Factored Facade Acquisition using Symmetric Line Arrangements

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Virtual Environments & Computer Graphics
UNIVERSITY COLLEGE LONDON

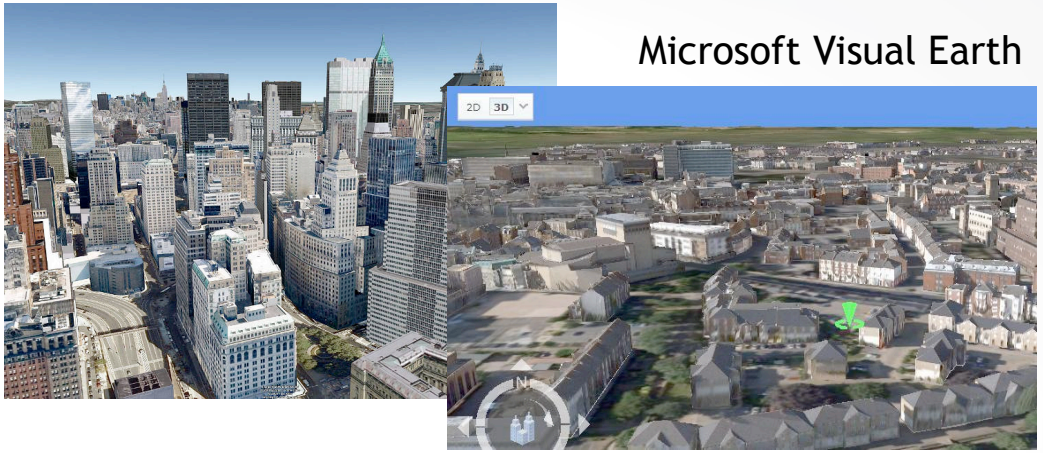
Columbia Computer Graphics Group
COLUMBIA UNIVERSITY

3D Reconstruction of Urban Scenes

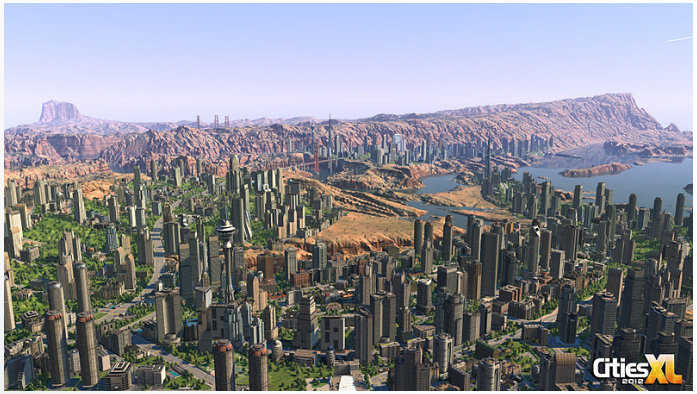
urban design

Google Earth

Microsoft Visual Earth



mapping and navigation



content creation

virtual tours

Factored Facade Acquisition Using Symmetric Line Arrangements, Ceylan et al.

State of the Art

Factored Facade Acquisition Using Symmetric Line Arrangements, Ceylan et al.

State of the Art

Multi-View Stereo

Factored Facade Acquisition Using Symmetric Line Arrangements, Ceylan et al.

State of the Art

Multi-View Stereo

Furukawa et al.
CVPR'07

State of the Art

Multi-View Stereo

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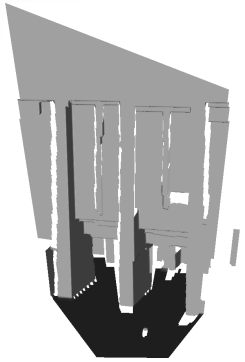
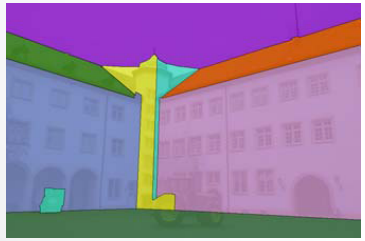


Furukawa et al.
CVPR'09



Sinha et al.
ICCV'09

State of the Art

Multi-View Stereo

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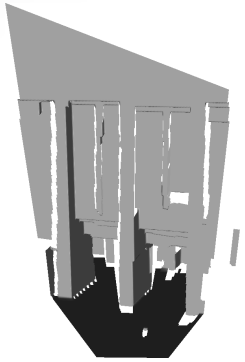

Furukawa et al.
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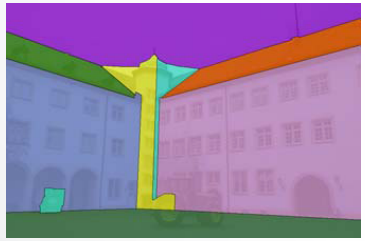
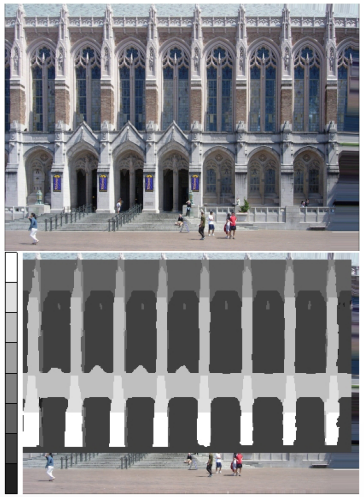


Sinha et al.
ICCV'09

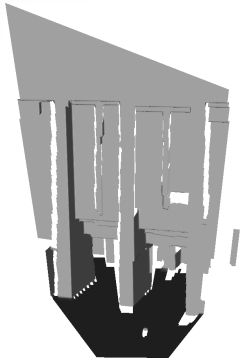


Wu et al.
CVPR'11

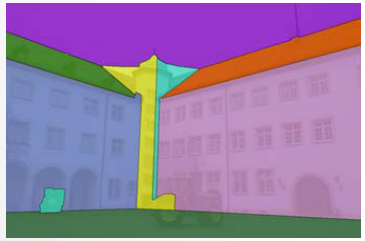
State of the Art

Multi-View Stereo

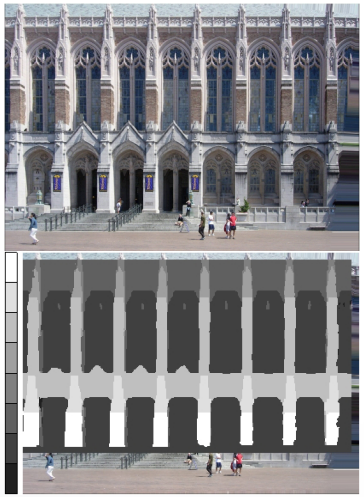
Furukawa et al.
CVPR'07



Furukawa et al.
CVPR'09

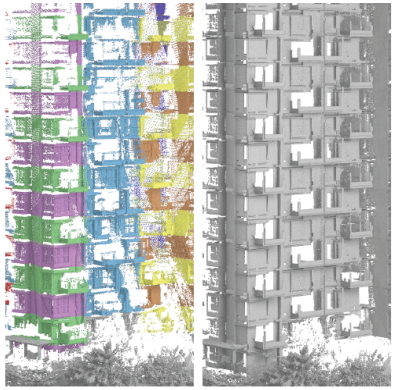


Sinha et al.
ICCV'09



Wu et al.
CVPR'11

Other Data Sources



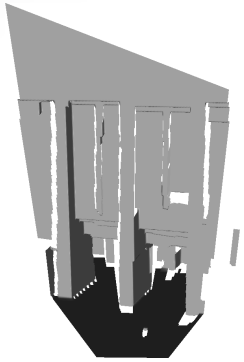
Zheng et al.
Siggraph'10

Li et al.
ICCV'11

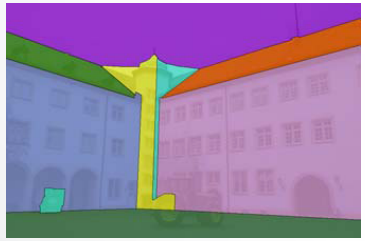
State of the Art

Multi-View Stereo

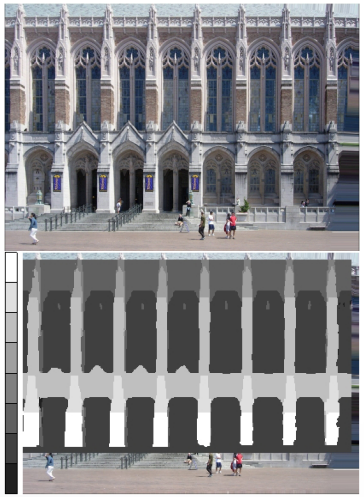
Furukawa et al.
CVPR'07



Furukawa et al.
CVPR'09

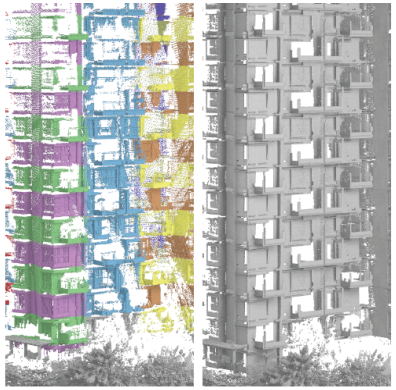


Sinha et al.
ICCV'09



Wu et al.
CVPR'11

Other Data Sources

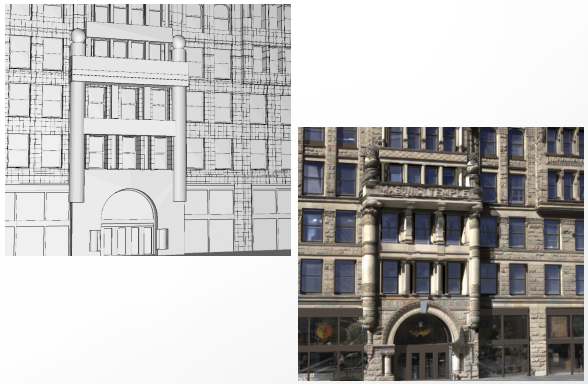


Zheng et al.
Siggraph'10

Li et al.
ICCV'11

Procedural Modeling

Muller et al.
Siggraph'08



Xiao et al.
Siggraph'08

Challenges

Challenges

tall buildings

Challenges

tall buildings

textureless regions

Challenges

tall buildings

textureless regions

strong variation in illumination

Factored Facade Acquisition Using Symmetric Line Arrangements, Ceylan et al.

Challenges

tall buildings

textureless regions

reflective surfaces

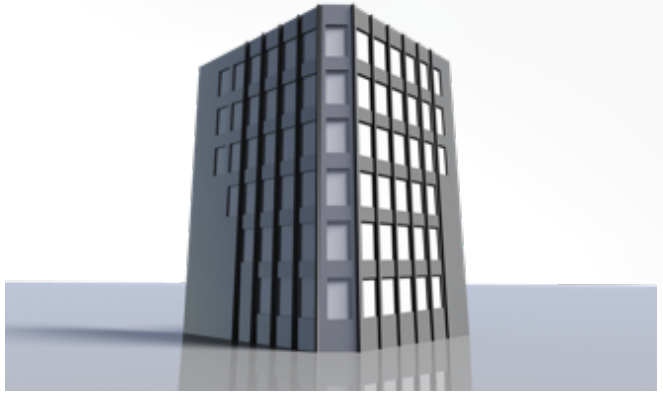
strong variation in illumination

Factored Facade Acquisition Using Symmetric Line Arrangements, Ceylan et al.

Our Algorithm

Our Algorithm

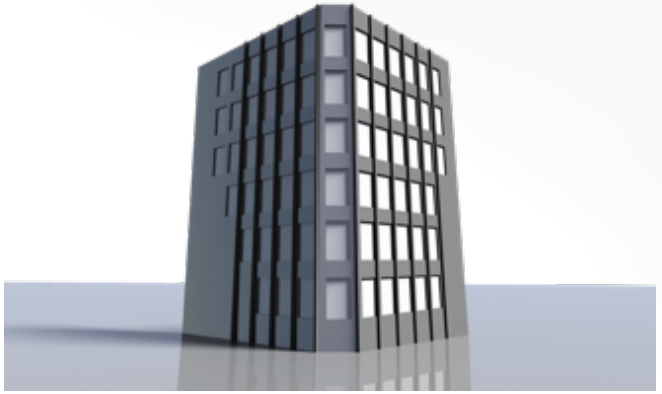
input images



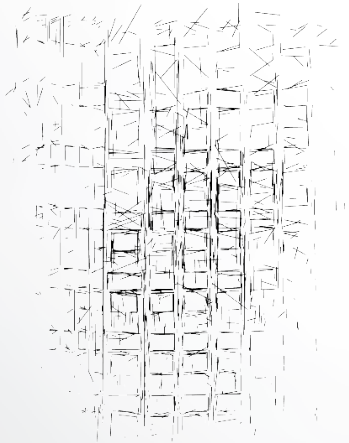
output reconstruction

Our Algorithm

input images



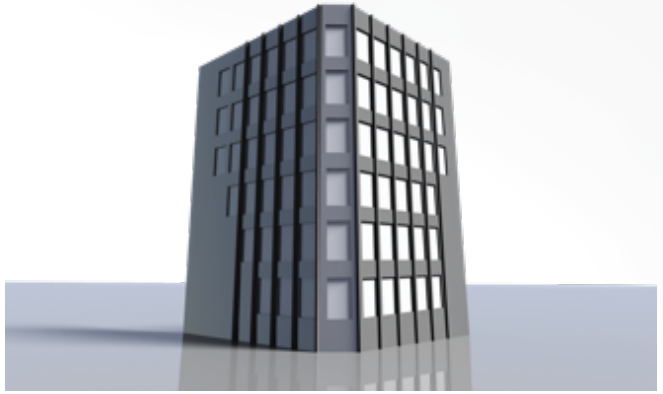
output reconstruction



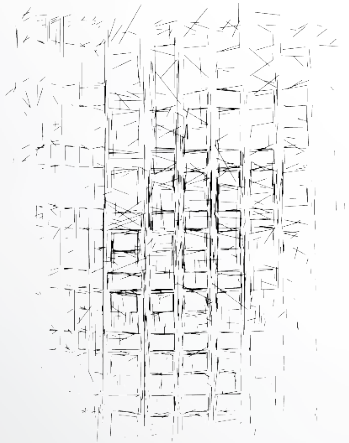
3D lines

Our Algorithm

input images



output reconstruction



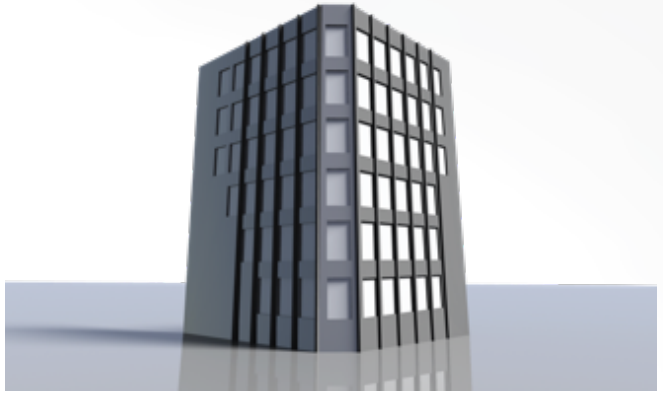
3D lines

plane fitting

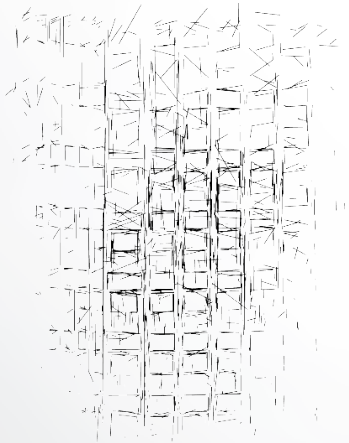
Factored Facade Acquisition Using Symmetric Line Arrangements, Ceylan et al.

Our Algorithm

input images

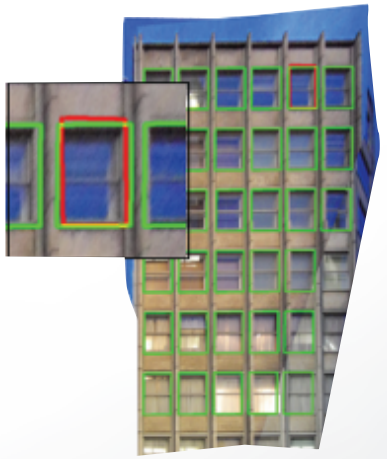


output reconstruction



3D lines

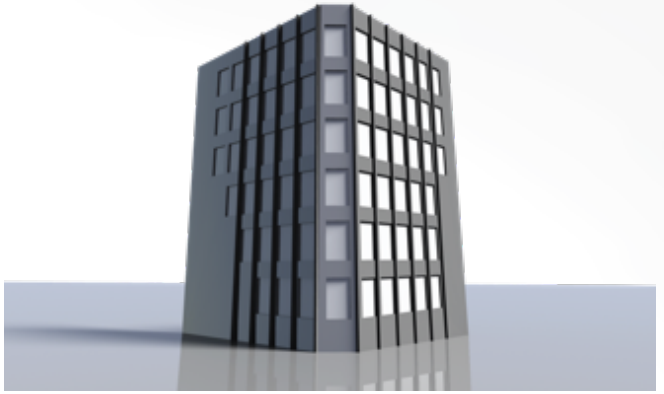
plane fitting



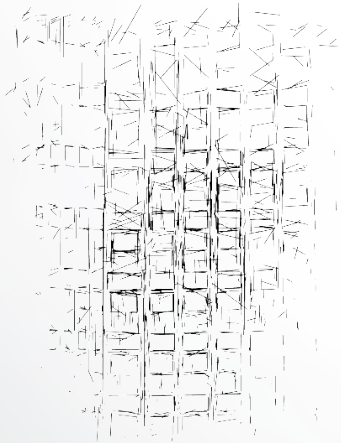
structure detection

Factored Facade Acquisition Using Symmetric Line Arrangements, Ceylan et al.

input images

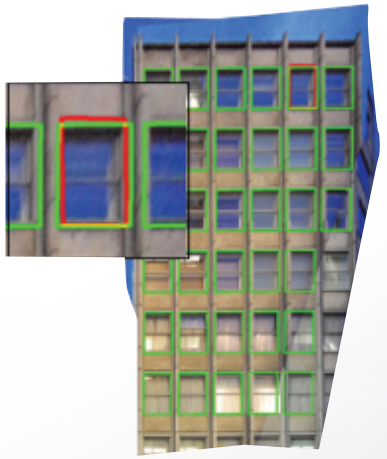


output reconstruction



3D lines

plane fitting



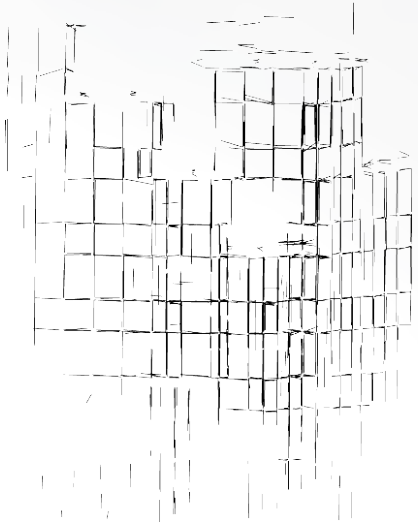
structure detection

Factored Facade Acquisition Using Symmetric Line Arrangements, Ceylan et al.

3D Line Reconstruction

. . .

multi-view stereo
on the edges



2D edges

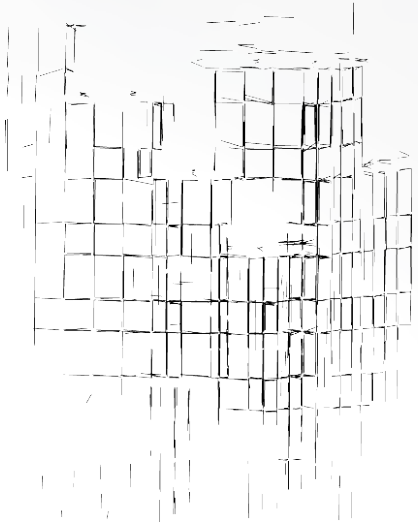
3D lines

Factored Facade Acquisition Using Symmetric Line Arrangements, Ceylan et al.

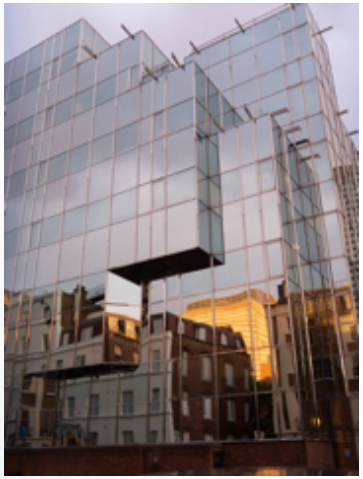
3D Line Reconstruction

2D edges

multi-view stereo on the edges



3D lines



input image

Factored Facade Acquisition Using Symmetric Line Arrangements, Ceylan et al.

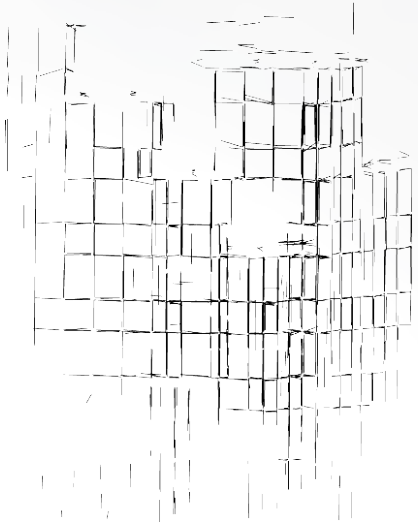
3D Line Reconstruction



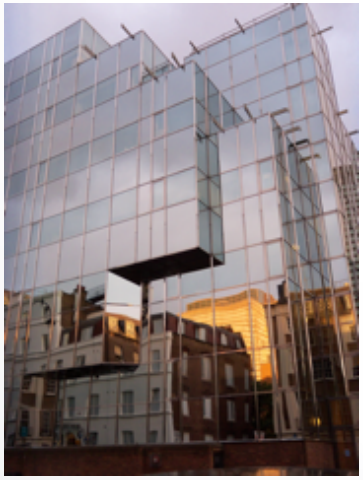
. . .


2D edges

multi-view stereo
on the edges



3D lines



input image

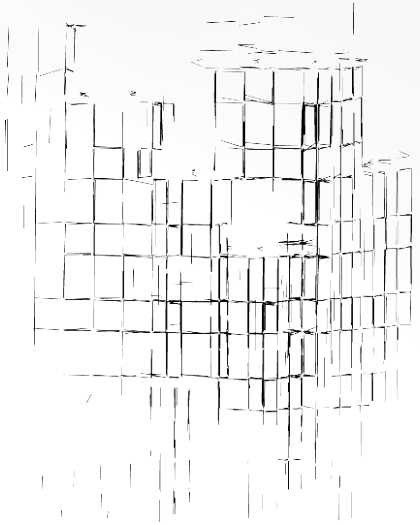
2D edges

Factored Facade Acquisition Using Symmetric Line Arrangements, Ceylan et al.

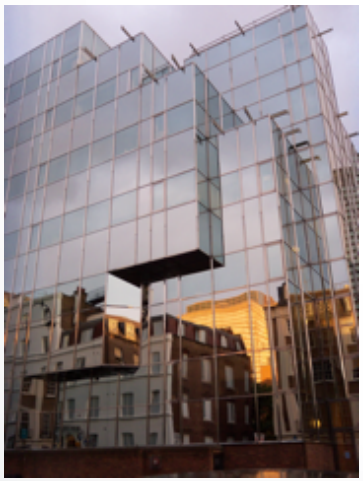
3D Line Reconstruction

2D edges

multi-view stereo on the edges



3D lines



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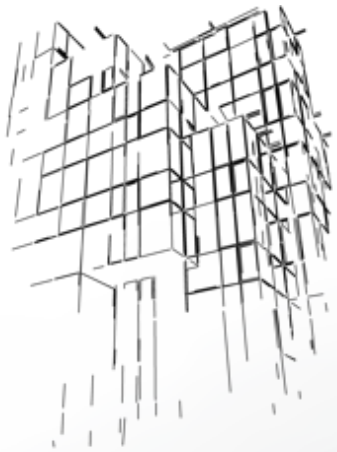
2D edges



projected 3D lines

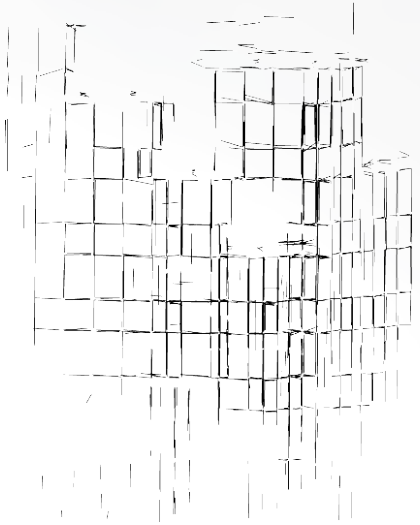
Factored Facade Acquisition Using Symmetric Line Arrangements, Ceylan et al.

3D Line Reconstruction

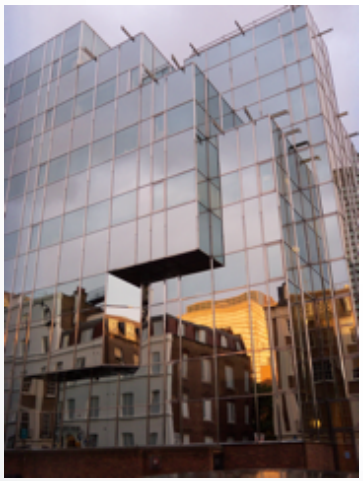
. . .

2D edges

multi-view stereo on the edges

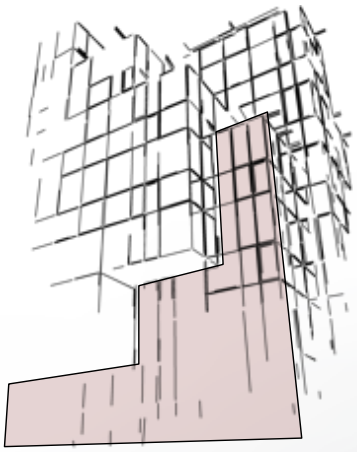


3D lines



input image

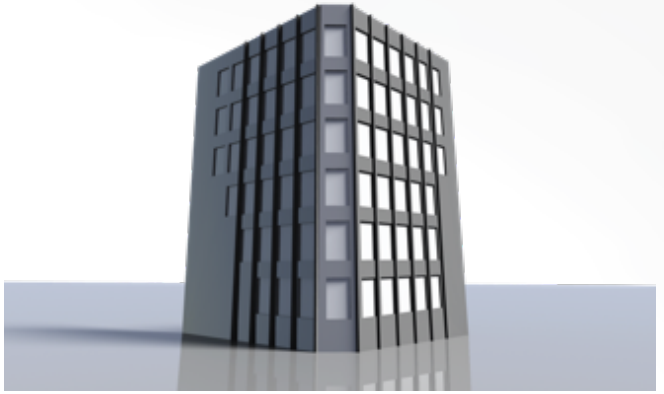
2D edges



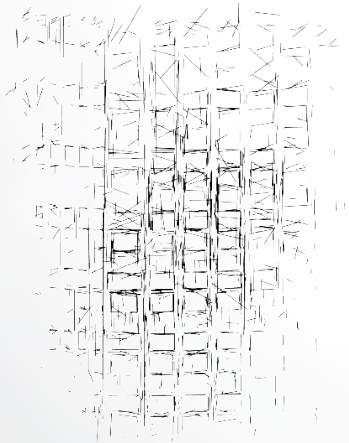
projected 3D lines

Factored Facade Acquisition Using Symmetric Line Arrangements, Ceylan et al.

input images

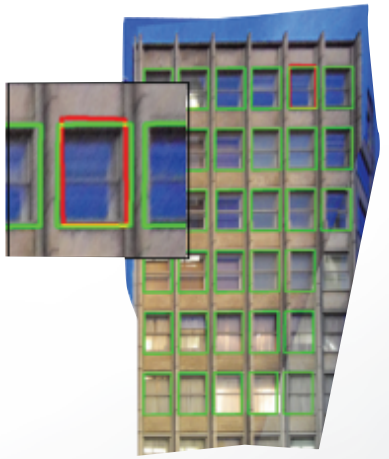


output reconstruction



3D lines

plane fitting



structure detection

Factored Facade Acquisition Using Symmetric Line Arrangements, Ceylan et al.

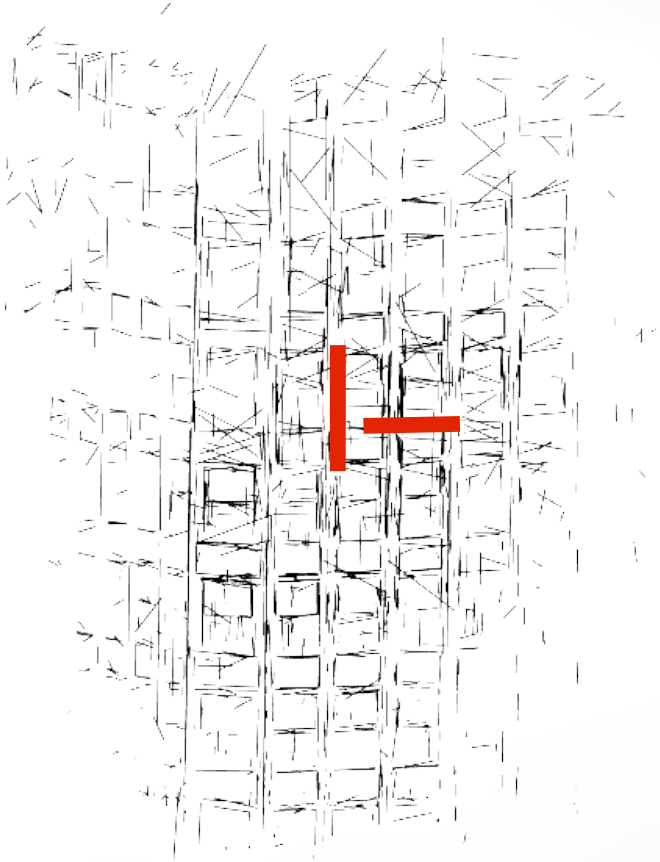
Candidate Plane Generation

Candidate Plane Generation

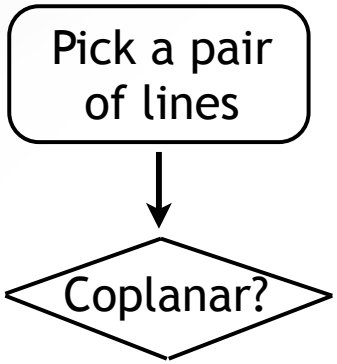
Pick a pair of lines

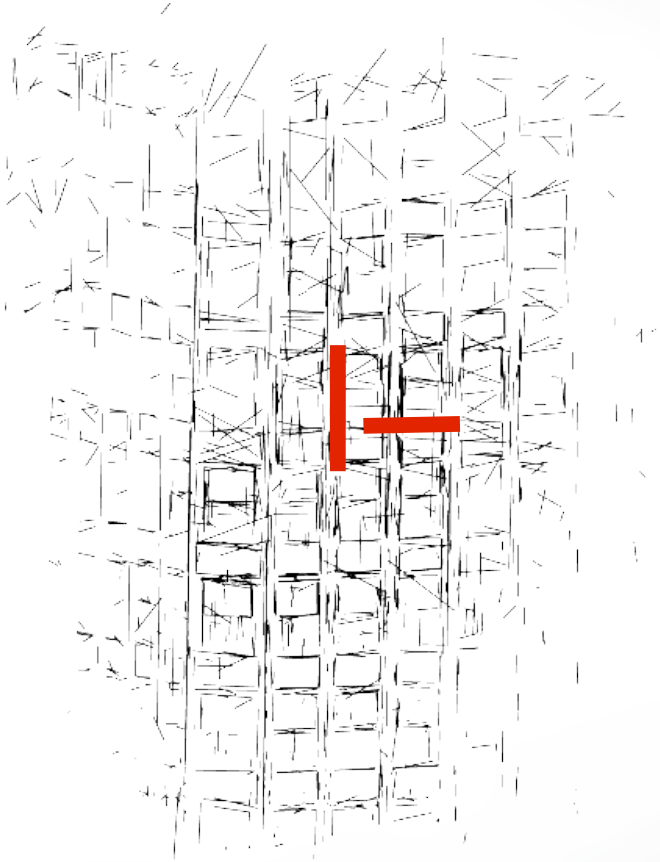
Candidate Plane Generation

Pick a pair of lines



Candidate Plane Generation





Factored Facade Acquisition Using Symmetric Line Arrangements, Ceylan et al.

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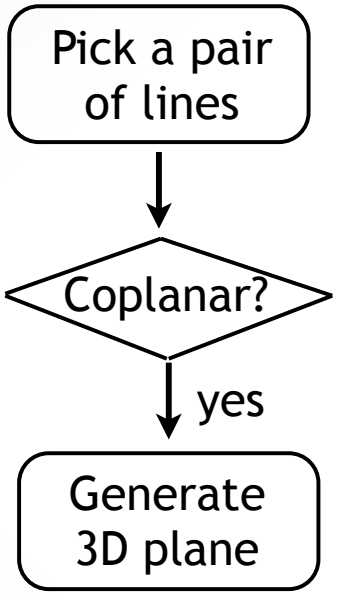

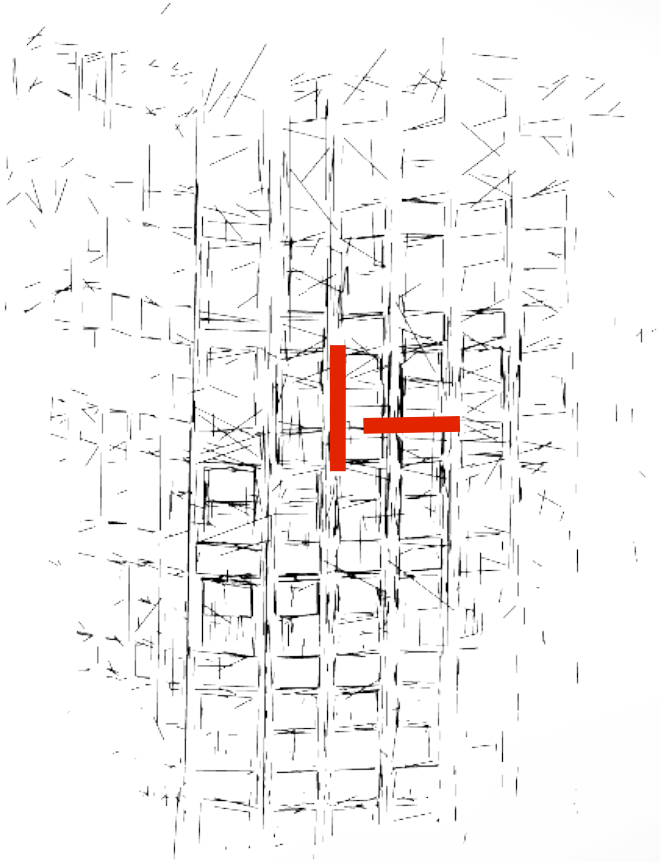

Factored Facade Acquisition Using Symmetric Line Arrangements, Ceylan et al.

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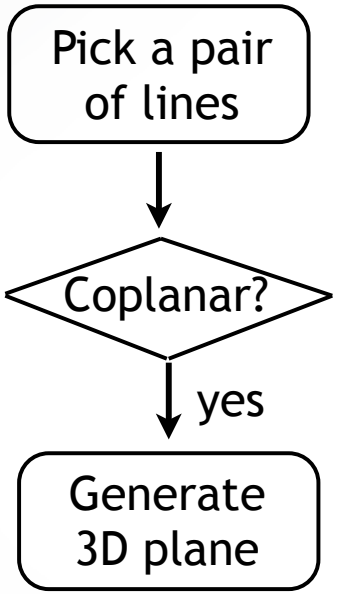

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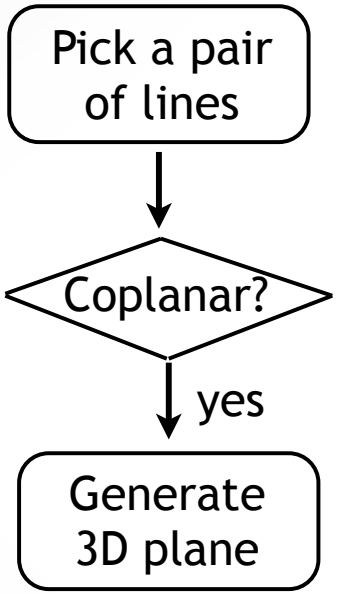
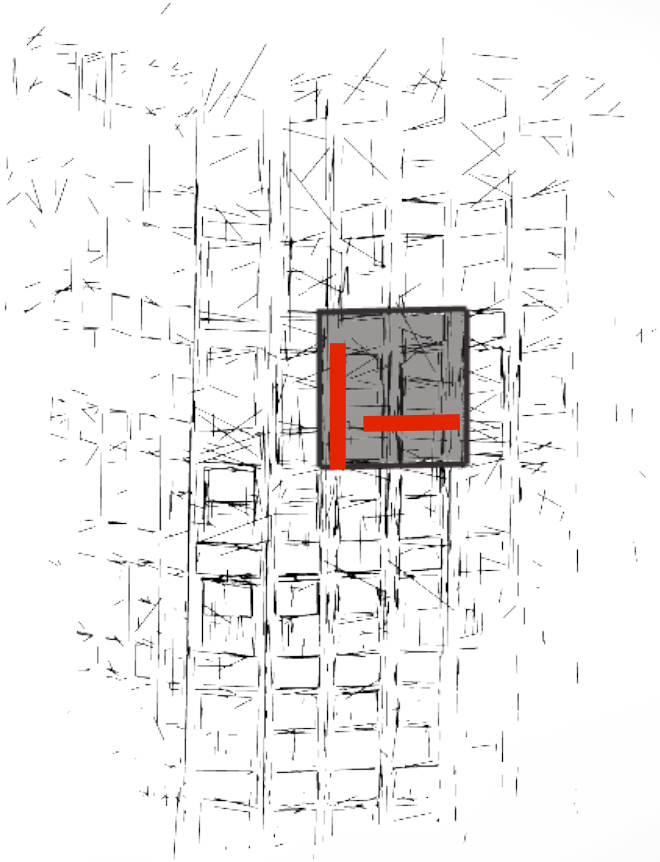
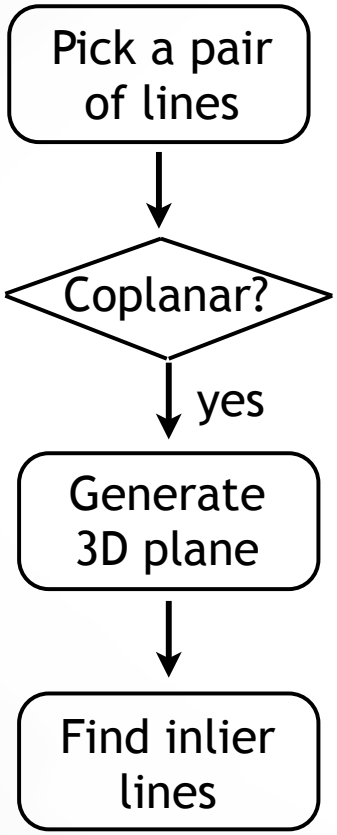
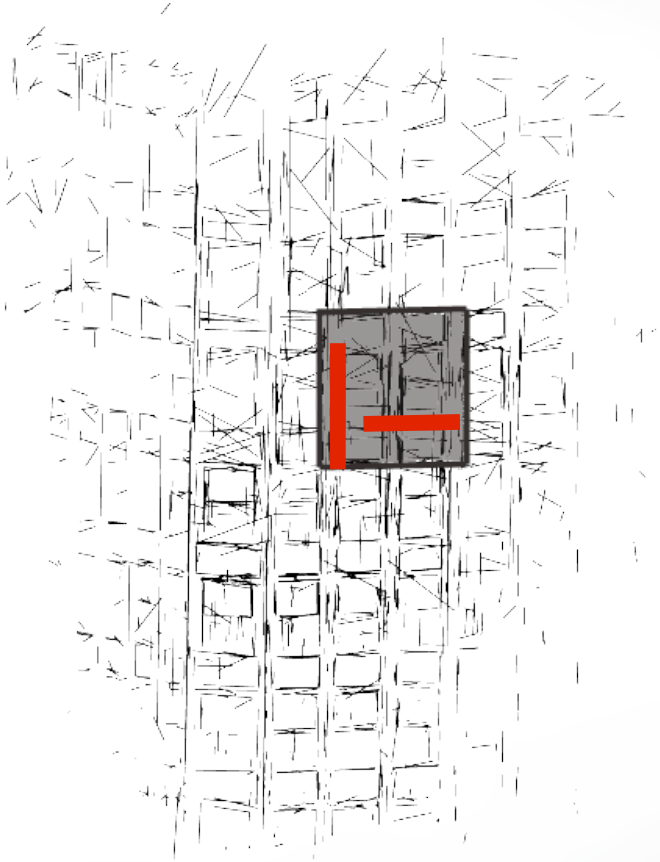




Factored Facade Acquisition Using Symmetric Line Arrangements, Ceylan et al.

Candidate Plane Generation





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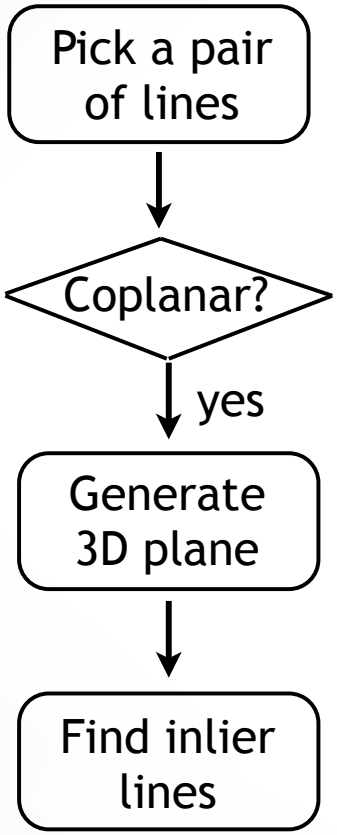
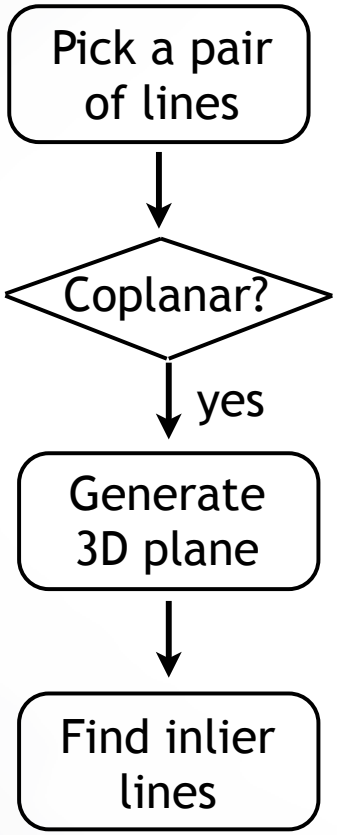
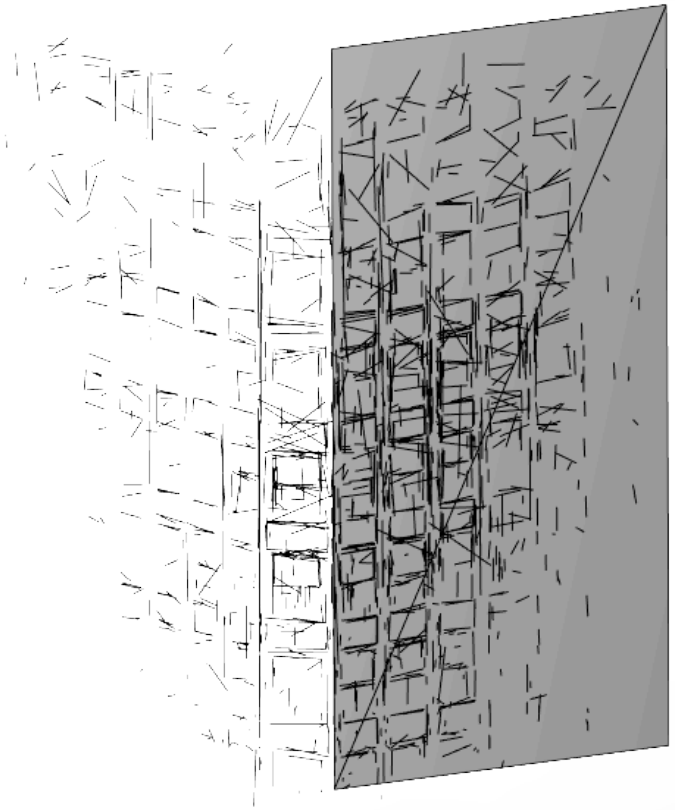


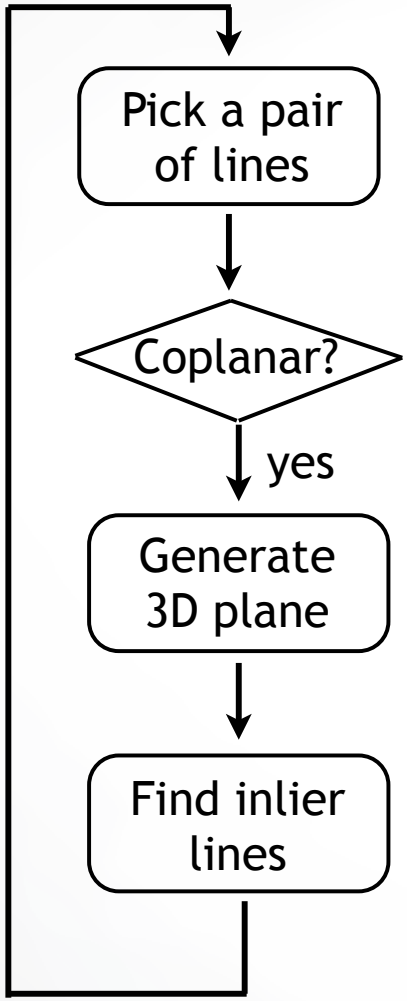
Candidate Plane Generation

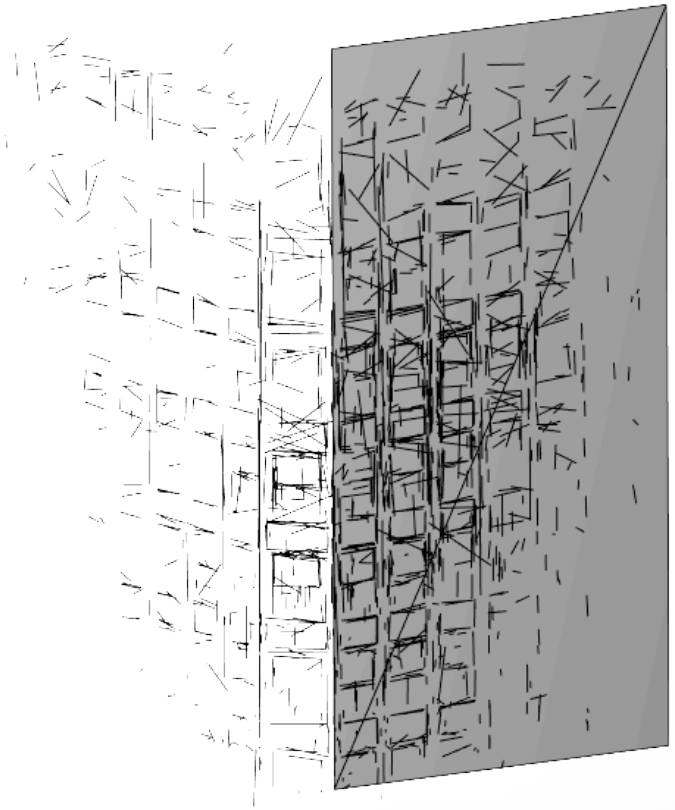




Factored Facade Acquisition Using Symmetric Line Arrangements, Ceylan et al.

Candidate Plane Generation





Factored Facade Acquisition Using Symmetric Line Arrangements, Ceylan et al.

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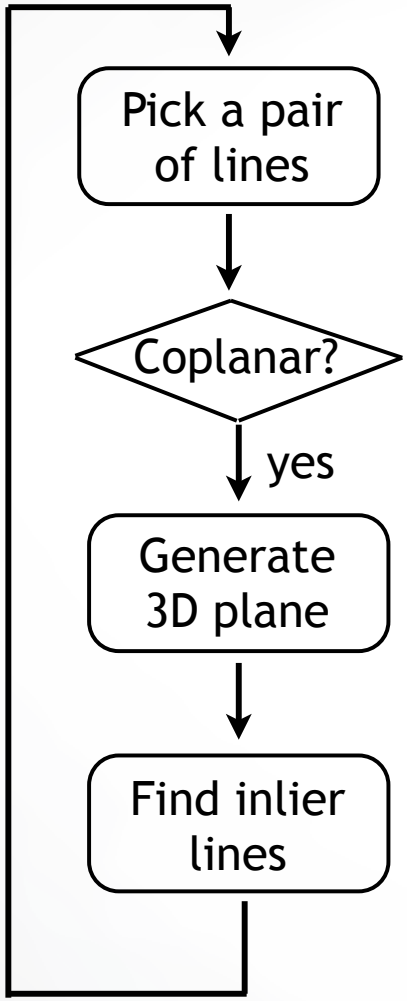

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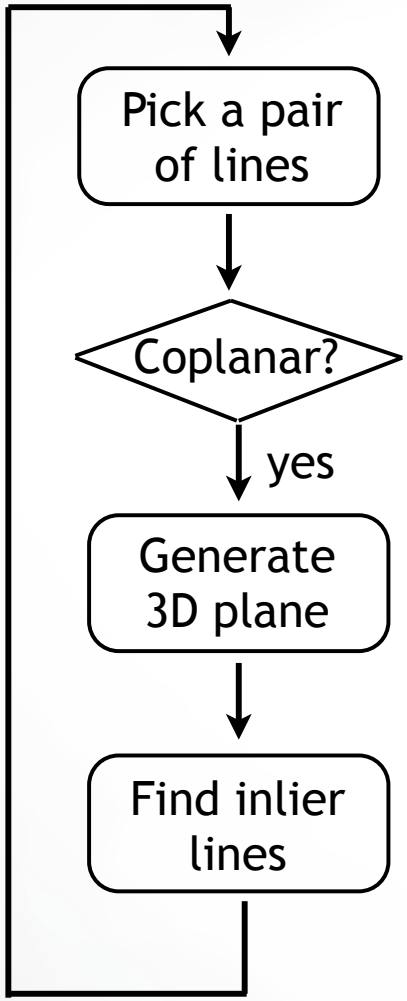
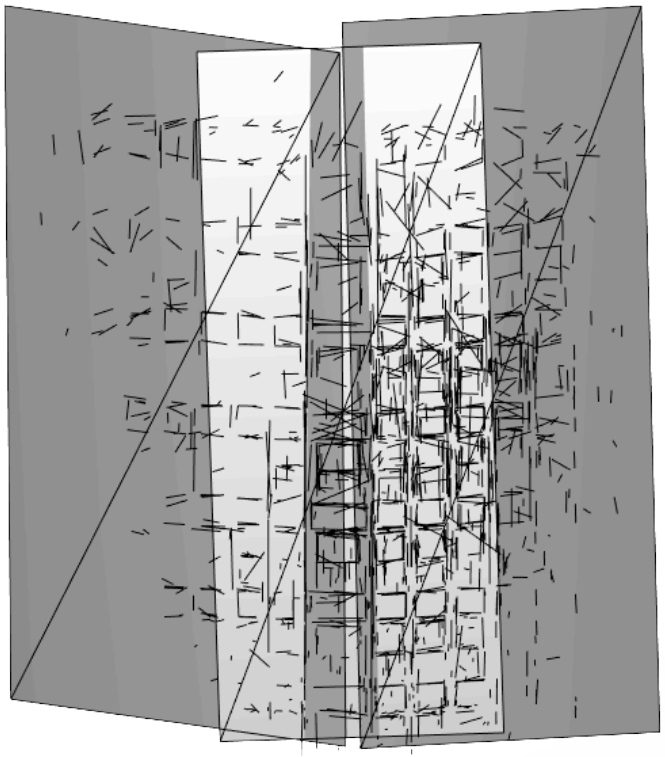
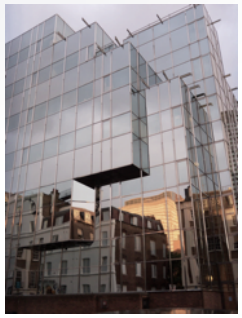
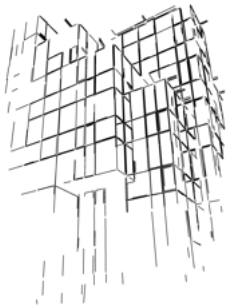


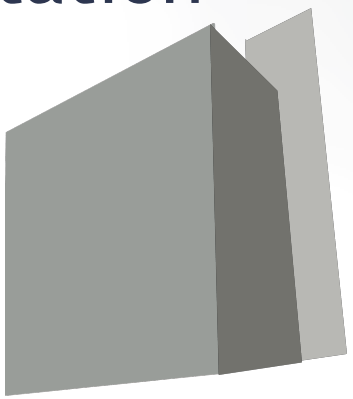


Factored Facade Acquisition Using Symmetric Line Arrangements, Ceylan et al.

Image Segmentation







Factored Facade Acquisition Using Symmetric Line Arrangements, Ceylan et al.

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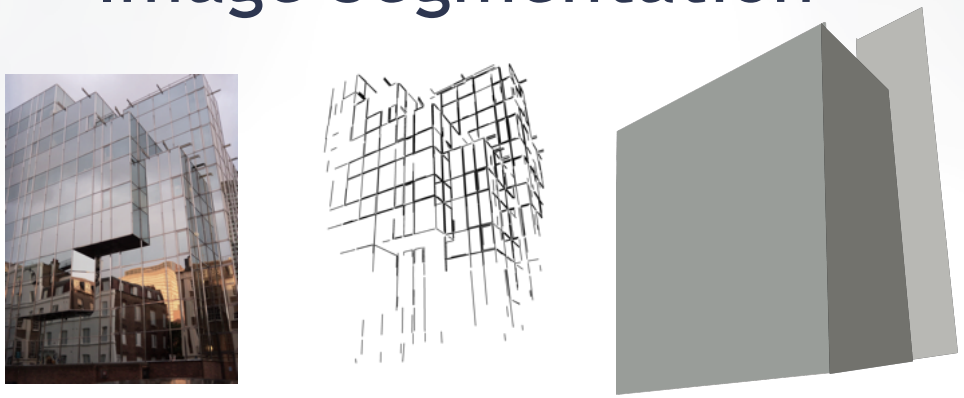
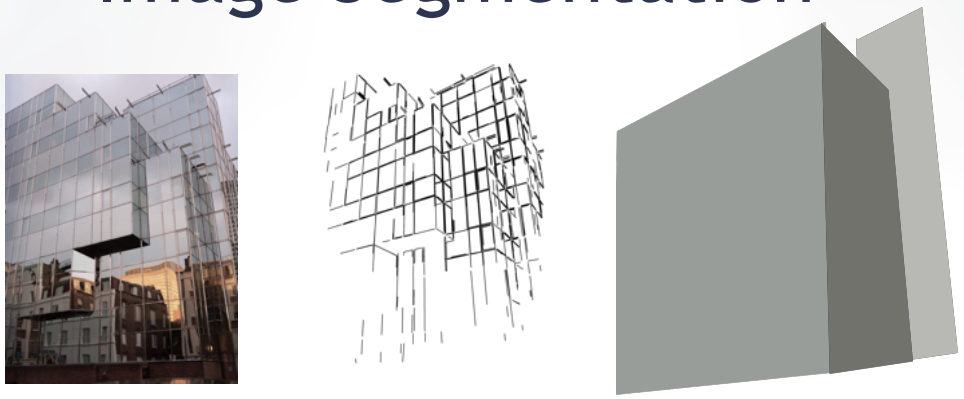


What is the most likely plane assignment for each pixel?

Image Segmentation



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Factored Facade Acquisition Using Symmetric Line Arrangements, Ceylan et al.

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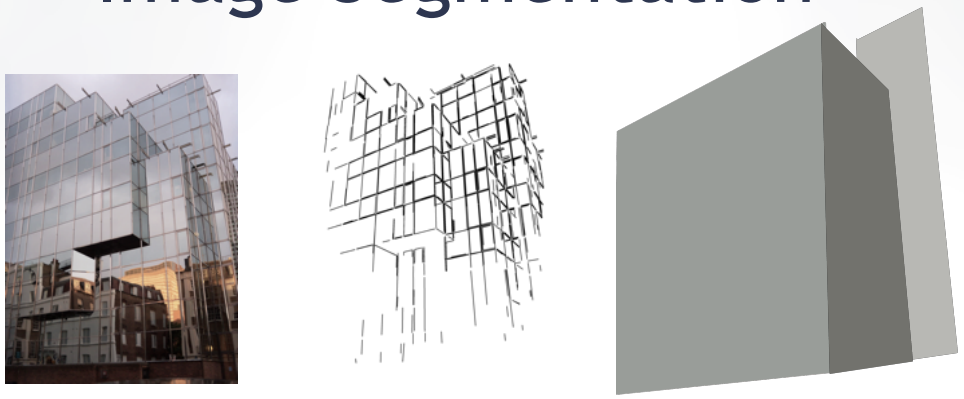

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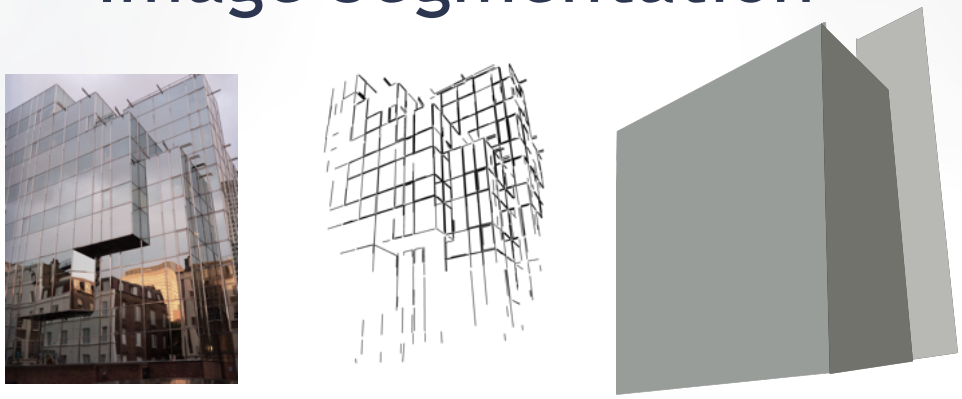

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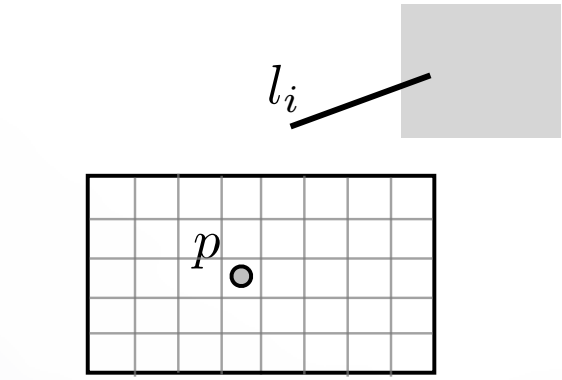
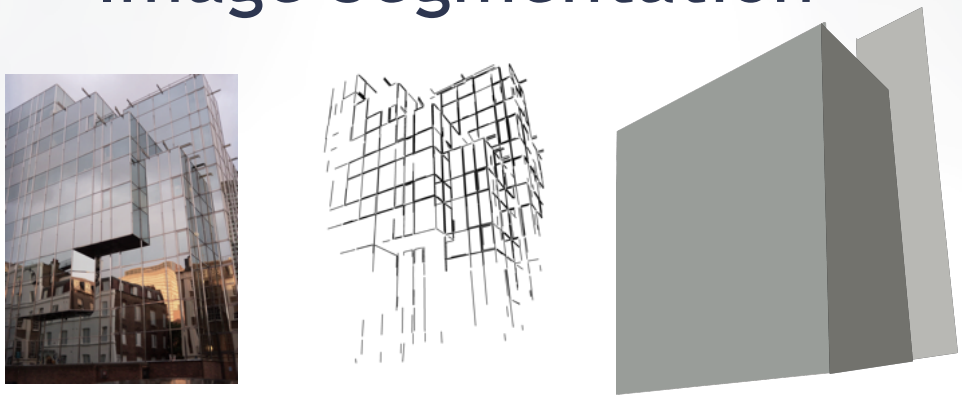


Image Segmentation



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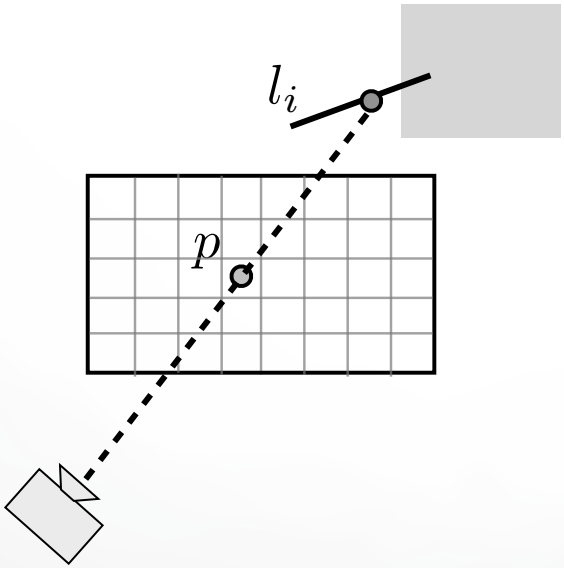

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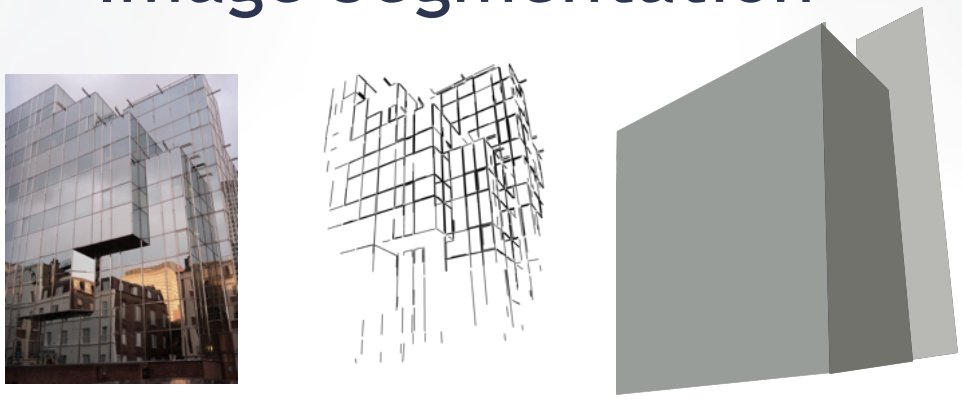

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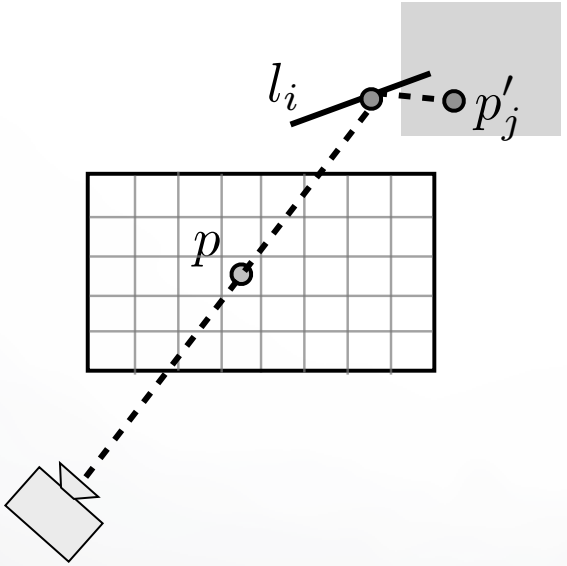

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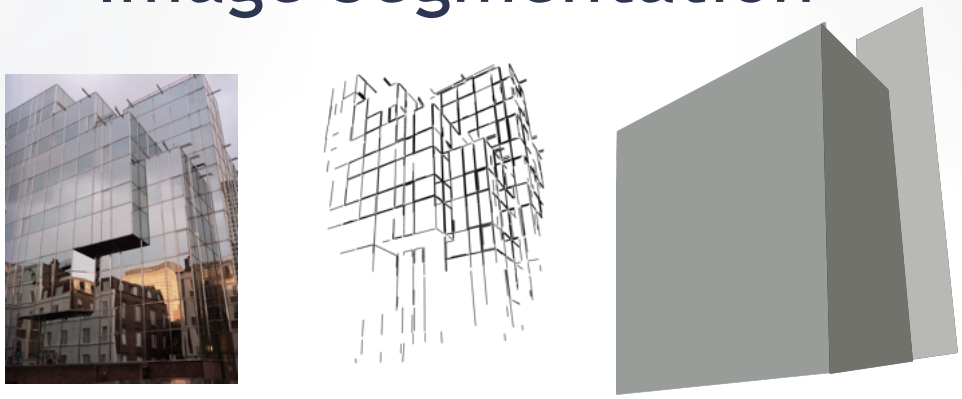

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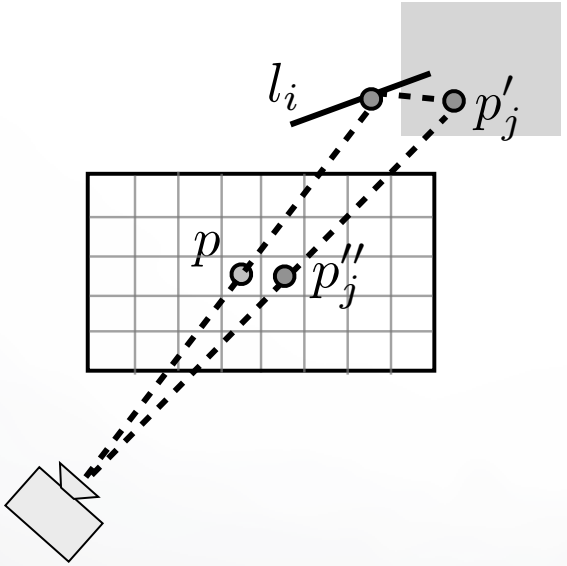
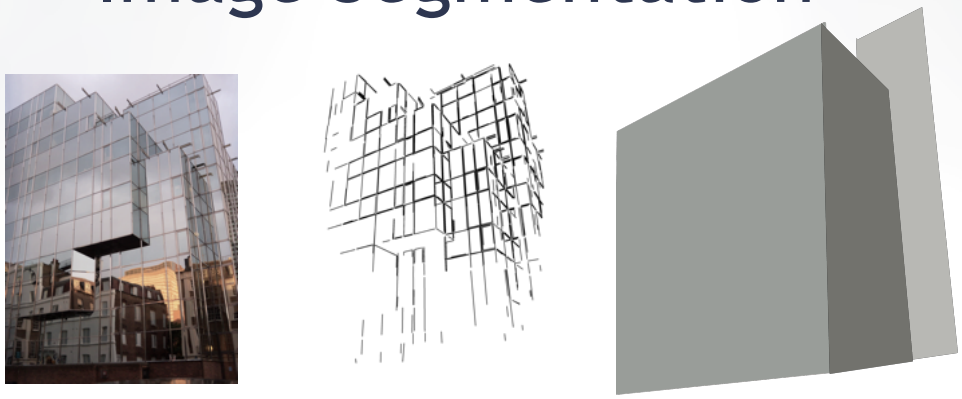


Factored Facade Acquisition Using Symmetric Line Arrangements, Ceylan et al.

Image Segmentation



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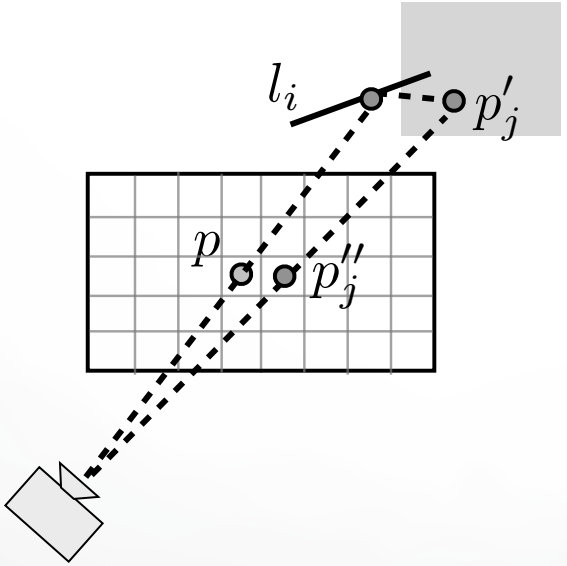

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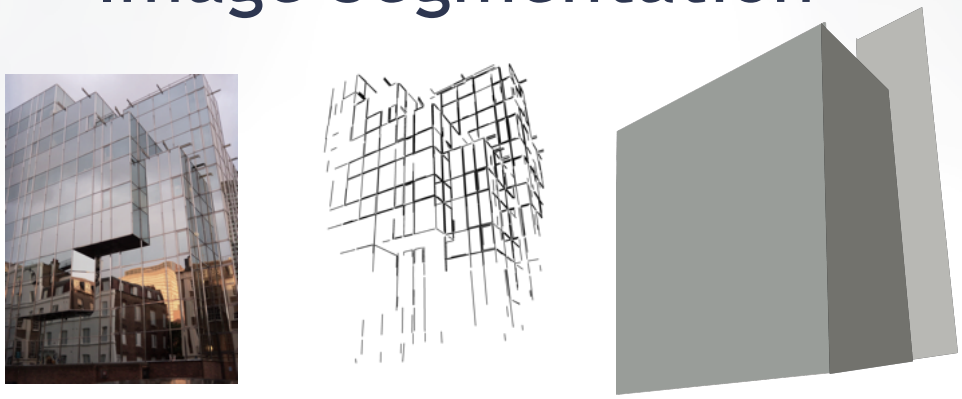

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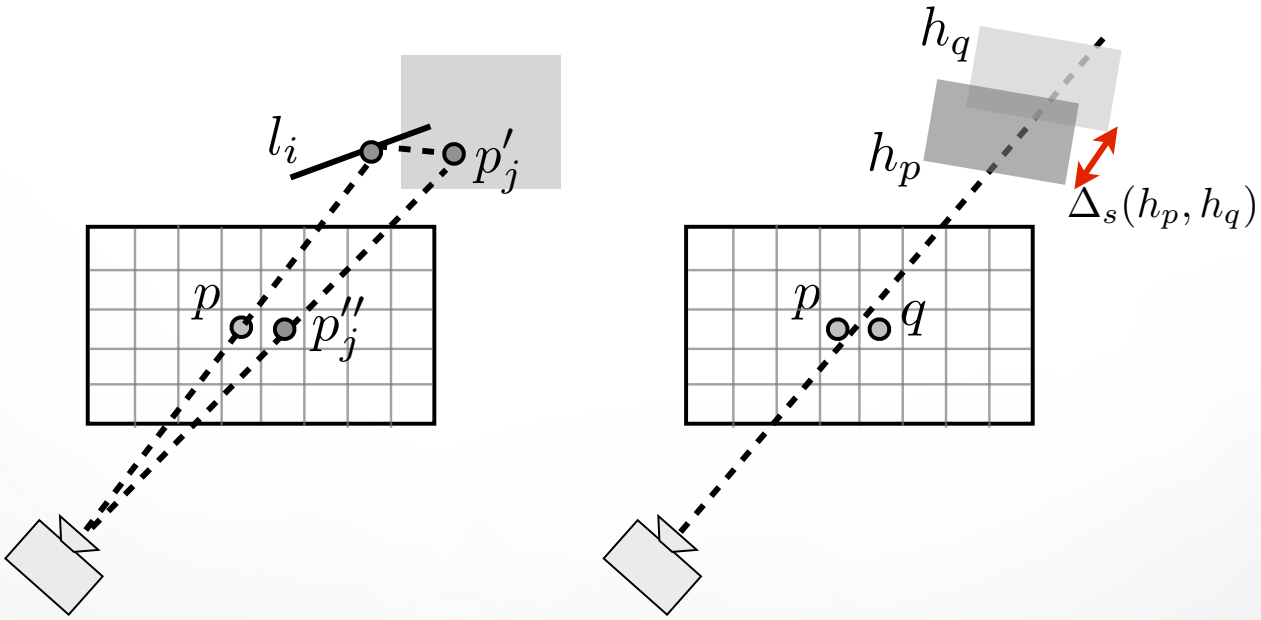
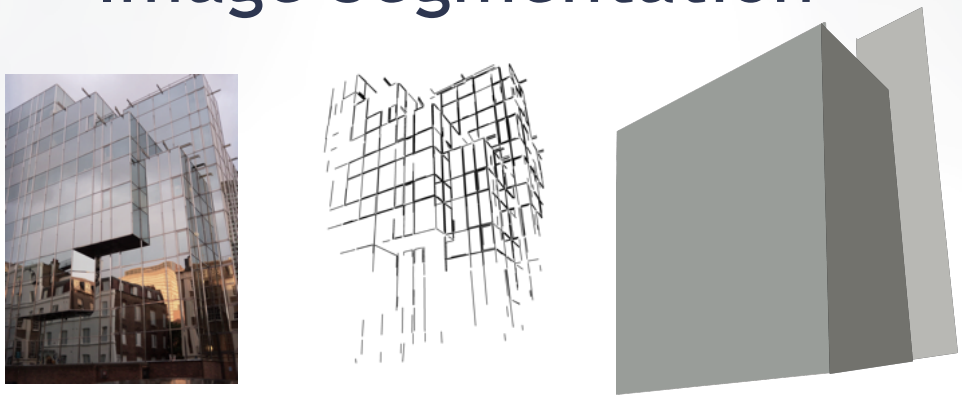


Image Segmentation



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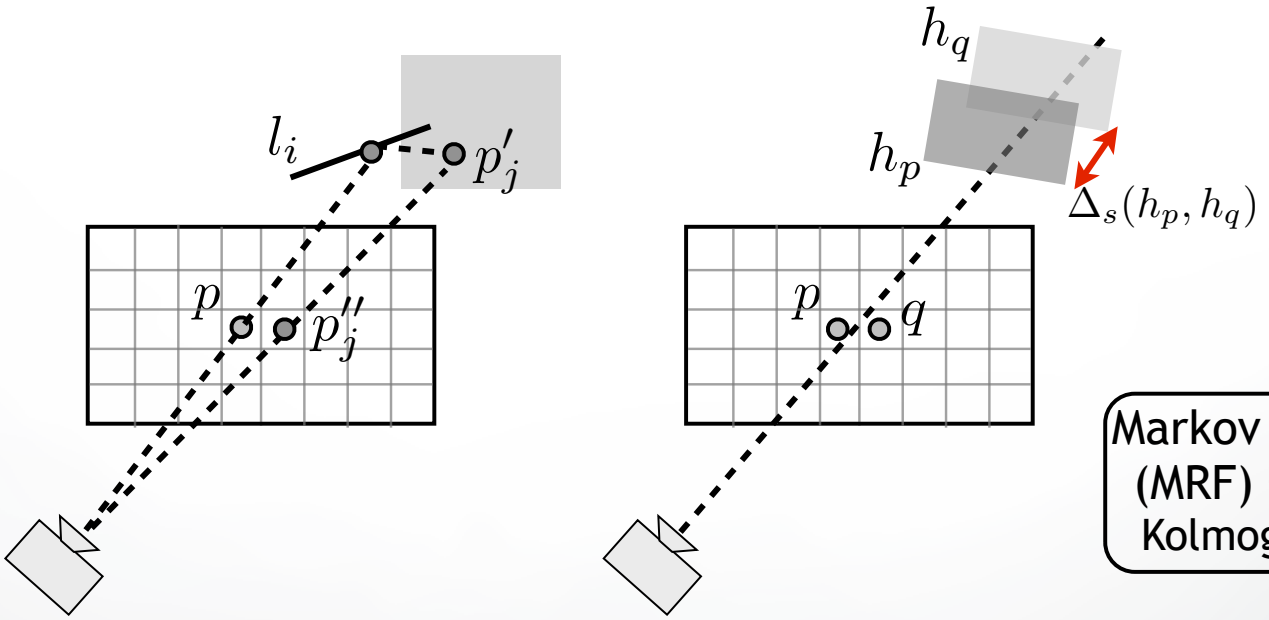


Markov Random Field (MRF) Optimization
Kolmogorov Pami'06

Factored Facade Acquisition Using Symmetric Line Arrangements, Ceylan et al.

Refined Segmentation

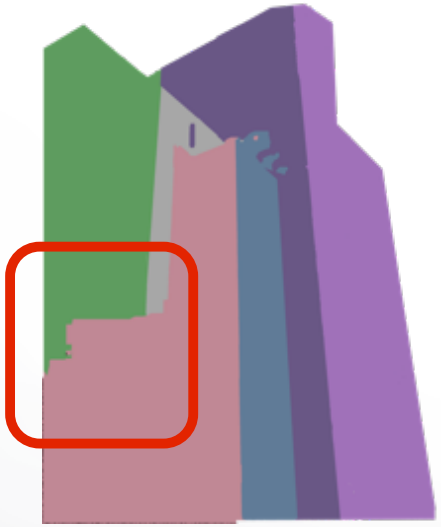
input

MRF optimization

Refined Segmentation

input

MRF optimization



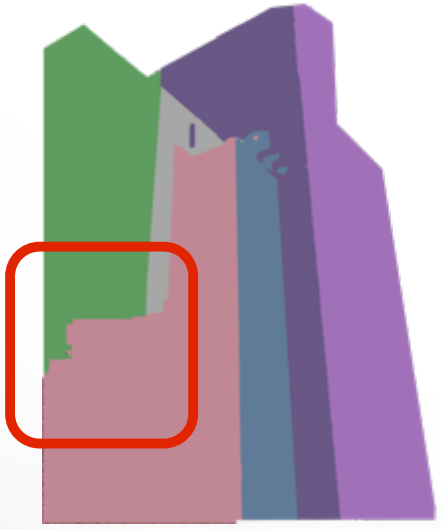
plane intersections

Factored Facade Acquisition Using Symmetric Line Arrangements, Ceylan et al.

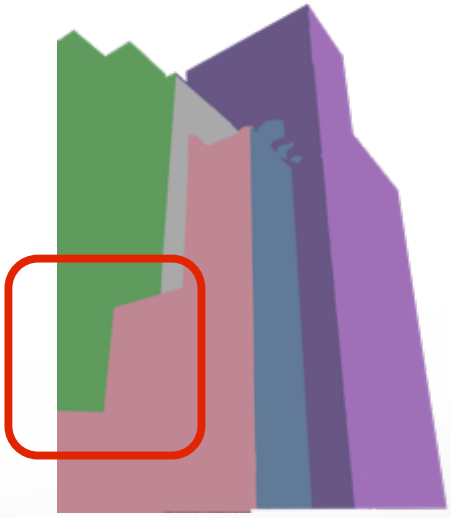
Refined Segmentation

input

MRF optimization



plane intersections

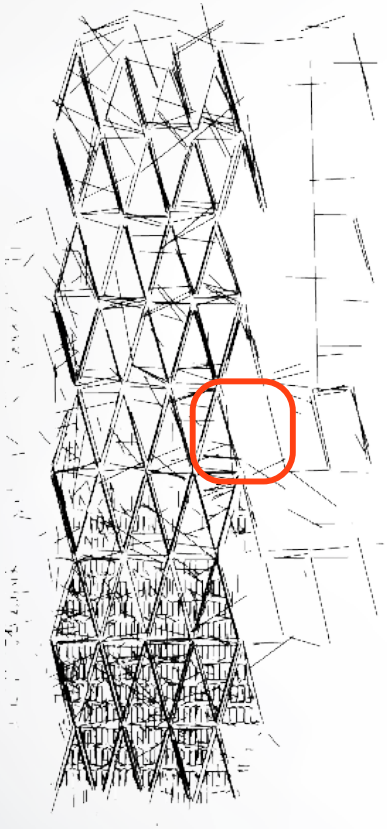


user correction

Factored Facade Acquisition Using Symmetric Line Arrangements, Ceylan et al.

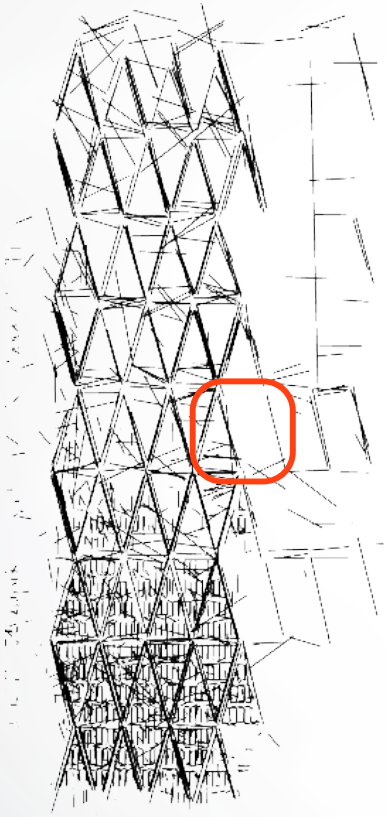
User Assistance

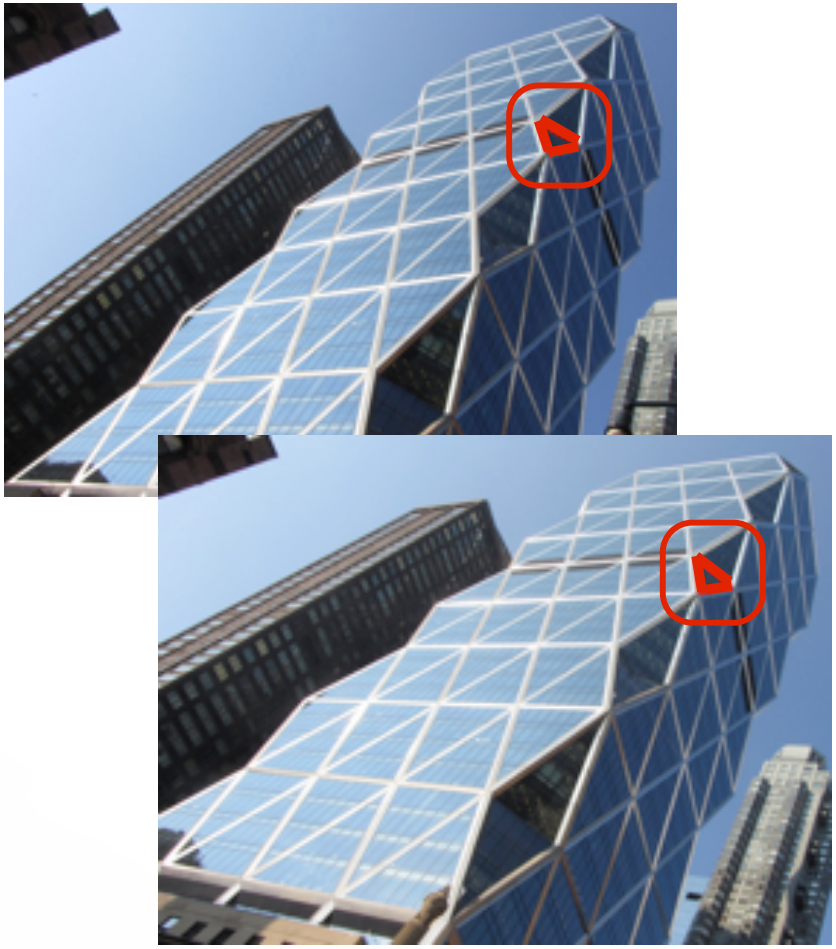
User Assistance



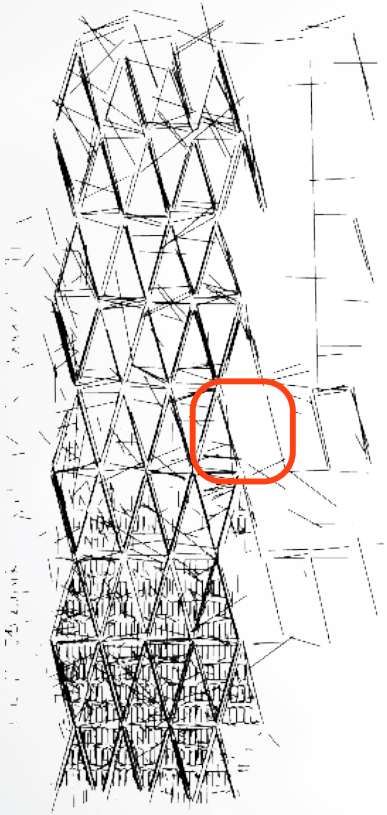
Factored Facade Acquisition Using Symmetric Line Arrangements, Ceylan et al.

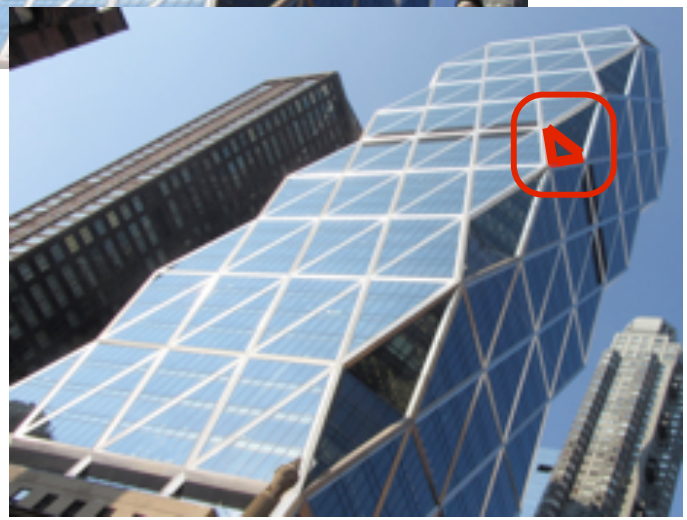
User Assistance

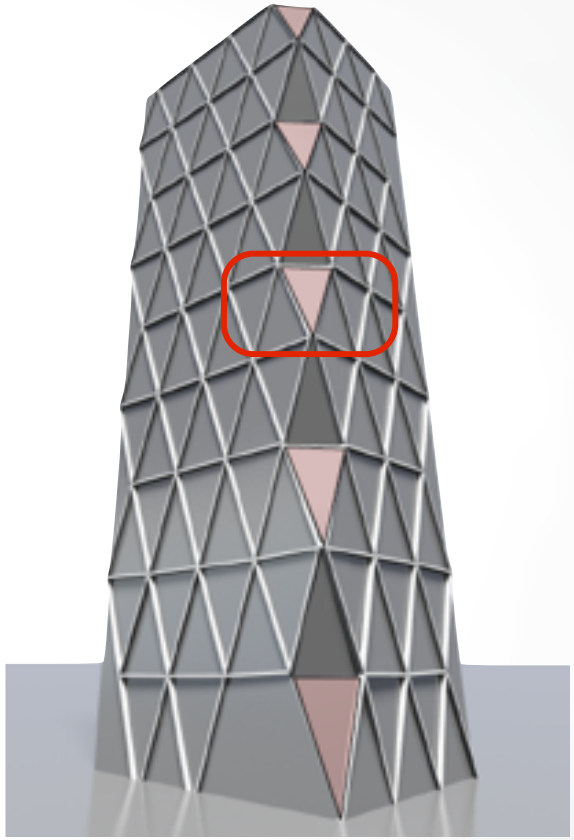




User Assistance

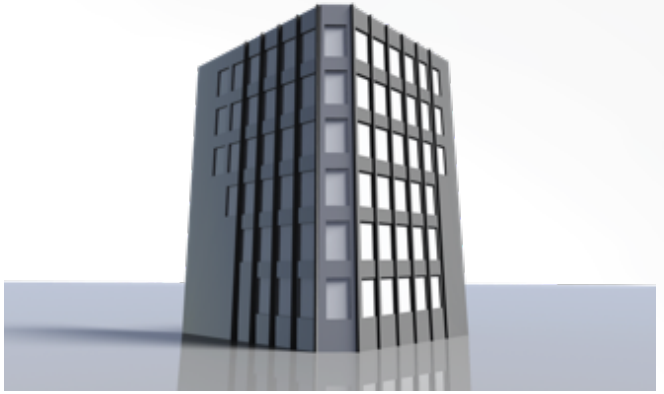




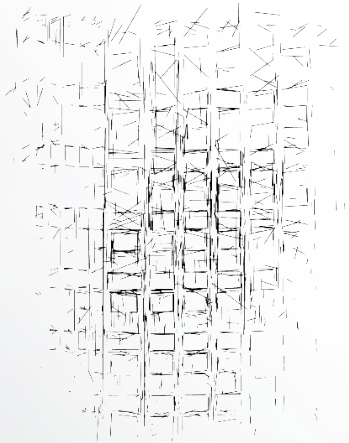


Factored Facade Acquisition Using Symmetric Line Arrangements, Ceylan et al.

input images

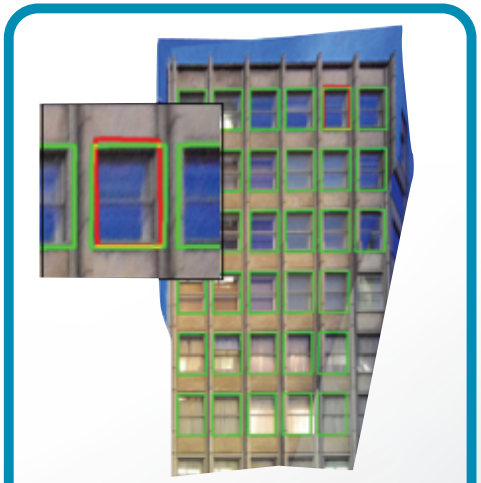


output reconstruction



3D lines

plane fitting

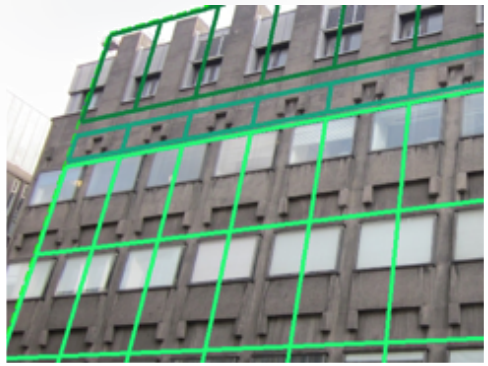


structure detection

Factored Facade Acquisition Using Symmetric Line Arrangements, Ceylan et al.

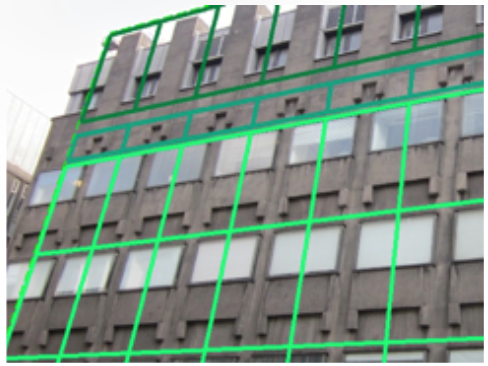
Symmetry Detection

Symmetry Detection



Wu et al. CVPR'10

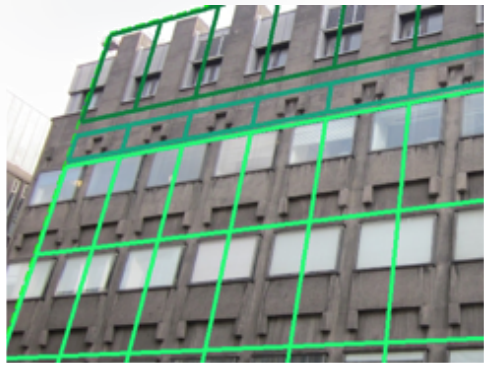
Symmetry Detection



Wu et al. CVPR'10

user-guided selection

Symmetry Detection

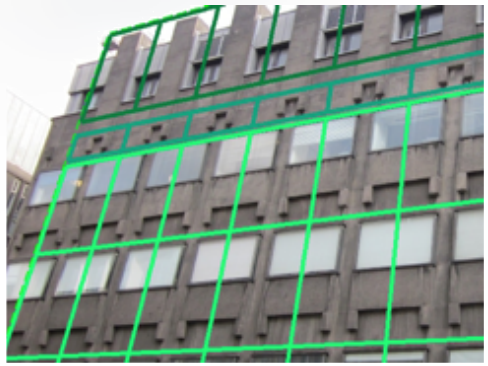


Wu et al. CVPR'10

user-guided selection

texture-based similarity

Symmetry Detection



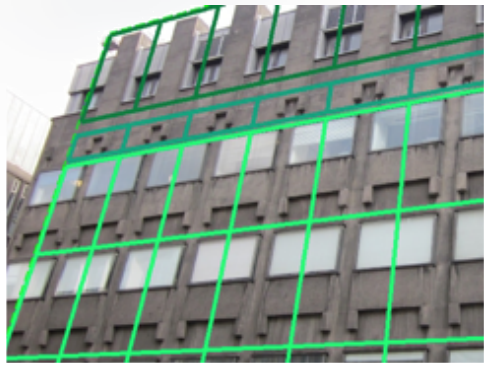
Wu et al. CVPR'10

user-guided selection

texture-based similarity

feature-line similarity

Symmetry Detection



Wu et al. CVPR'10

user-guided selection

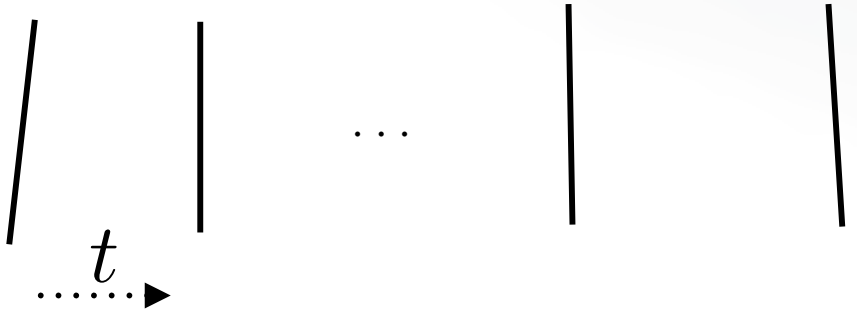
$\alpha \cdot$

texture-based similarity

$+\beta \cdot$

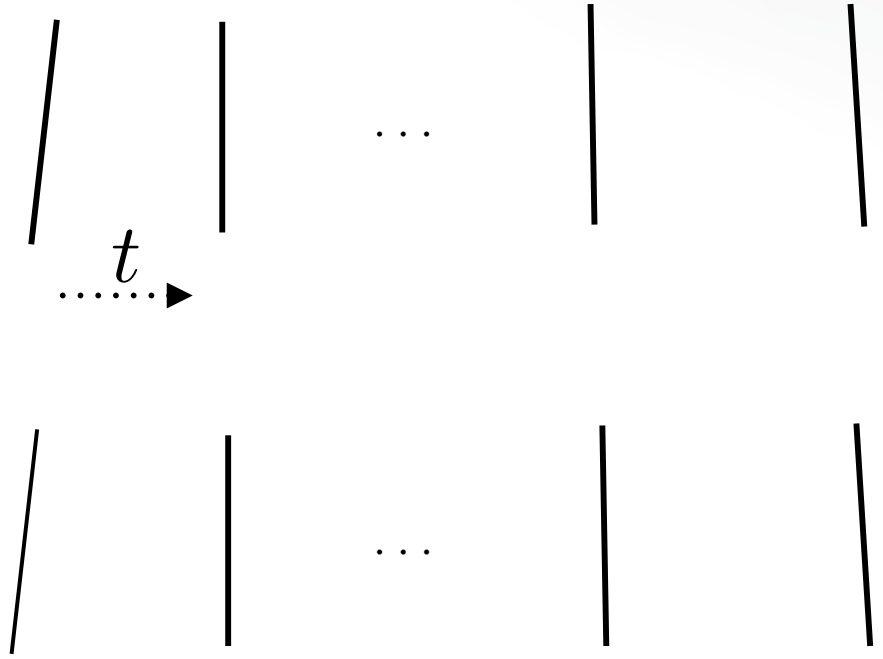
feature-line similarity

Symmetry Refinement



Factored Facade Acquisition Using Symmetric Line Arrangements, Ceylan et al.

Symmetry Refinement



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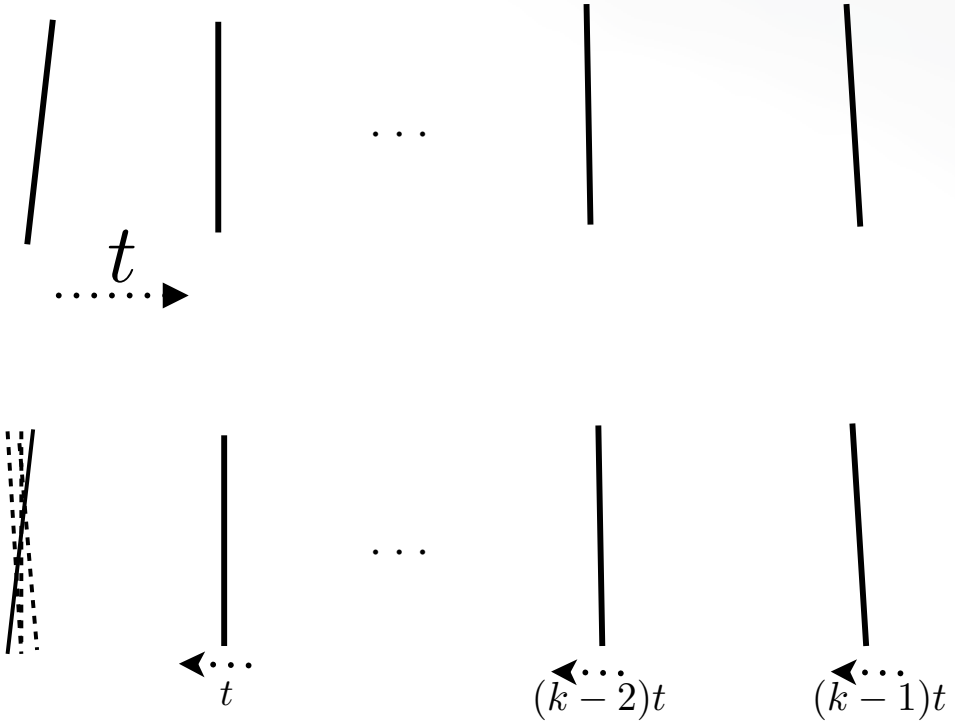

Factored Facade Acquisition Using Symmetric Line Arrangements, Ceylan et al.

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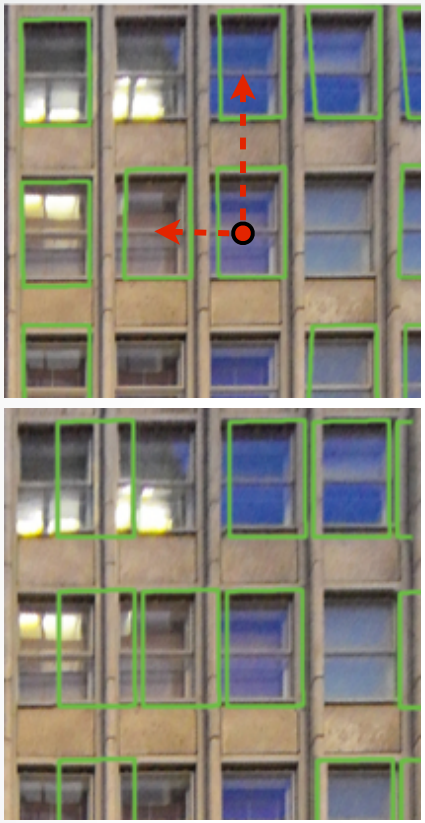
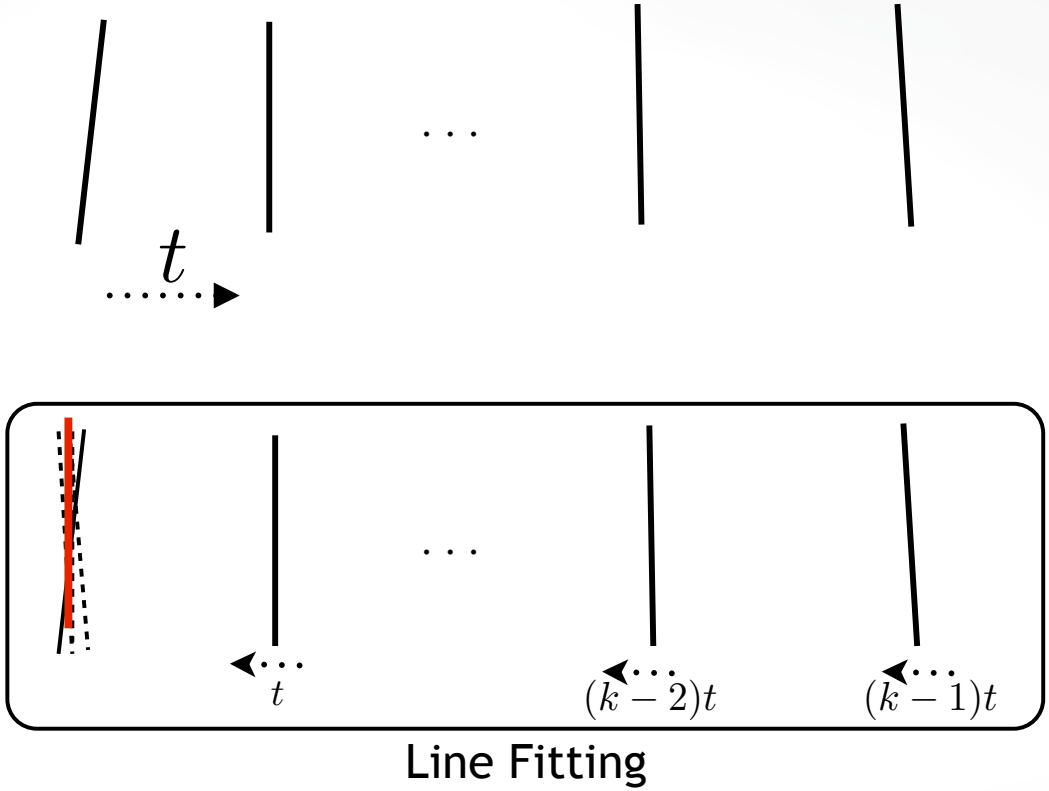
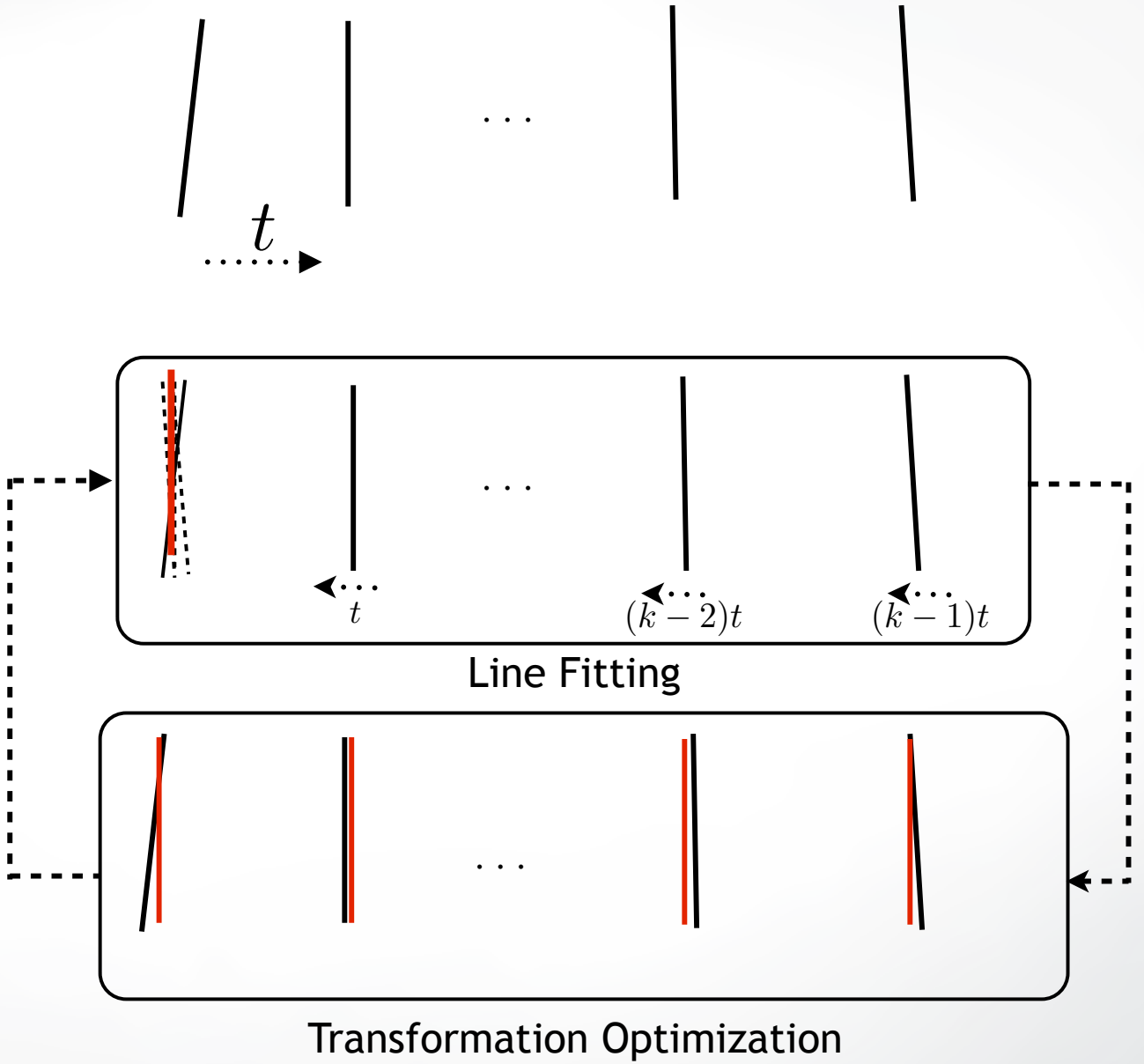




Line Fitting

Symmetry Refinement



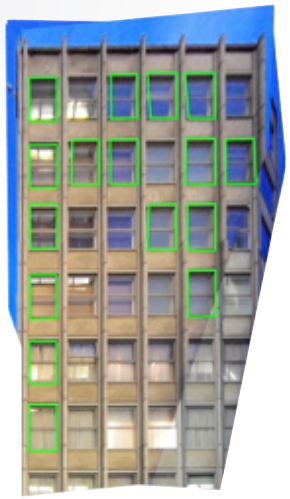
Factored Facade Acquisition Using Symmetric Line Arrangements, Ceylan et al.

Structure Completion

input

Structure Completion

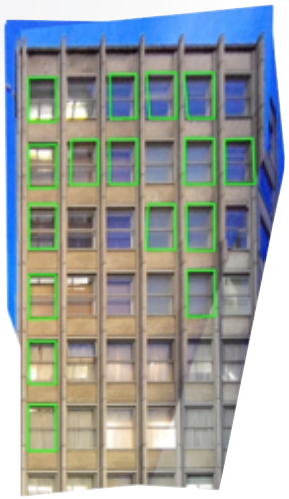
input



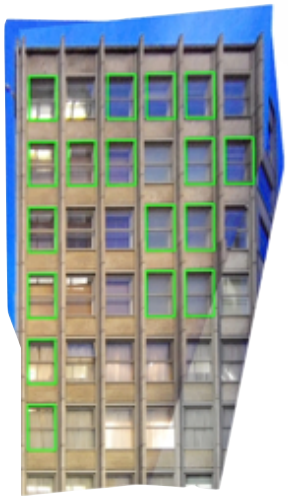
initial detection

Structure Completion

input



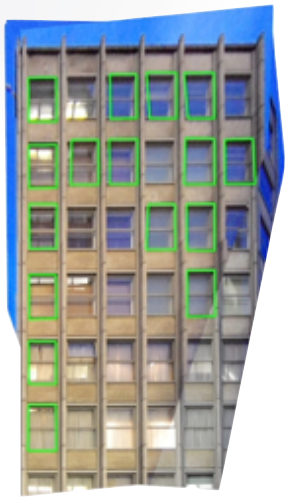
initial detection



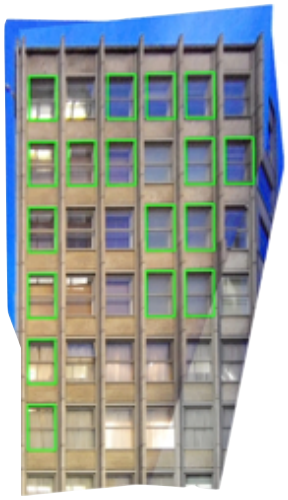
initial refinement

Structure Completion

input



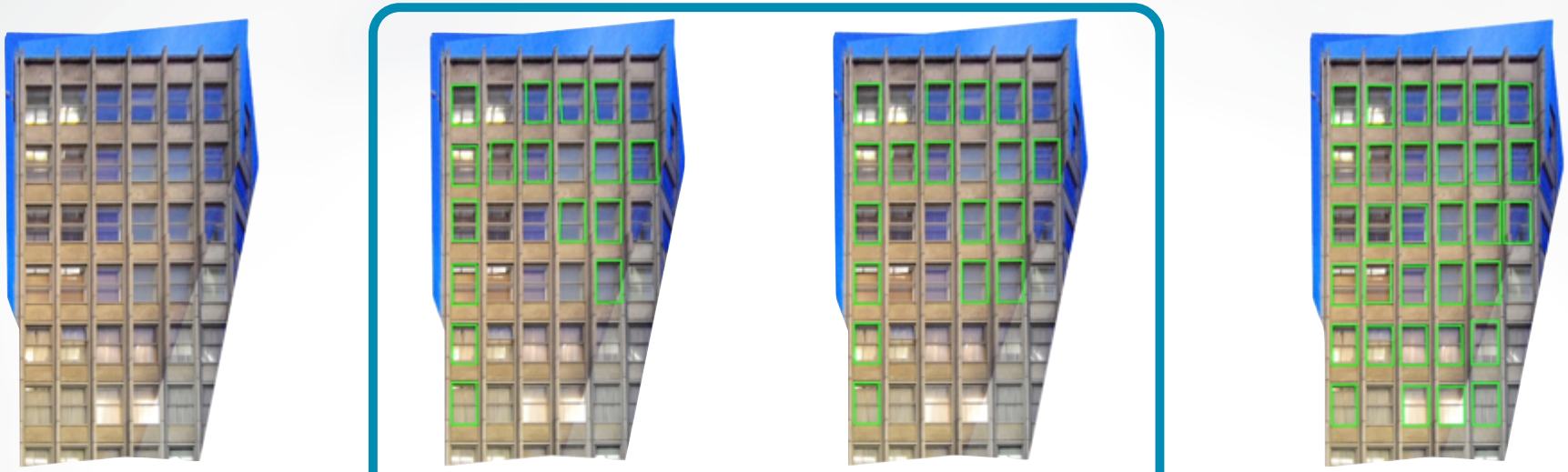
initial detection



initial refinement

projected 3D lines

Structure Completion

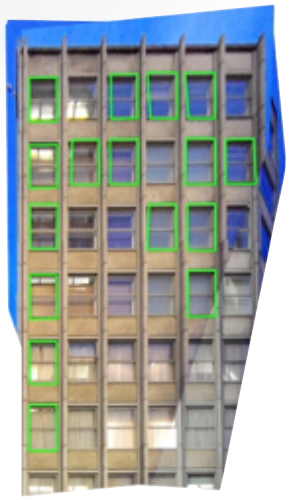


input | initial detection | initial refinement | completion

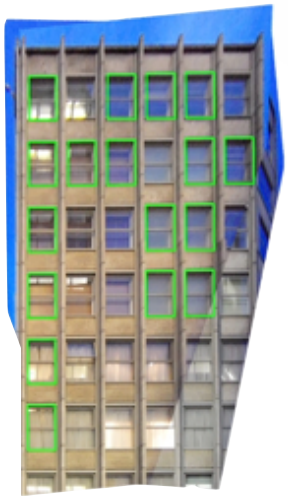
projected 3D lines

Structure Completion

input

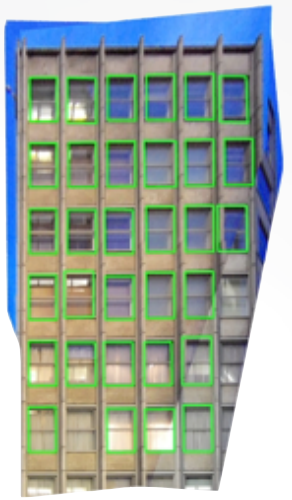


initial detection



initial refinement

projected 3D lines

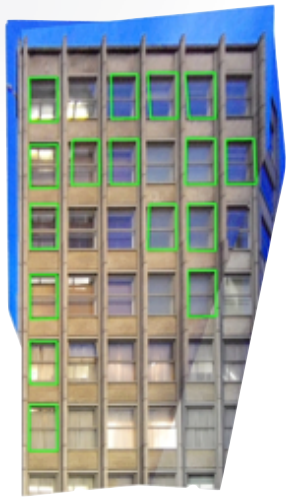


completion

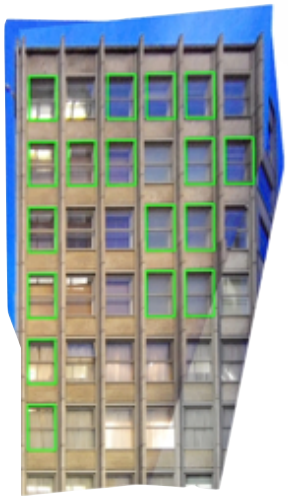
2D lines

Structure Completion

input

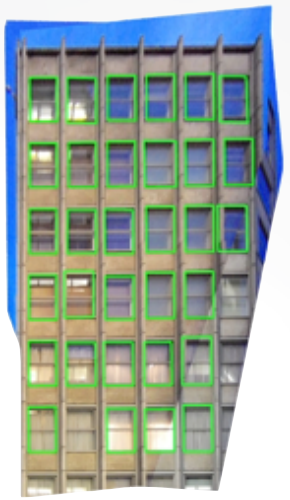


initial detection



initial refinement

projected 3D lines



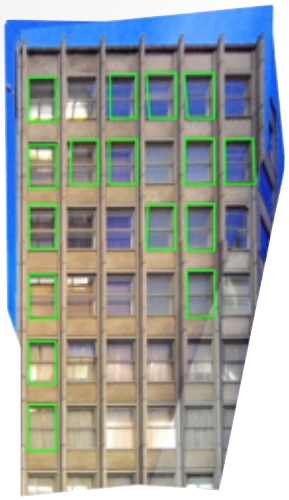
completion

2D lines

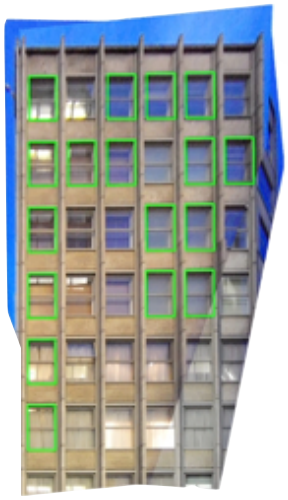
final refinement:

Structure Completion

input

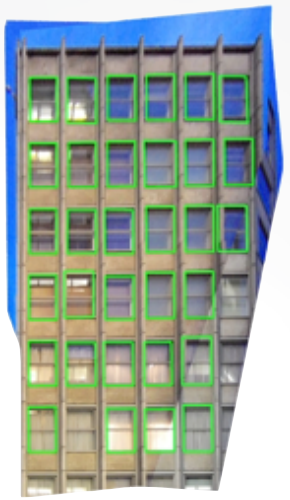


initial detection



initial refinement

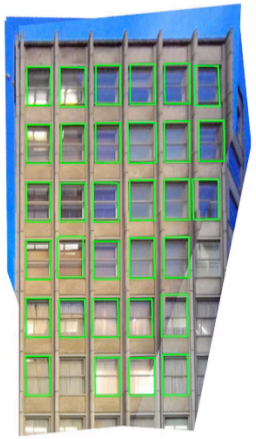
projected 3D lines



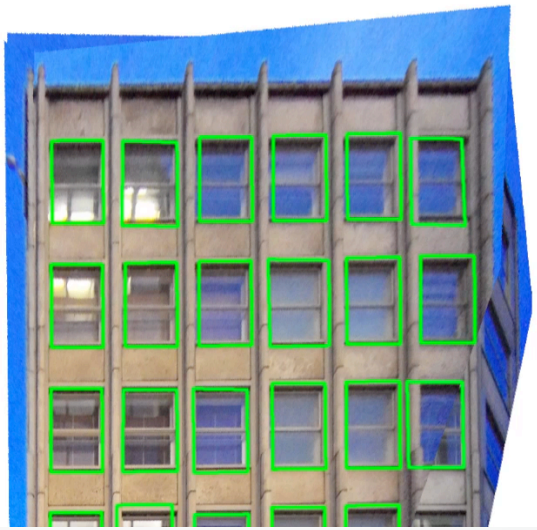
completion

2D lines

final refinement:

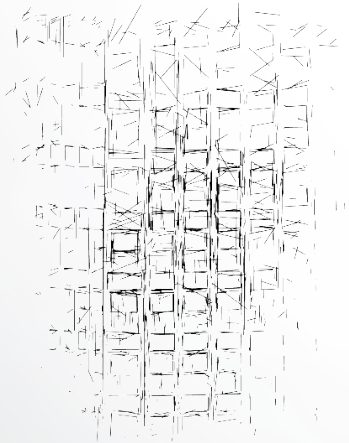


repetition completion



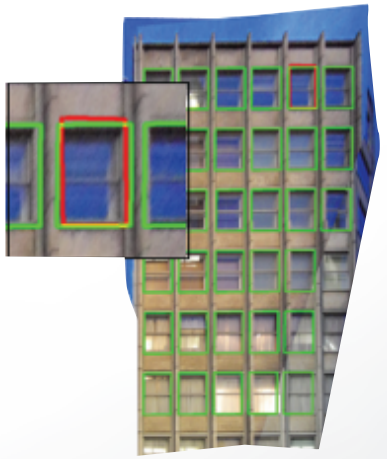
Factored Facade Acquisition Using Symmetric Line Arrangements, Ceylan et al.

input images

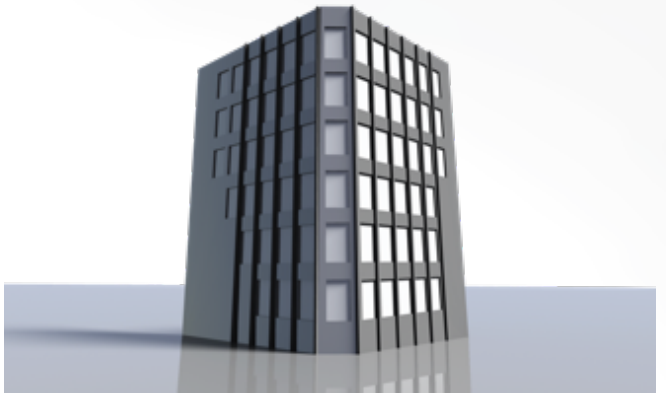


3D lines

plane fitting



structure detection



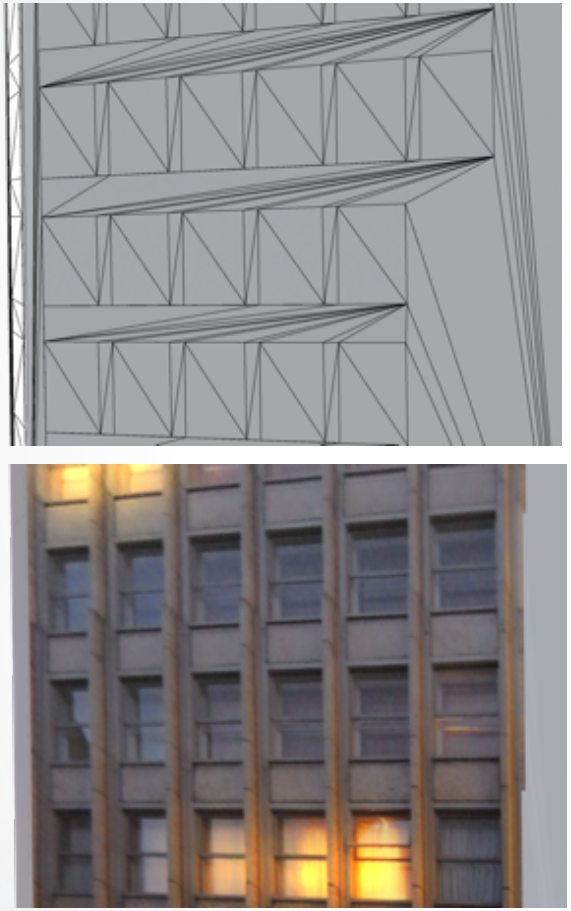
output reconstruction

Factored Facade Acquisition Using Symmetric Line Arrangements, Ceylan et al.

Procedural Depth Refinement

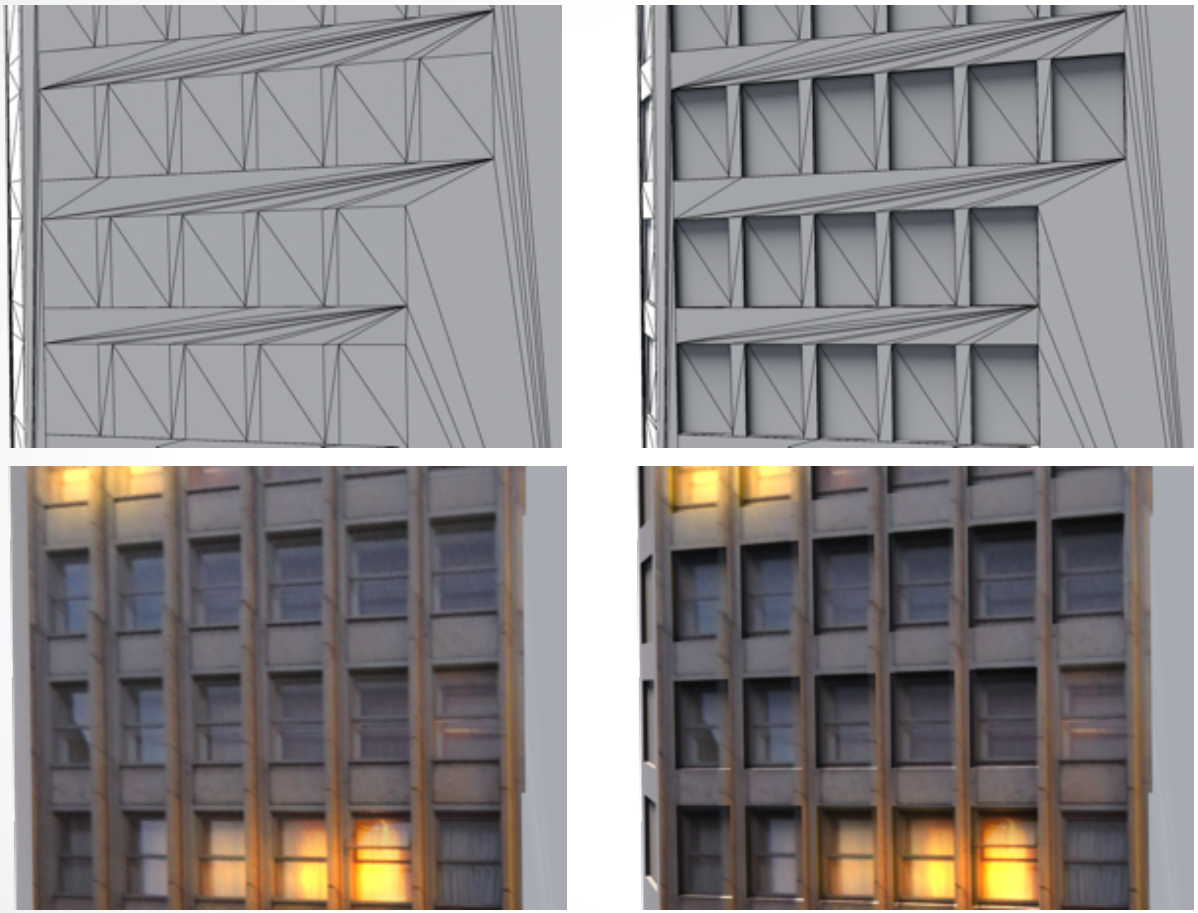
Factored Facade Acquisition Using Symmetric Line Arrangements, Ceylan et al.

Procedural Depth Refinement



no user edit

Procedural Depth Refinement



no user edit

window extrusion

Factored Facade Acquisition Using Symmetric Line Arrangements, Ceylan et al.

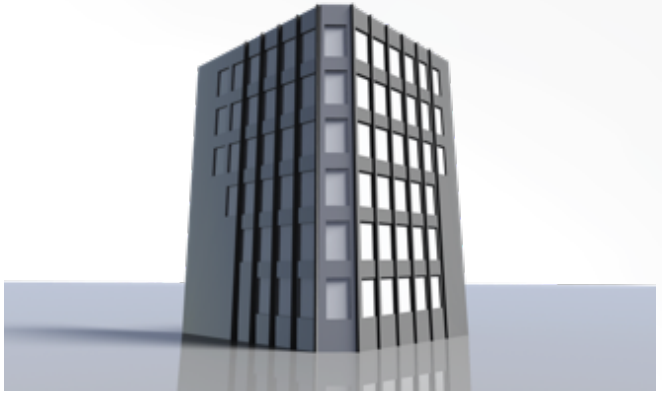
Procedural Depth Refinement

no user edit | window extrusion | beam extrusion

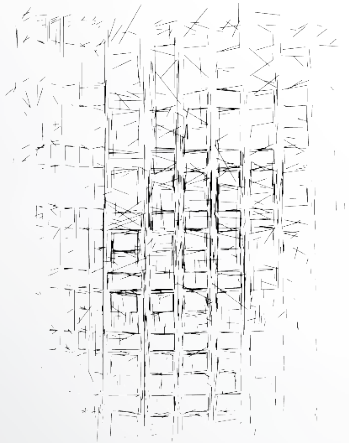
Factored Facade Acquisition Using Symmetric Line Arrangements, Ceylan et al.

Summary

input images

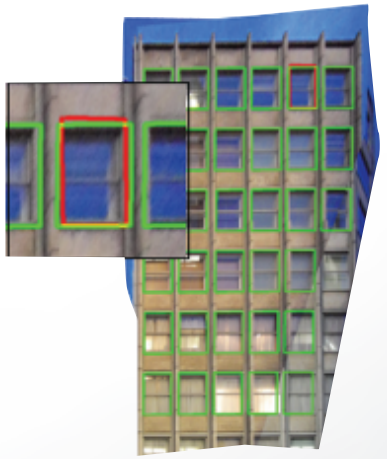


output reconstruction



3D lines

plane fitting

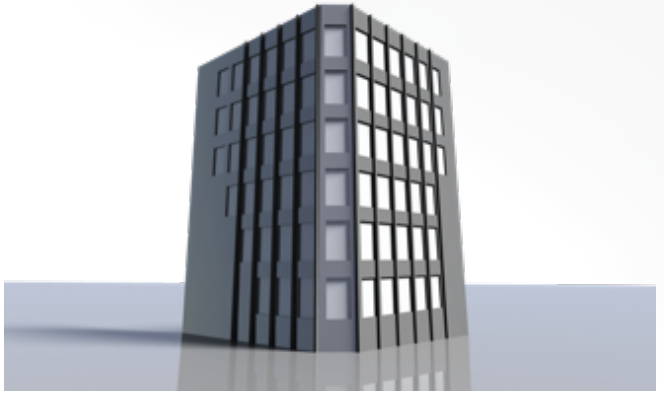


structure detection

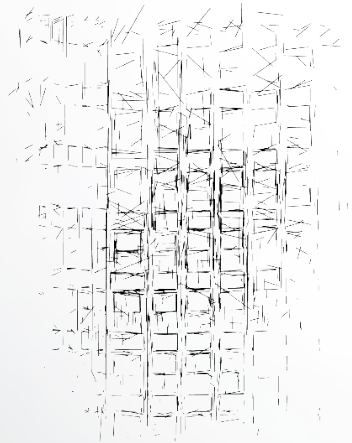
Factored Facade Acquisition Using Symmetric Line Arrangements, Ceylan et al.

Summary

input images



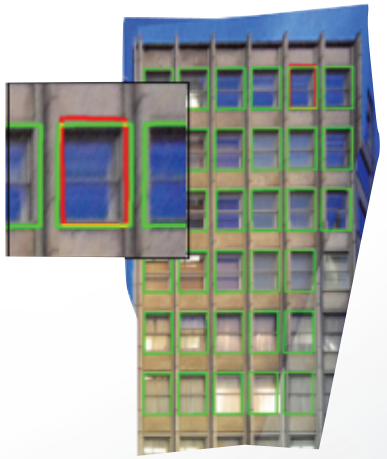
output reconstruction



3D lines

plane fitting

geometric priors



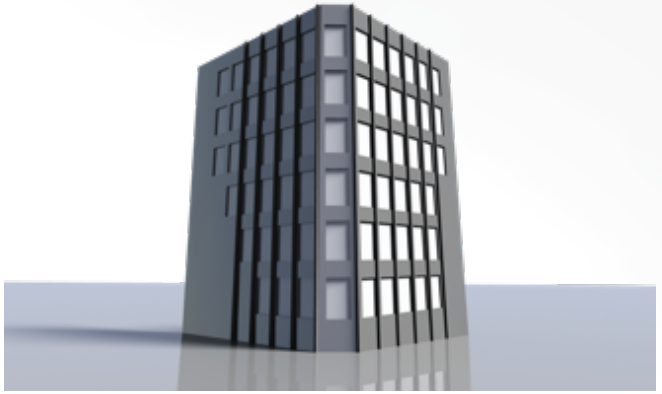
structure detection

structural priors

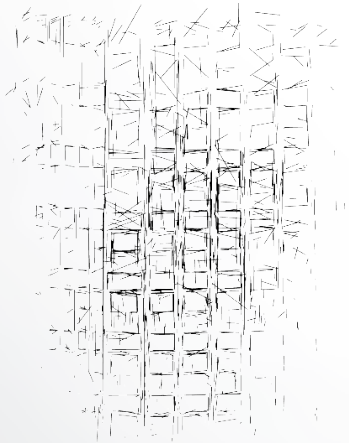
Factored Facade Acquisition Using Symmetric Line Arrangements, Ceylan et al.

Summary

input images

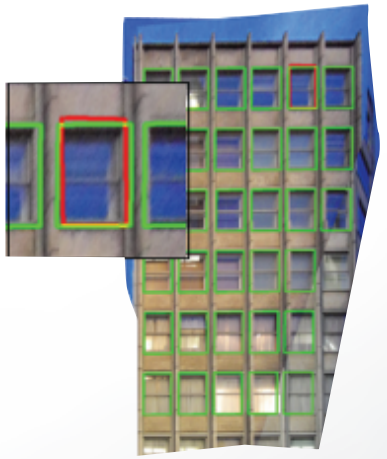


output reconstruction



3D lines

plane fitting

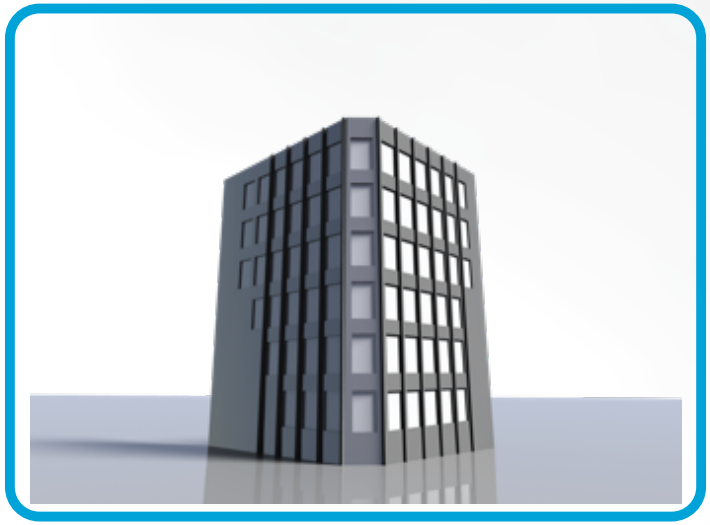


structure detection

Factored Facade Acquisition Using Symmetric Line Arrangements, Ceylan et al.

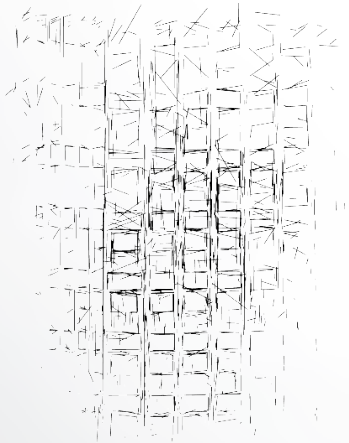
Summary

input images



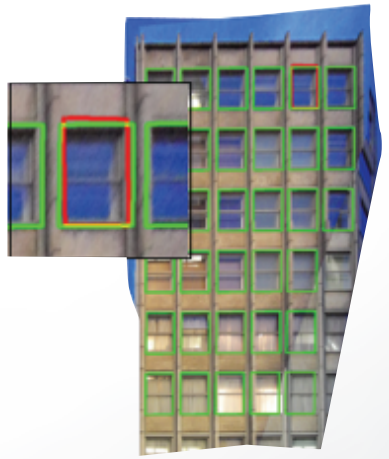
output reconstruction

user assistance



3D lines

plane fitting

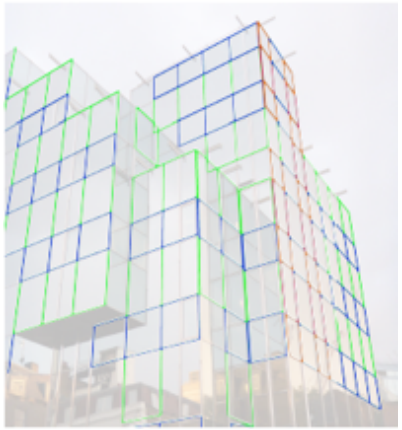


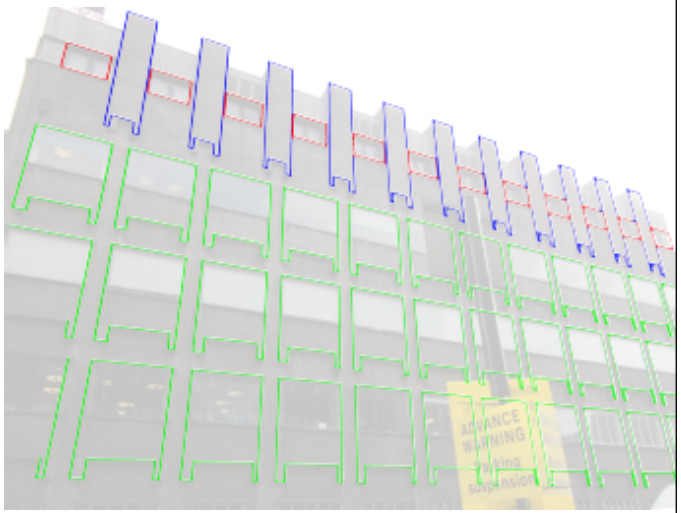
structure detection

Factored Facade Acquisition Using Symmetric Line Arrangements, Ceylan et al.

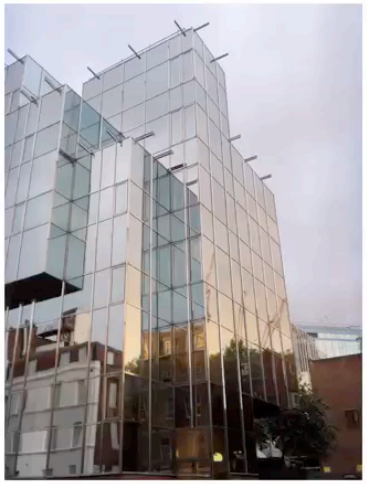
Results

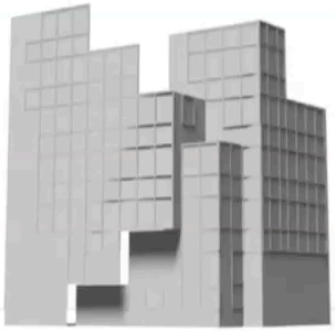
Results

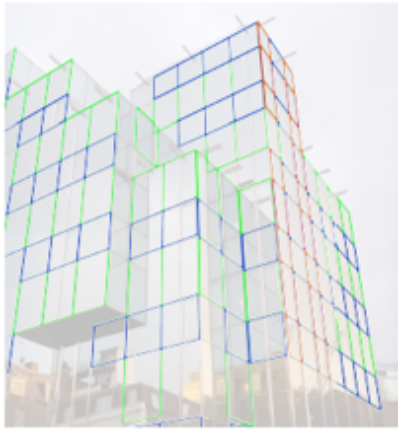


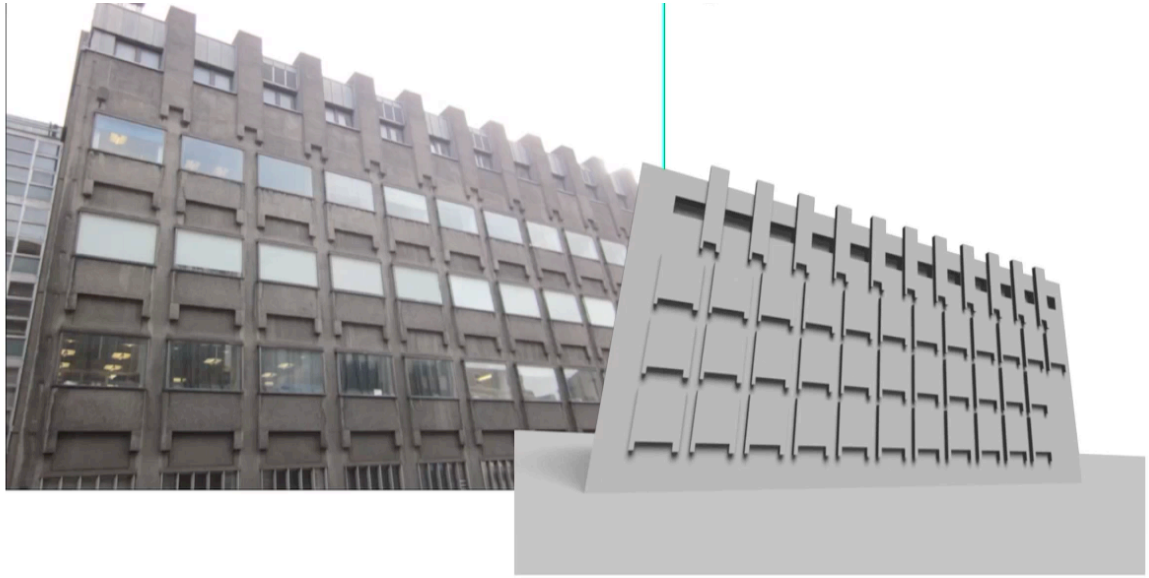


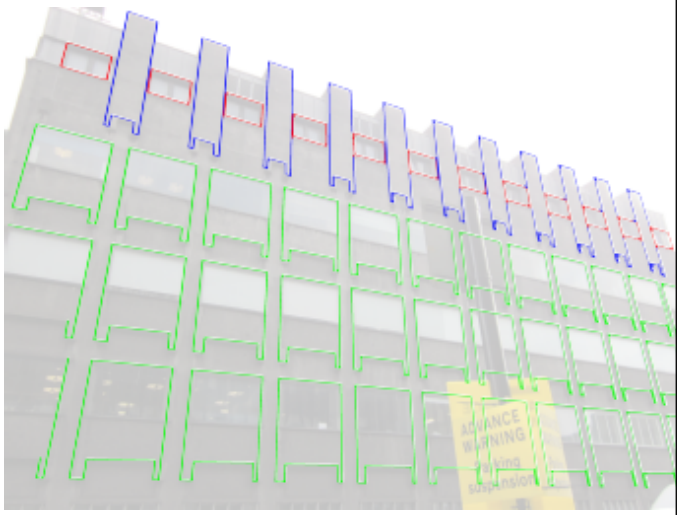
Results







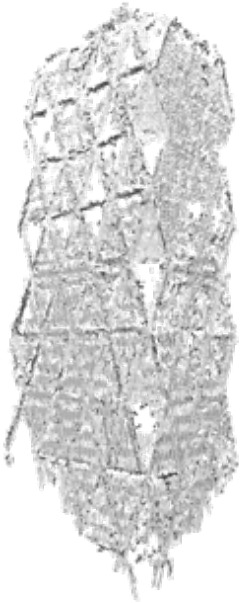




Factored Facade Acquisition Using Symmetric Line Arrangements, Ceylan et al.

Comparison to PMVS

input

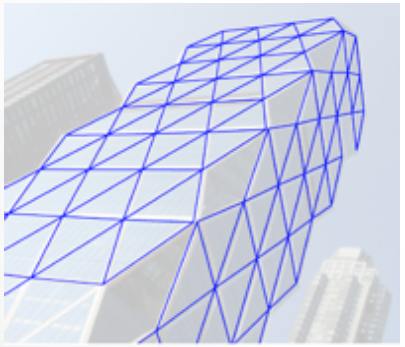


PMVS
Furukawa et al. ’09

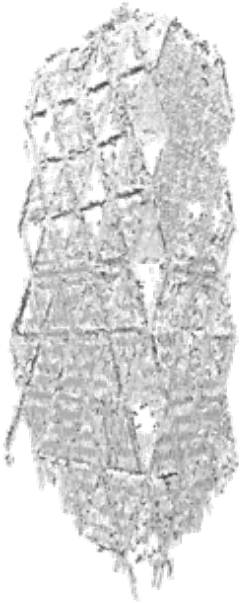
PMVS + Poisson

Comparison to PMVS

input



repetition detection



PMVS
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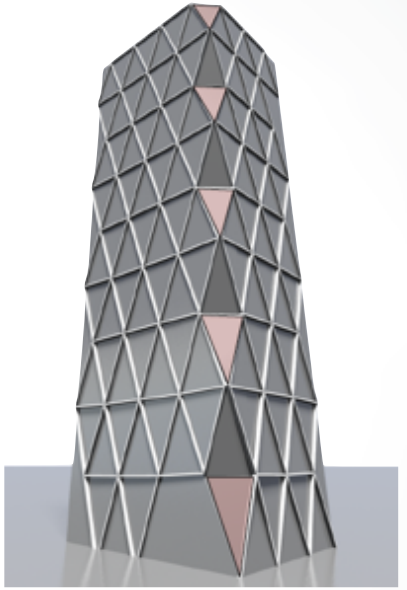
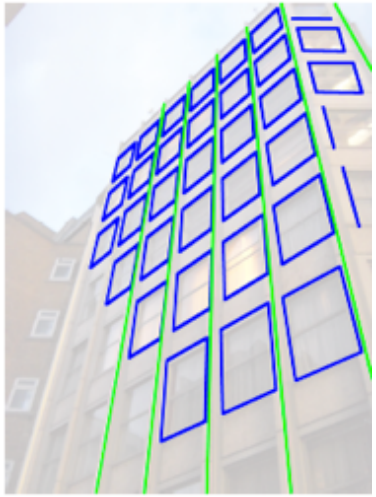
PMVS + Poisson



our reconstruction

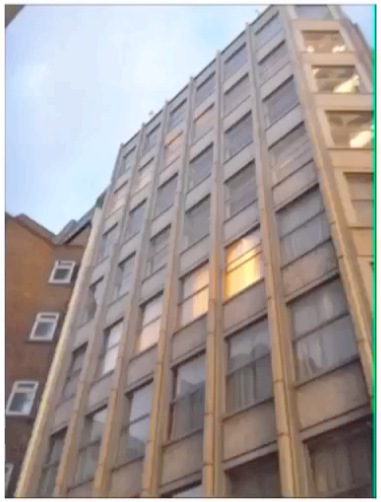
More Results

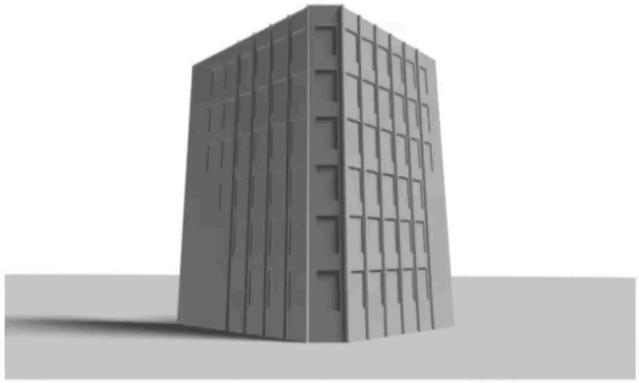
More Results

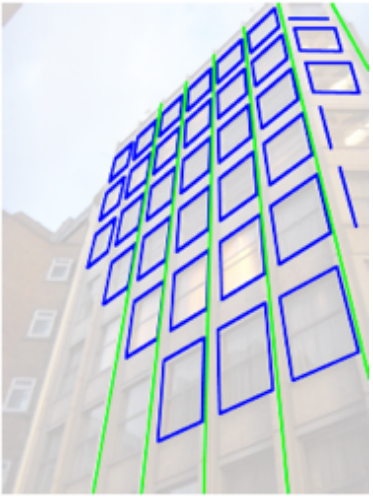


Factored Facade Acquisition Using Symmetric Line Arrangements, Ceylan et al.

More Results



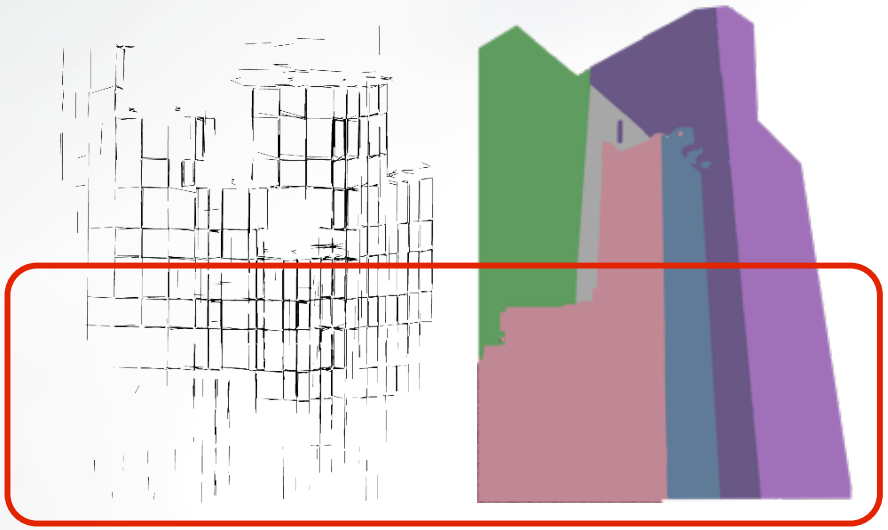




Factored Facade Acquisition Using Symmetric Line Arrangements, Ceylan et al.

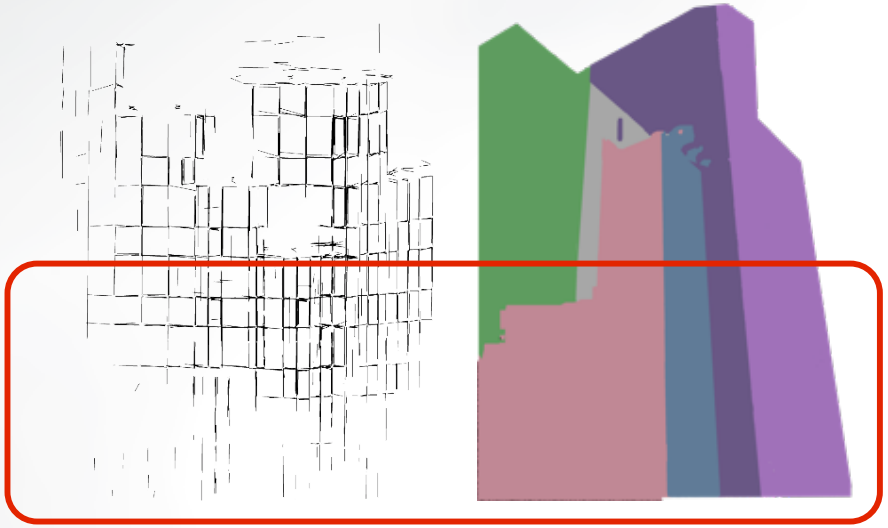
Limitations

Limitations



insufficient lines

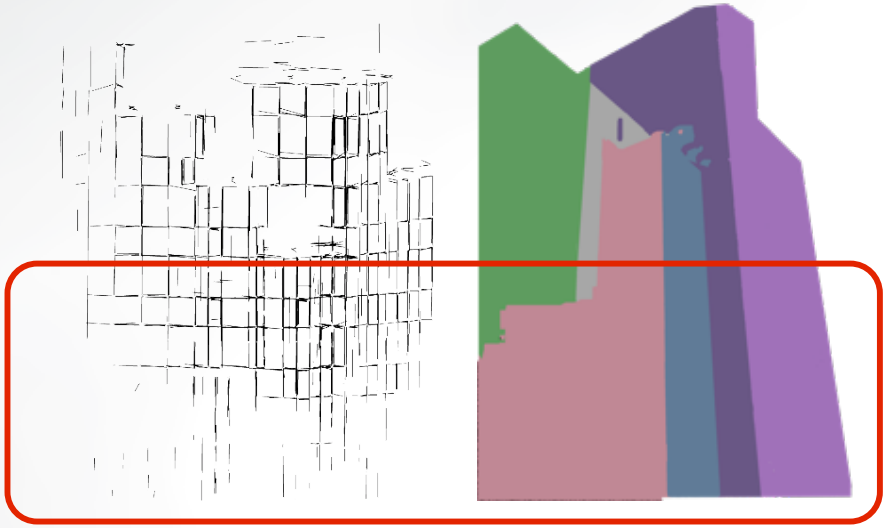
Limitations



insufficient lines

variations in repetitions

Limitations



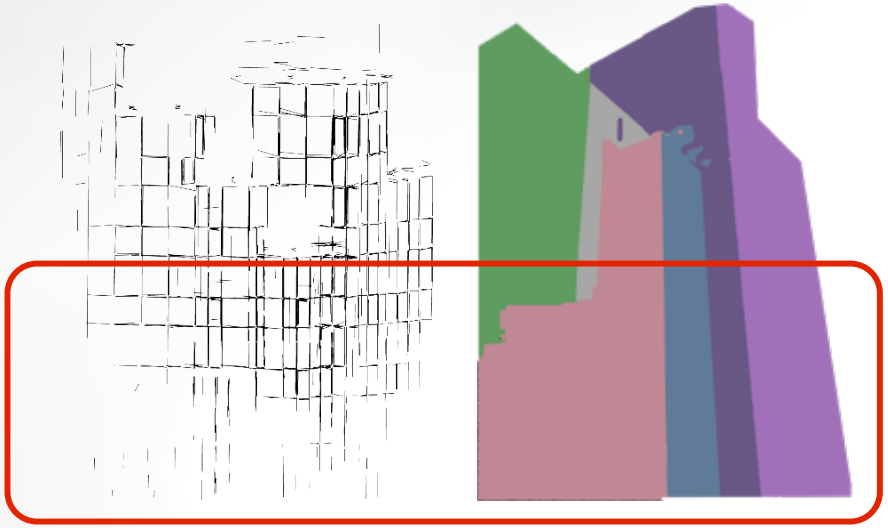
insufficient lines

variations in repetitions

curved features

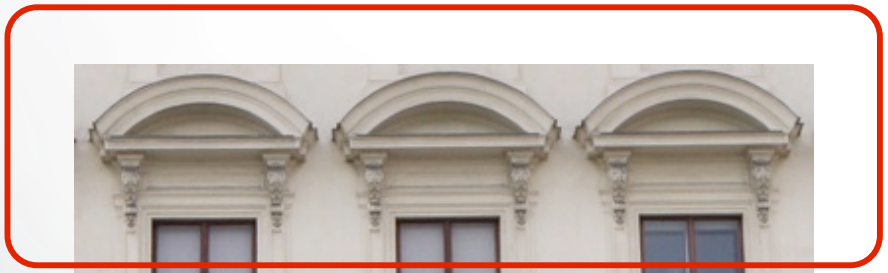
Factored Facade Acquisition Using Symmetric Line Arrangements, Ceylan et al.

Limitations



insufficient lines

variations in repetitions



curved features

no repetitions

Factored Facade Acquisition Using Symmetric Line Arrangements, Ceylan et al.

What's Next?

building colonies

similar architecture style

Structure-from-Motion

Factored Facade Acquisition Using Symmetric Line Arrangements, Ceylan et al.

Acknowledgements

ERC Starting Grant 257453 COSYM

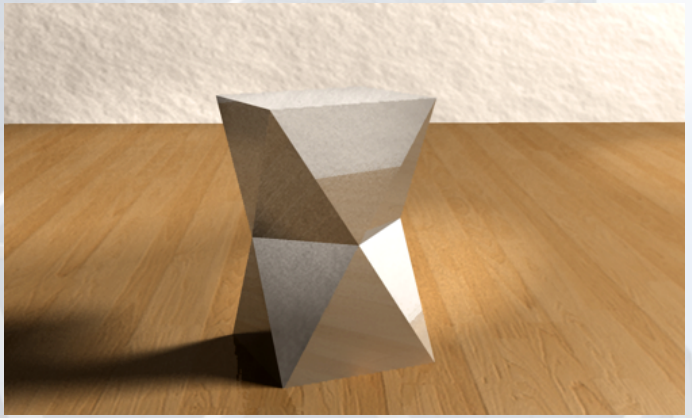
KAUST Visiting Student Grant

Marie Curie Career Integration Grant 303541

Thanks…

?

input



output

http://www.duygu-ceylan.com/duygu-ceylan/symmFacade.html