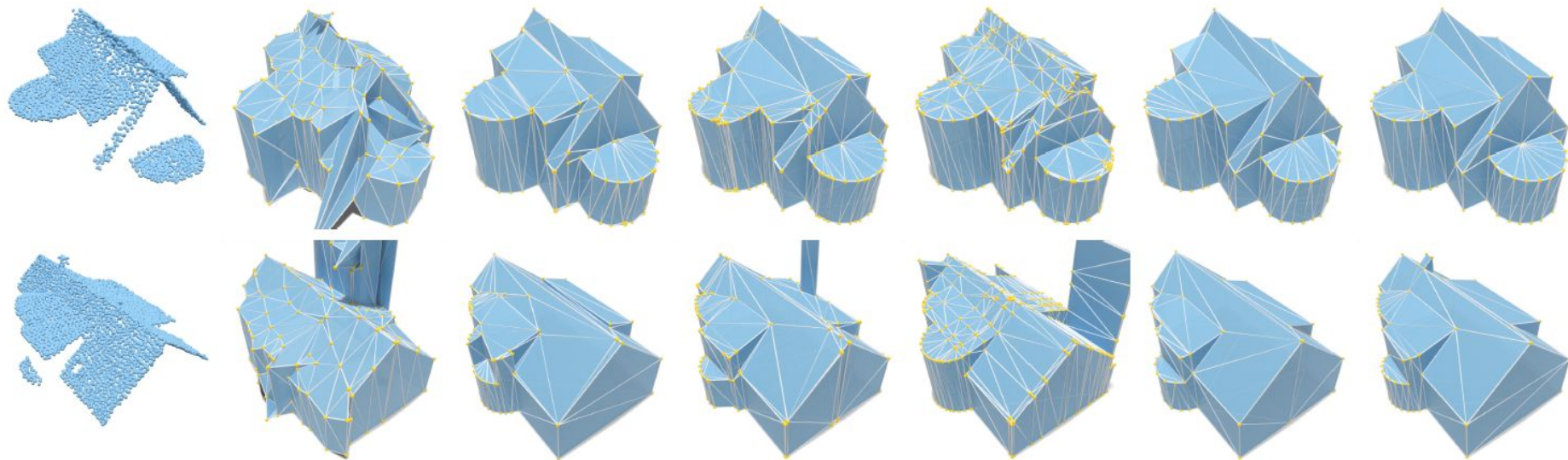


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Input

2.5DC
[Zhou '10]

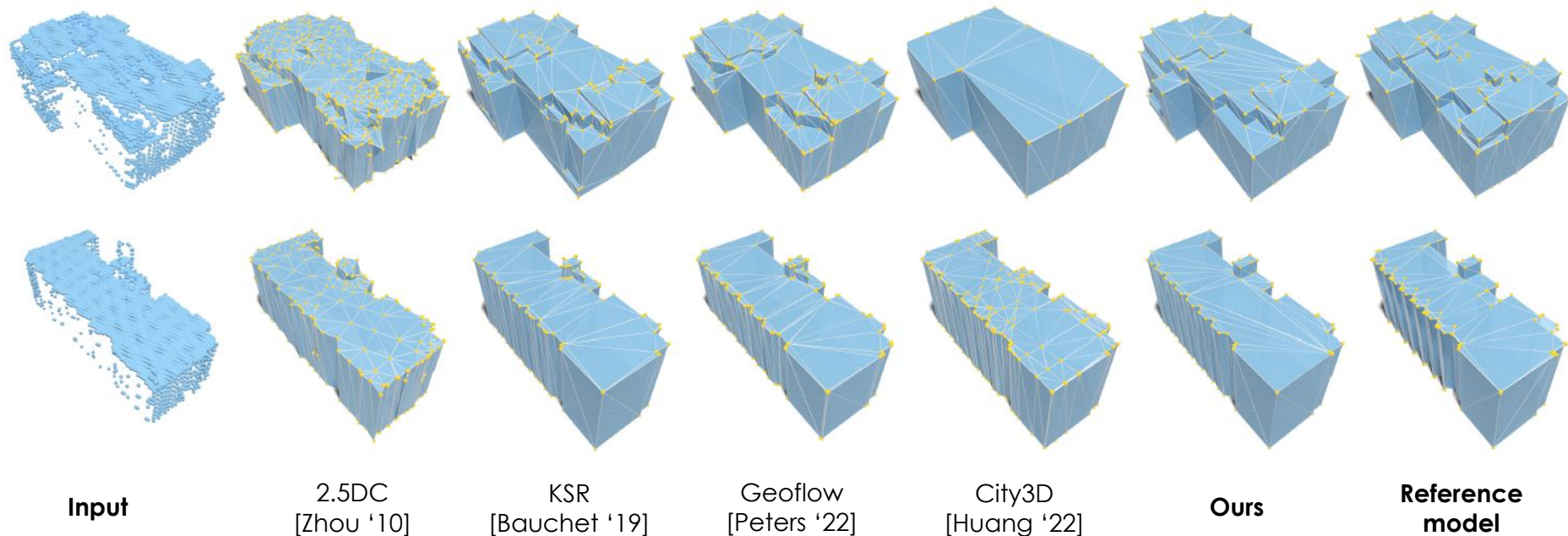
KSR
[Bauchet '19]

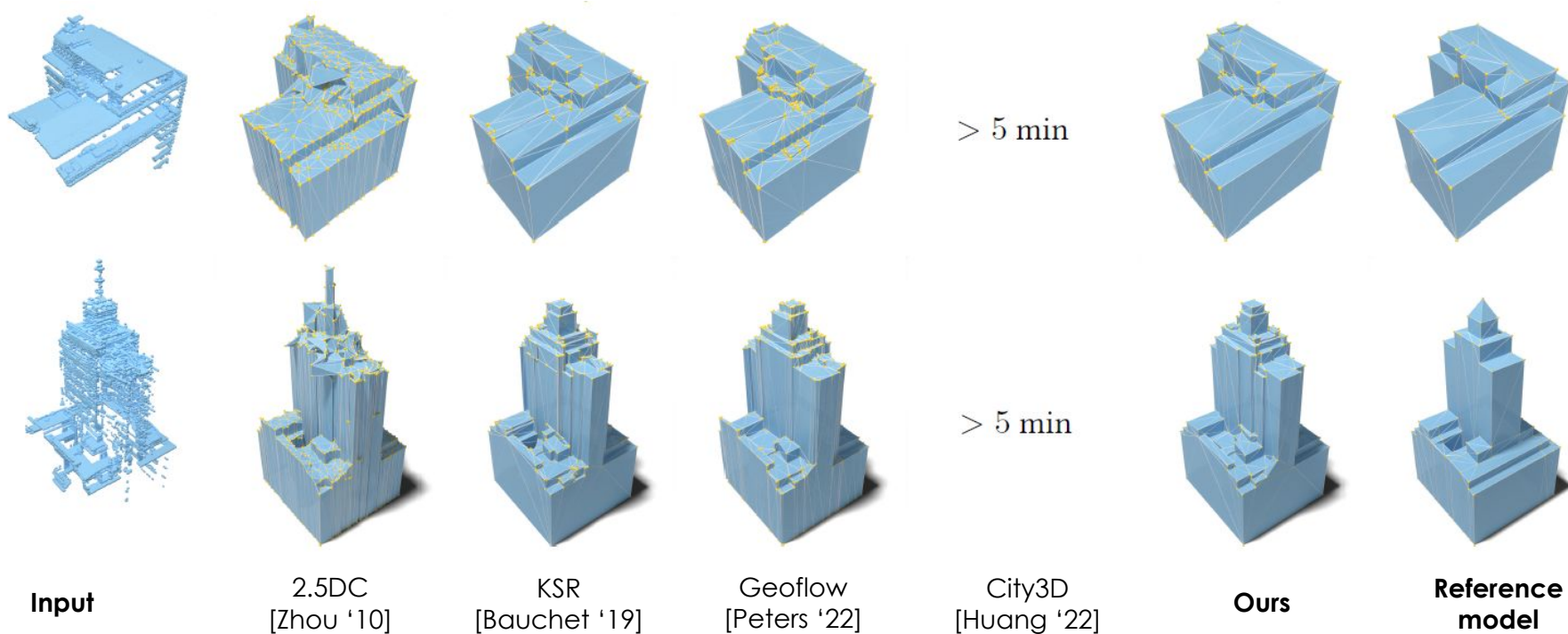
Geoflow
[Peters '22]

City3D
[Huang '22]

Ours

**Reference
model**





- Our pipeline achieves similar accuracy and performance compared with state-of-the-art techniques, while delivering more compact meshes

		Complexity			Accuracy		Perform.
		$ V $	$ F $	$E_{<0.5\text{ m}}$ [%]	$CD_{\text{Imp} \rightarrow \text{Rec}}$ [cm]	$CD_{\text{Rec} \rightarrow \text{Ref}}$ [cm]	Time [s]
Tallinn	Reference [63]	84.6	47.5	1.28	6.68	-	-
	2.5DC [74]	112	187	2.86	11.9	81.9	0.13
	KSR	67.8	71.4	8.35	8.07	15.9	10.4
	Geoflow [51]	180	172	28.0	7.18	36.4	4.03
	City3D [†] [22]	116	199	25.0	9.39	7.24	49.1
	Ours	32.2	58.2	4.39	9.34	13.2	4.19
Zurich	Reference [48]	54.6	77.2	4.48	58.3	-	-
	2.5DC [74]	140	241	2.57	16.4	50.6	0.052
	KSR [5]	116	139	8.72	22.0	33.2	6.52
	Geoflow [51]	227	220	27.0	28.1	50.0	1.59
	City3D [†] [22]	112	193	28.3	30.6	20.0	42.3
	Ours	58.3	109	7.48	26.6	26.0	3.82
Helsinki	Reference [46]	203	236	8.97	66.2	-	-
	2.5DC [74]	570	1045	2.67	22.6	69.9	1.15
	KSR [5]	619	704	14.5	39.8	39.2	67.9
	Geoflow [51]	900	883	23.1	34.2	54.7	6.12
	Ours	214	393	9.5	32.3	37.1	6.81

- Future works include:
 - ✓ Extension to more complex models (CityGML LOD3)
 - ✓ Building segmentation or contouring problems
 - ✓ Retrieval of more complex geometric relationships (e.g. symmetries)
 - ✓ Release of our pipeline as a Web service

