Thesis Defense

Sérénic Monté

27-06-2024

TU Delft

Creating a methodology to more objectively measure the performance of reconstruction algorithms for large urban objects generated from low detailed complete ground truth models

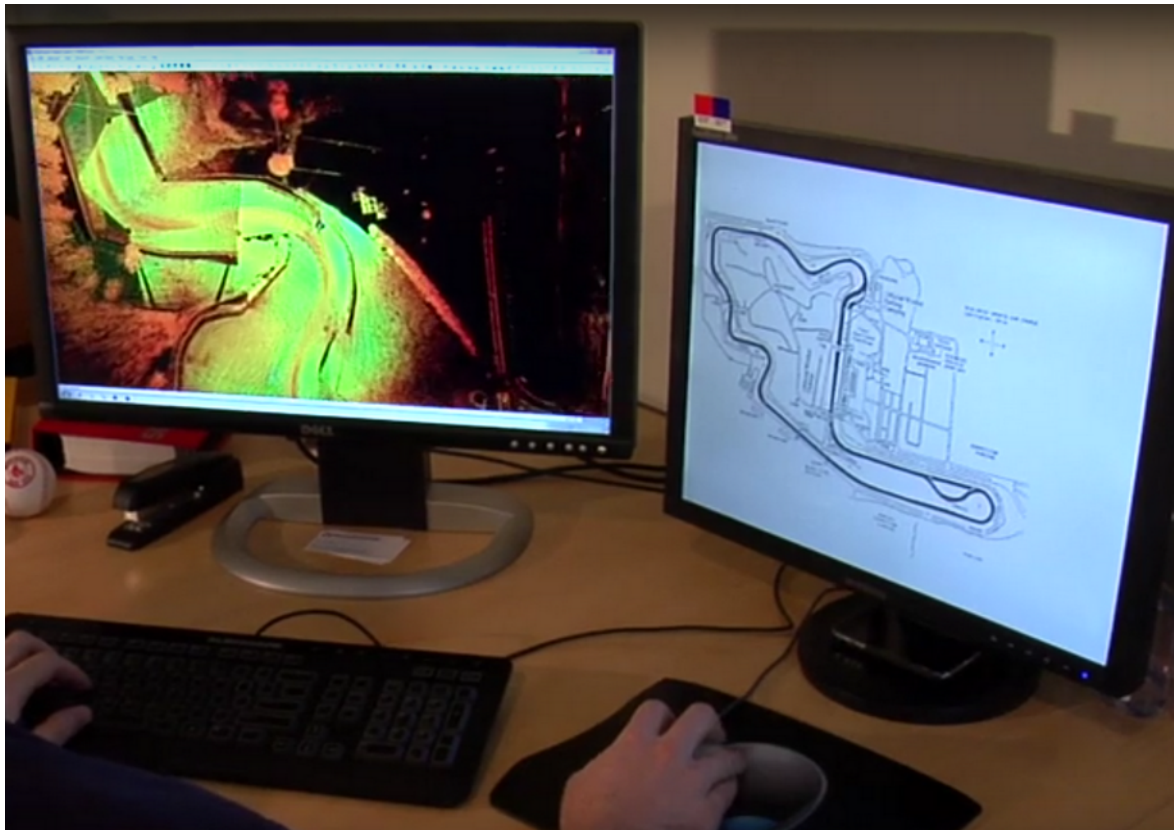
Why are reconstruction algortihms usefull?

[3]

Why are reconstruction algortihms usefull?

[6]

[6]

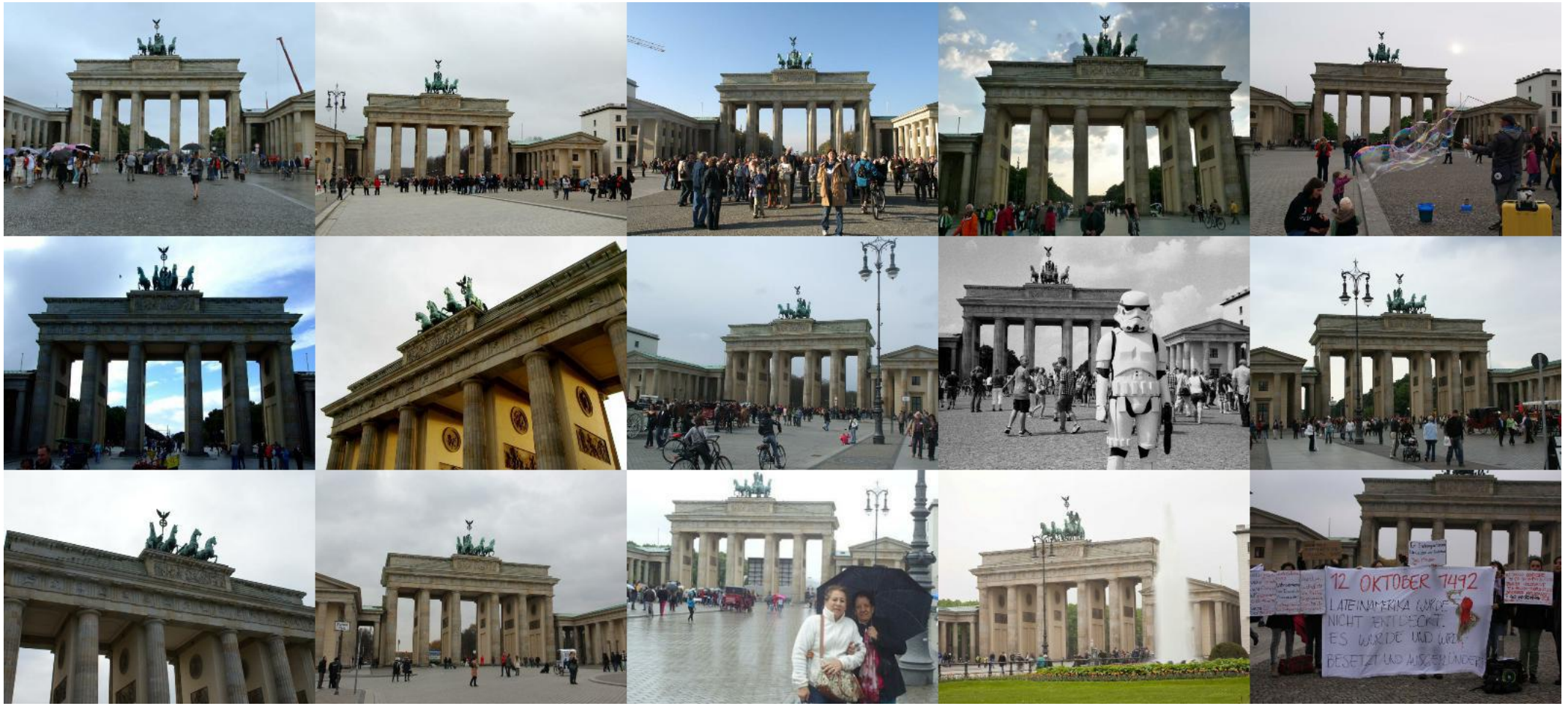


How to get a model

- Using pictures or video
- Scanning
- Modeling in the computer

Photos and videos

[8]



Photos and videos

[8]

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Pros and Cons

- Is cheap to make
- Is easy to make

- Low quality models

Scanning

[5]

Scanning

[6]

Scanning

Scanning

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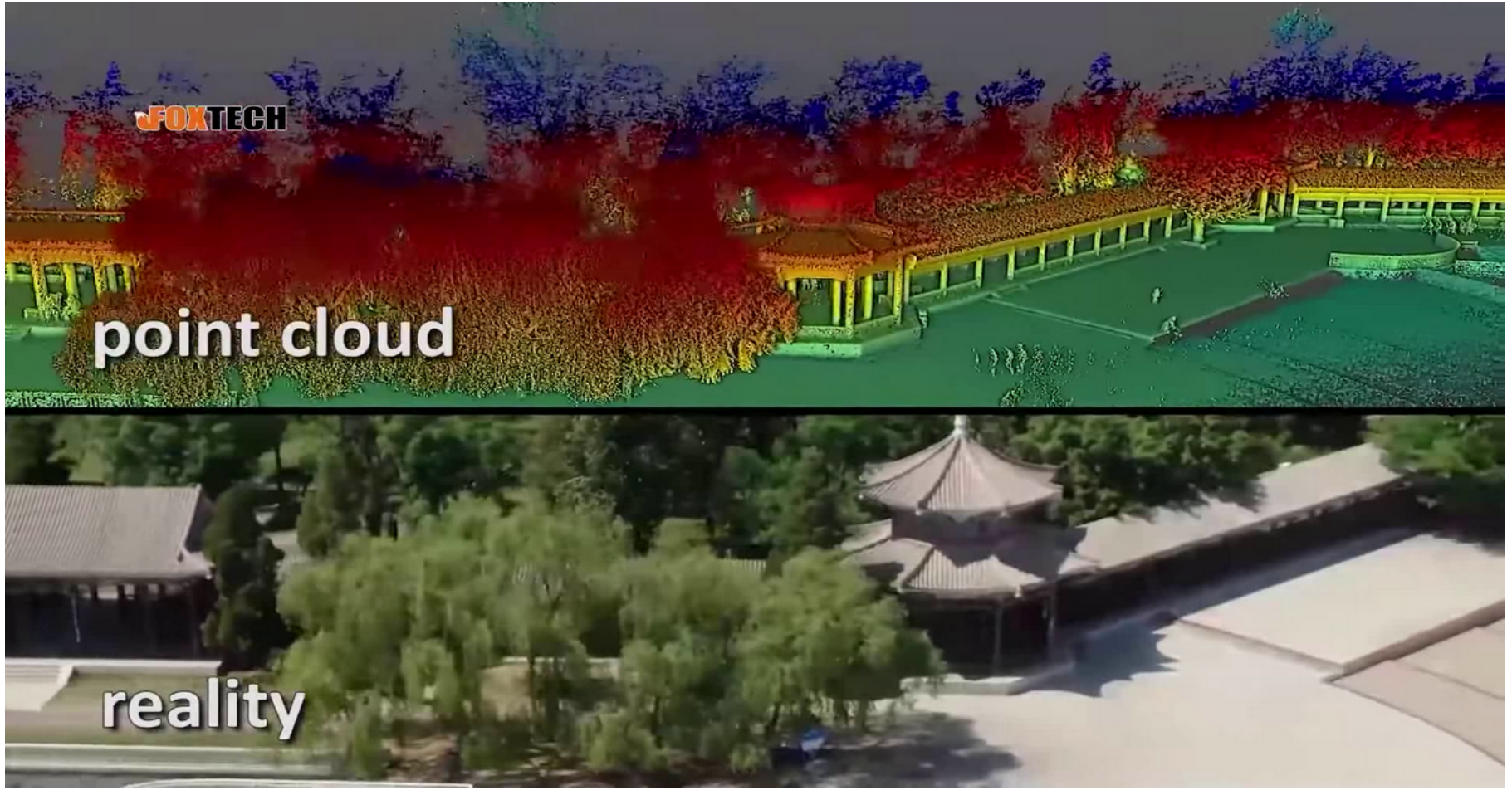
Scanning

[2]



Pros and Cons

- Very detailed
- Good for small objects and objects that have no obstruction and can be seen from the scanner

- Takes lots of time
- Expensive
- Obstructions
- Missing elements

Modeling by hand

[7]

Pros and Cons

- Details take lots of time
- Simple structures can be made quickly and are complete

Creating a methodology to more objectively measure the performance of reconstruction algorithms for large urban objects generated from low detailed complete ground truth models

Reconstruction algorithms

Reconstruction algorithms

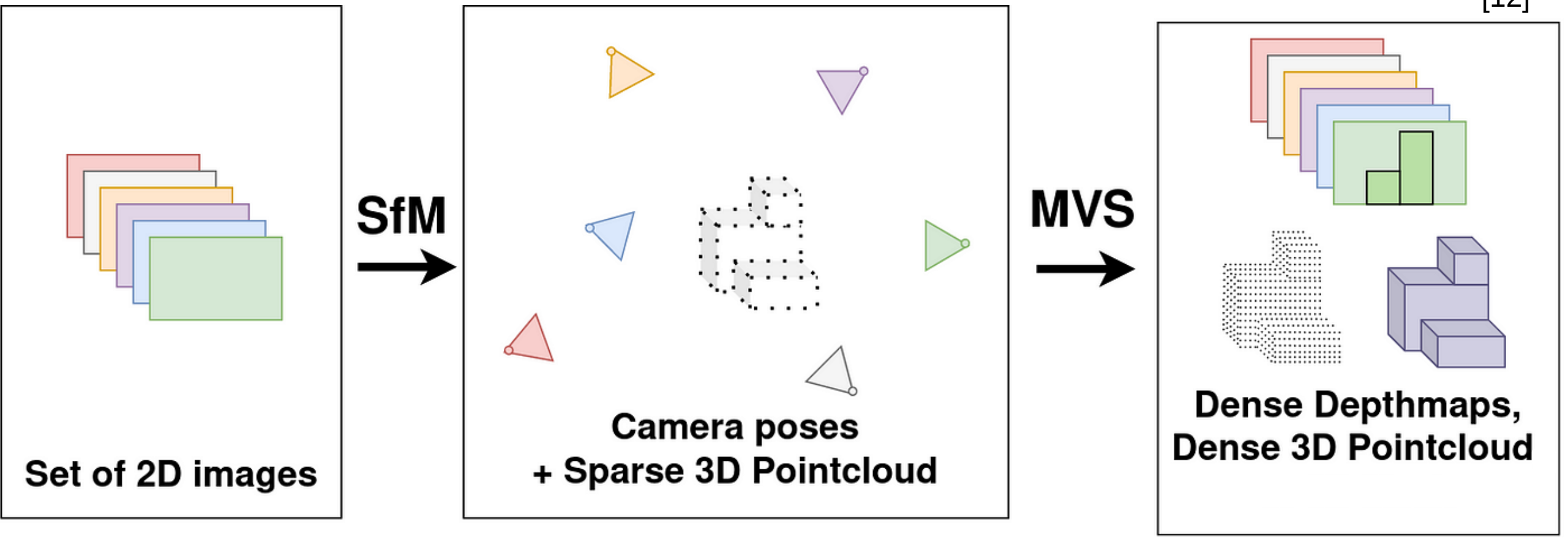
Multi-View Stereo	Novel View Synthesis	Neural Surface Reconstruction

Reconstruction algorithms

Multi-View Stereo	Novel View Synthesis	Neural Surface Reconstruction
COLMAP	Nerfacto	Neus-Facto
PatchmatchNet	Gaussian splatting	VolSDF

Multi view stereo

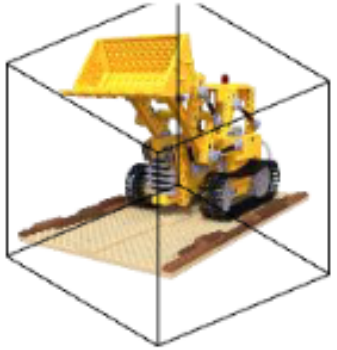
[12]



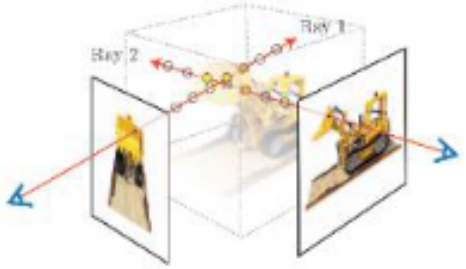
NVS NeRF

[1]

Radiance Field



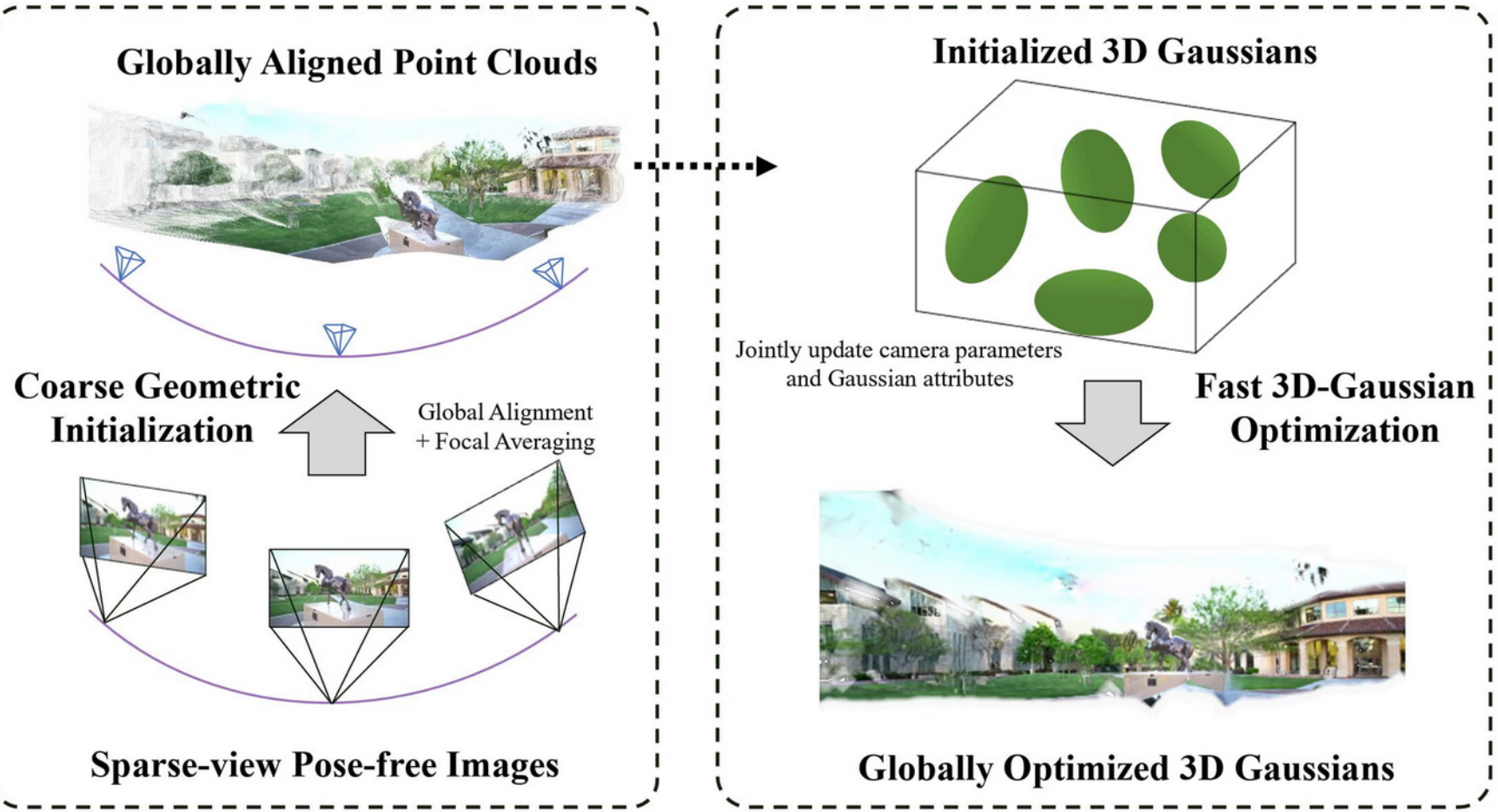
Volume Rendering



RGB Image

NVS Gausian splatting

[11]



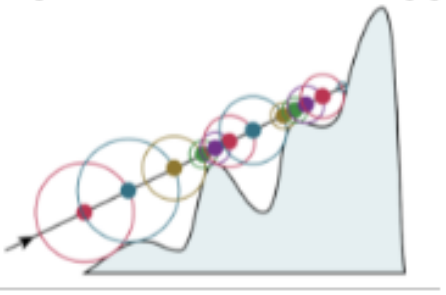
[10]

NSR

[1]

Signed Distance Field

Sphere Tracing



Depth

Normal

Reconstruction algorithms

	Multi-View Stereo	Novel View Synthesis	Neural Surface Reconstruction
input	Images	Images	Images
output	Point cloud	Images	Mesh

Creating a methodology to more objectively measure the performance of reconstruction algorithms for large urban objects generated from low detailed complete ground truth models

How to measure performance

How to measure performance

	Pictures	Model
MVS		X
NVS	X	
NSR		X

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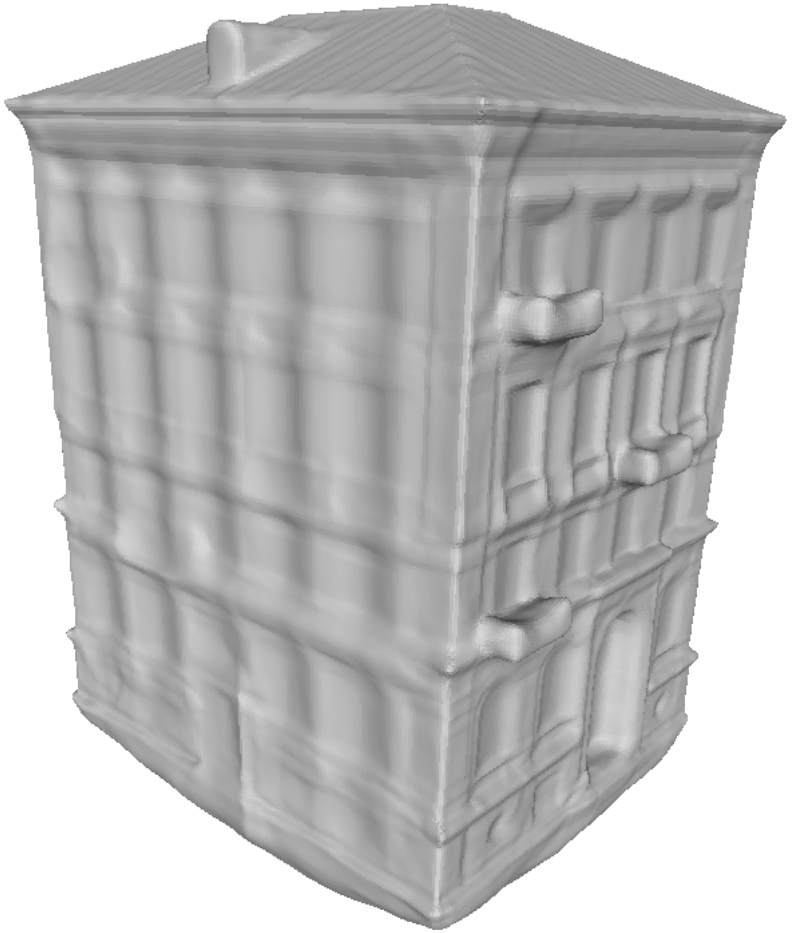
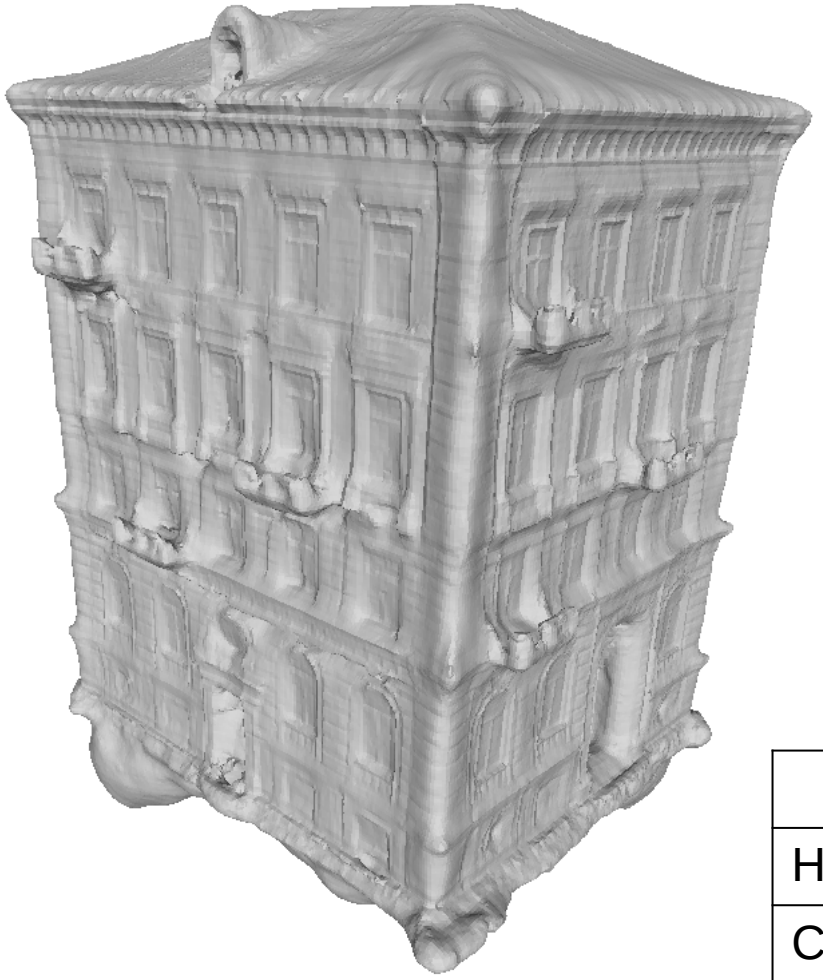
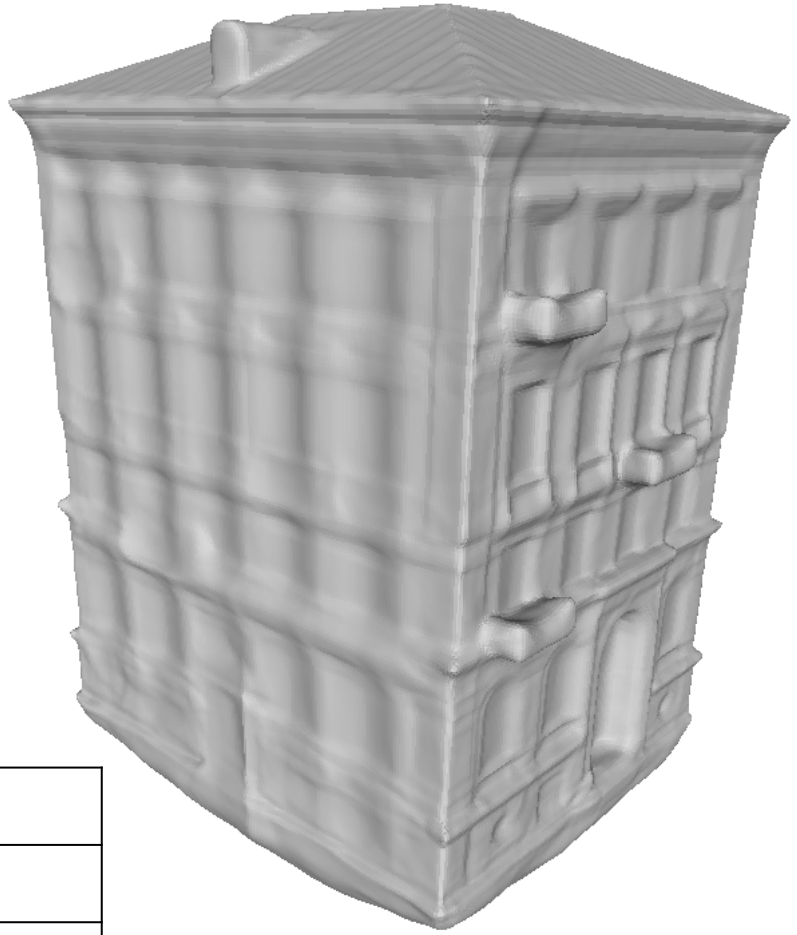
Large urban objects

How to measure performance



How to measure performance



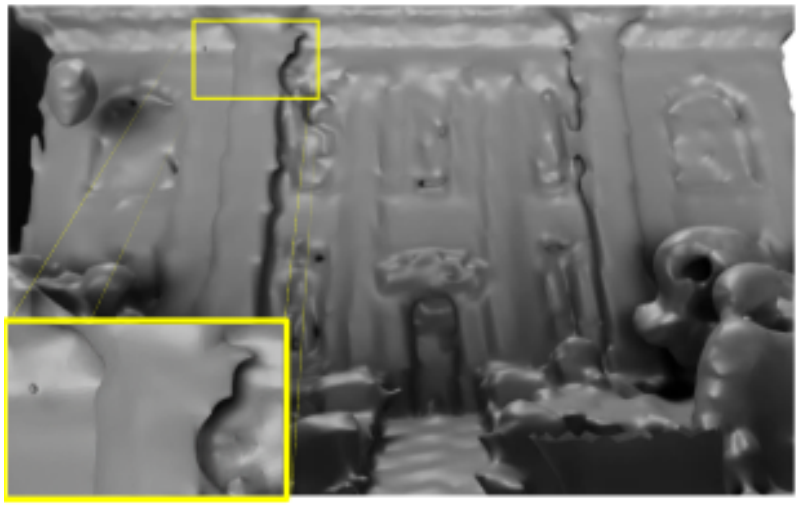


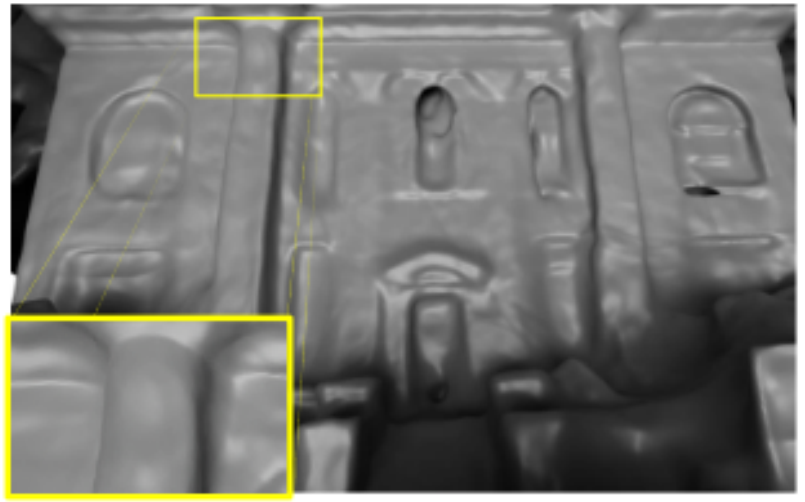
	Left	Right
Hausdorff	6.188	**5.677**
Chamfer	0.553	**0.437**
F-Score	**0.484**	0.439

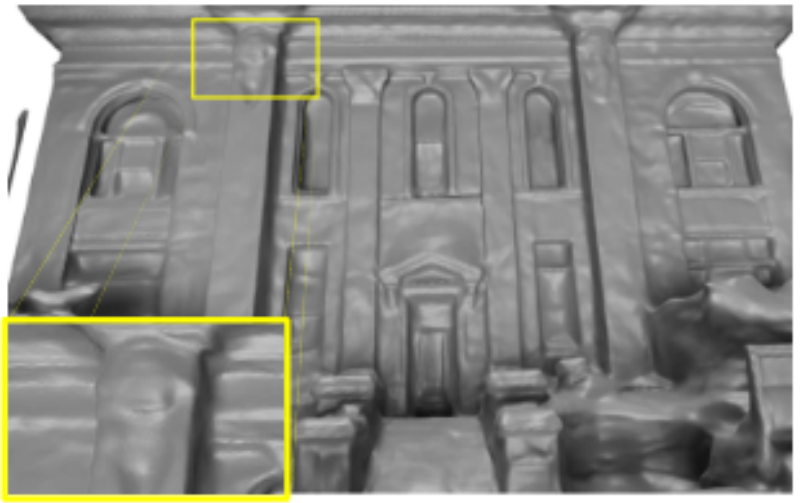
How to measure performance

[4]

Courthouse



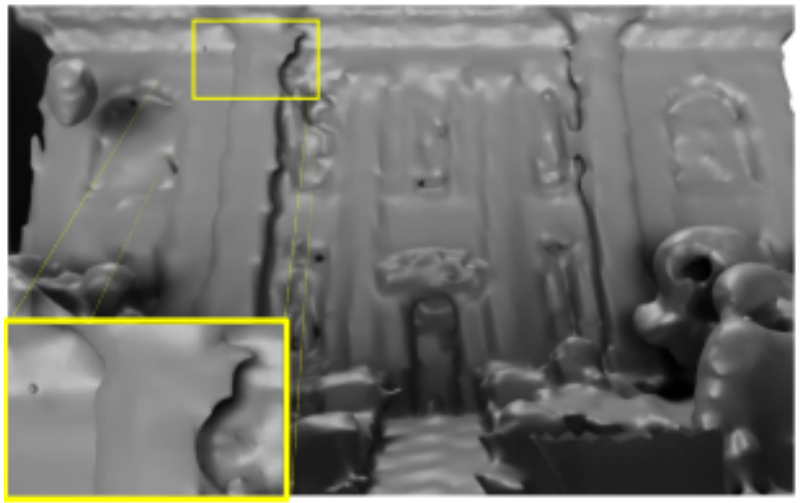


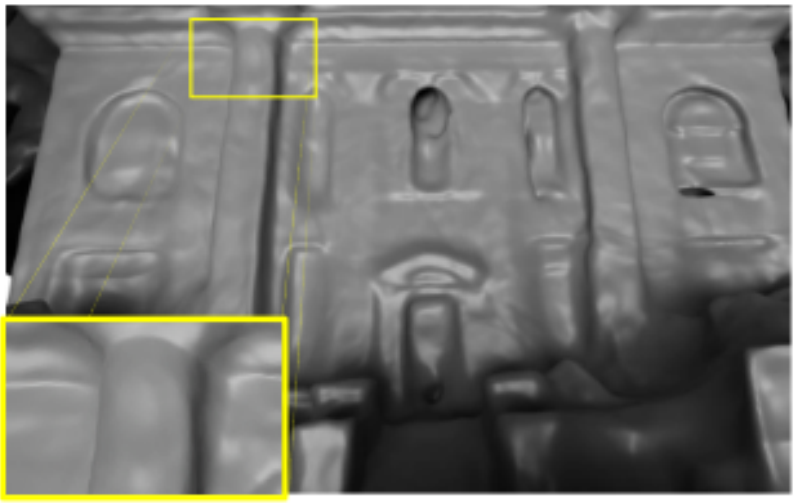


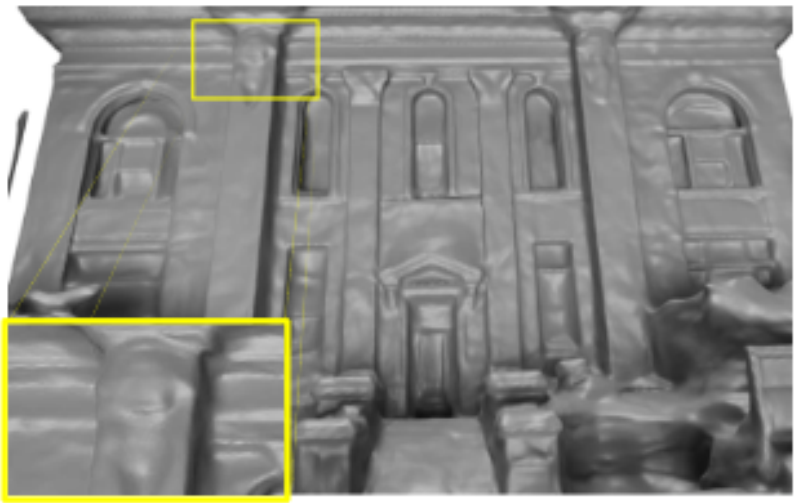
Can we develop a methodology that allows us to evaluate the quality of reconstruction algorithms, for architectural purposes, without the use of a highly detailed complete ground truth model?

[4]

Courthouse







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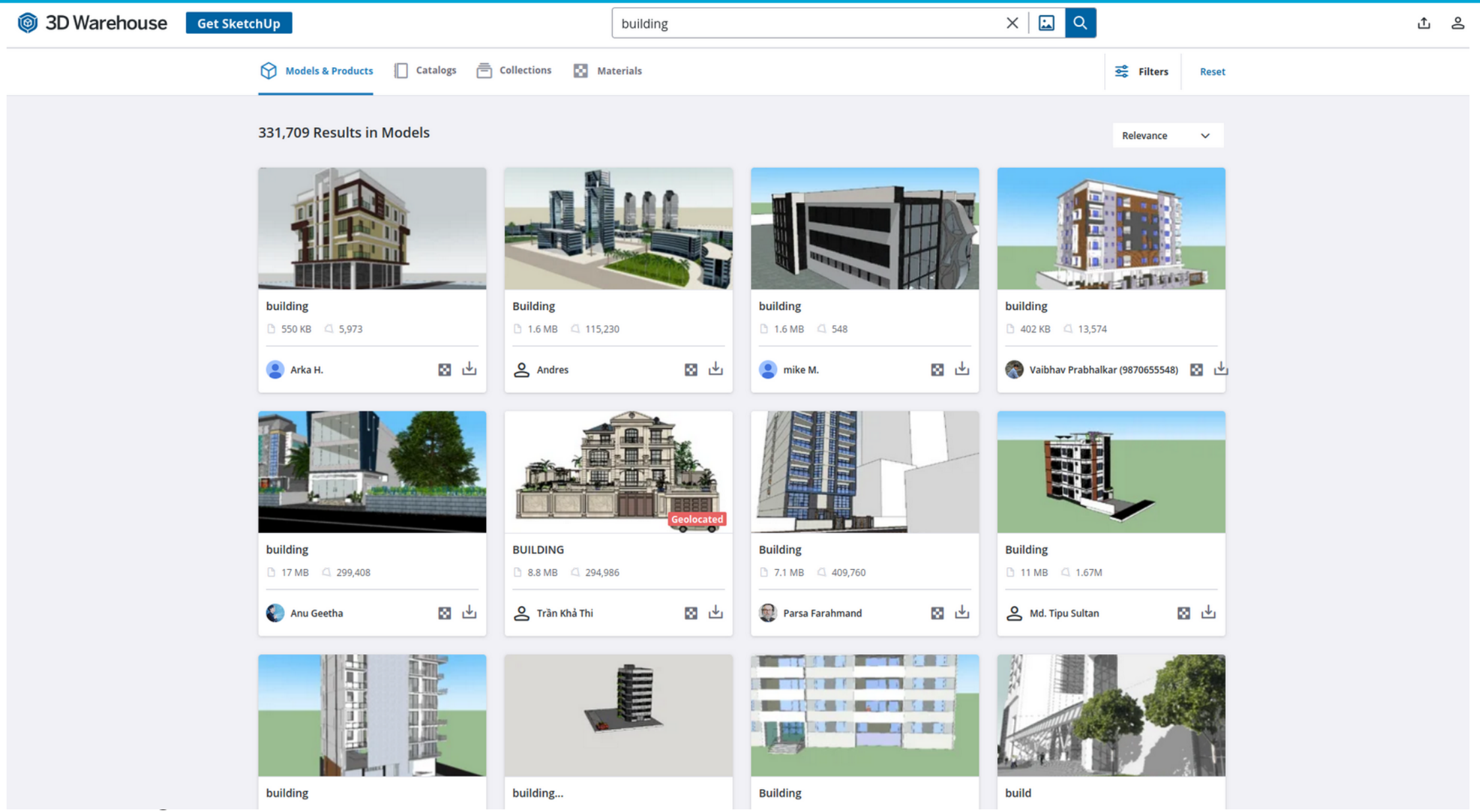
How to get complete ground truth models?



[9]

Research question

Main: Can we develop a methodology that allows us to evaluate the quality of reconstruction algorithms, for architectural purposes, without the use of a highly detailed complete ground truth model?

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1. Are the reconstruction algorithms able to reconstruct a scene from a low resolution model of a large urban object.

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Main: Can we develop a methodology that allows us to evaluate the quality of reconstruction algorithms, for architectural purposes, without the use of a highly detailed complete ground truth model?

1. Are the reconstruction algorithms able to reconstruct a scene from a low resolution model of a large urban object.
2. What are the features that we can extract from a low resolution model, that can be used to test the quality of the generated meshes.

Research question

Main: Can we develop a methodology that allows us to evaluate the quality of reconstruction algorithms, for architectural purposes, without the use of a highly detailed complete ground truth model?

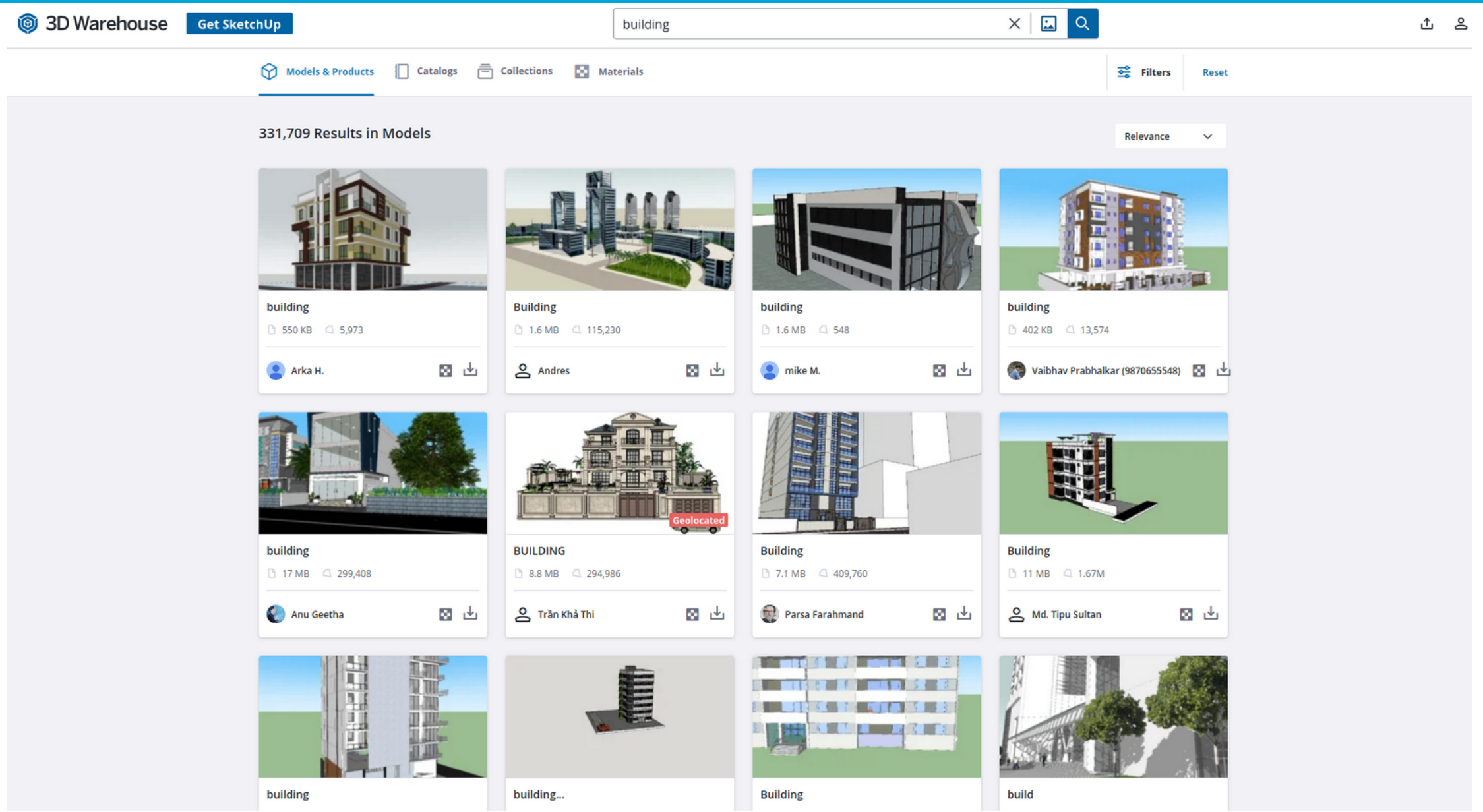
1. Are the reconstruction algorithms able to reconstruct a scene from a low resolution model of a large urban object.
2. What are the features that we can extract from a low resolution model, that can be used to test the quality of the generated meshes.
3. Does the width of the region around the extracted feature influence the quality of the evaluation metrics.

Are the reconstruction algorithms able to reconstruct a scene from a low resolution model of a large urban object

Are the reconstruction algorithms able to reconstruct a scene from a low resolution model of a large urban object

1) Search for models
2) Create dataset from the models
3) Run algorithm

Are the reconstruction algorithms able to reconstruct a scene from a low resolution model of a large urban object



[9]

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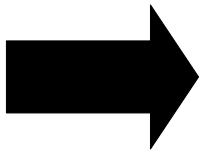
Are the reconstruction algorithms able to reconstruct a scene from a low resolution model of a large urban object

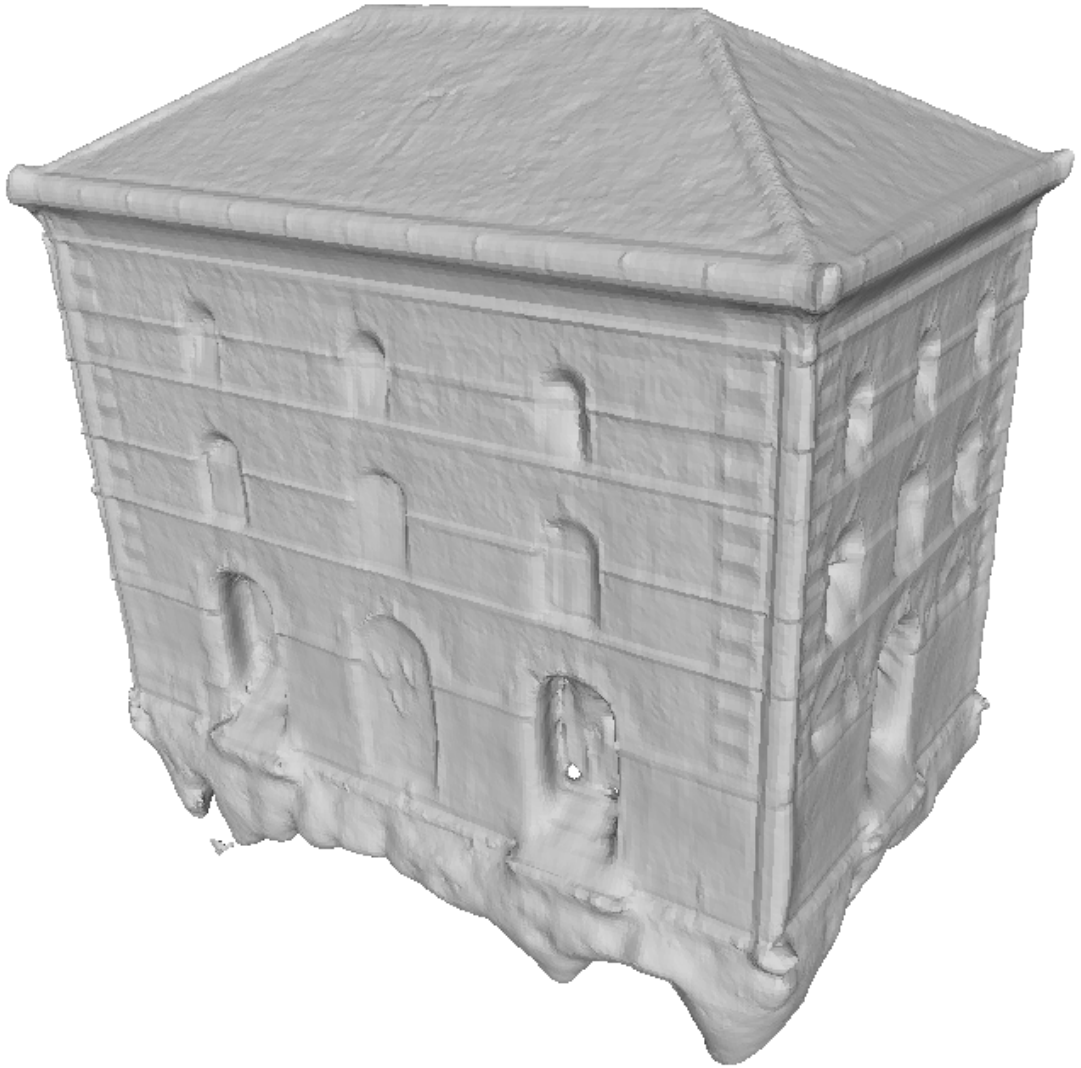
Are the reconstruction algorithms able to reconstruct a scene from a low resolution model of a large urban object

1) Search for models that after conversion have no or minor texture errors
2) Create dataset from the models
3) Run algorithm

Are the reconstruction algorithms able to reconstruct a scene from a low resolution model of a large urban object

Are the reconstruction algorithms able to reconstruct a scene from a low resolution model of a large urban object





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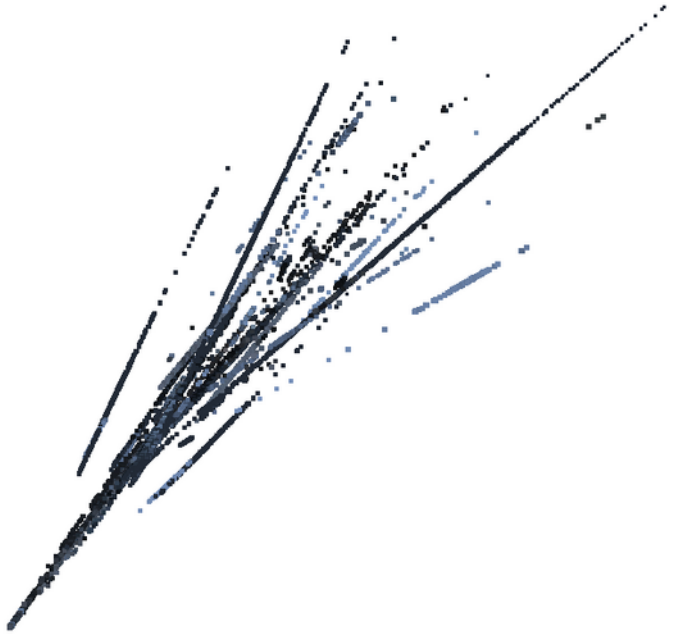
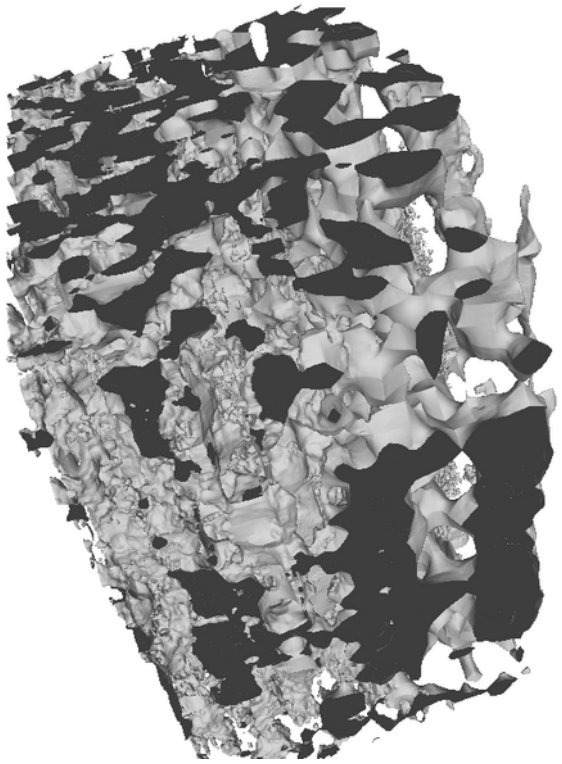
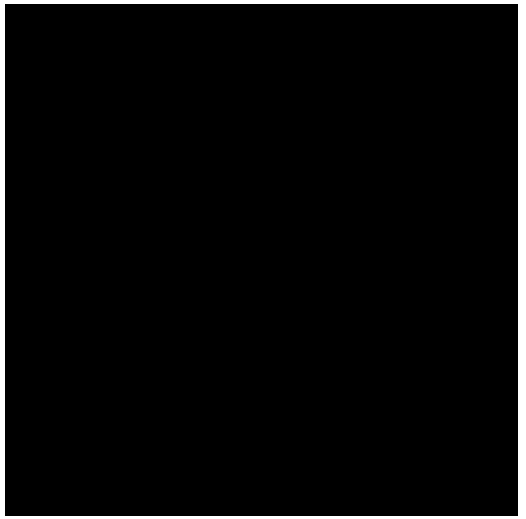
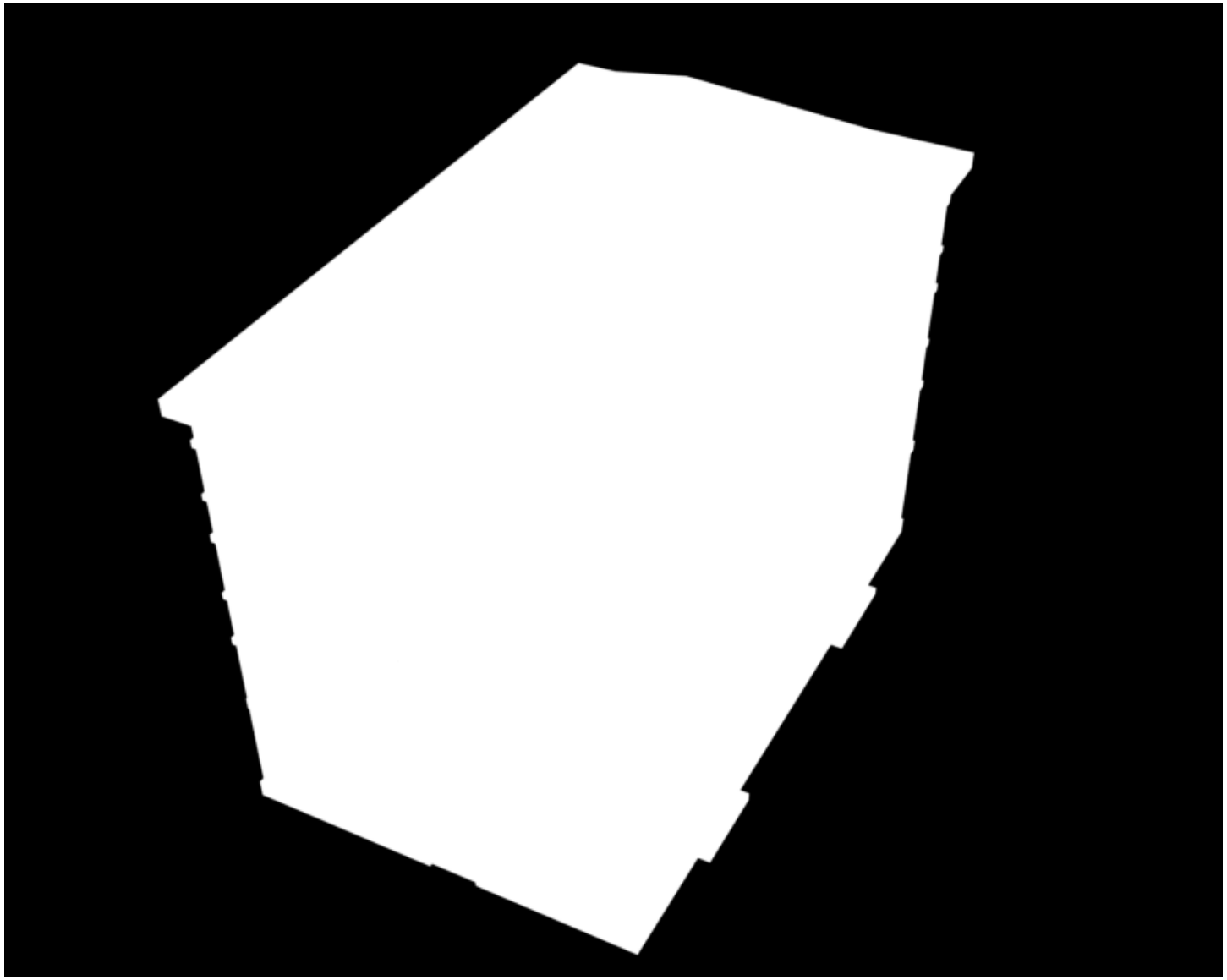






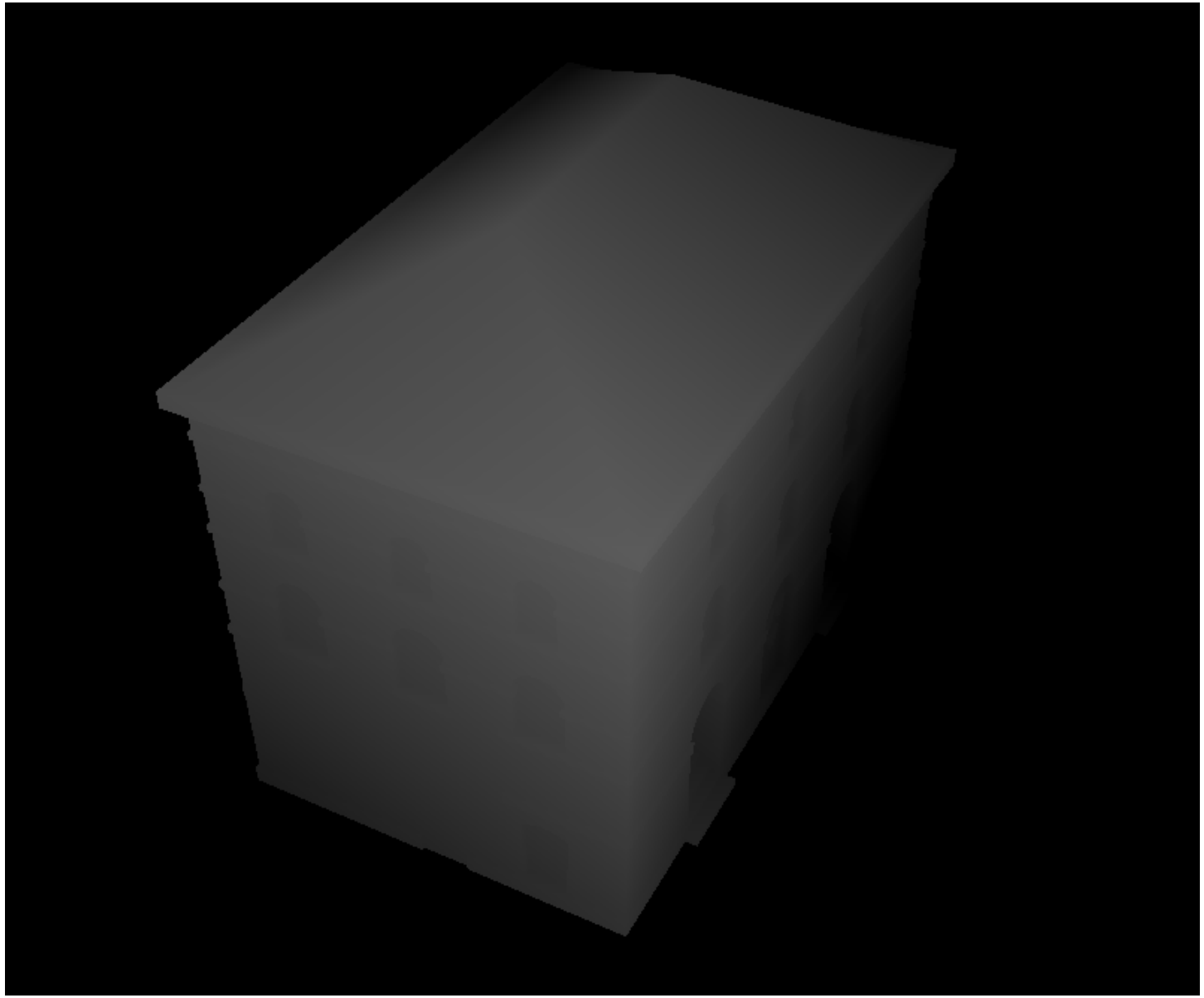
Are the reconstruction algorithms able to reconstruct a scene from a low resolution model of a large urban object

- Alpha masks



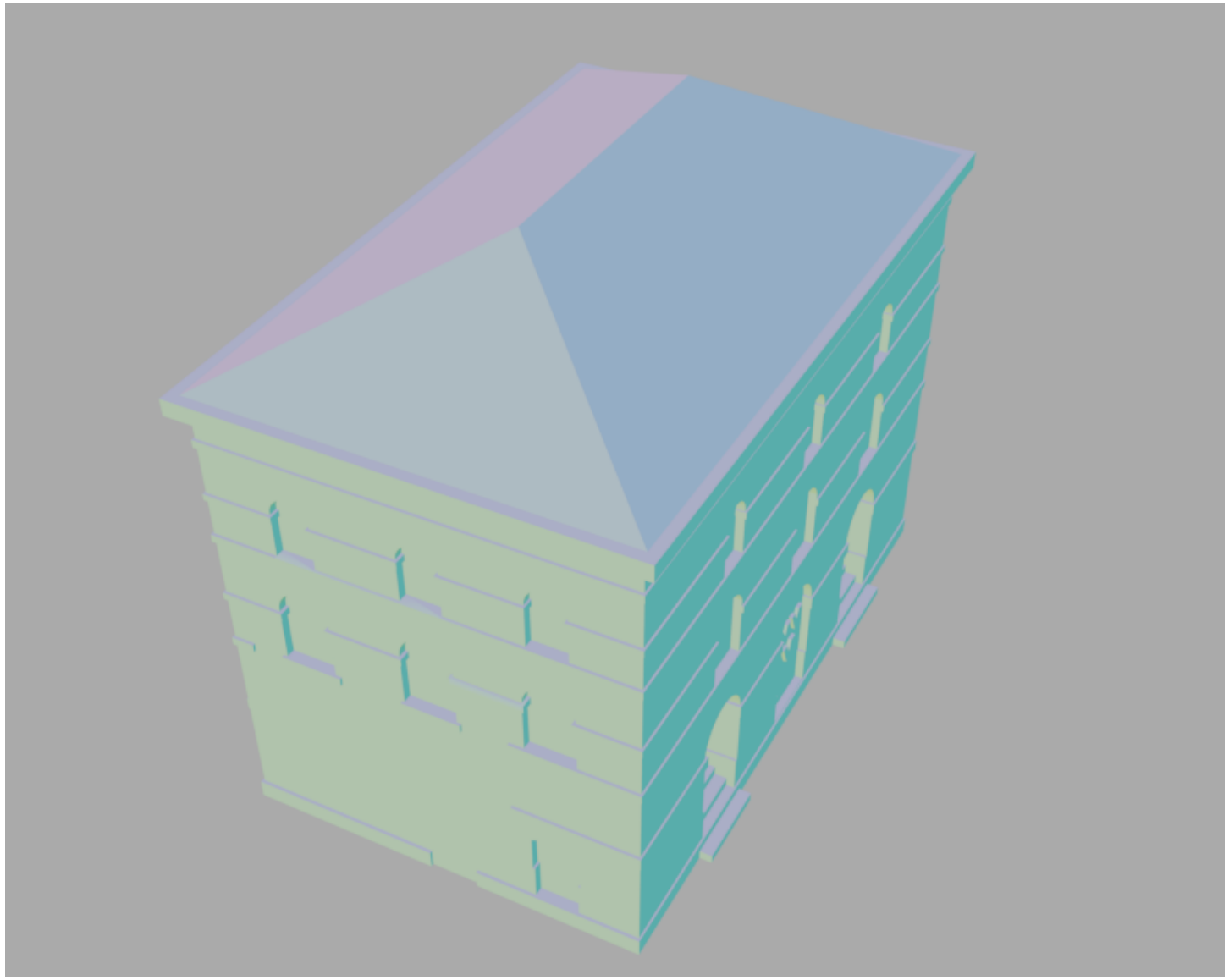
Are the reconstruction algorithms able to reconstruct a scene from a low resolution model of a large urban object

- Alpha masks
- Depth maps



Are the reconstruction algorithms able to reconstruct a scene from a low resolution model of a large urban object

- Alpha masks
- Depth maps
- Normal maps



Are the reconstruction algorithms able to reconstruct a scene from a low resolution model of a large urban object

- Alpha masks
- Depth maps
- Normal maps
- Number of images

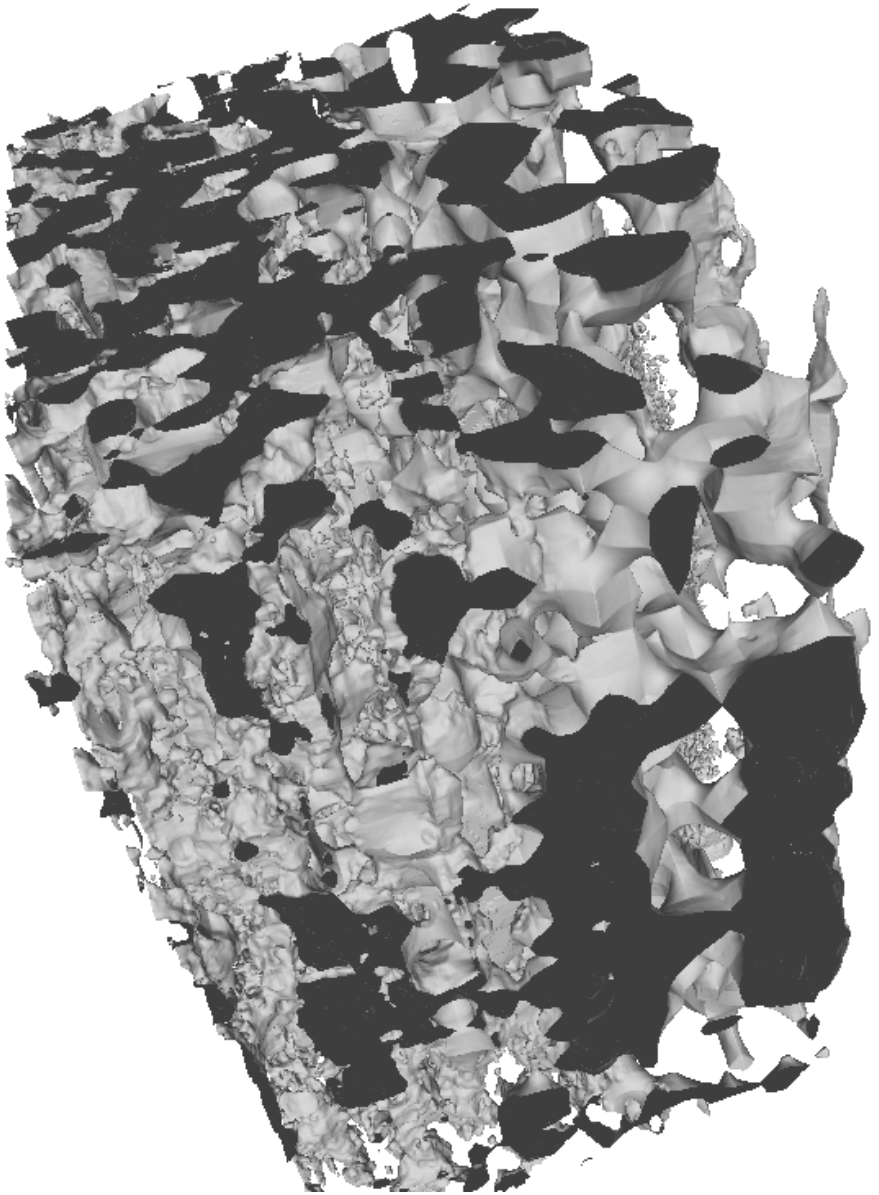
Are the reconstruction algorithms able to reconstruct a scene from a low resolution model of a large urban object

- Alpha masks
- Depth maps
- Normal maps
- Number of images
- Distance of camera to object

Are the reconstruction algorithms able to reconstruct a scene from a low resolution model of a large urban object

- Alpha masks
- Depth maps
- Normal maps
- Number of images
- Distance of camera to object
- Maximum vertical oscillation

Are the reconstruction algorithms able to reconstruct a scene from a low resolution model of a large urban object



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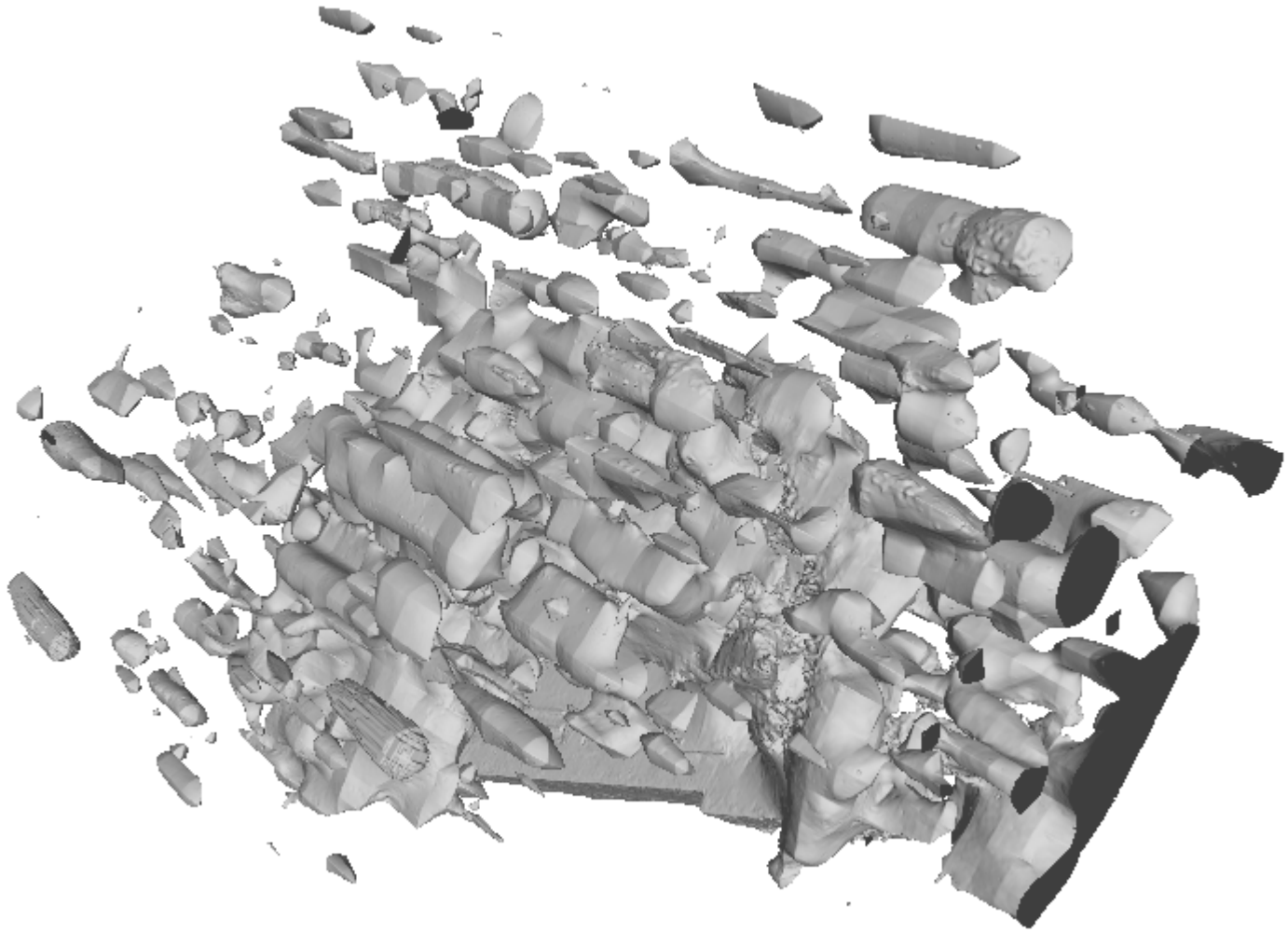


Are the reconstruction algorithms able to reconstruct a scene from a low resolution model of a large urban object

- Alpha masks
- Depth maps
- Normal maps
- Number of images
- Distance of camera to object
- Maximum vertical oscillation
- COLMAP poses

Are the reconstruction algorithms able to reconstruct a scene from a low resolution model of a large urban object

- Alpha masks
- Depth maps
- Normal maps
- Number of images
- Distance of camera to object
- Maximum vertical oscillation
- COLMAP poses
- Directional light

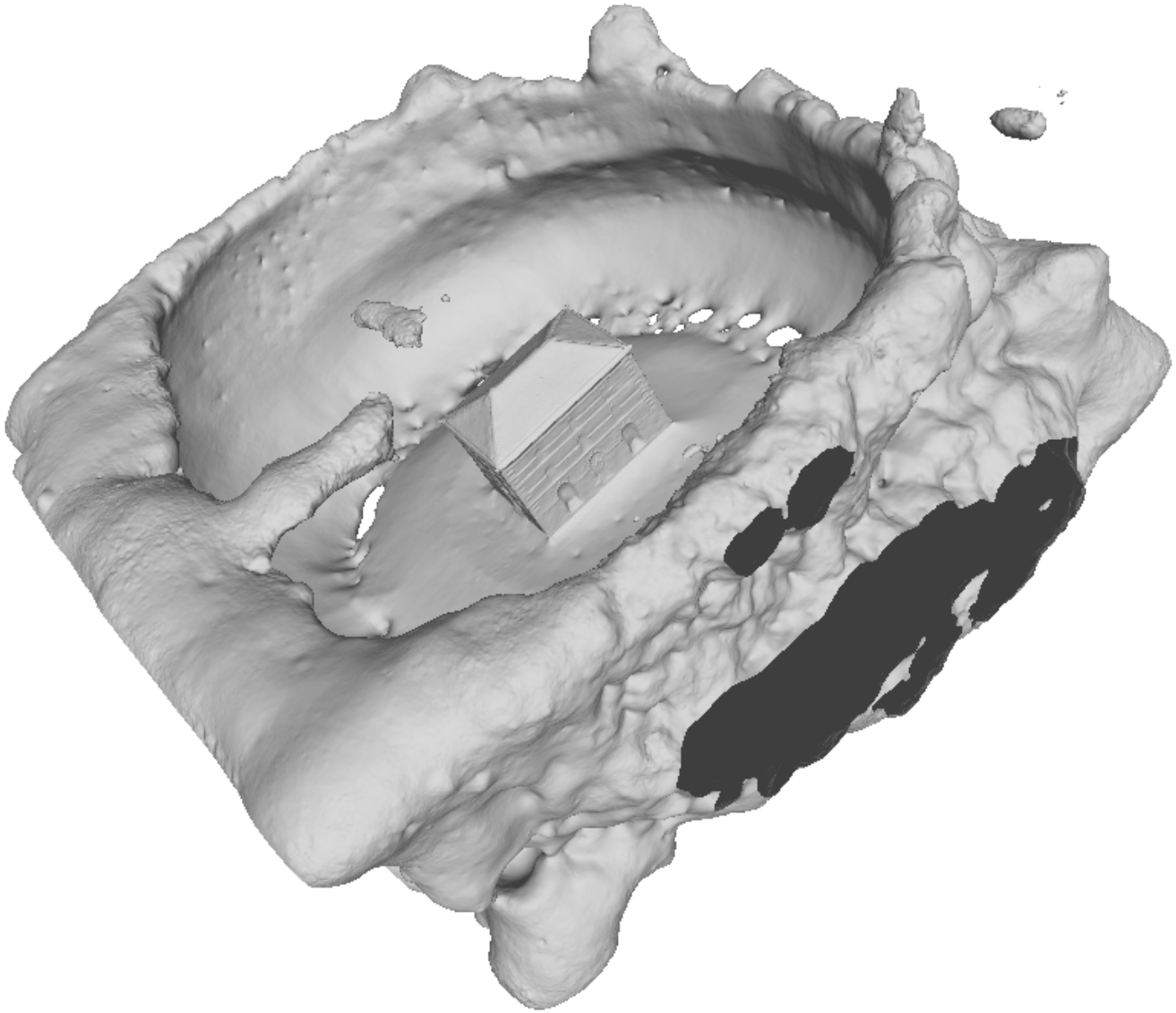
Are the reconstruction algorithms able to reconstruct a scene from a low resolution model of a large urban object

- Alpha masks
- Depth maps
- Normal maps
- Number of images
- Distance of camera to object
- Maximum vertical oscillation
- COLMAP poses
- Directional light
- Environment lighting

Are the reconstruction algorithms able to reconstruct a scene from a low resolution model of a large urban object

- Alpha masks
- Depth maps
- Normal maps
- Number of images
- Distance of camera to object
- Maximum vertical oscillation
- COLMAP poses
- Directional light
- Environment lighting
- Light intensity

Are the reconstruction algorithms able to reconstruct a scene from a low resolution model of a large urban object



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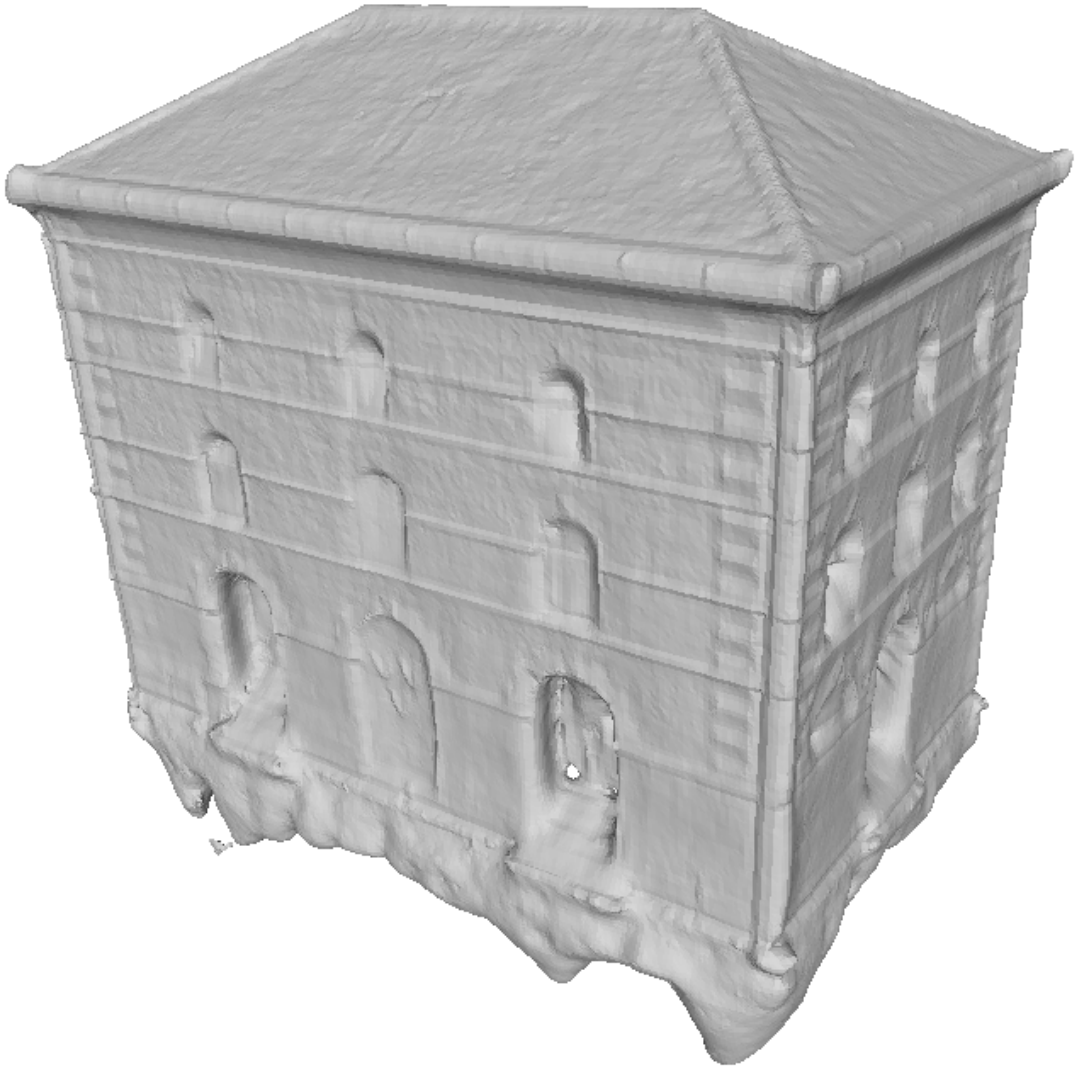

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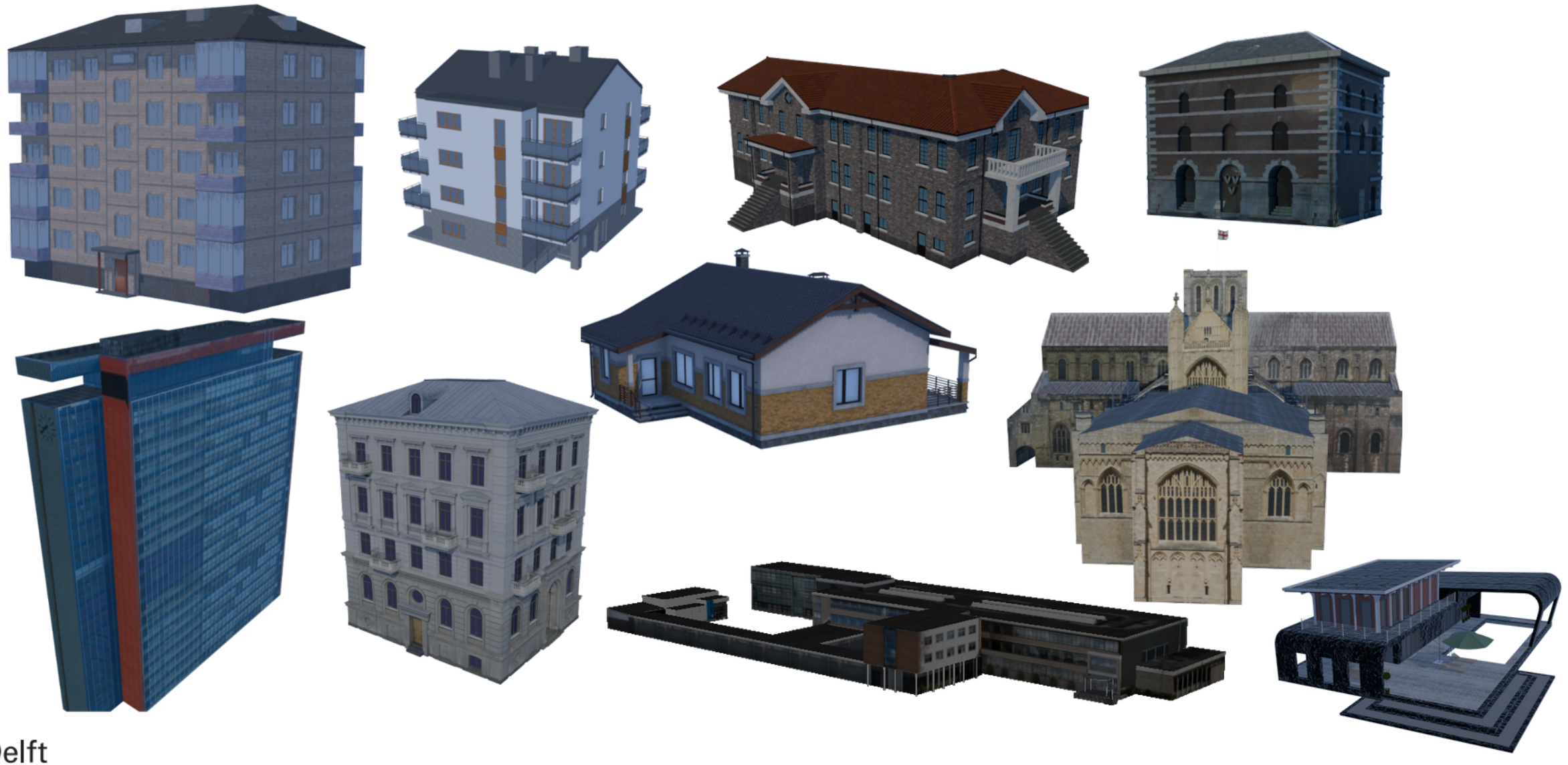

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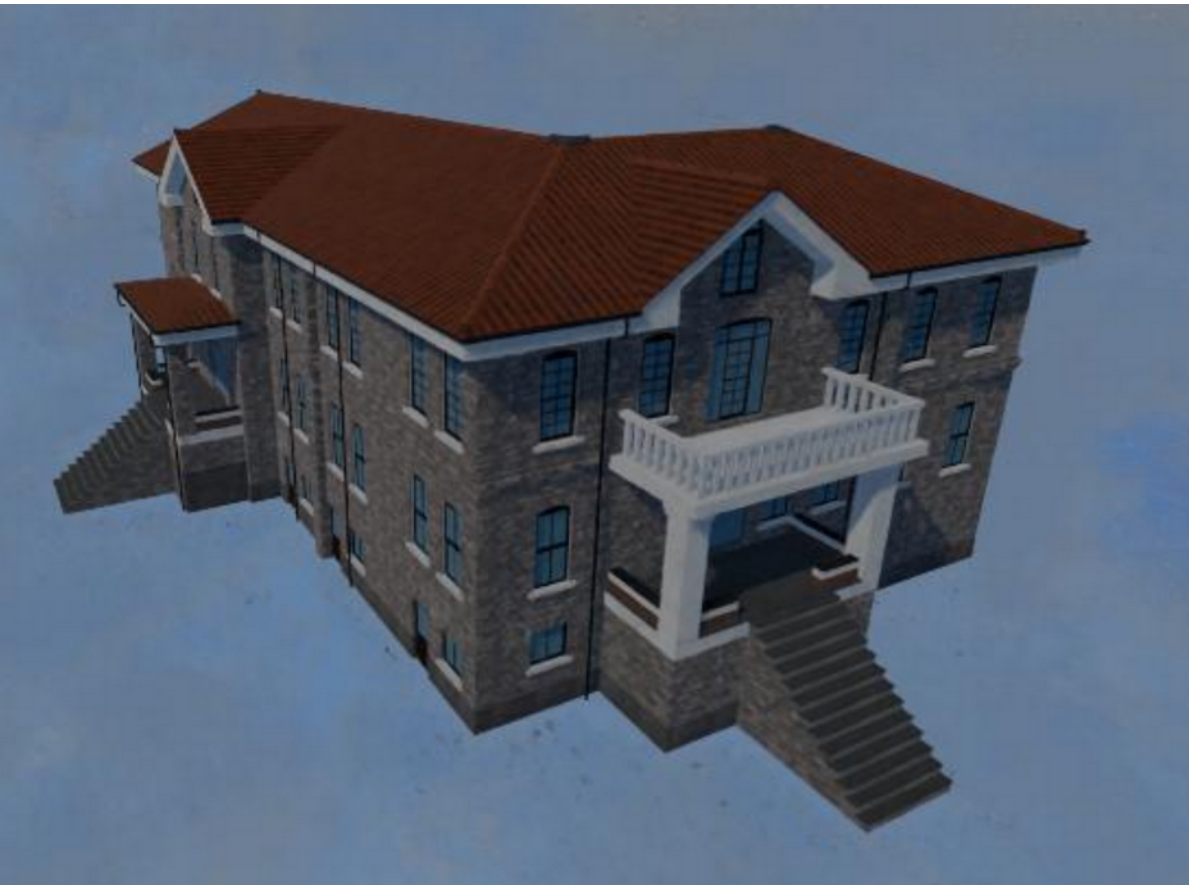
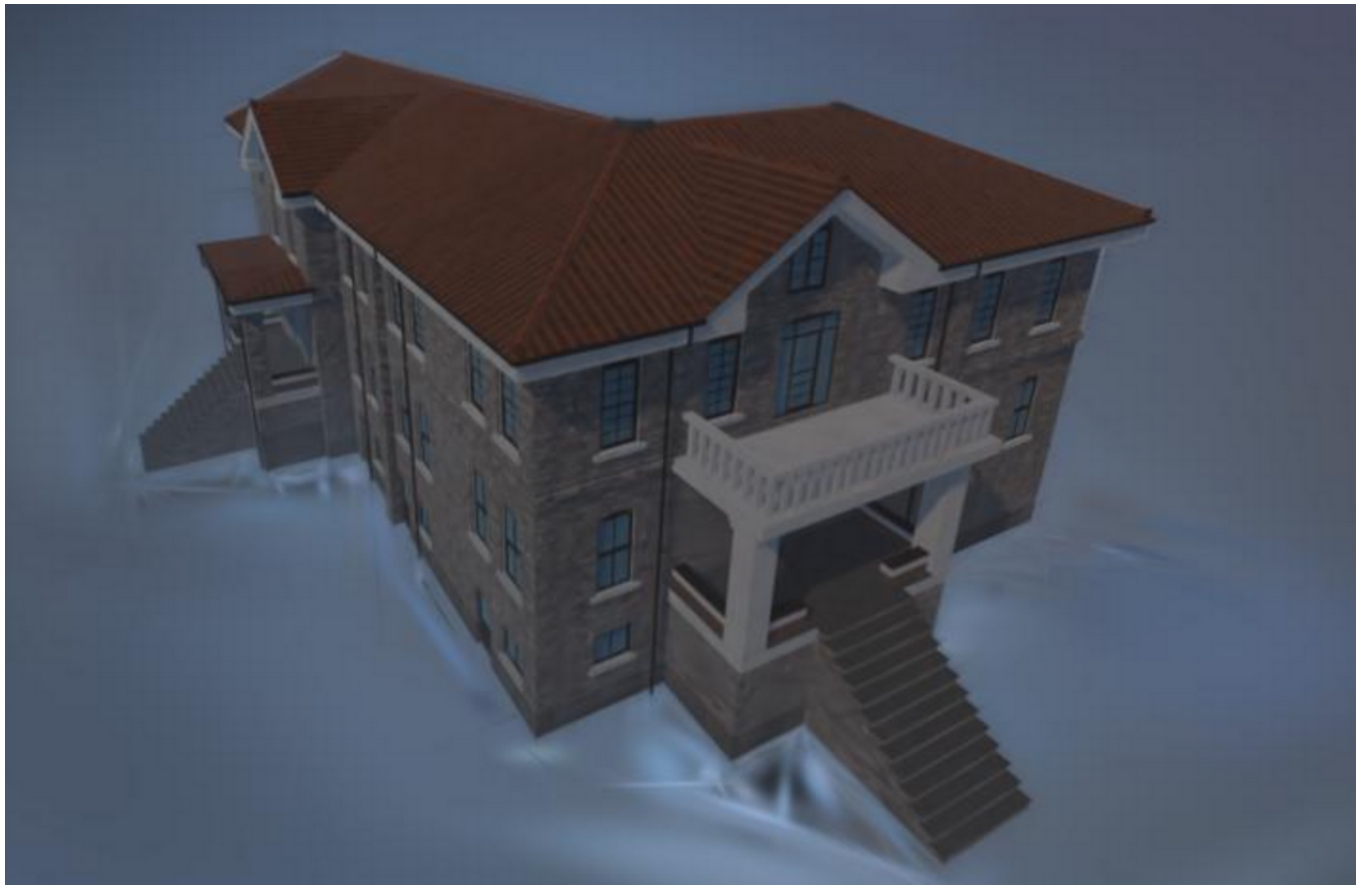
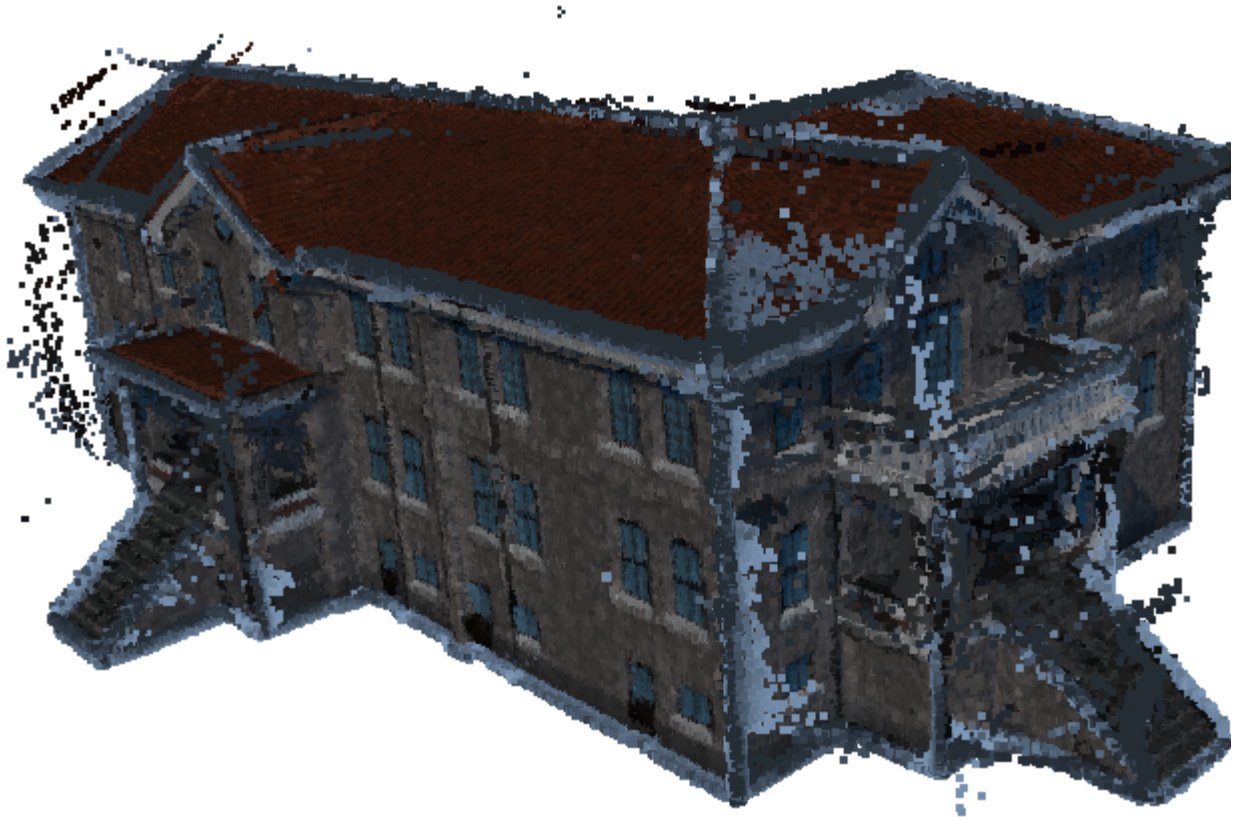


Nerfacto

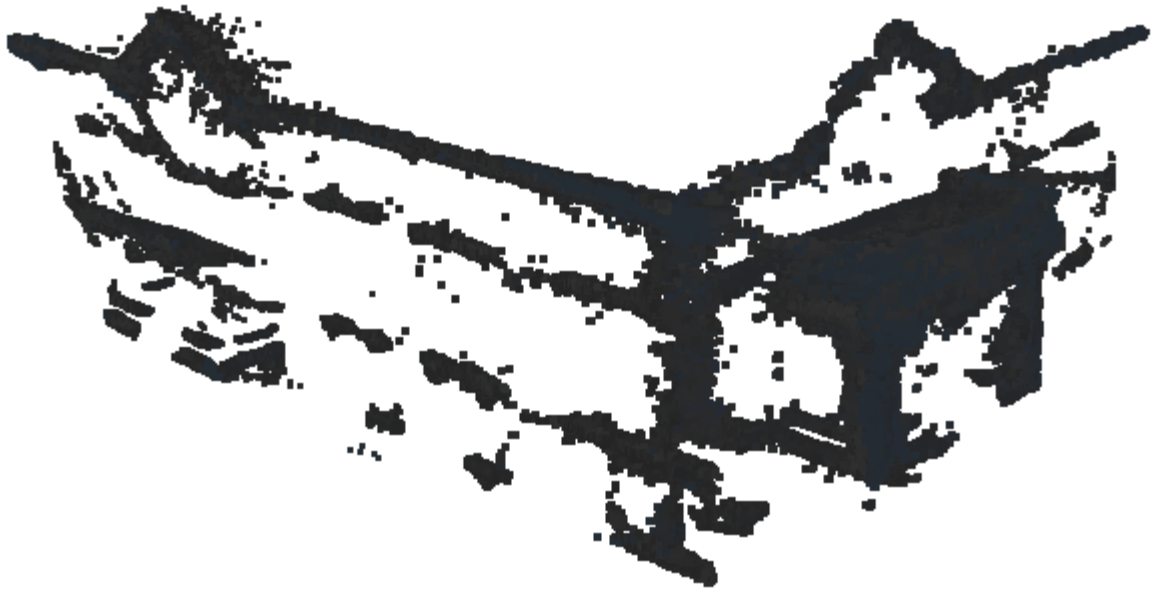


Splatfacto

Are the reconstruction algorithms able to reconstruct a scene from a low resolution model of a large urban object

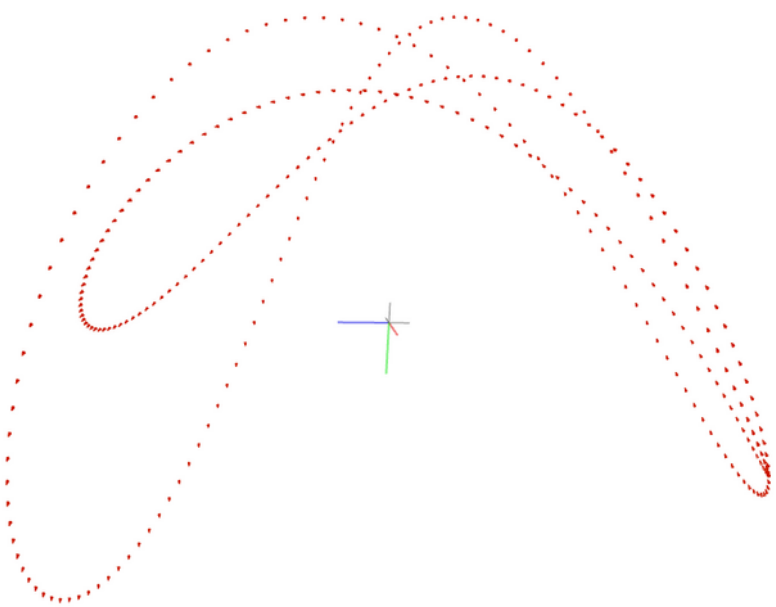


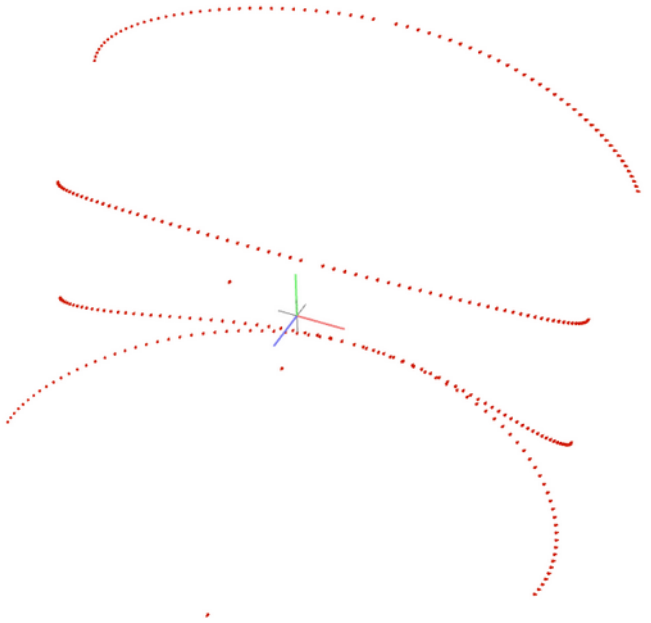
COLMAP



PatchmatchNet

Are the reconstruction algorithms able to reconstruct a scene from a low resolution model of a large urban object





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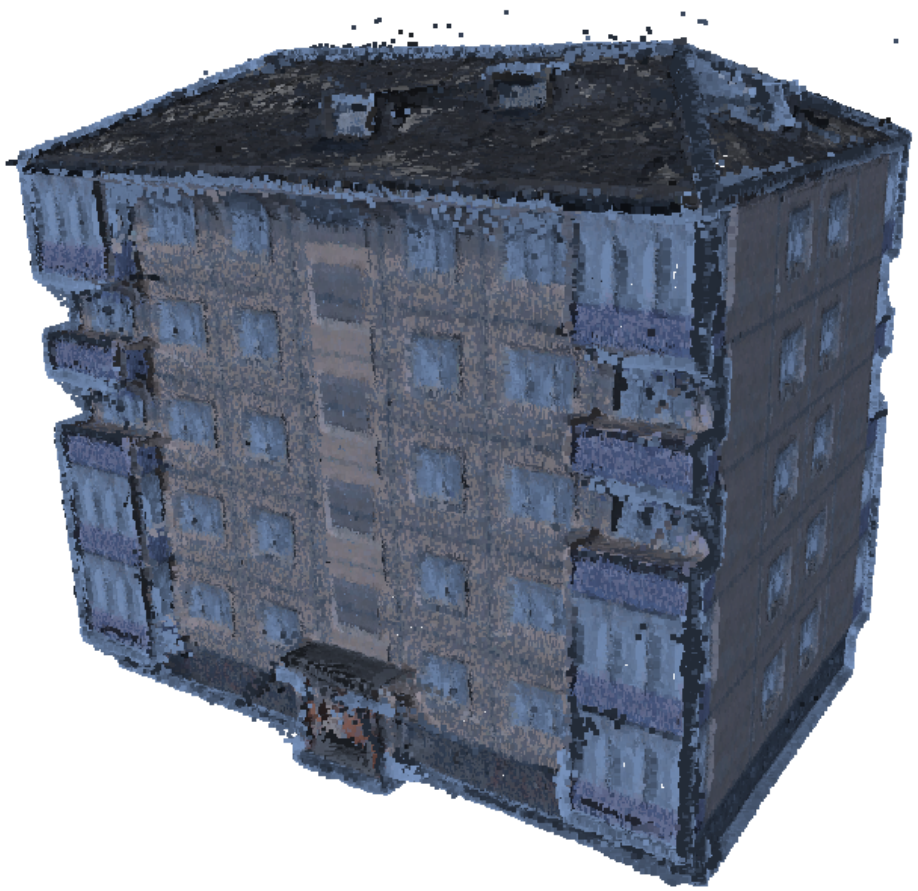
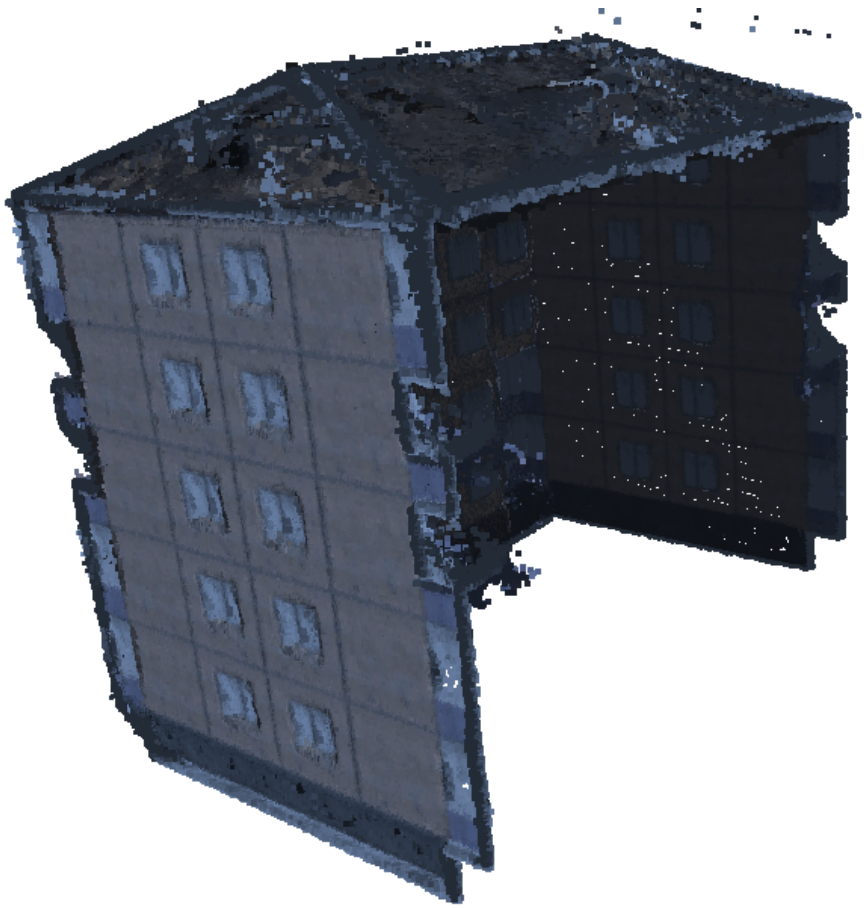


COLMAP



COLMAP

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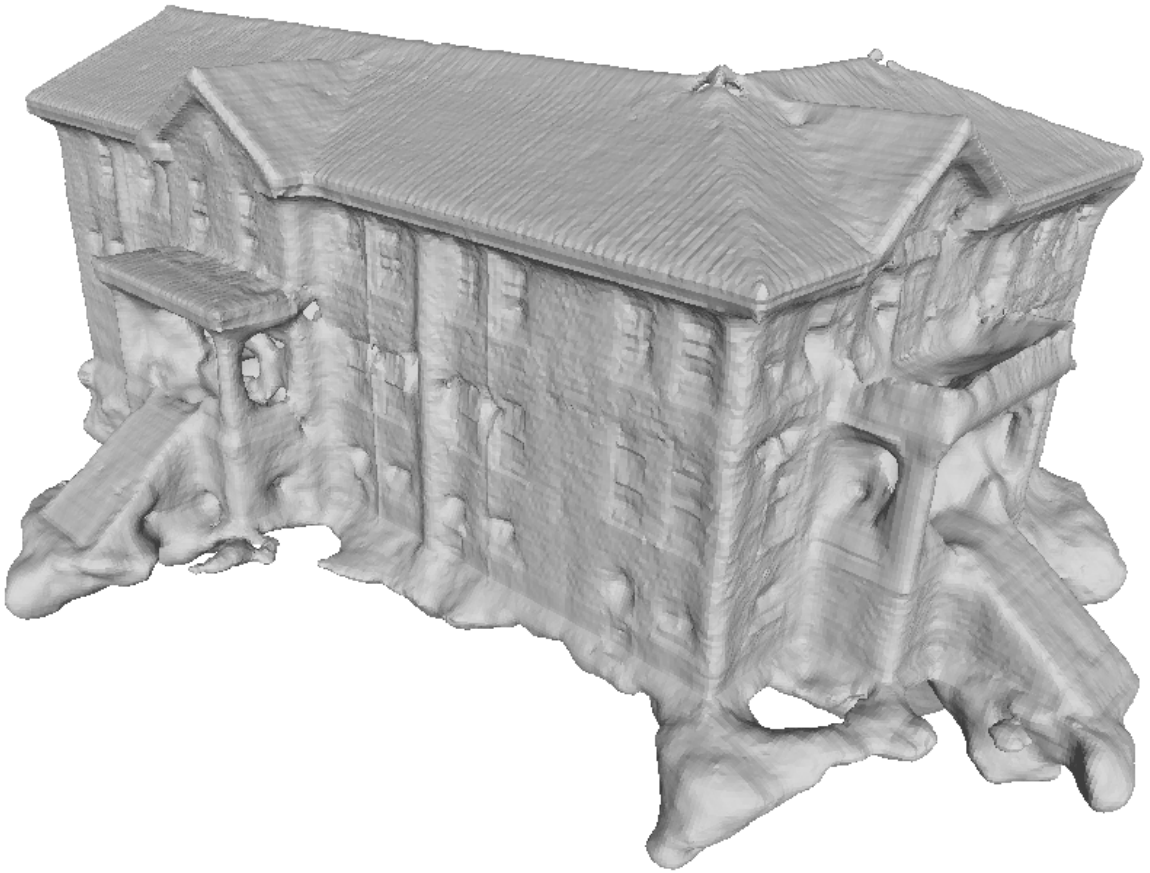
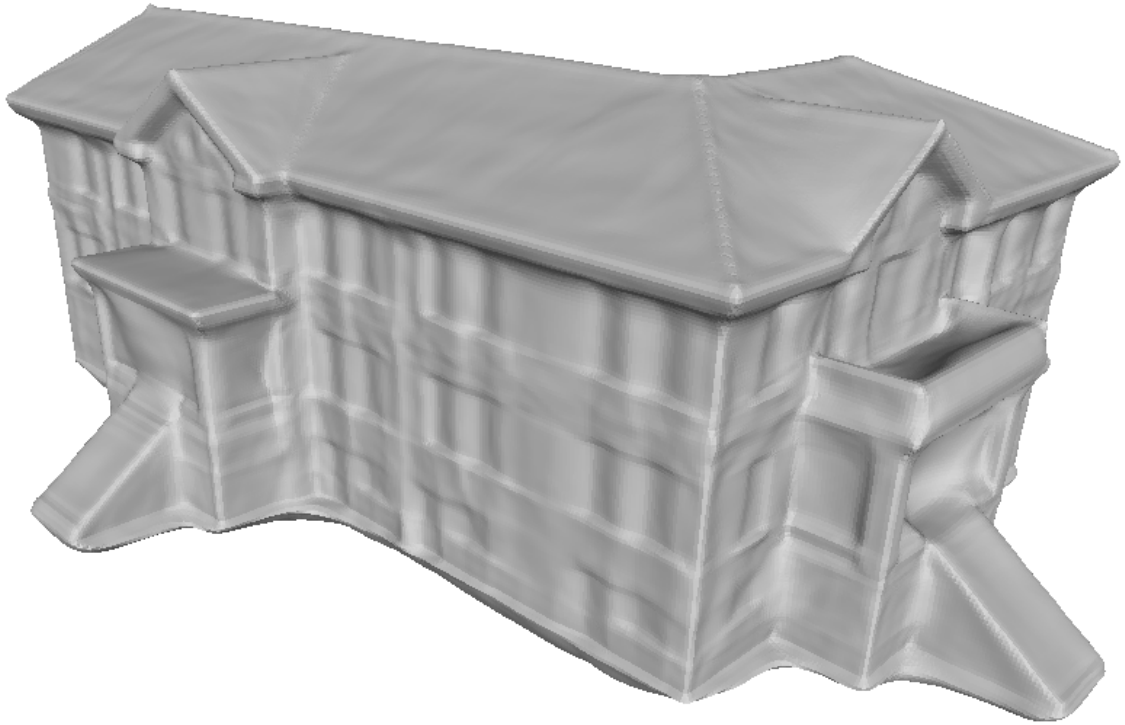


NeuS-facto



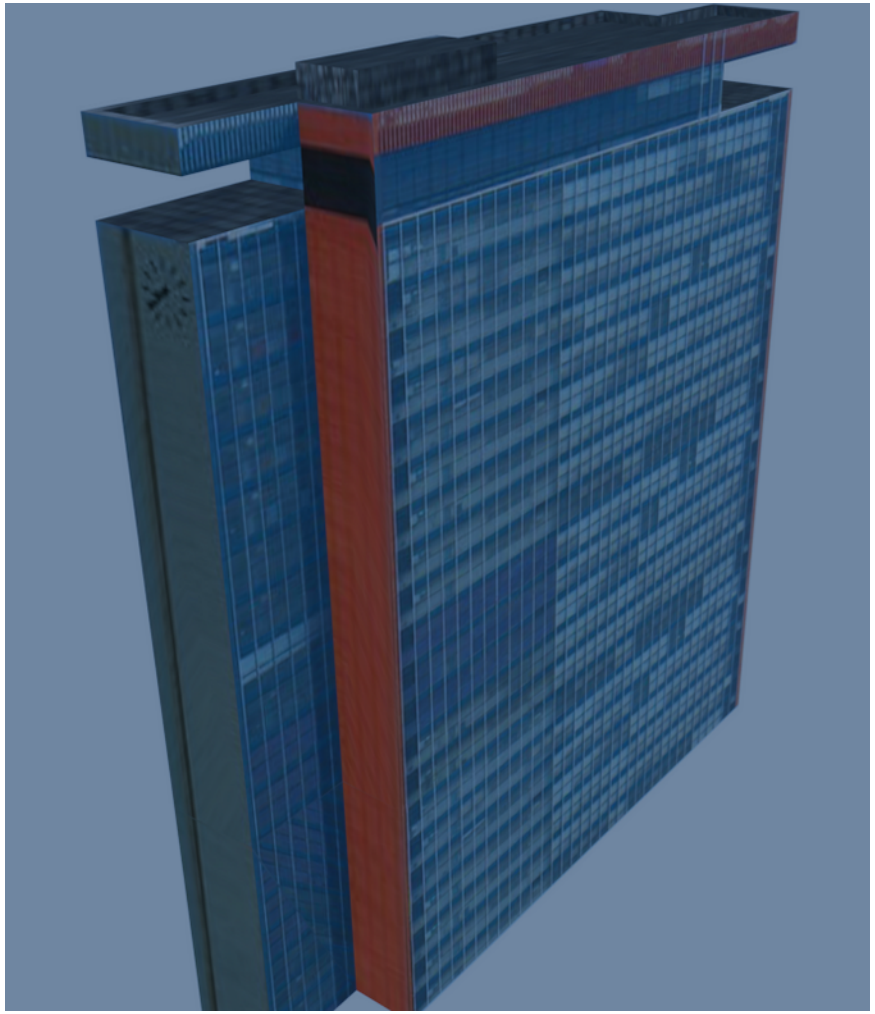
VolSDF

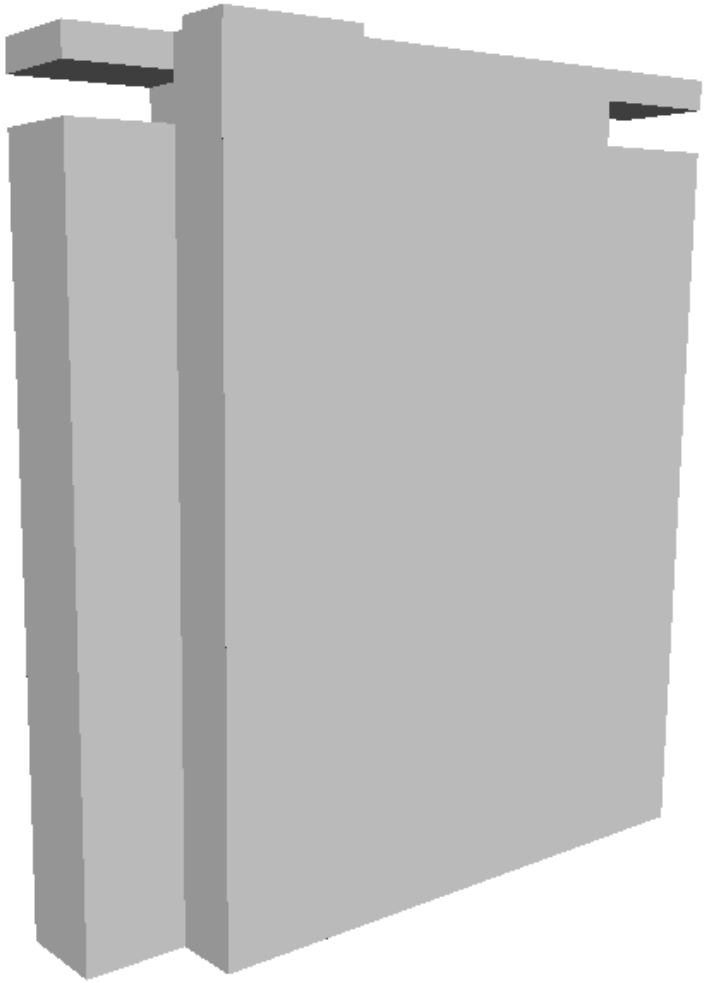
Research question

Main: Can we develop a methodology that allows us to evaluate the quality of reconstruction algorithms, for architectural purposes, without the use of a highly detailed complete ground truth model?

1. Are the reconstruction algorithms able to reconstruct a scene from a low resolution model of a large urban object.
2. What are the features that we can extract from a low resolution model, that can be used to test the quality of the generated meshes.
3. Does the width of the region around the extracted feature influence the quality of the evaluation metrics.

What are the features that we can extract from a low resolution model, that can be used to test the quality of the generated meshes.





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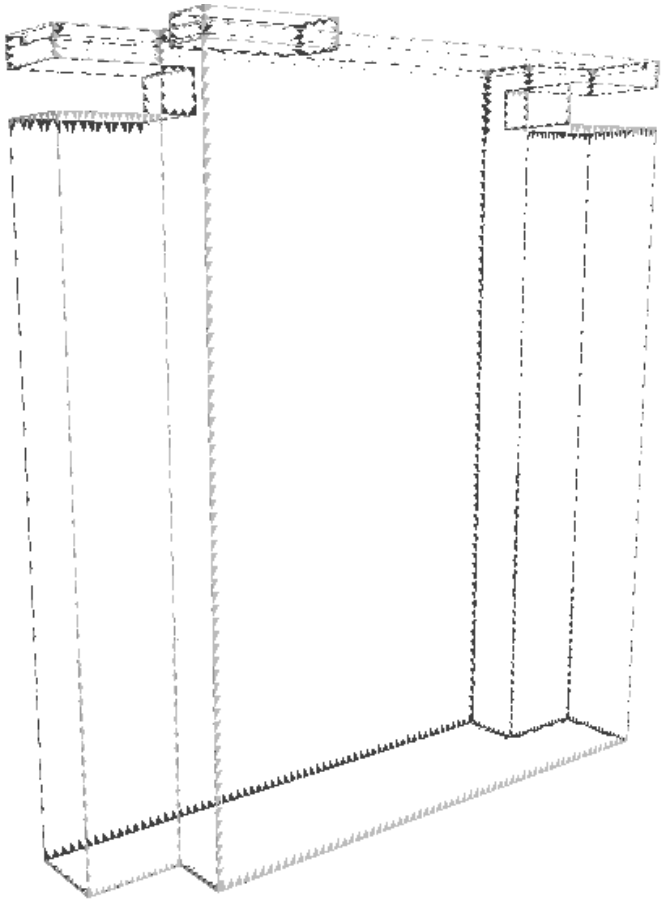

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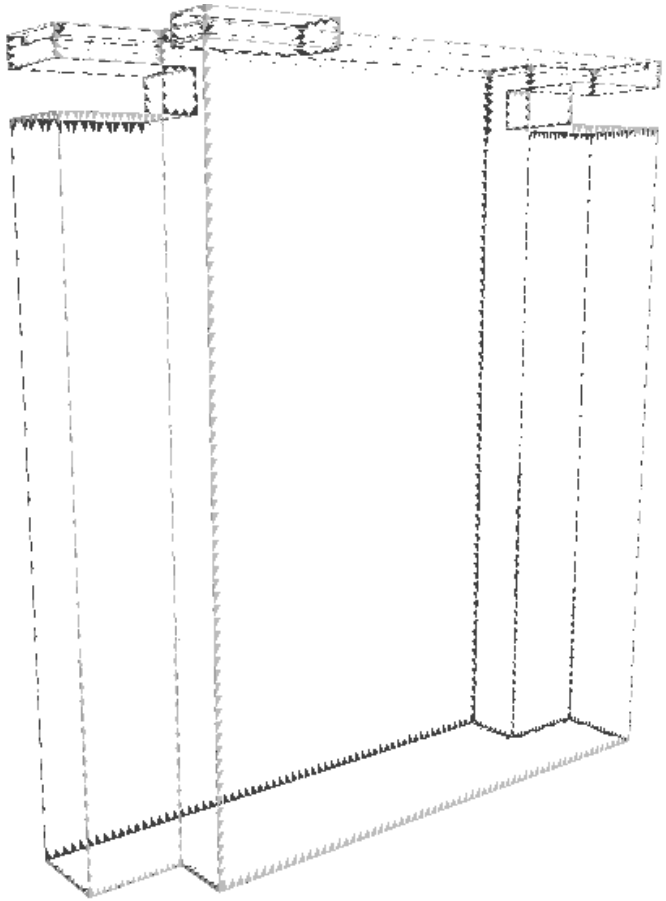

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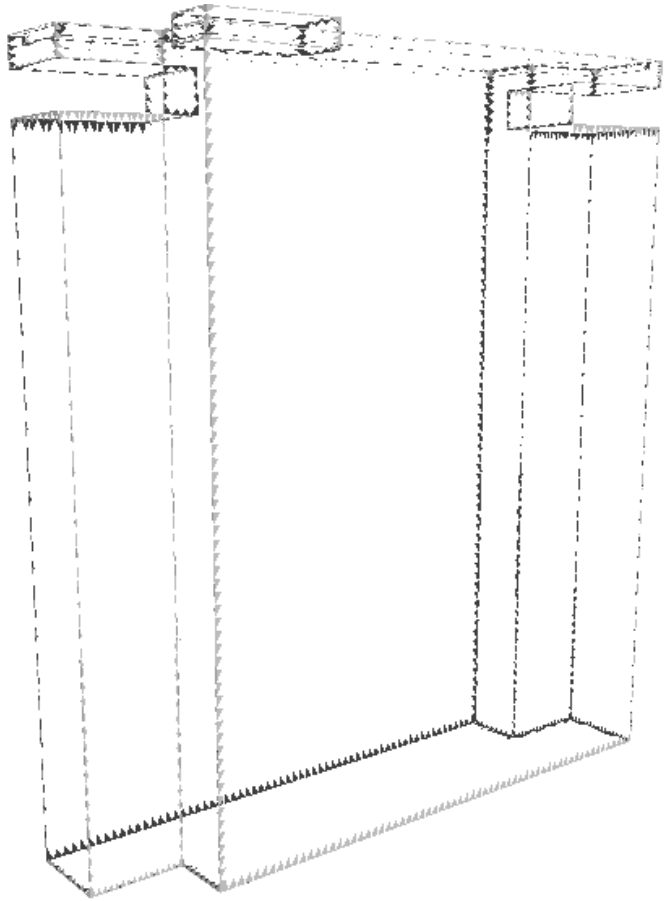

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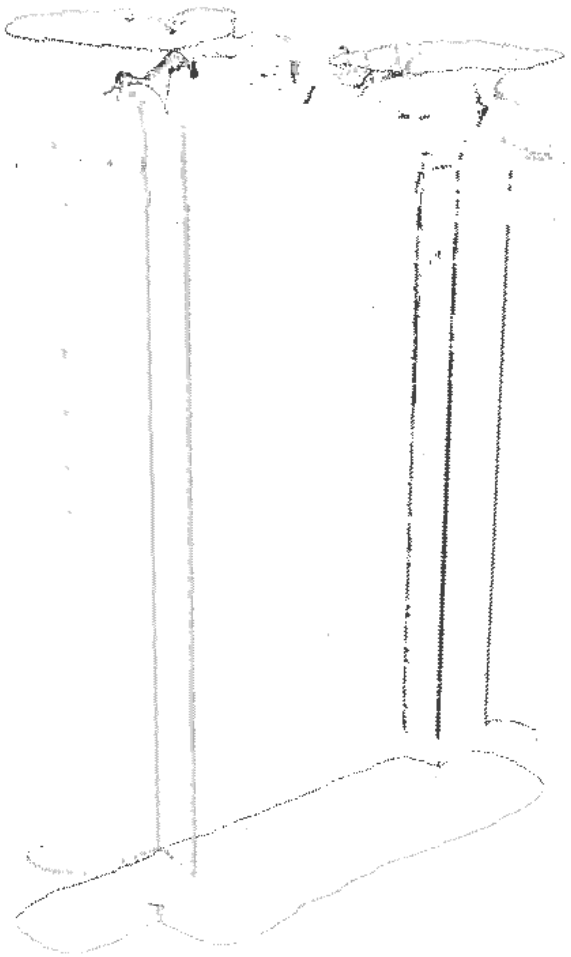
What are the features that we can extract from a low resolution model, that can be used to test the quality of the generated meshes.



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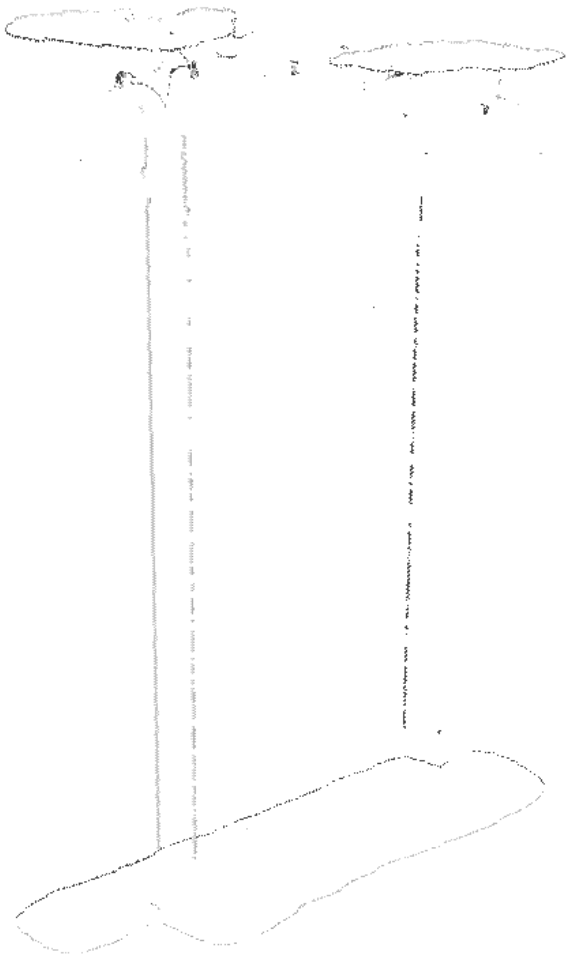

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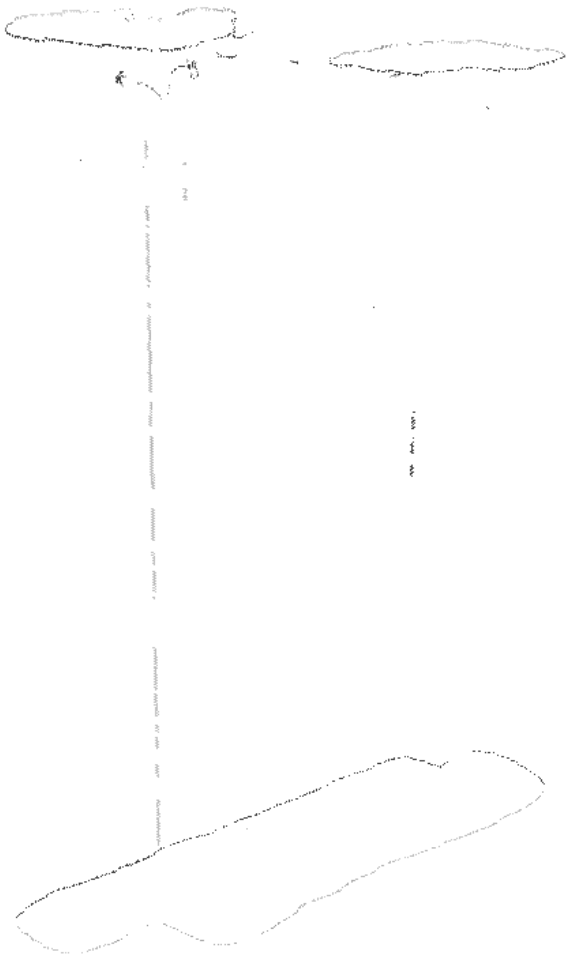

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Research question

Main: Can we develop a methodology that allows us to evaluate the quality of reconstruction algorithms, for architectural purposes, without the use of a highly detailed complete ground truth model?

1. Are the reconstruction algorithms able to reconstruct a scene from a low resolution model of a large urban object.
2. What are the features that we can extract from a low resolution model, that can be used to test the quality of the generated meshes.
3. Does the width of the region around the extracted feature influence the quality of the evaluation metrics.

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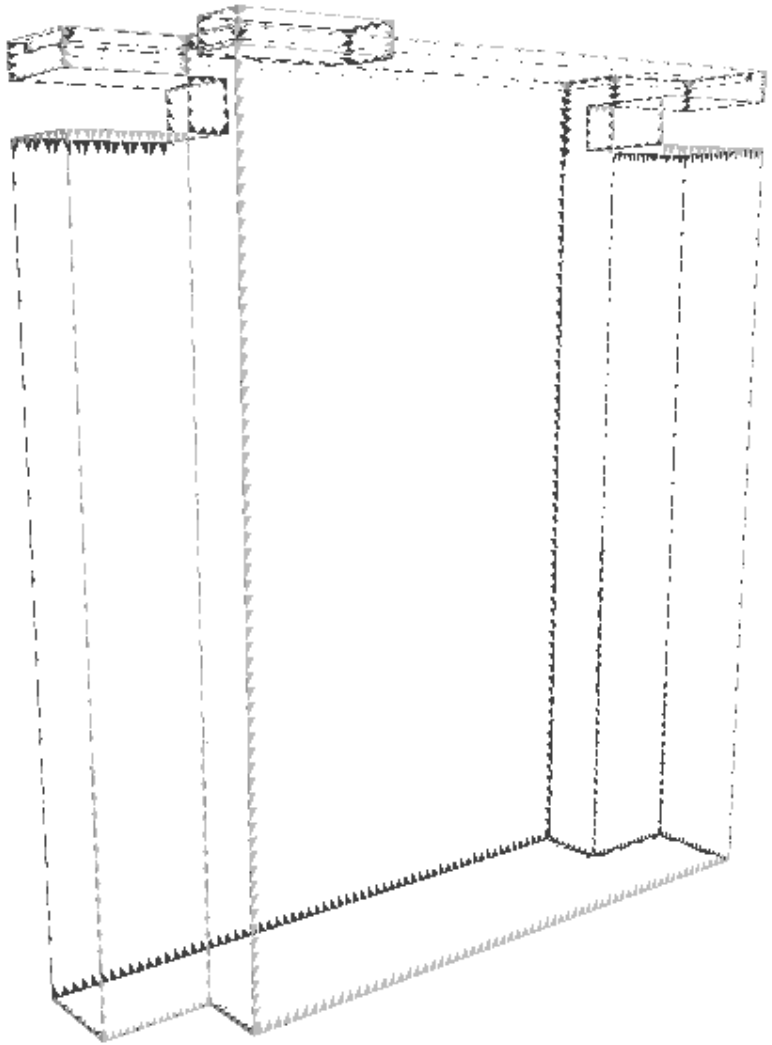

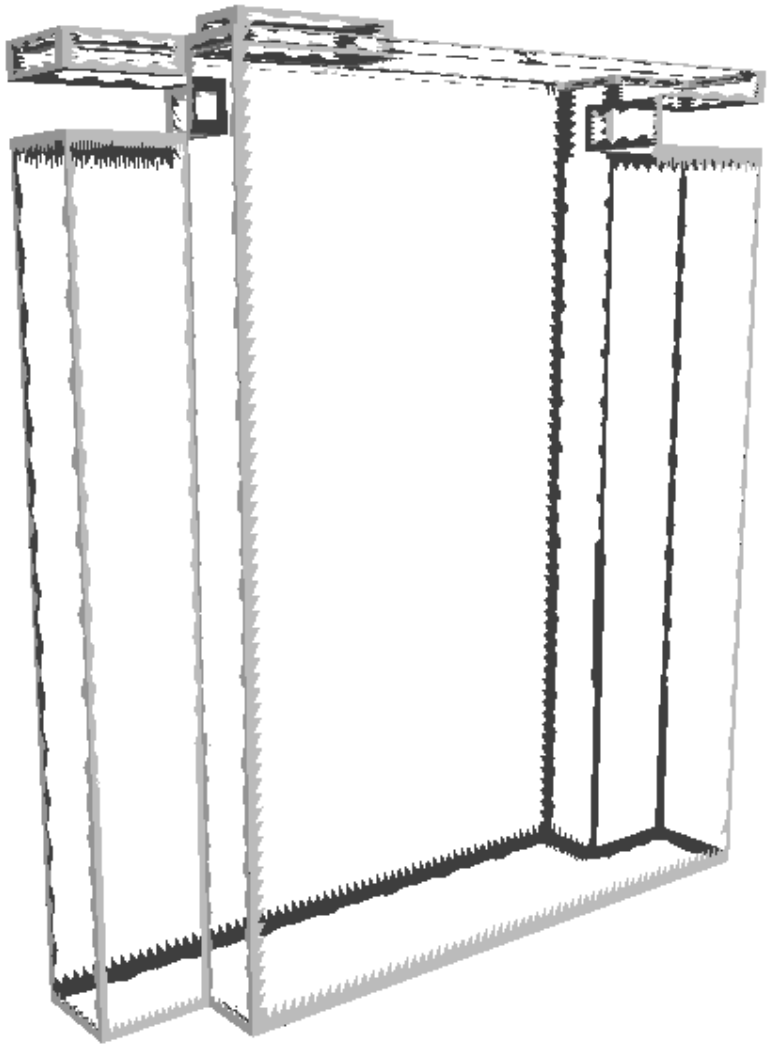

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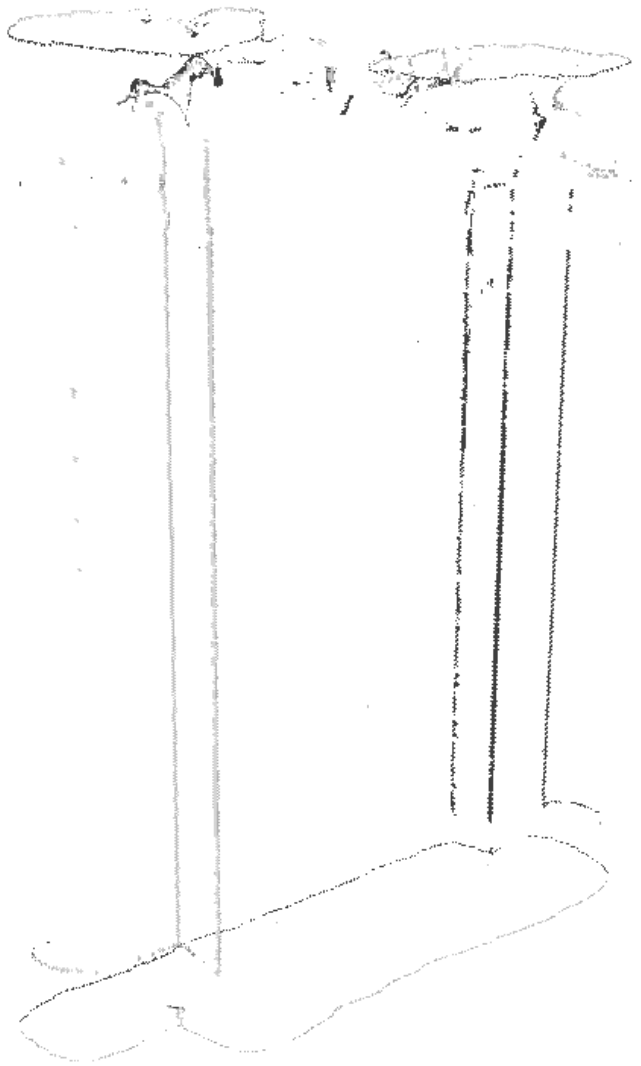

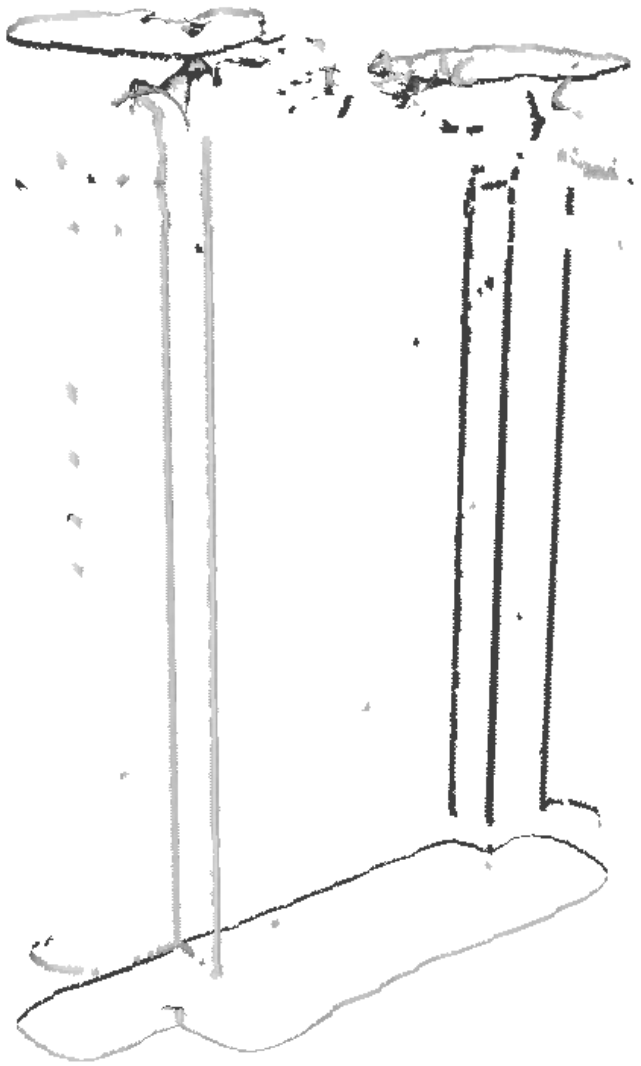

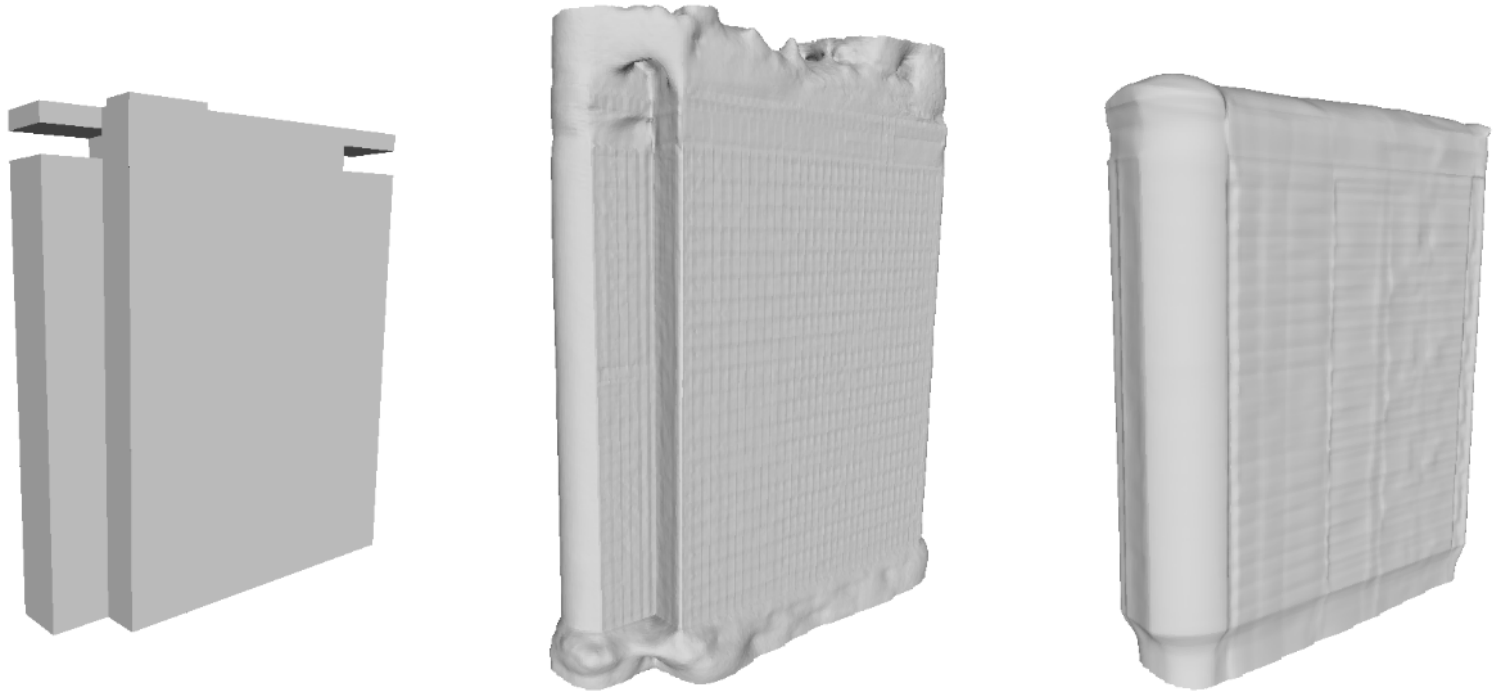

	NeuS-facto	VolSDF

		NeuS-facto			VolSDF		
		Hausdorff↓	chamfer↓	F-score↑	Hausdorff↓	chamfer↓	F-score↑
	25	22.570	5.097	0.188	22.135	5.047	0.457
large	40	20.931	6.871	0.240	35.061	8.986	0.402
	60	27.048	9.561	0.234	39.463	13.761	0.084
	25	22.998	4.997	0.185	22.579	5.556	0.473
small	40	20.980	6.814	0.257	35.293	10.165	0.435
	60	27.277	9.774	0.233	39.870	14.245	0.049
	full	17.407	1.801	0.397	11.907	1.159	0.541

		Hausdorff	chamfer	F-score	combined
	25	50%	50%	40%	46.7%
large	40	50%	70%	30%	50%
	60	50%	70%	40%	53.3%
	25	60%	60%	40%	53.3%
small	40	60%	70%	40%	56.7%
	60	50%	70%	50%	56.7%
	full	50%	40%	50%	46.7%

Research question

Main: Can we develop a methodology that allows us to evaluate the quality of reconstruction algorithms, for architectural purposes, without the use of a highly detailed complete ground truth model?

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Conclusion

In this thesis we show that it is possible to create a methodology for a more objective evaluation of the performance of mesh reconstruction algorithms of large urban objects generated from low detailed complete ground truth models. We have also demonstrated that it is possible to render large urban objects from low detailed manual modeled buildings with photo (realistic) textures for the three algorithm groups.

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Thank you for your attention