Applications of 3D modelling of the built environment

GEO1004:
3D modelling of the built environment

3D geoinformation
Department of Urbanism
Faculty of Architecture and the Built Environment
Delft University of Technology


Visibility analysis
Solar potential estimation
3D cadastre
Energy demand estimation
Infrastructure planning
Emergency response
Shadow estimation
Indoor navigation
Noise propagation
Utility management
TU Delft


dB
60
45
30

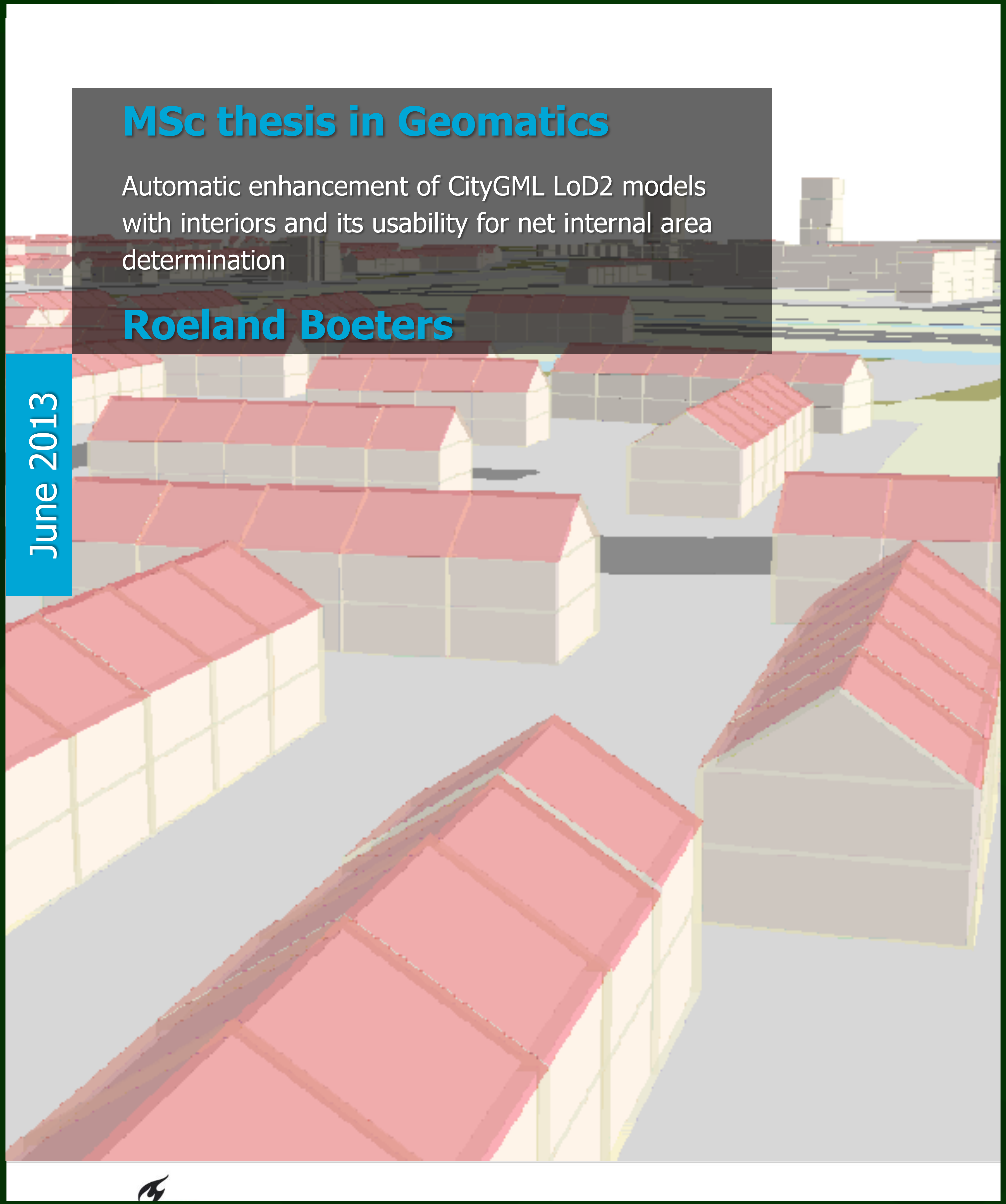

W/m2
600
500
400
300
200
100
0

Other applications

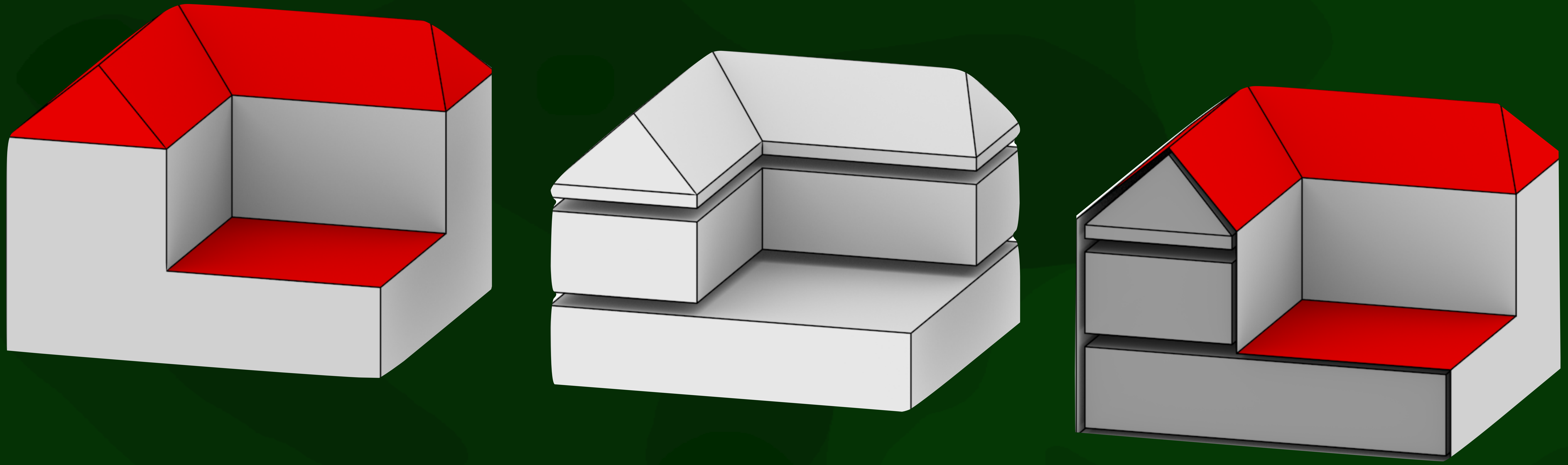
- Energy demand estimation (and potential for retrofitting)
- Visualisation (eg for gaming, tourism, navigation, etc)
- Computational fluid dynamics (eg for wind speeds, air quality, effects on buildings, etc)
- Shadow casting (eg for building permits, visibility analysis, improving energy demand/ solar potential calculations, etc)

4 MSc Geomatics theses

- Motivation: create (rough) indoor geometry from widely available outdoor geometry
- Definition of a CityGML LOD2 with interiors (LOD2+)
- Compute interior geometry from exterior geometry + number of storeys
- Compute net internal area

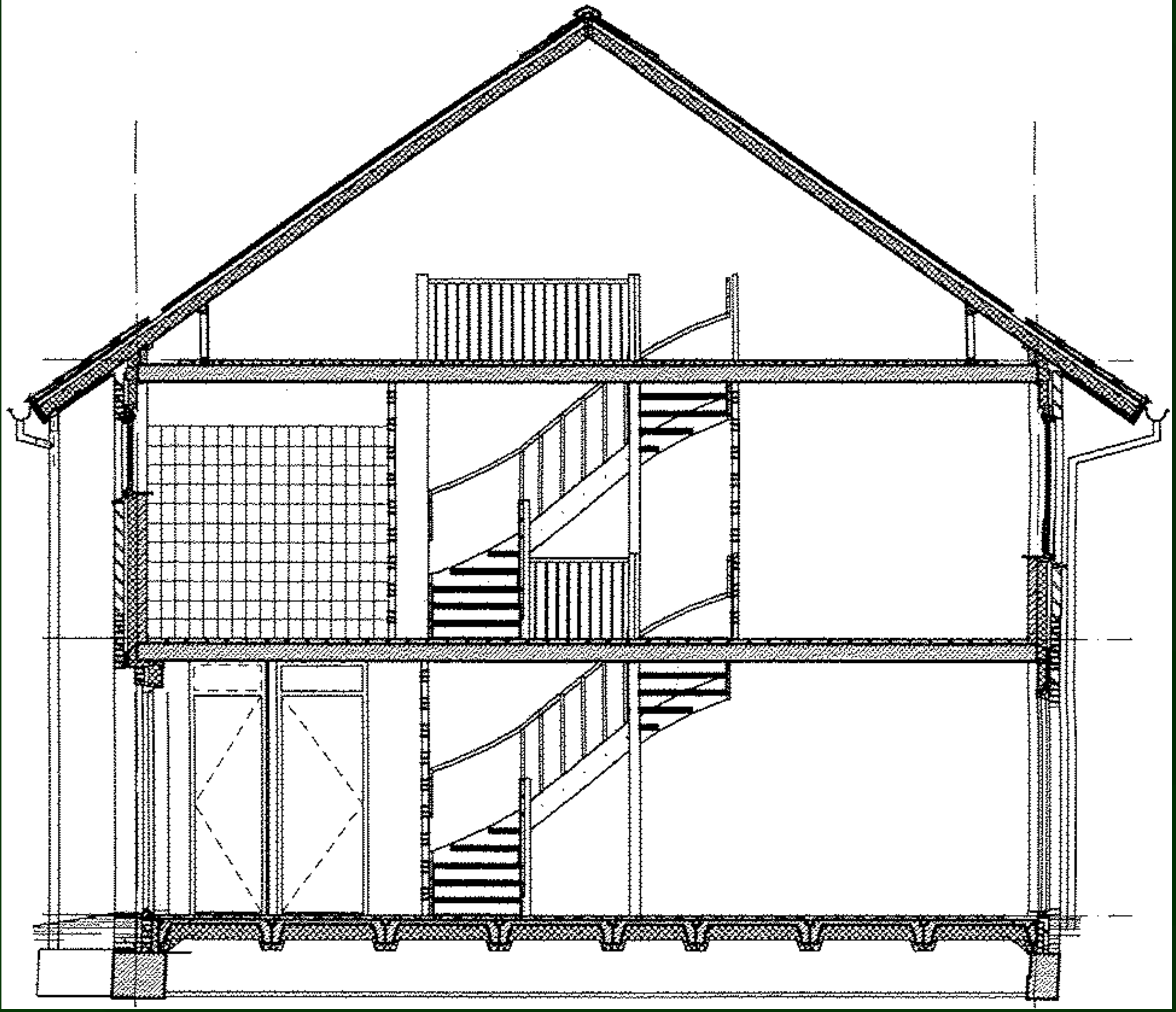


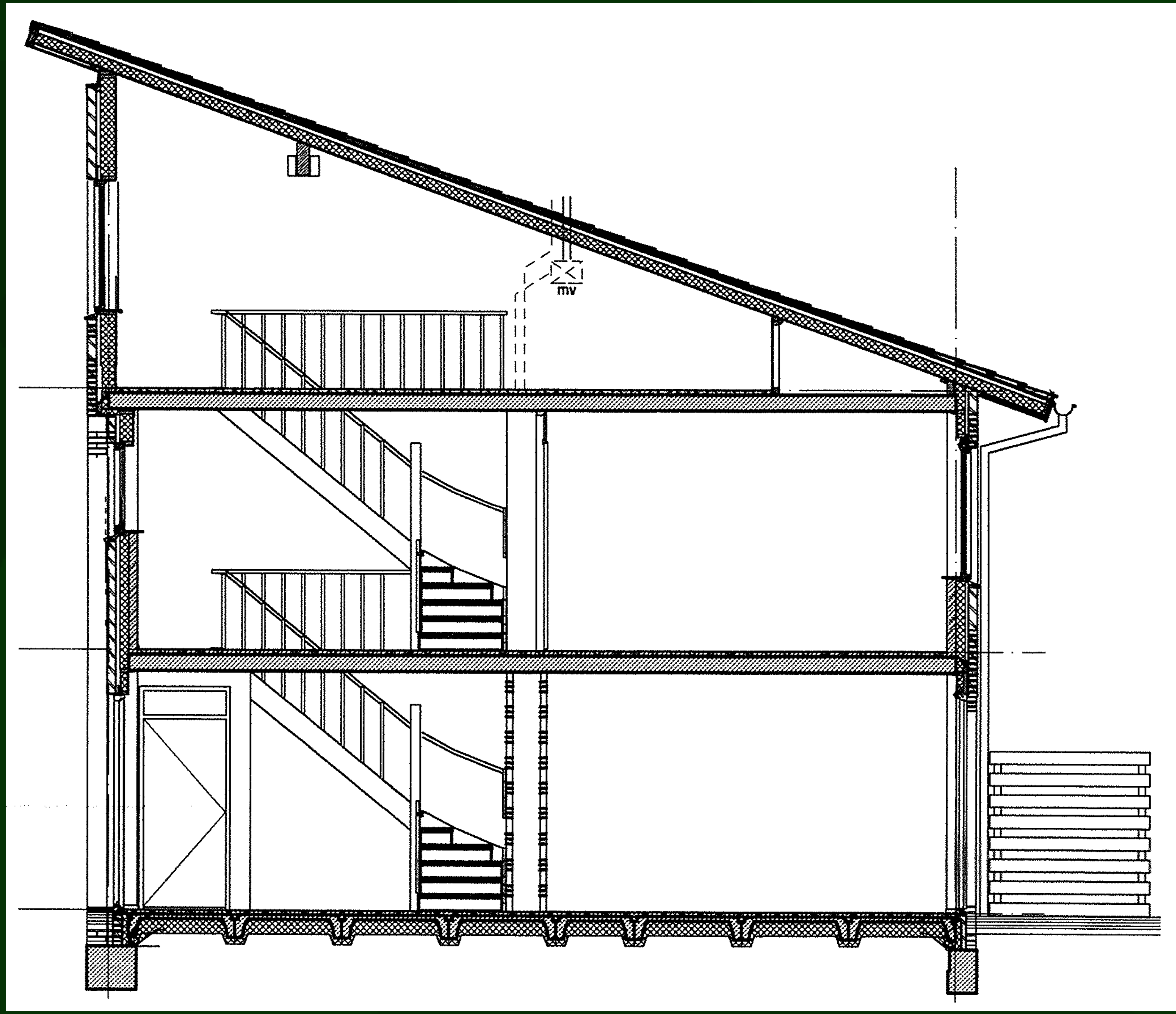
LOD2+



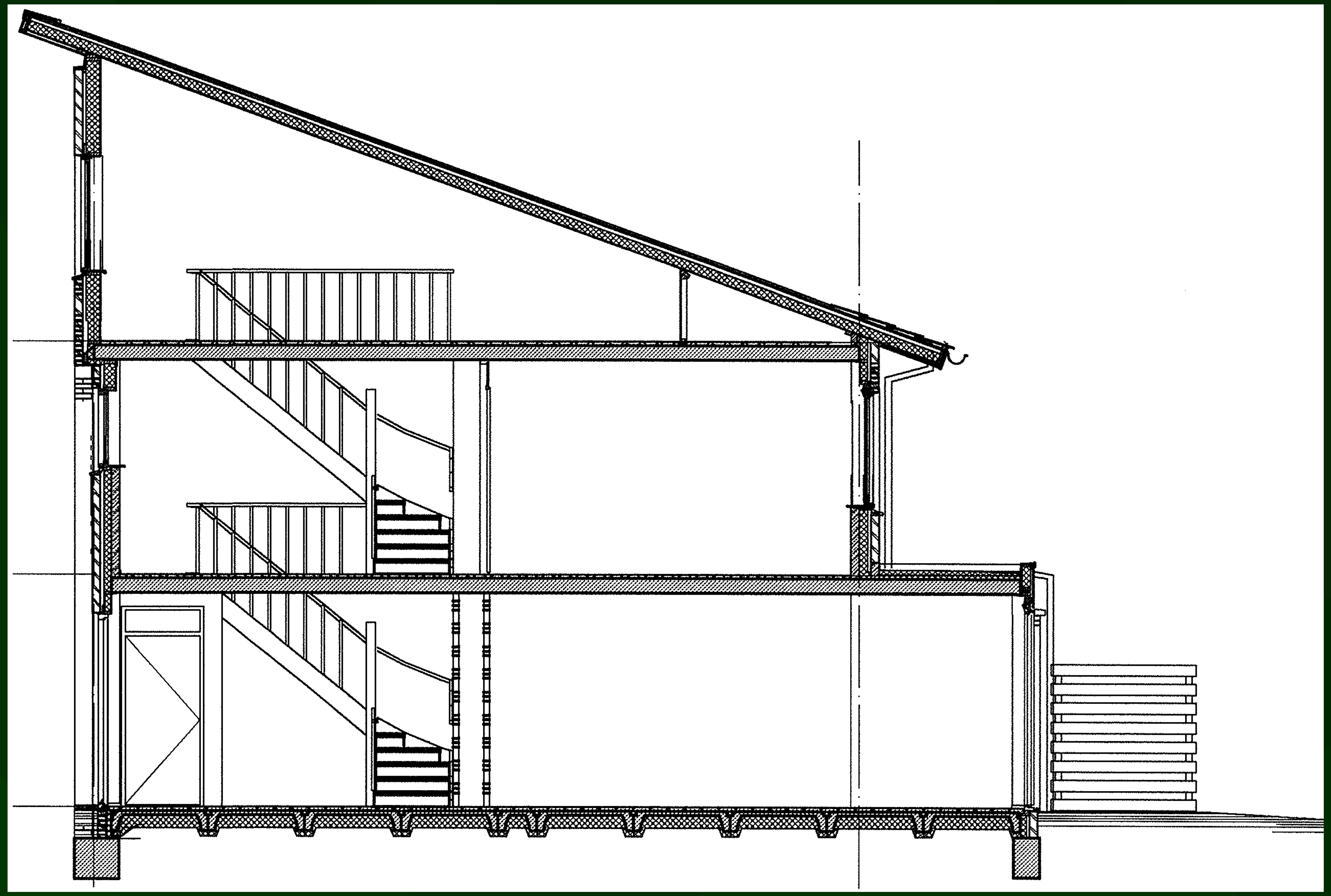
Exterior in LOD2	Interior in LOD2+
Buildings bodies are prisms	Storeys within building bodies are prisms
Simple roof shapes	Attic storey shapes corresponding to roof shapes
Thematically classified boundary surfaces	Thematically classified boundary surfaces
No openings in the exterior geometry	No openings in the indoor geometry

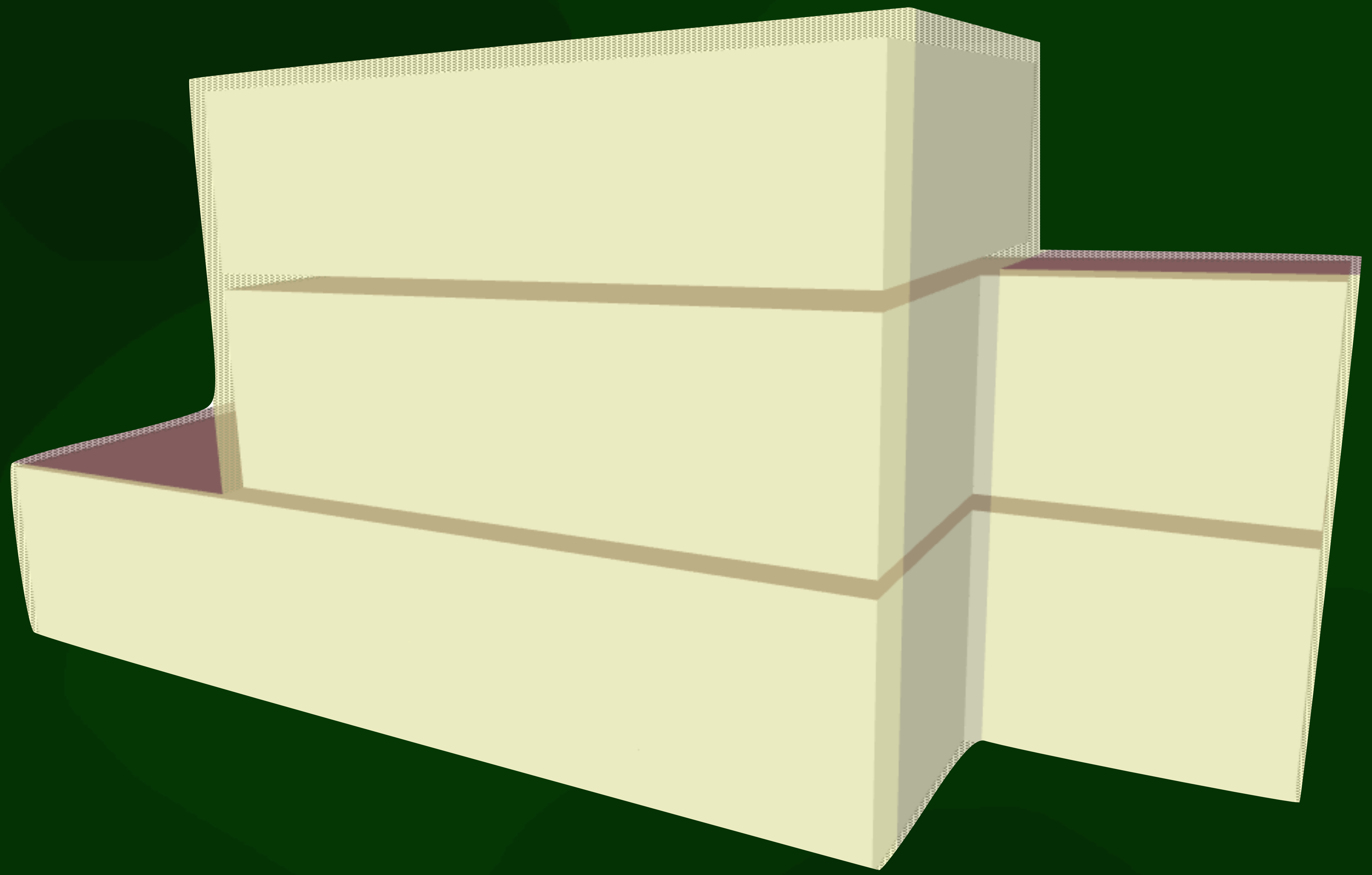
Indication of storeys





Indication of storeys

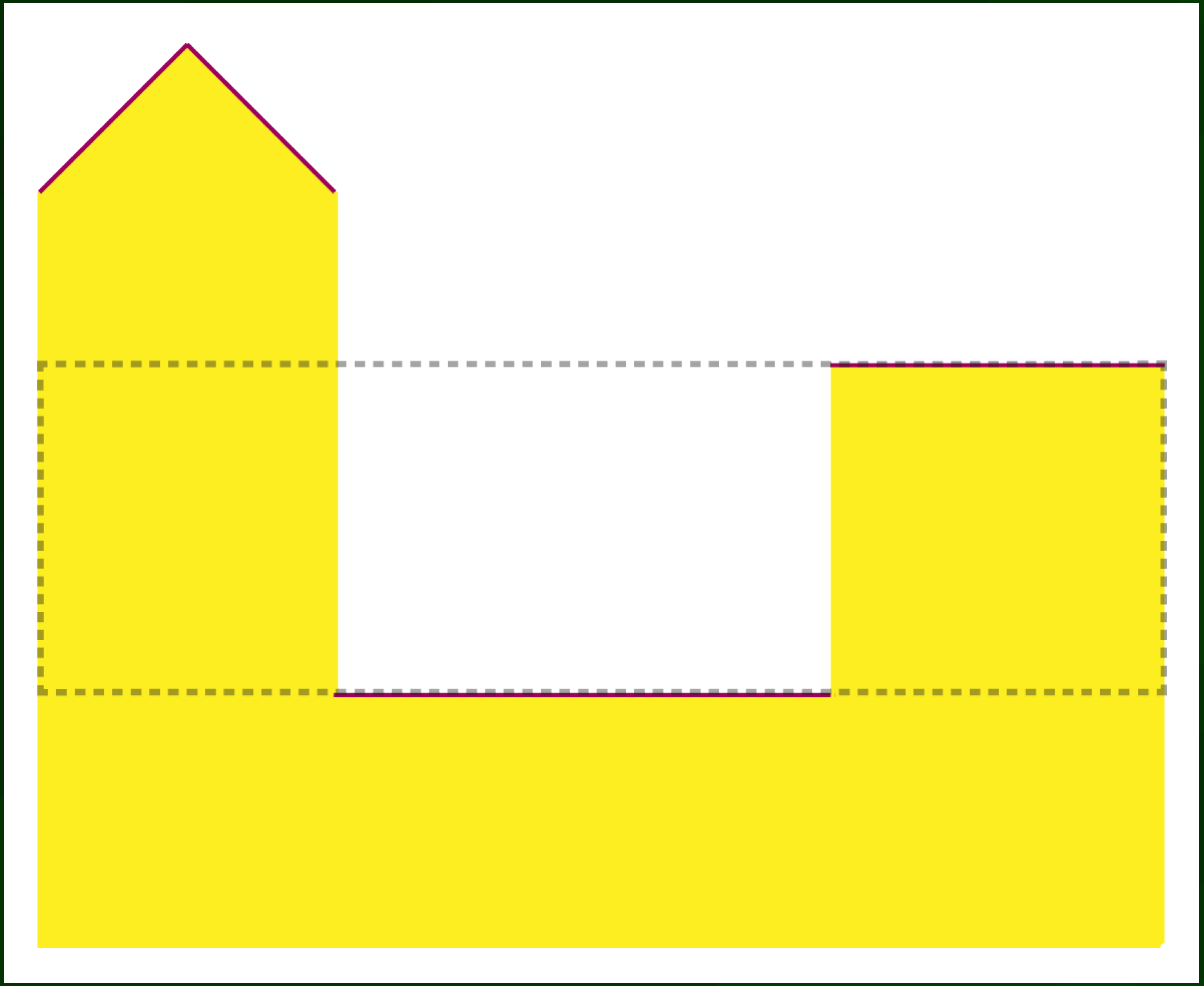




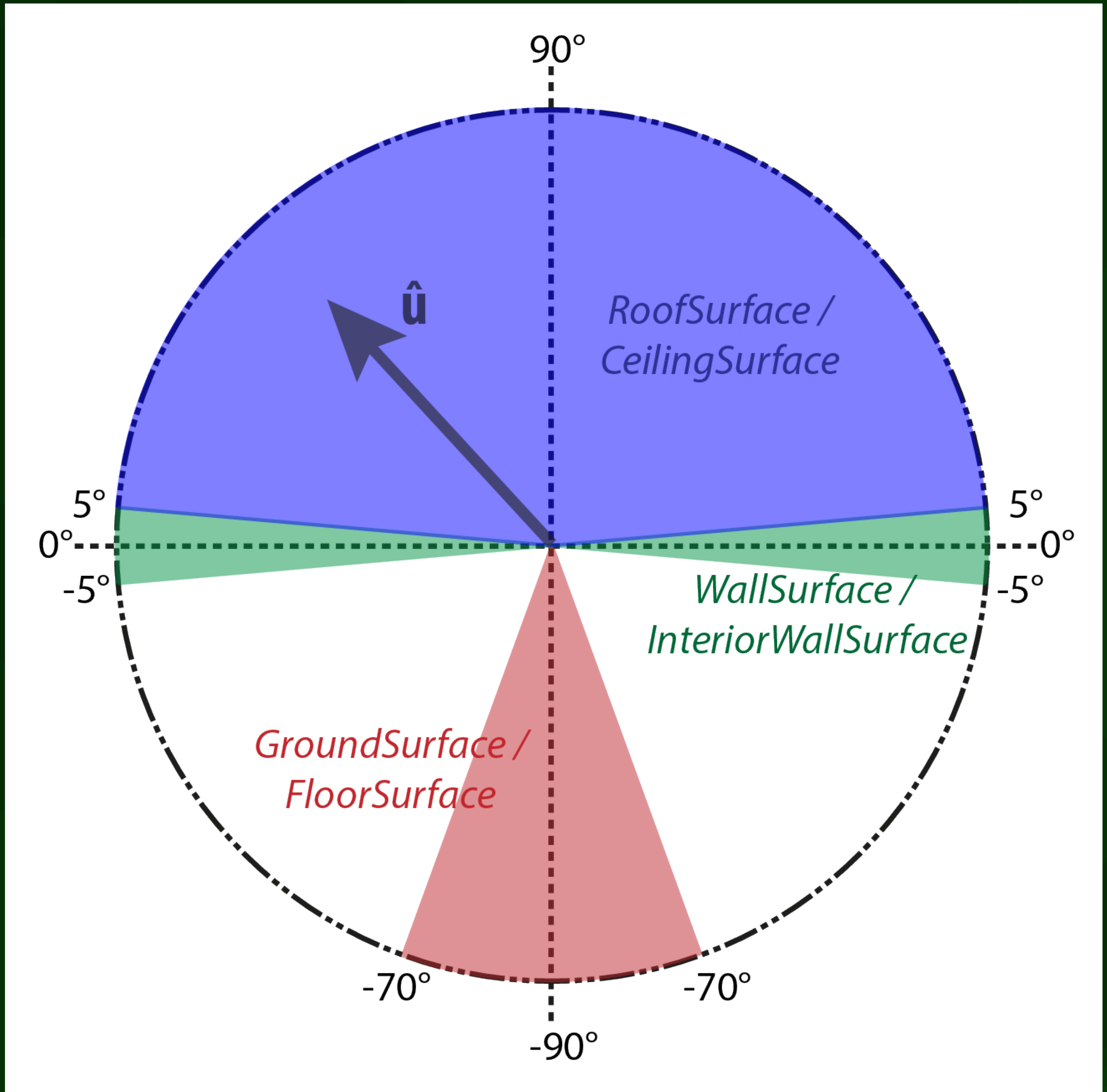
Wall thickness

Type	year y	storeys x	t_{ext} [cm]	t_{shared} [cm]
Non-stacked	$y < 1970$	$x \leq 2$	27	11
		$x \geq 3$	27	12
	$1970 \leq y \leq 1985$	$x = 2$	27	10
		$x = 3$	28	12
		$x = 4$	27	9
	$y > 1985$	$x = 2$	28	13
		$x = 3$	30	12
		$x = 4$	25	12
Stacked	$y < 1970$	$x \leq 5$	29	12
		$5 < x \leq 10$	38	11
		$x > 10$	25	9
	$1970 \leq y \leq 1985$	$x \leq 5$	28	11
		$5 < x \leq 10$	26	11
		$x > 10$	29	12
	$y > 1985$	$x \leq 5$	30	12
		$5 < x \leq 10$	38	13
		$x > 10$	35	15
Other types	$y < 1970$	$x = 1$	14	14
		$x \geq 2$	31	11
	$1970 \leq y \leq 1985$	$x = 1$	14	14
		$x \geq 2$	30	10
	$y > 1985$	$x = 1$	14	14
		$x \geq 2$	36	13

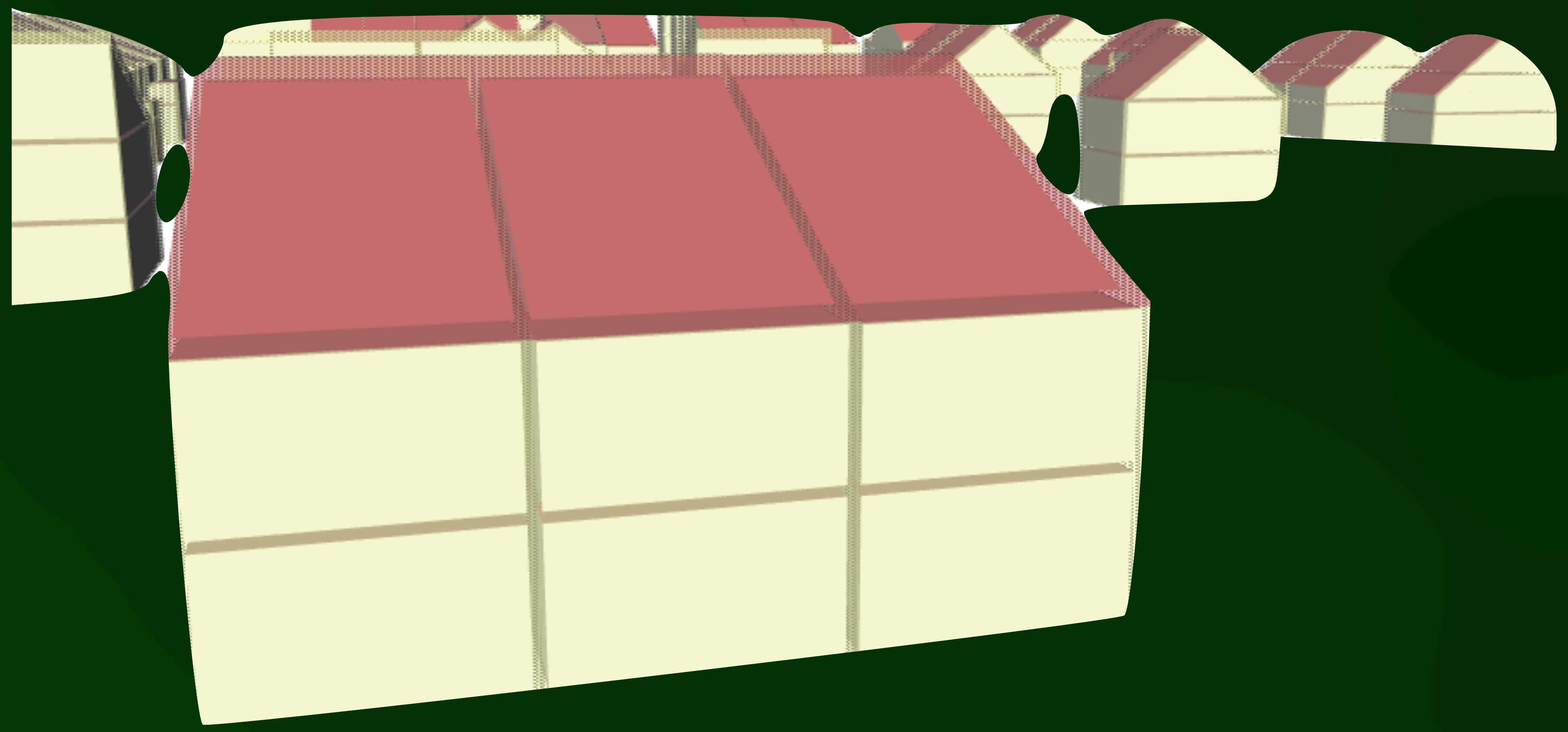
Boolean set intersection

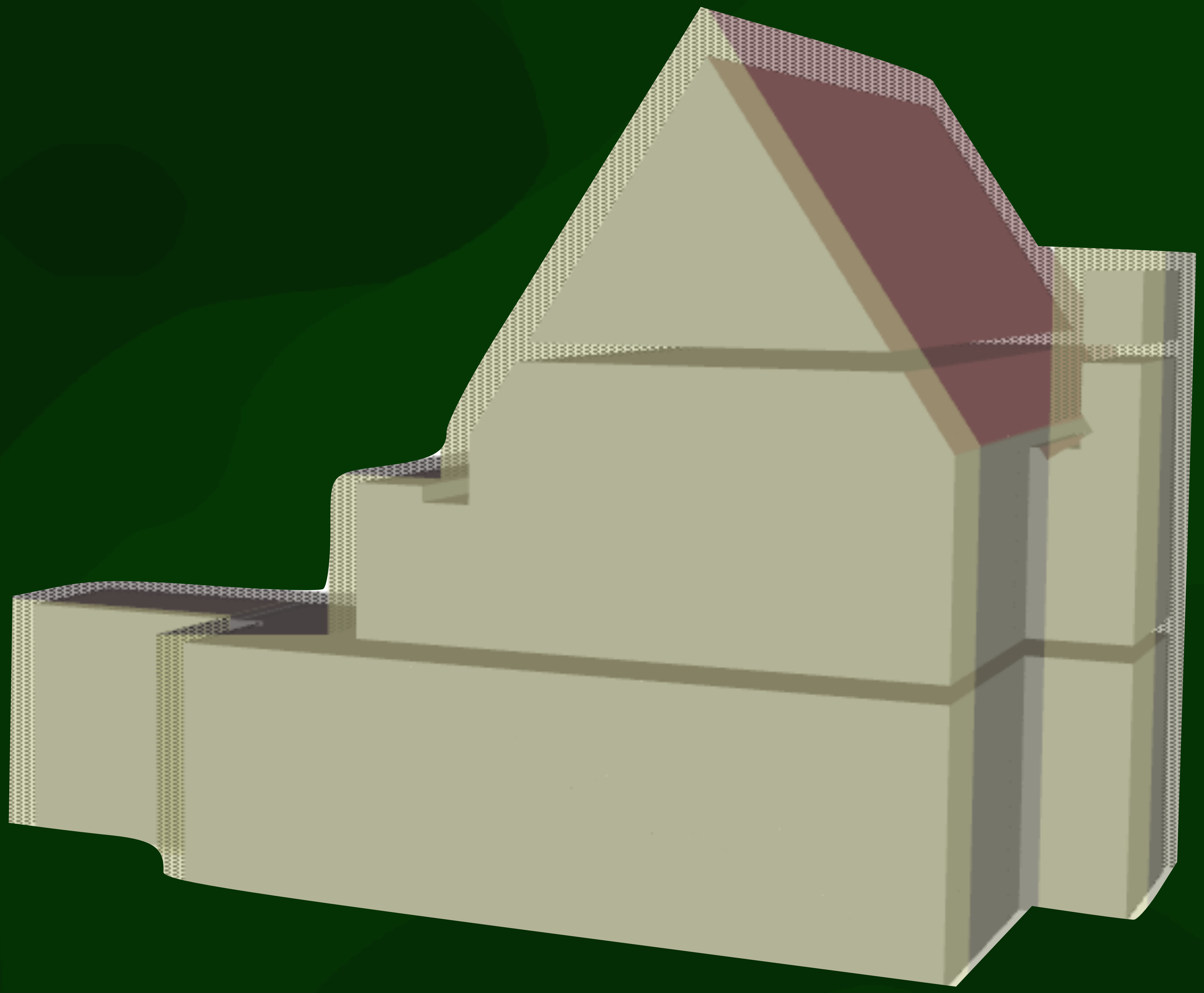


Classifying surfaces

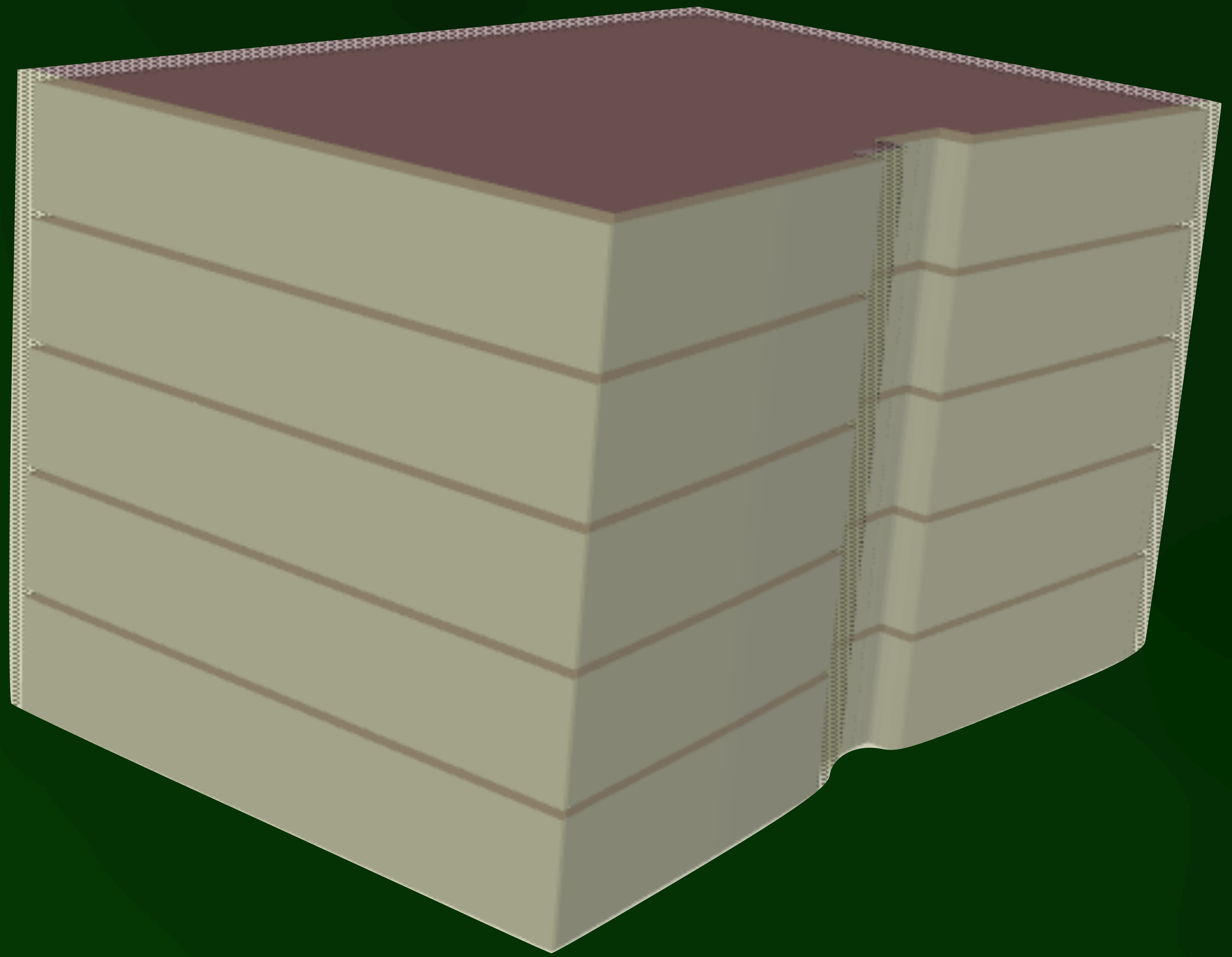


Results

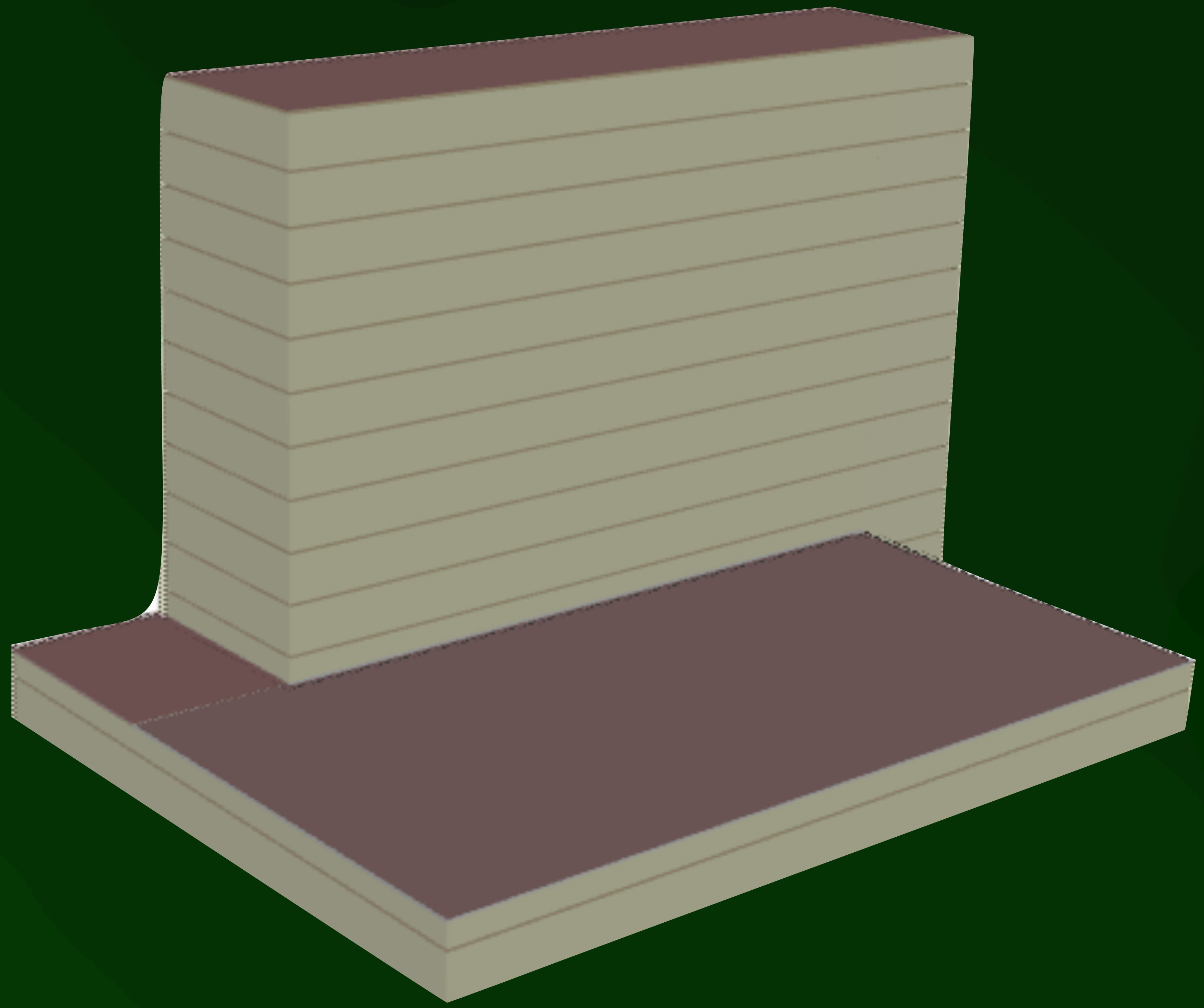




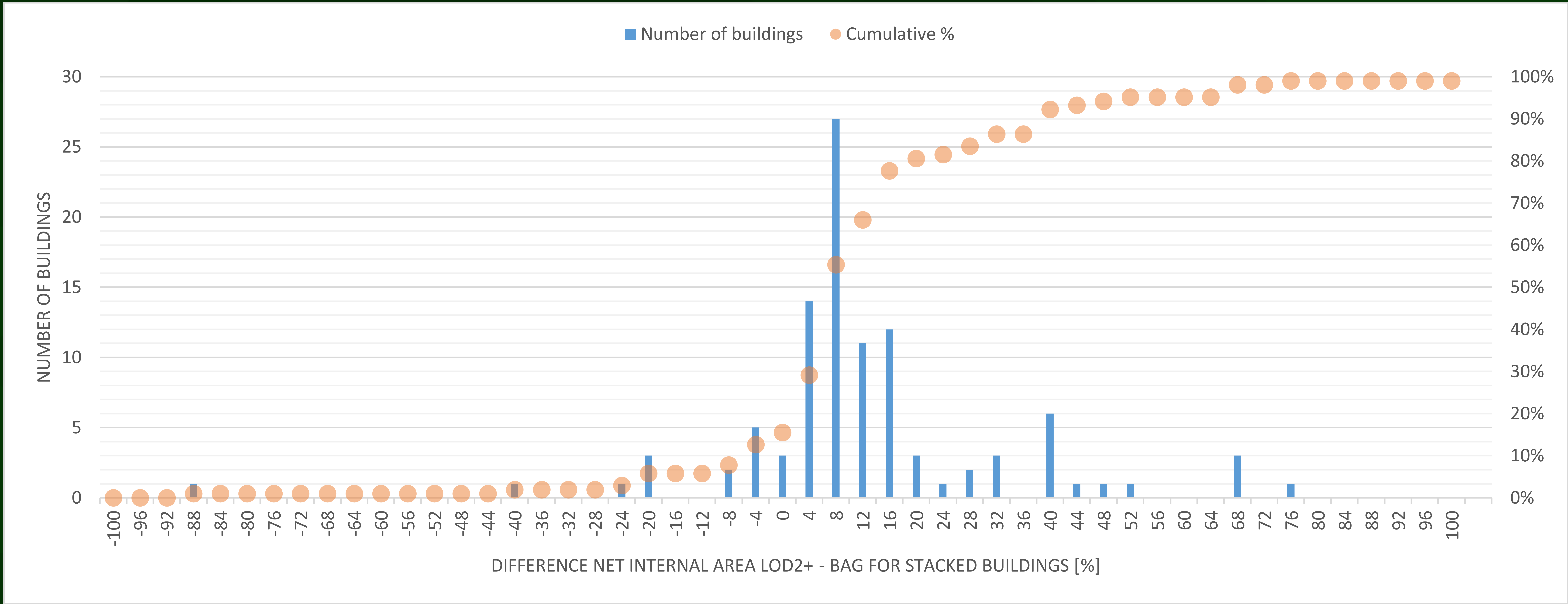
Results



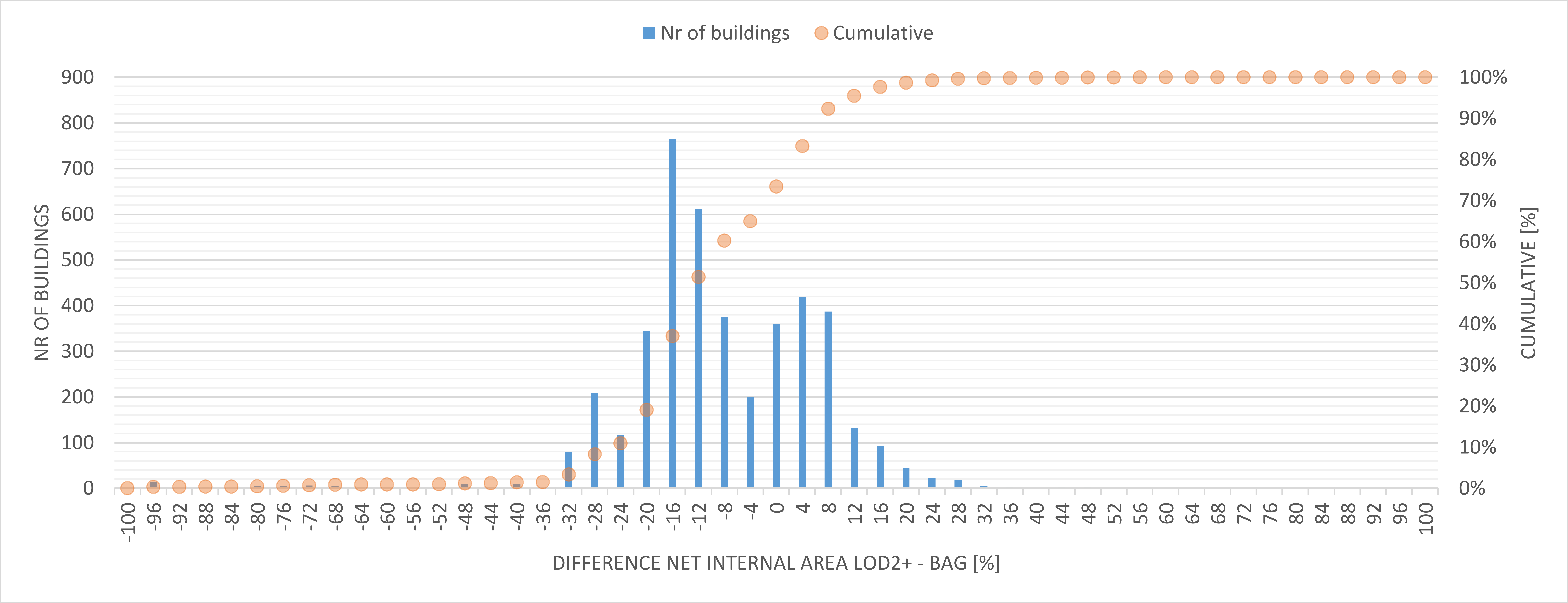
Results



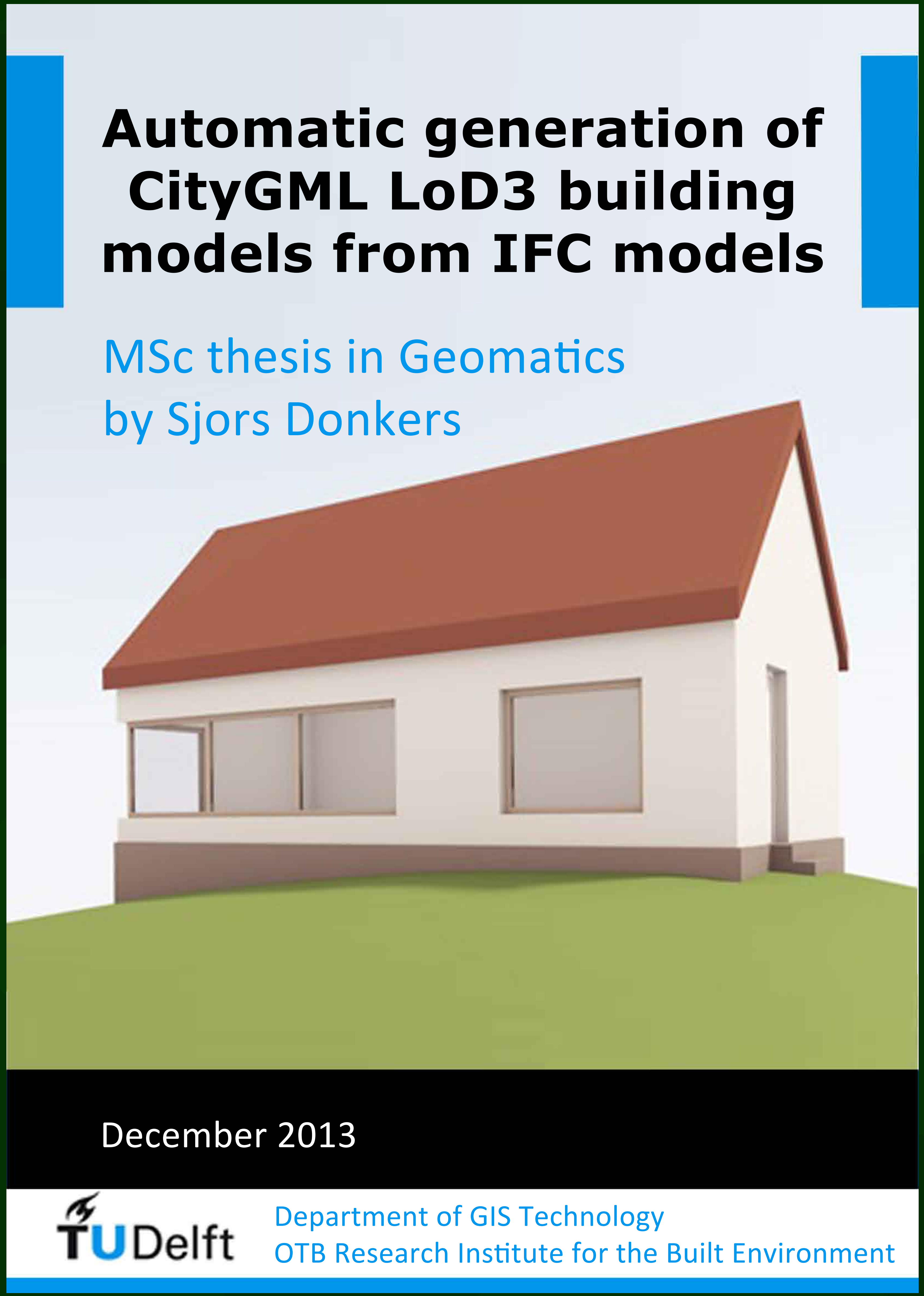
Net internal area (stacked)



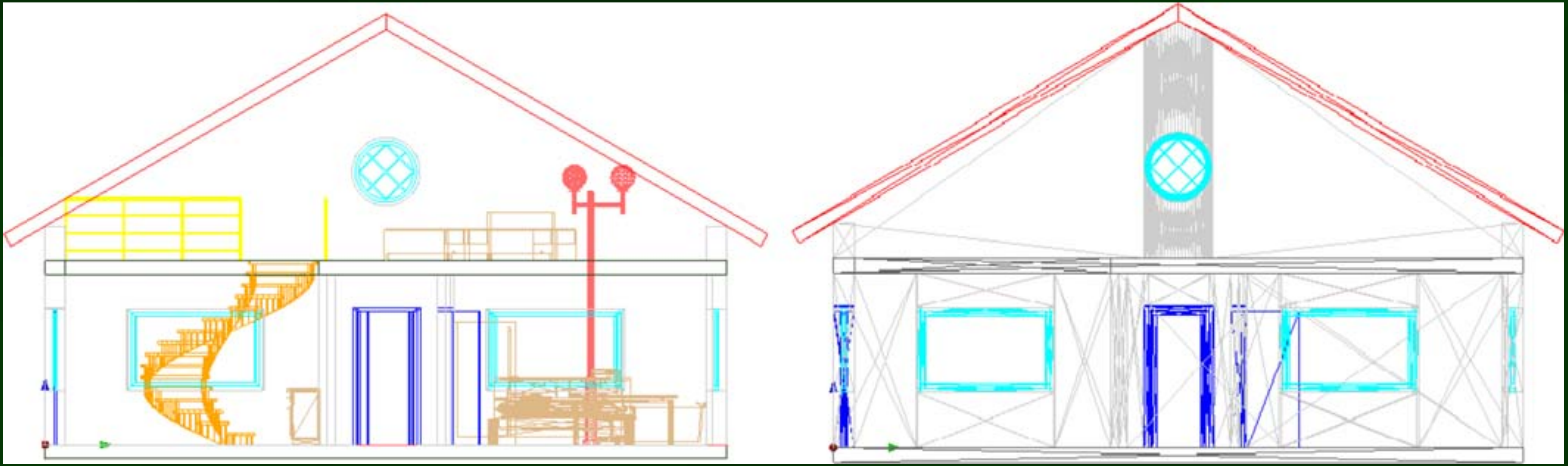
Net internal area (non-stacked)



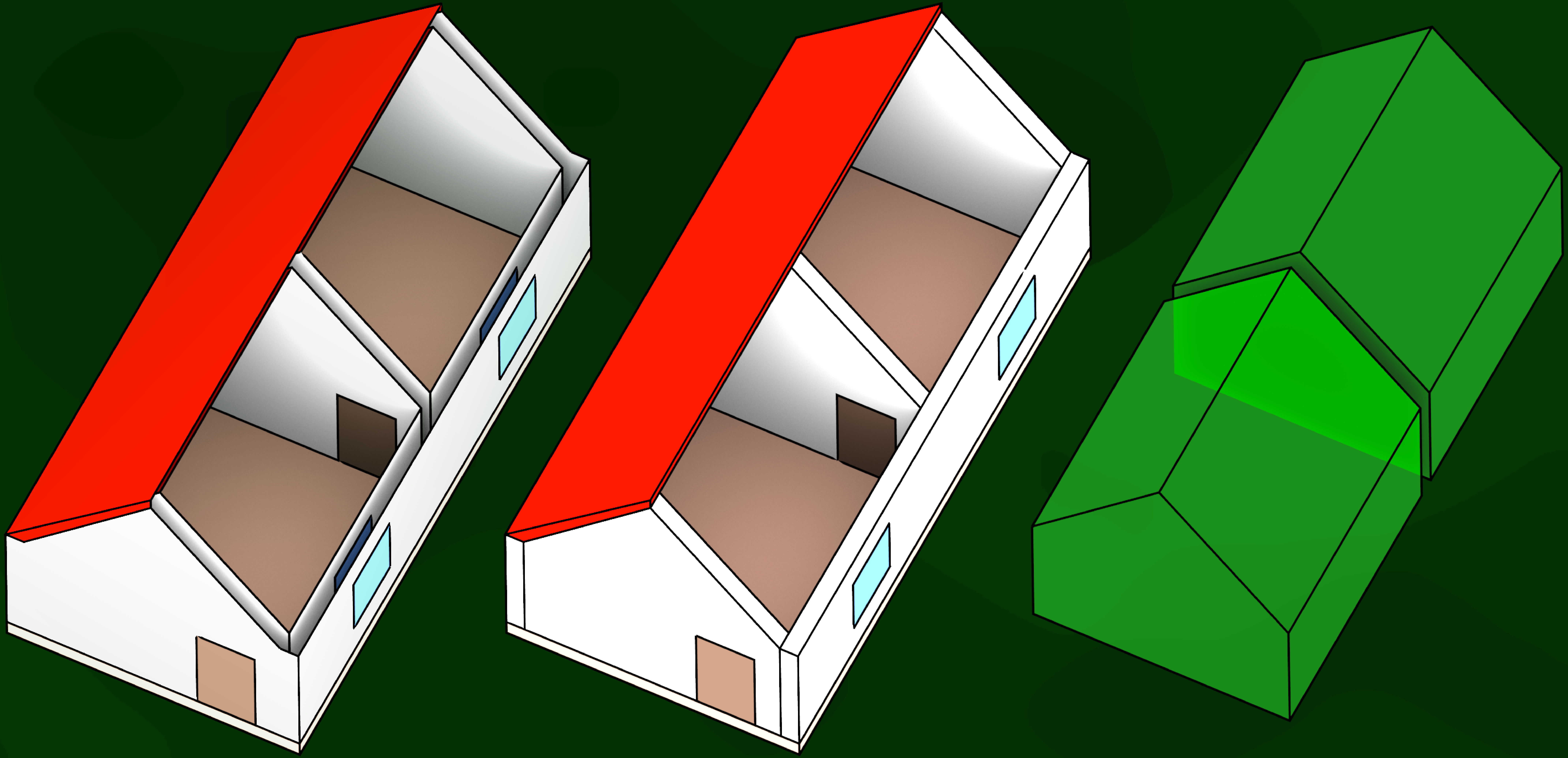
- Motivation: update 3D city models from designed BIM models (including potentially interiors)
- Fill gaps using Minkowski sum to increase size of elements
- Merge elements using Boolean set union
- Reclassify surfaces



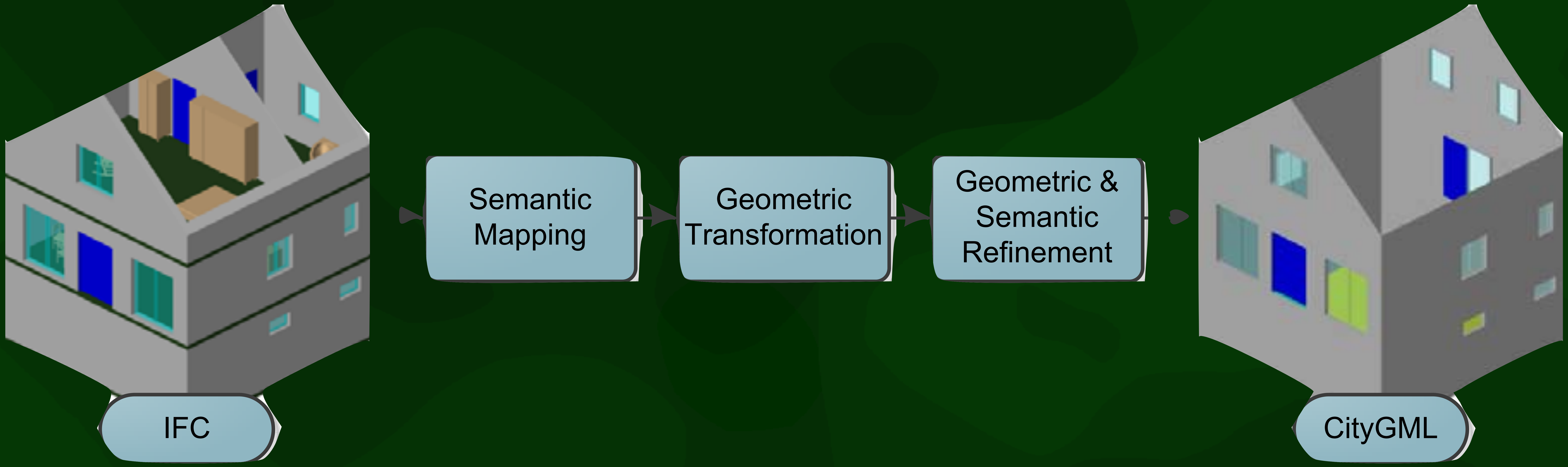
Goal



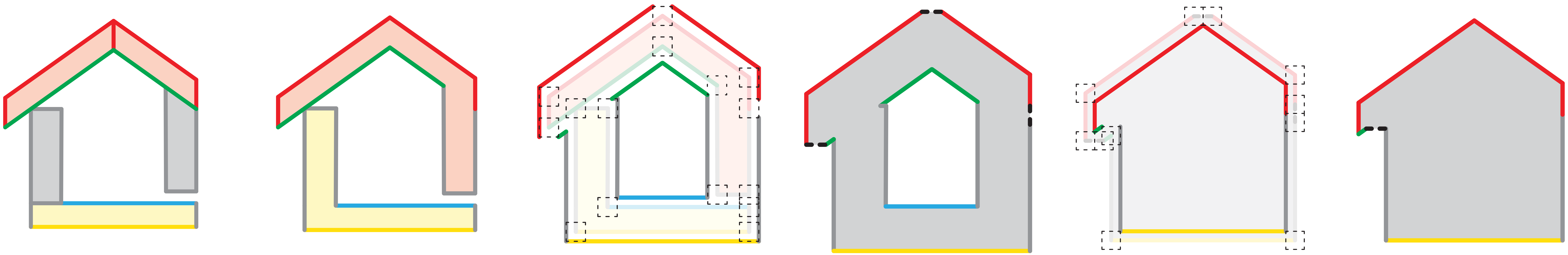
3DCM vs BIM



Methodology (semantics)

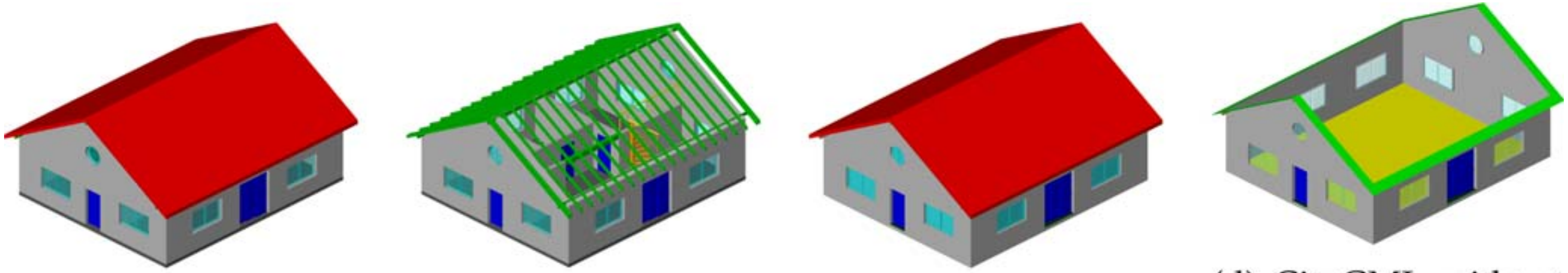


Methodology (geometry)



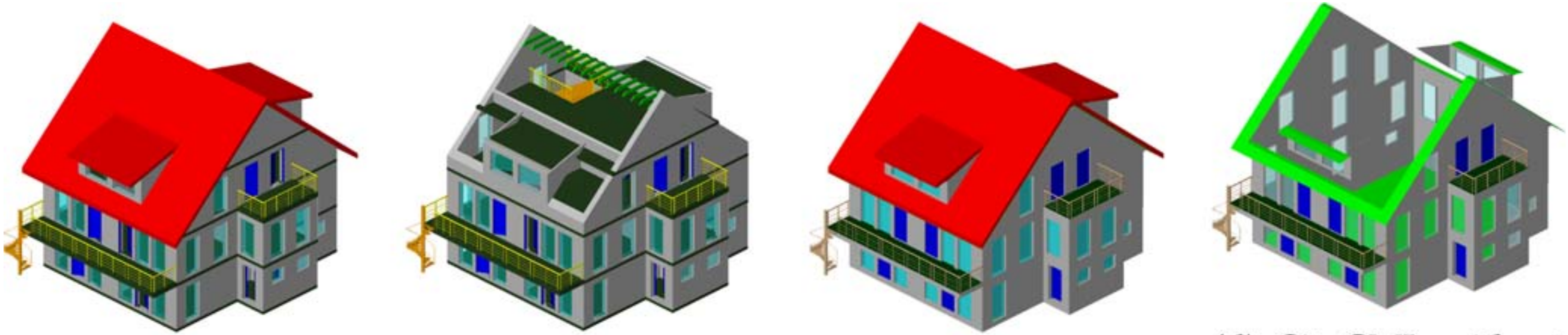
(a) input (b) union (c) dilation (d) result (e) erosion (f) final result

Results



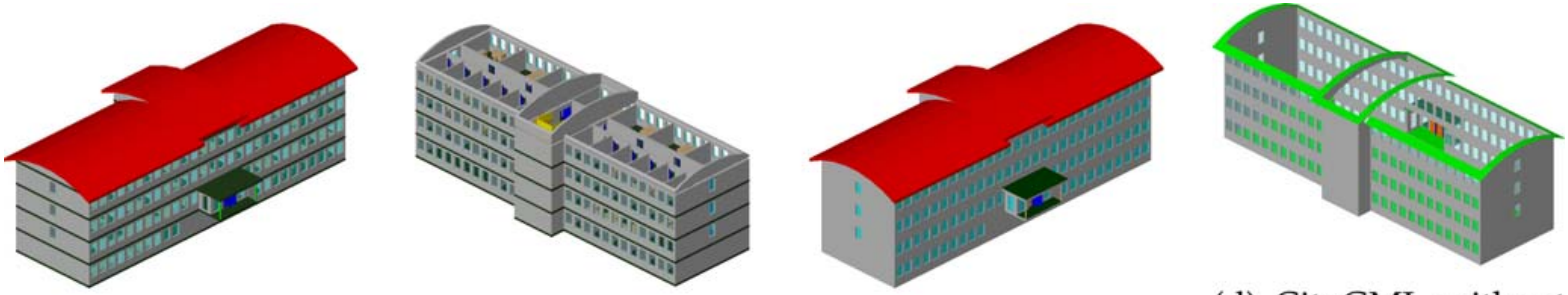
(a) input IFC (b) IFC without roof (c) output CityGML (d) CityGML without roof

Results



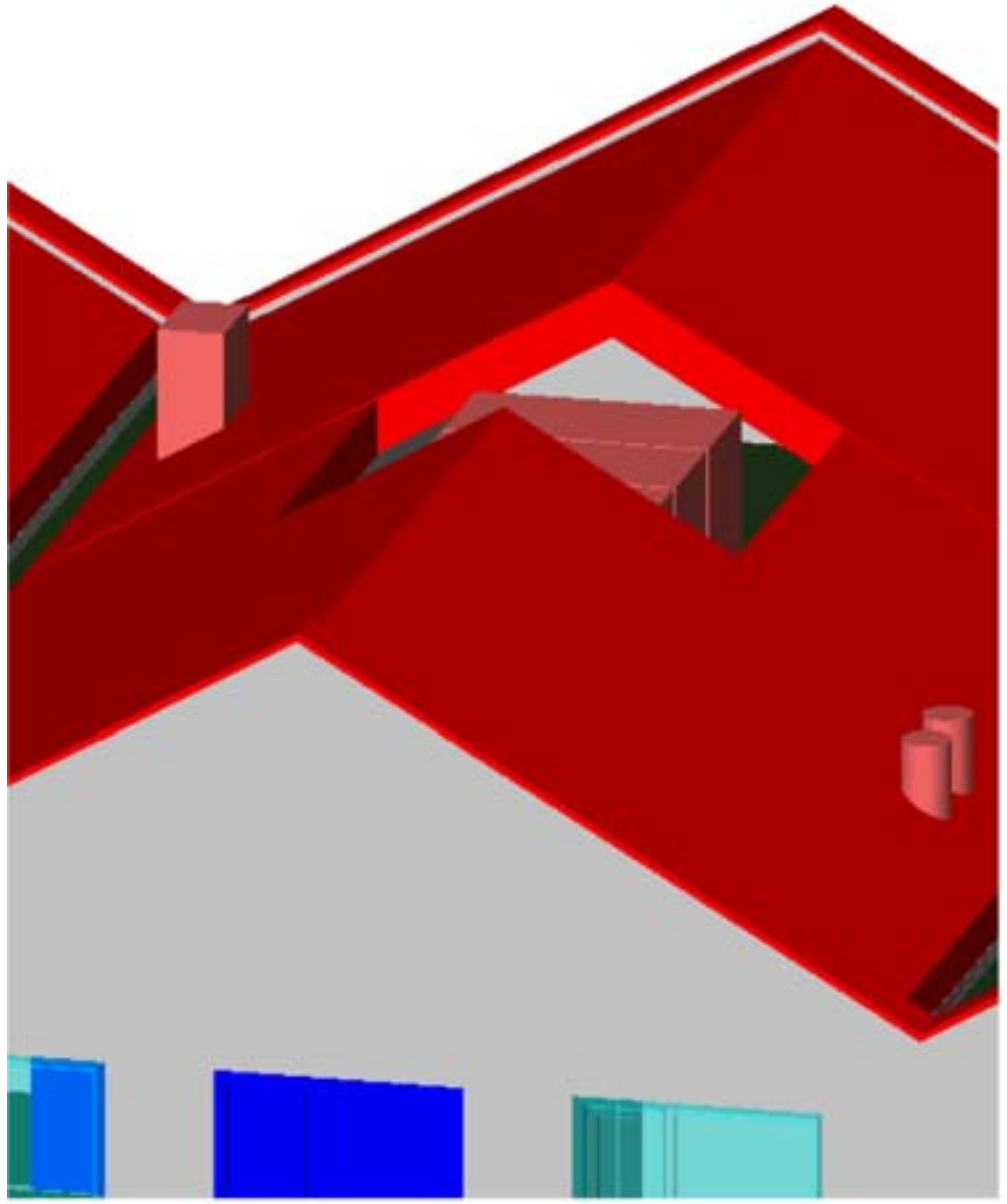
(a) input IFC (b) IFC without roof (c) output CityGML (d) CityGML without roof

Results

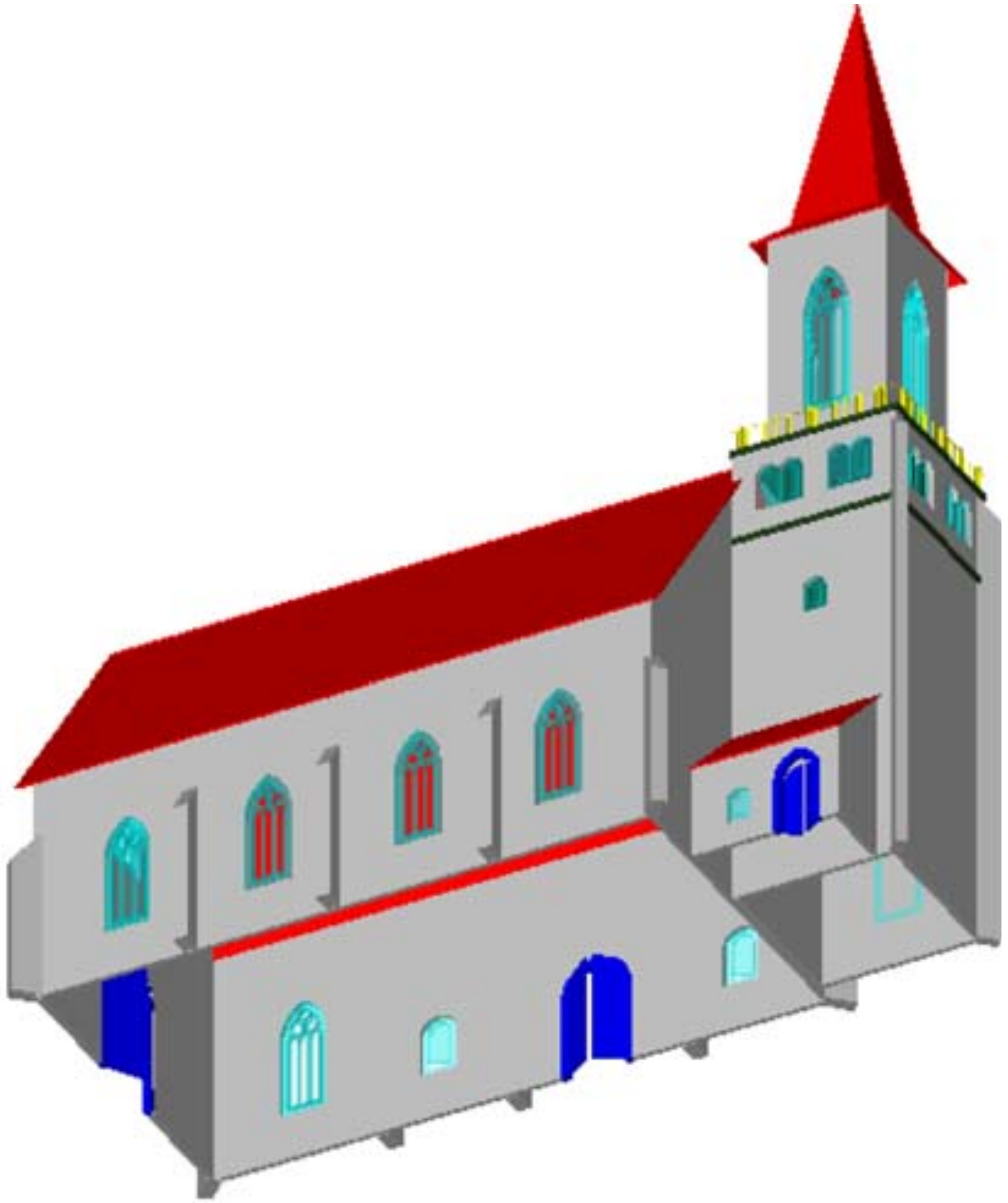


(a) input IFC (b) IFC without roof (c) output CityGML (d) CityGML without roof

Issues



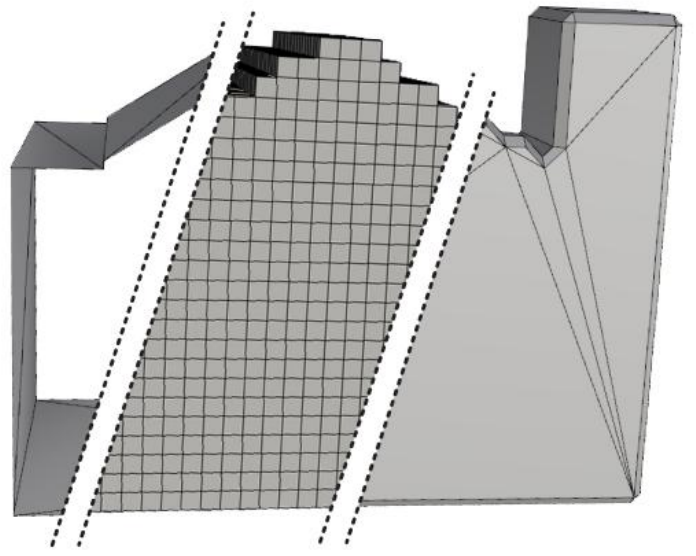
(a) Building where part of the roof is missing



(b) A church missing a base slab

- Motivation: repair 3D models so that they can be used in applications
- Voxelisation
- Reconstruction of mesh
- Obtain semantics and export

AUTOMATIC REPAIR OF 3D CITY BUILDING MODELS USING A VOXEL-BASED REPAIR METHOD



A thesis submitted to the Delft University of Technology in partial fulfillment of the requirements for the degree of

Master of Science in Geomatics

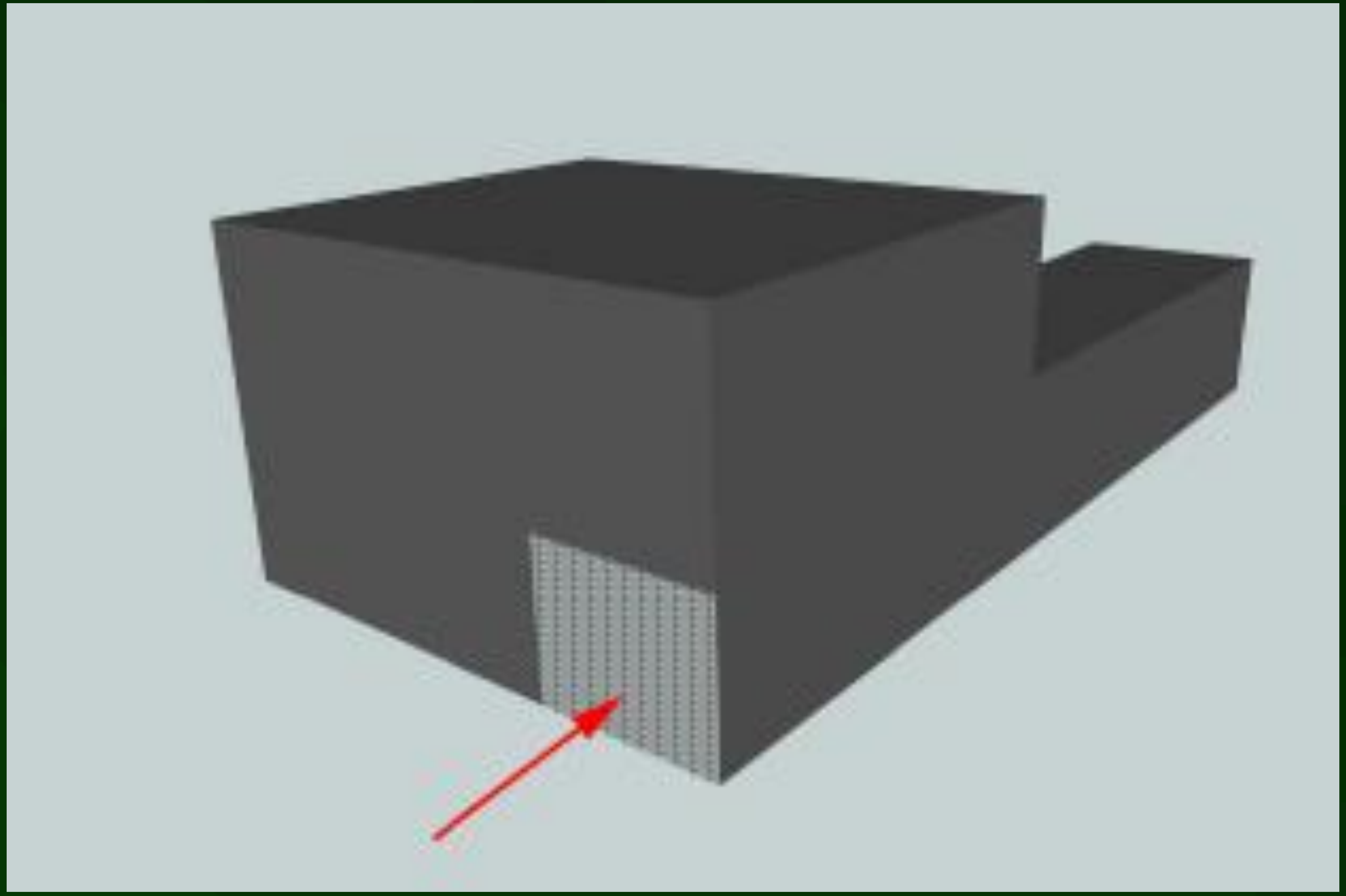
by

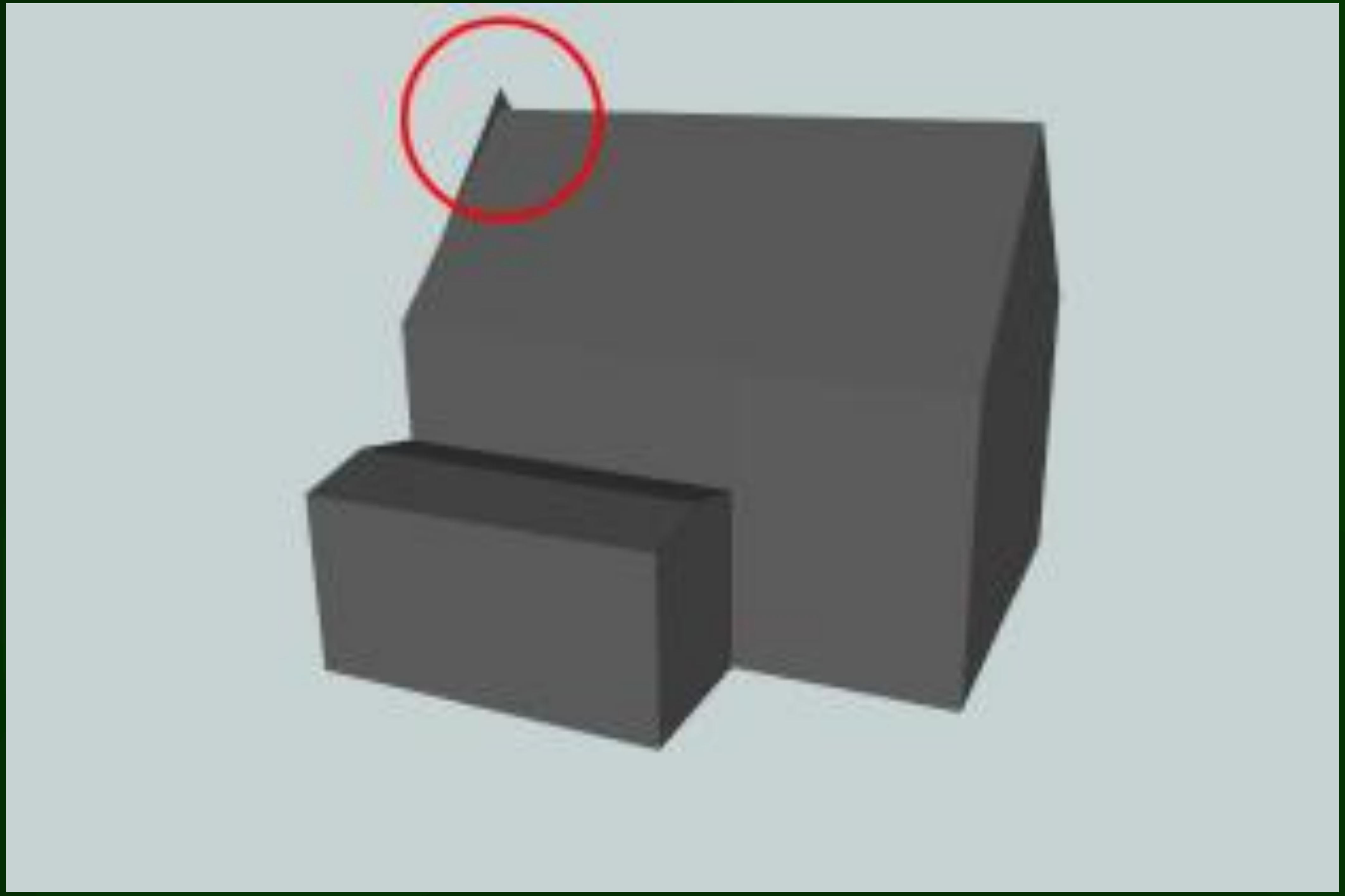
Damien Mulder

M.Sc Geomatics Thesis

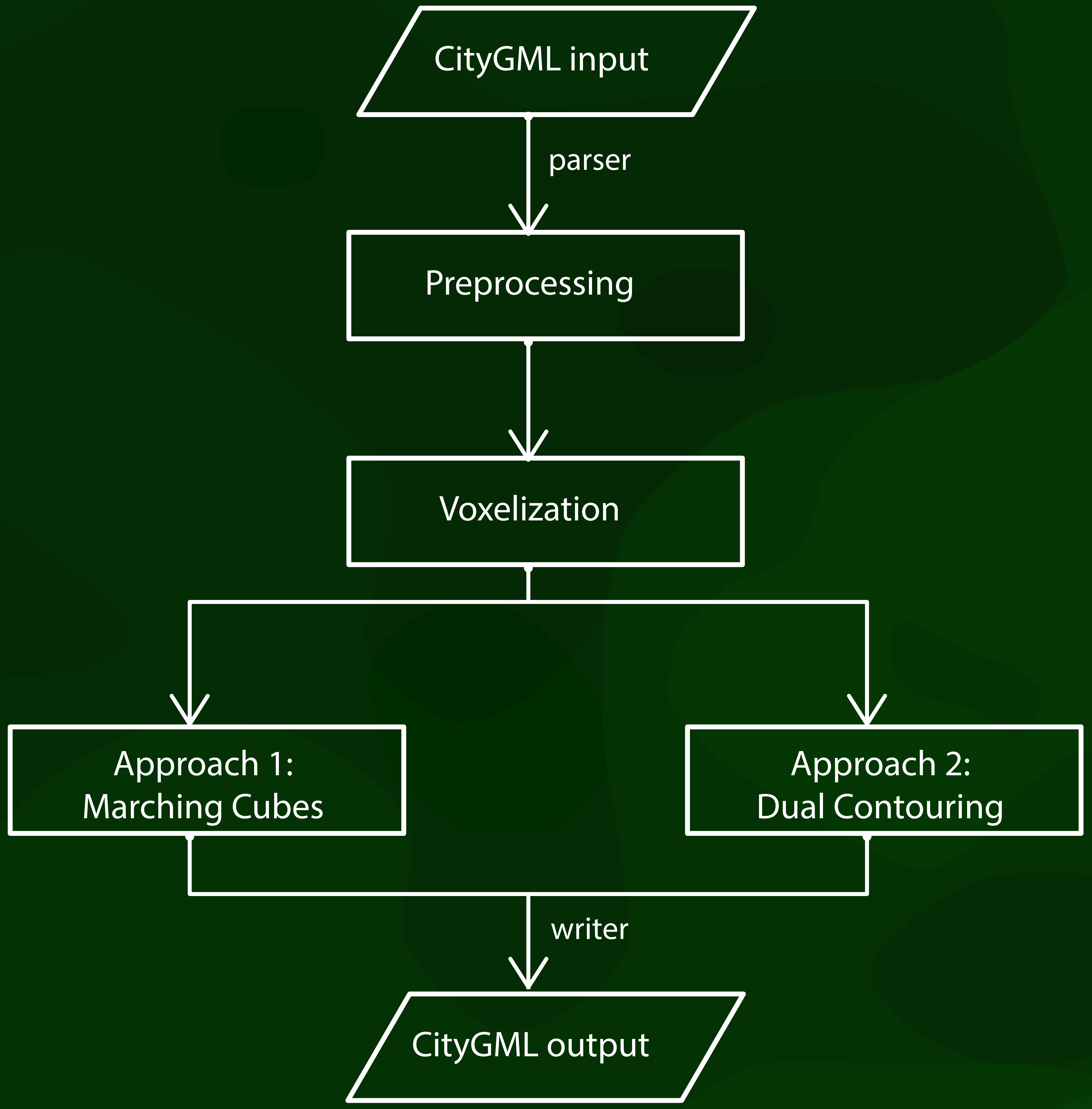
June 2015

Fixing 3D models

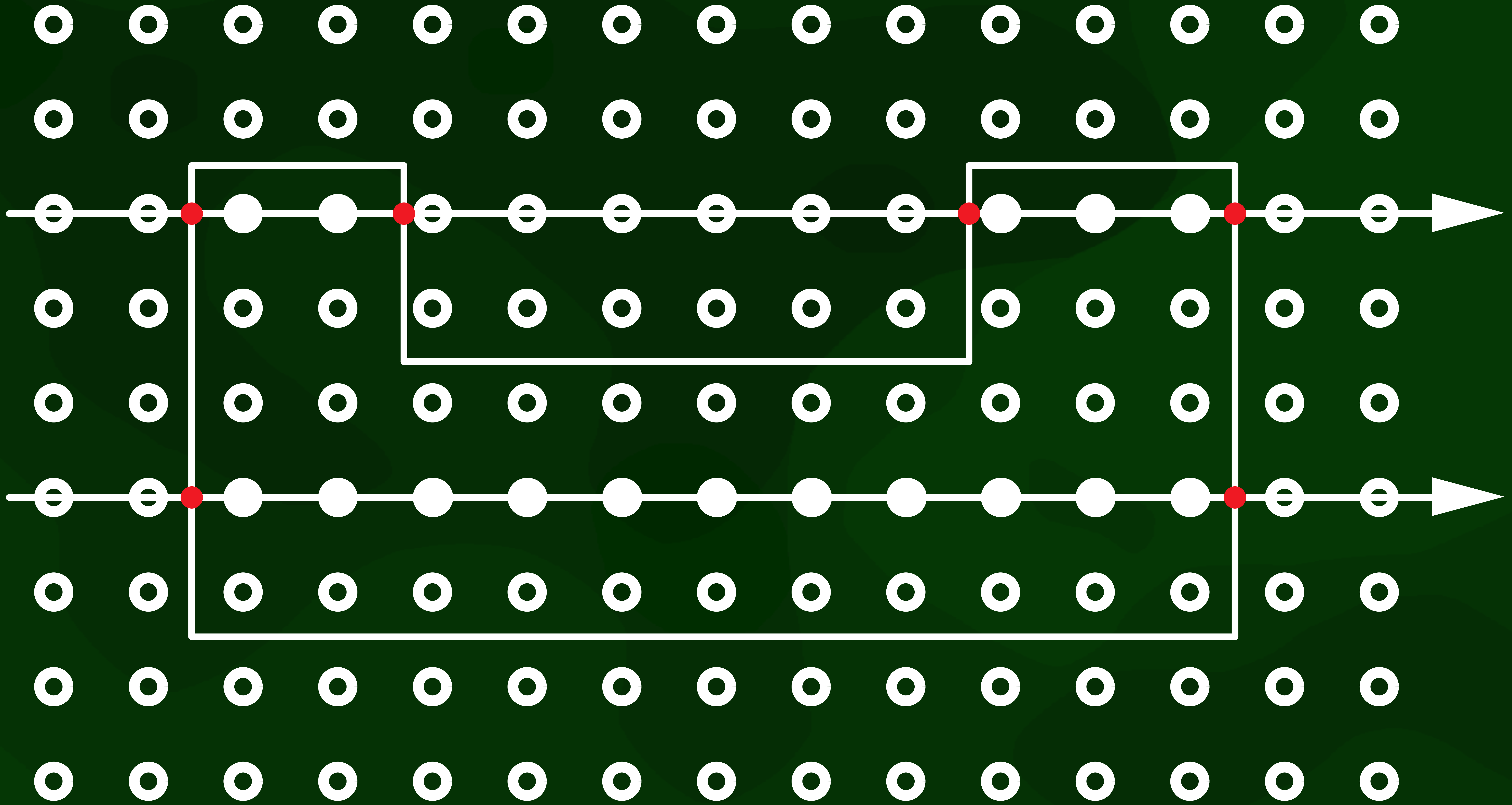




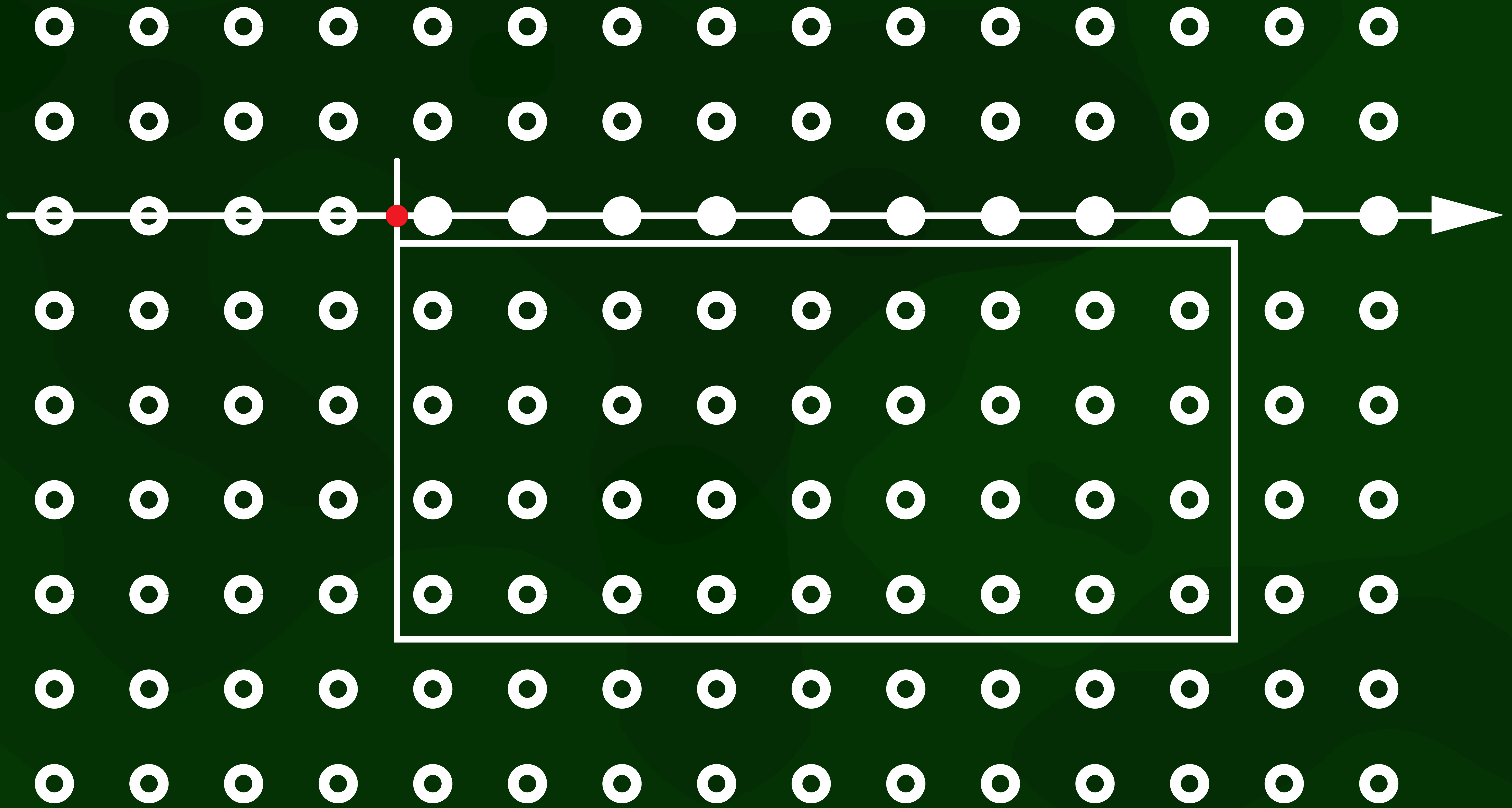
Methodology



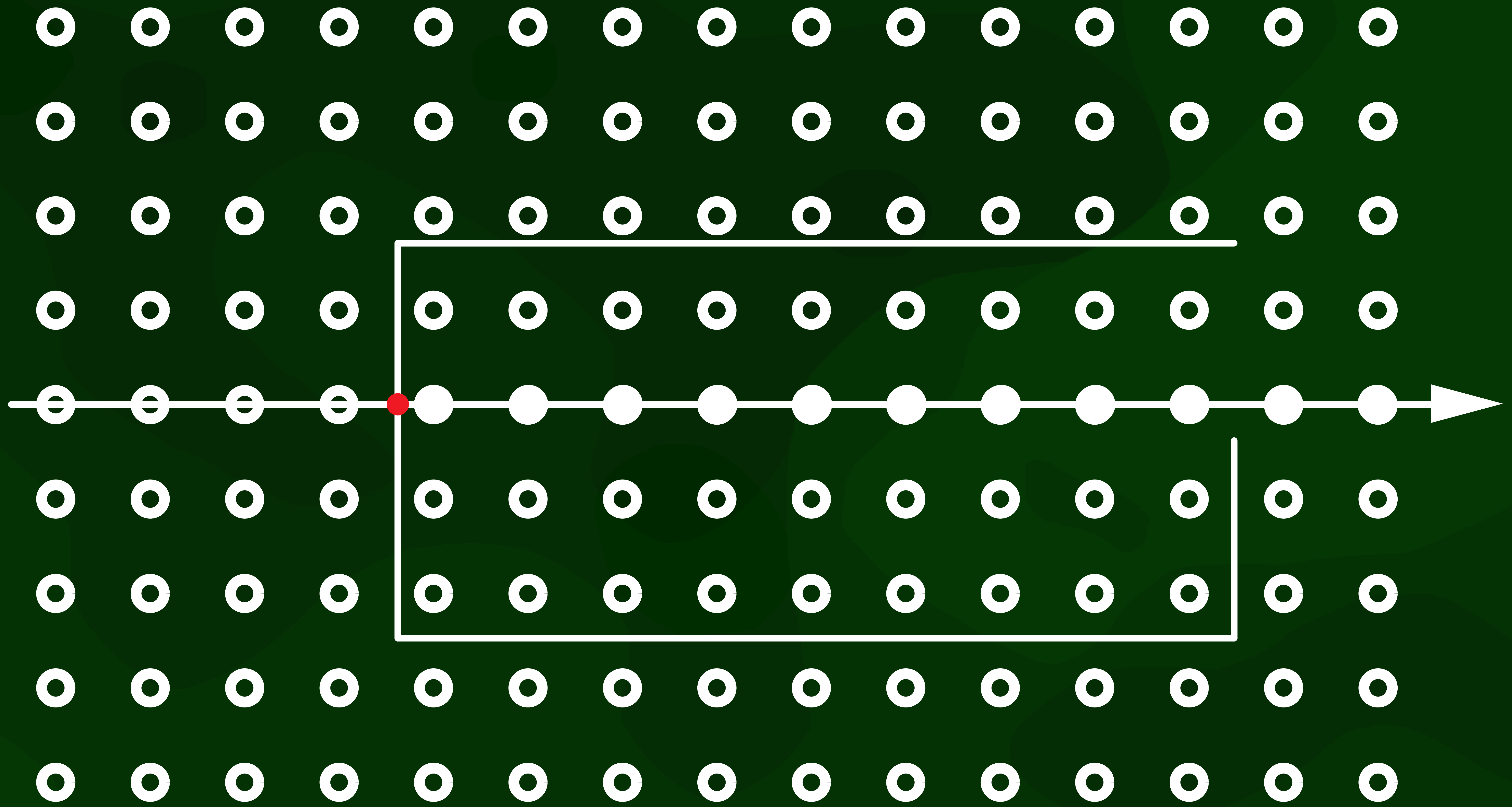
Voxelisation



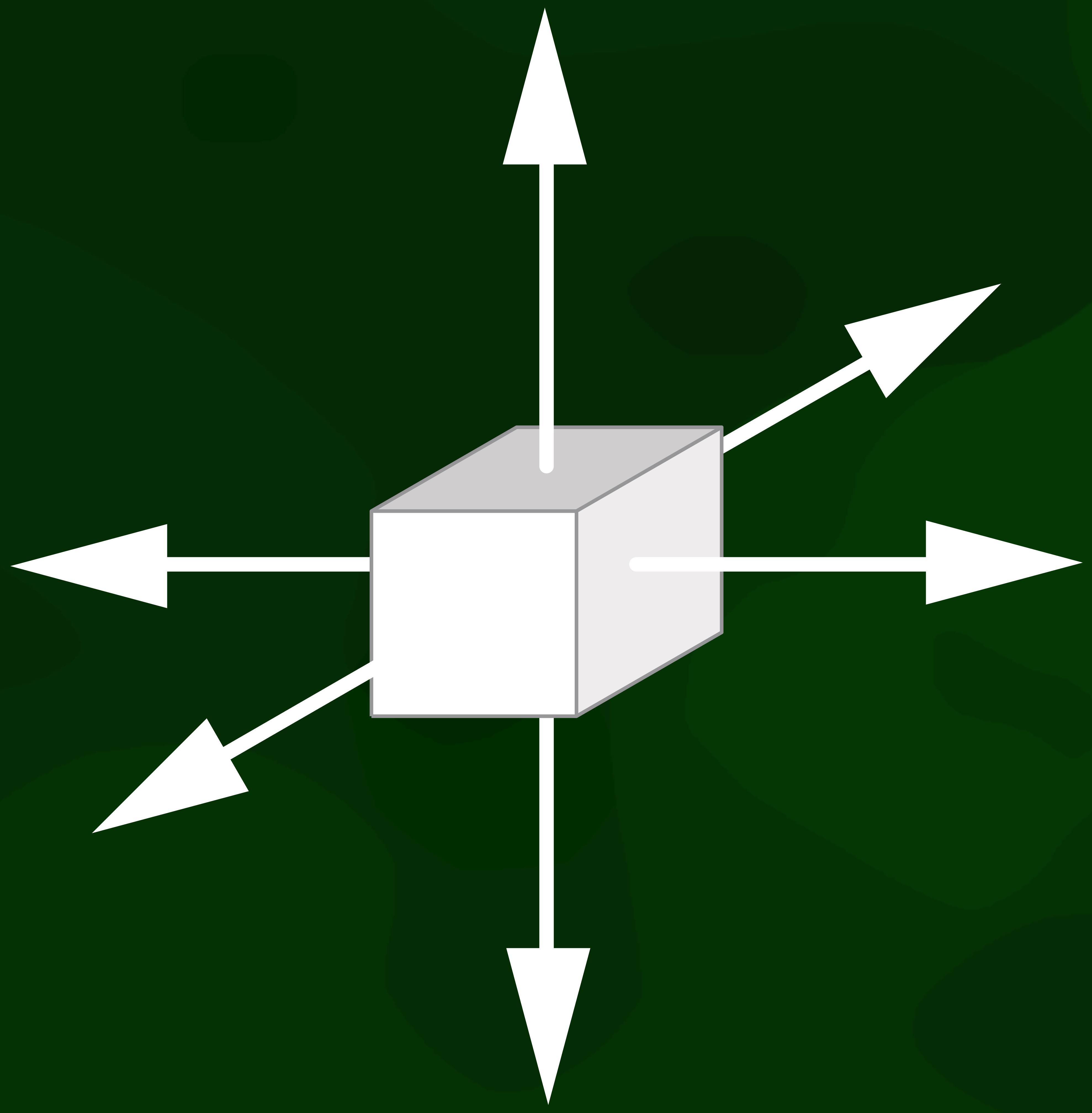
Voxelisation: overshoot



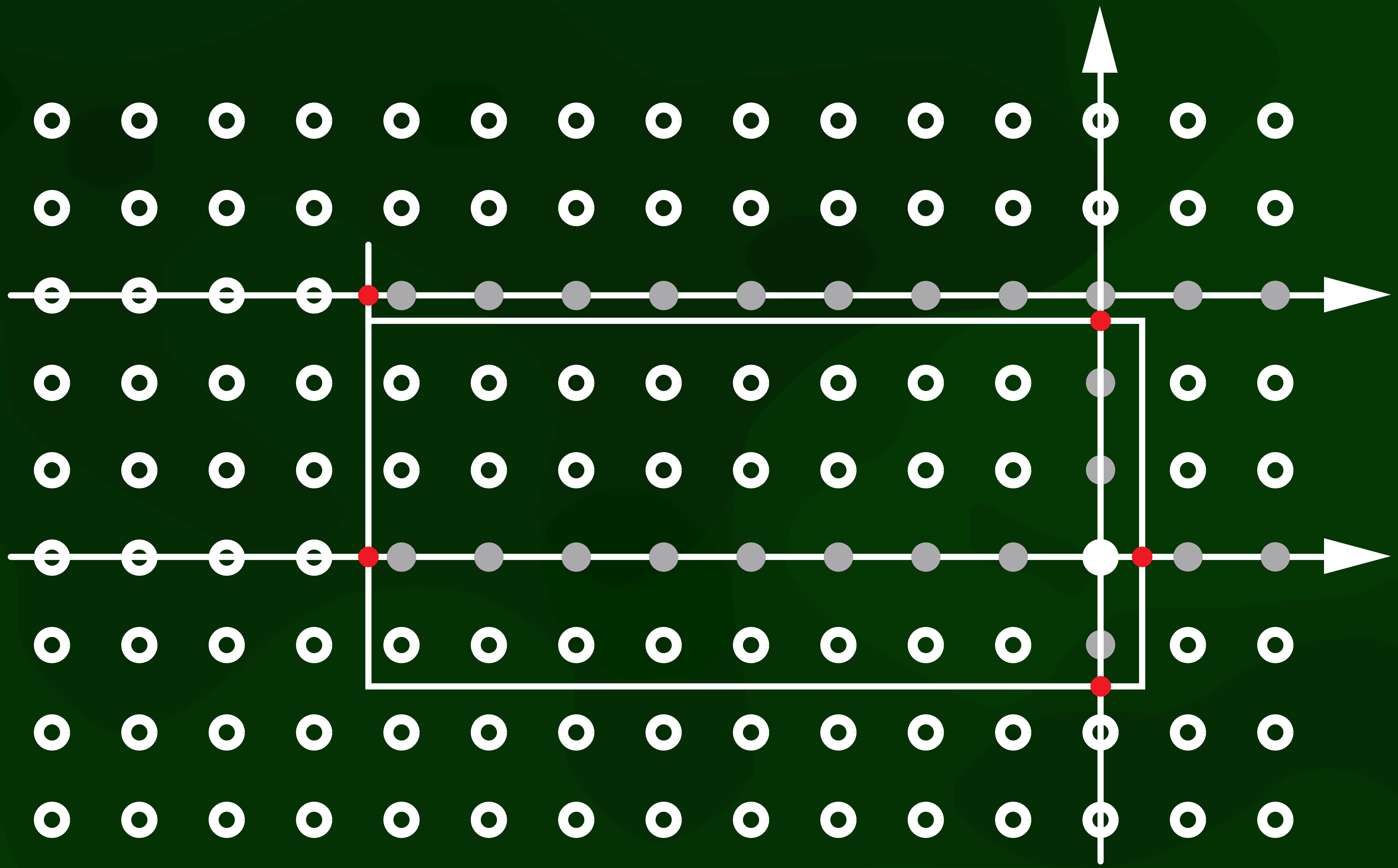
Voxelisation: gap



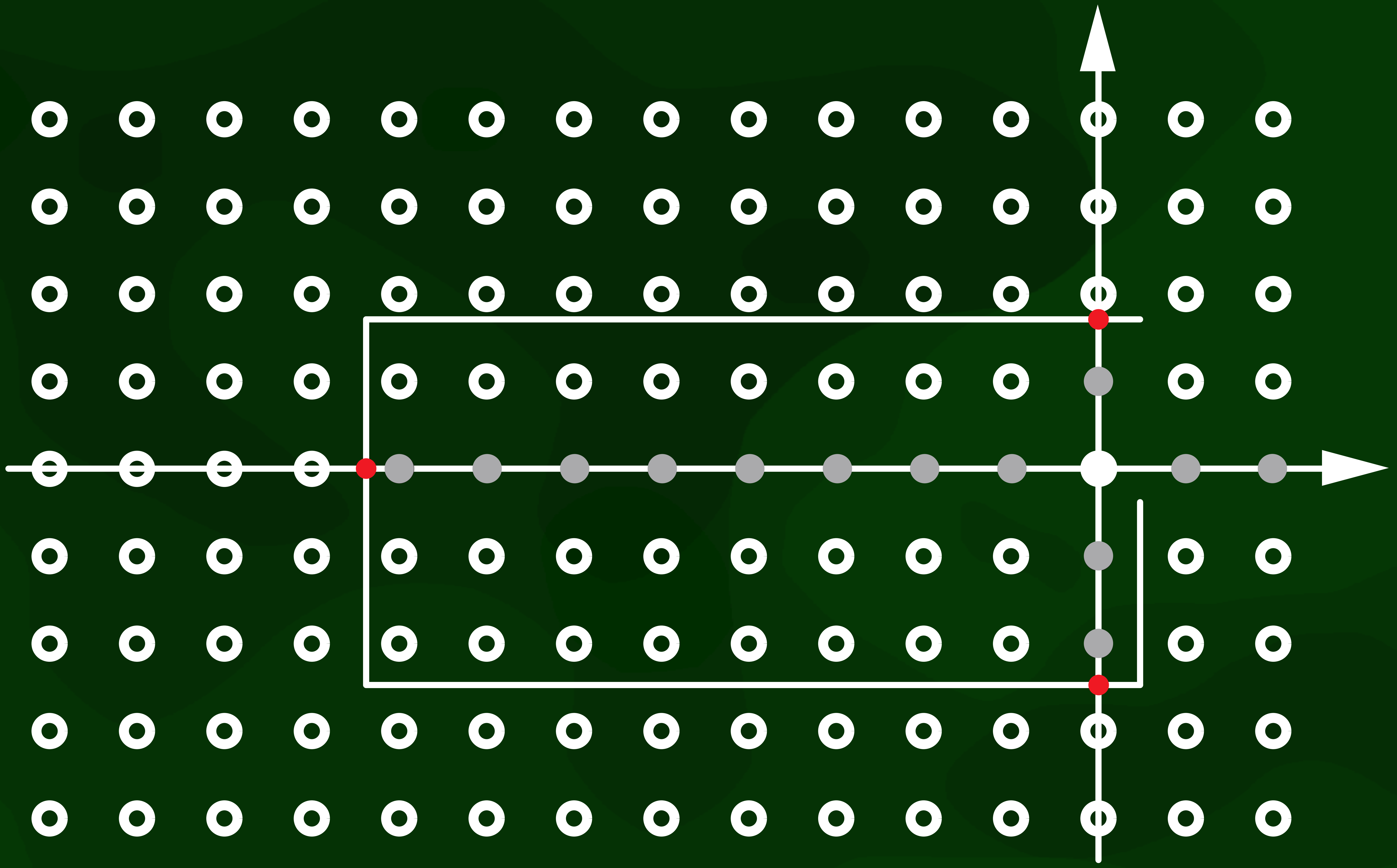
Voxelisation: shooting rays



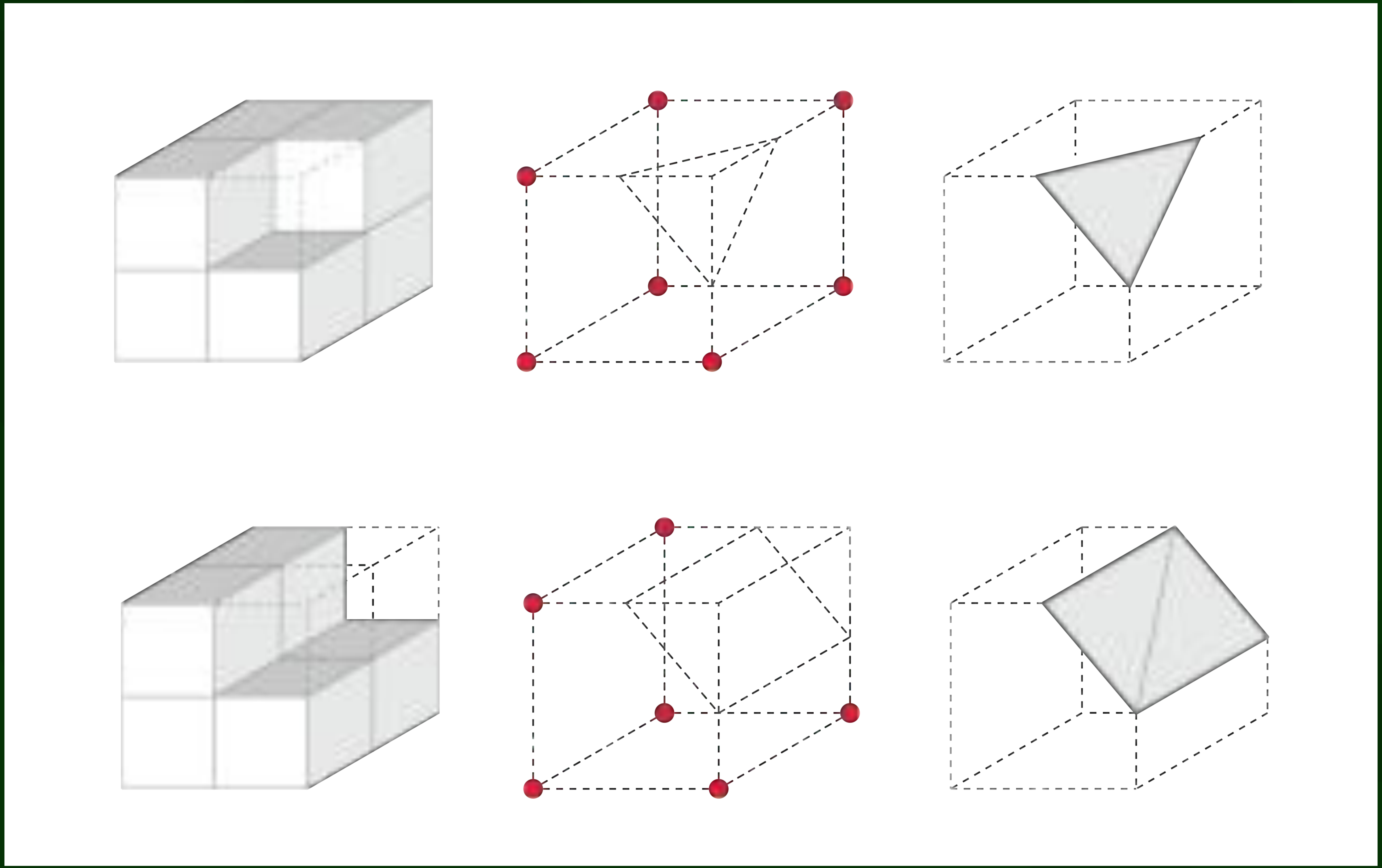
Majority counting: overshoot



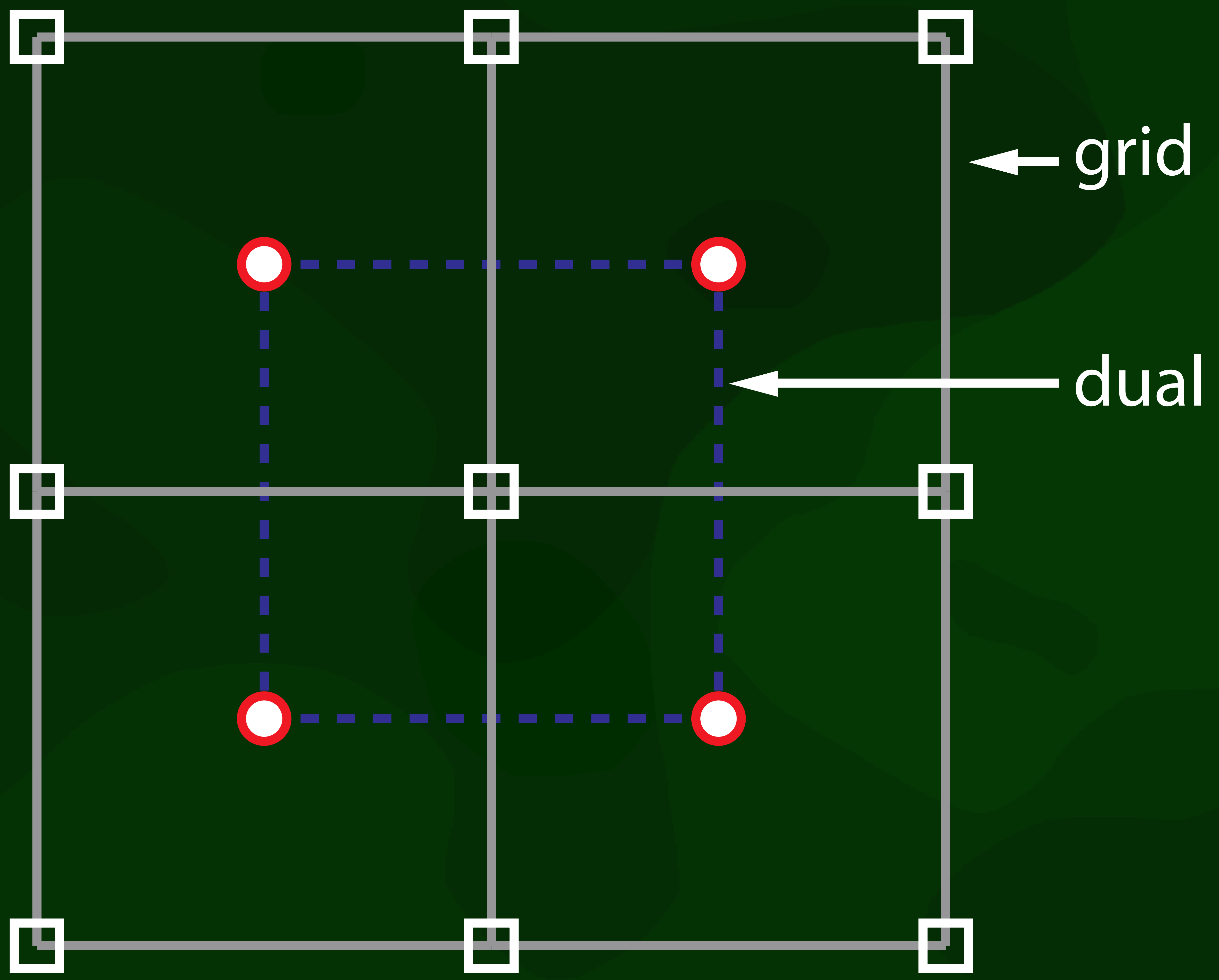
Majority counting: gap



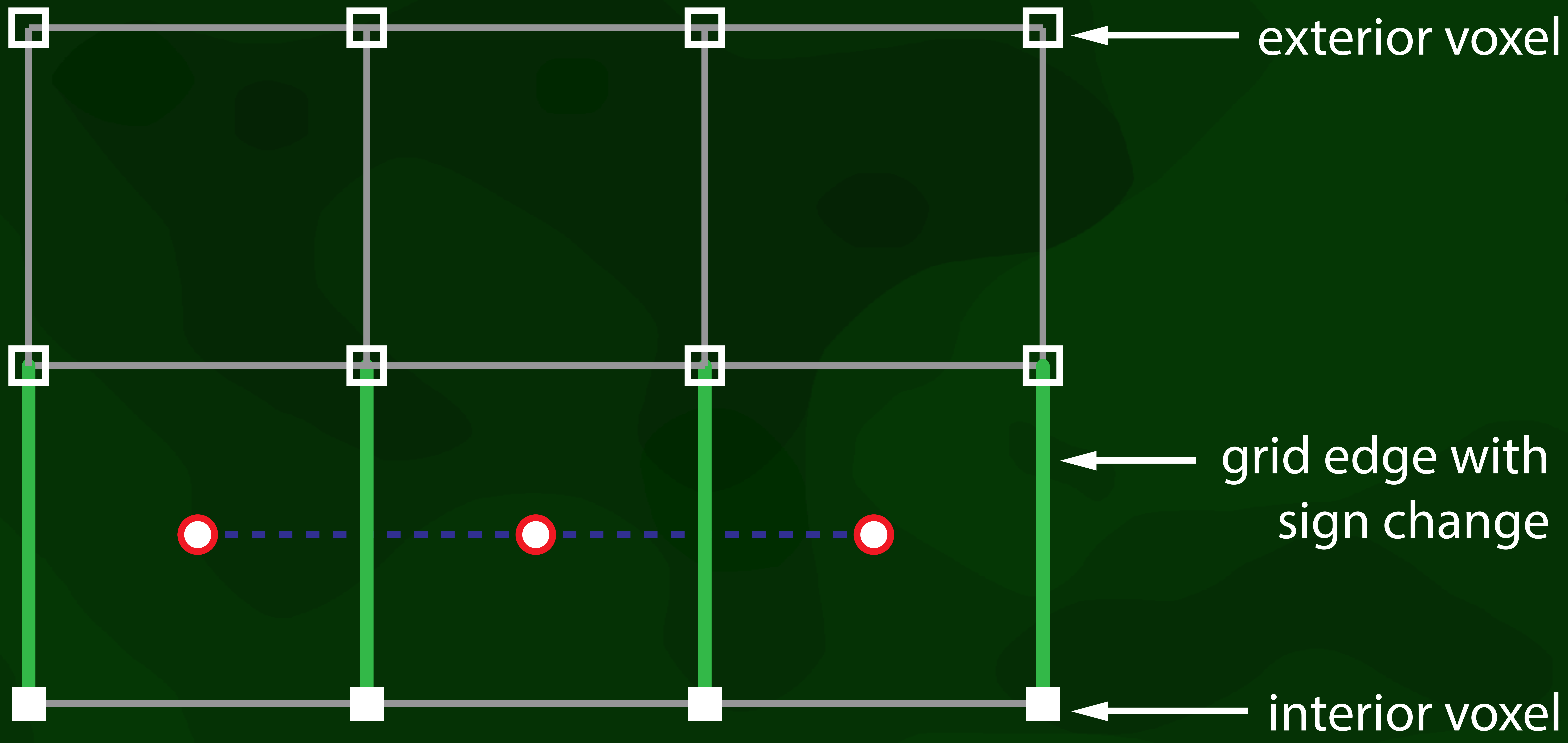
Marching cubes



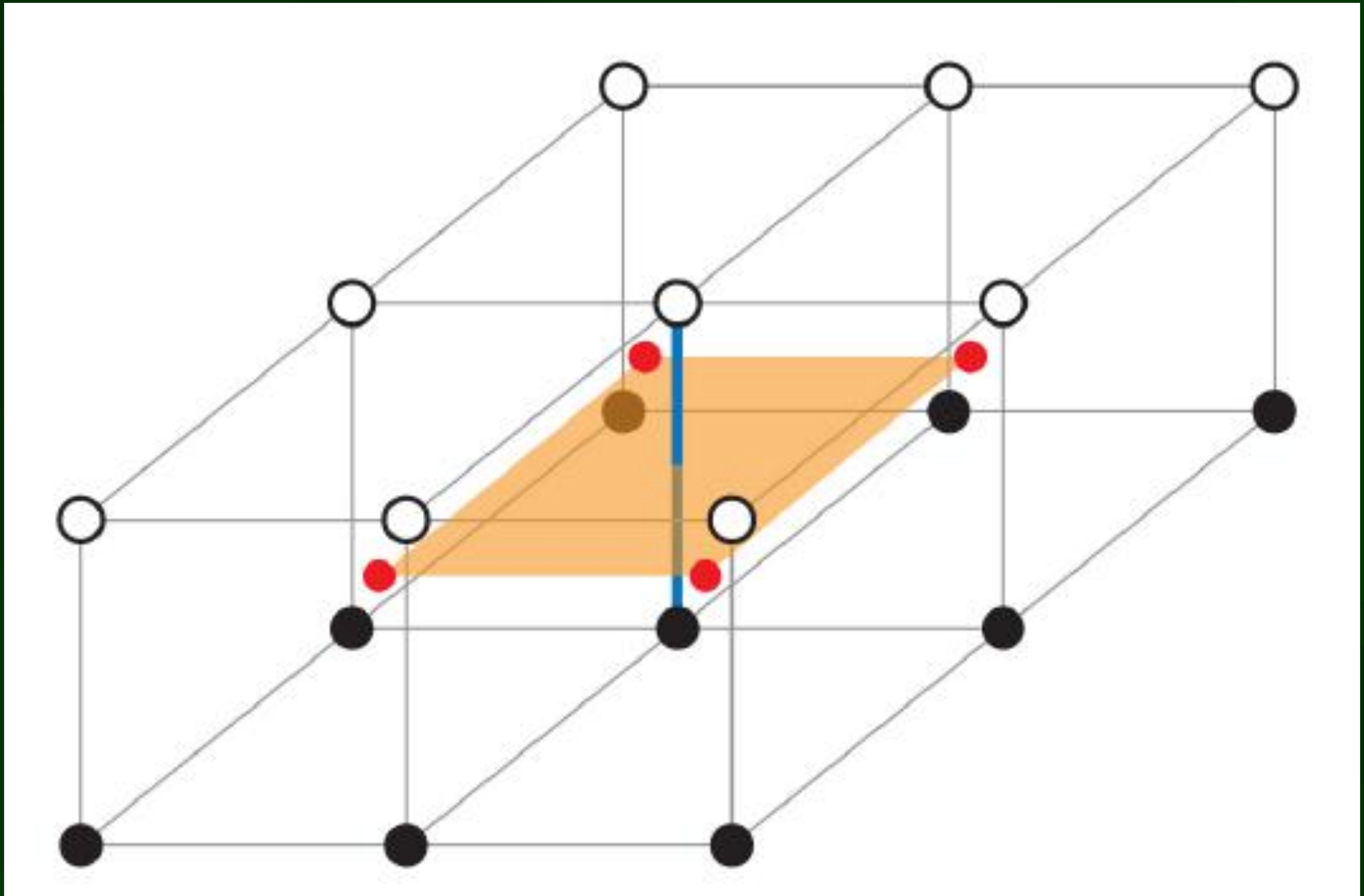
Dual contouring



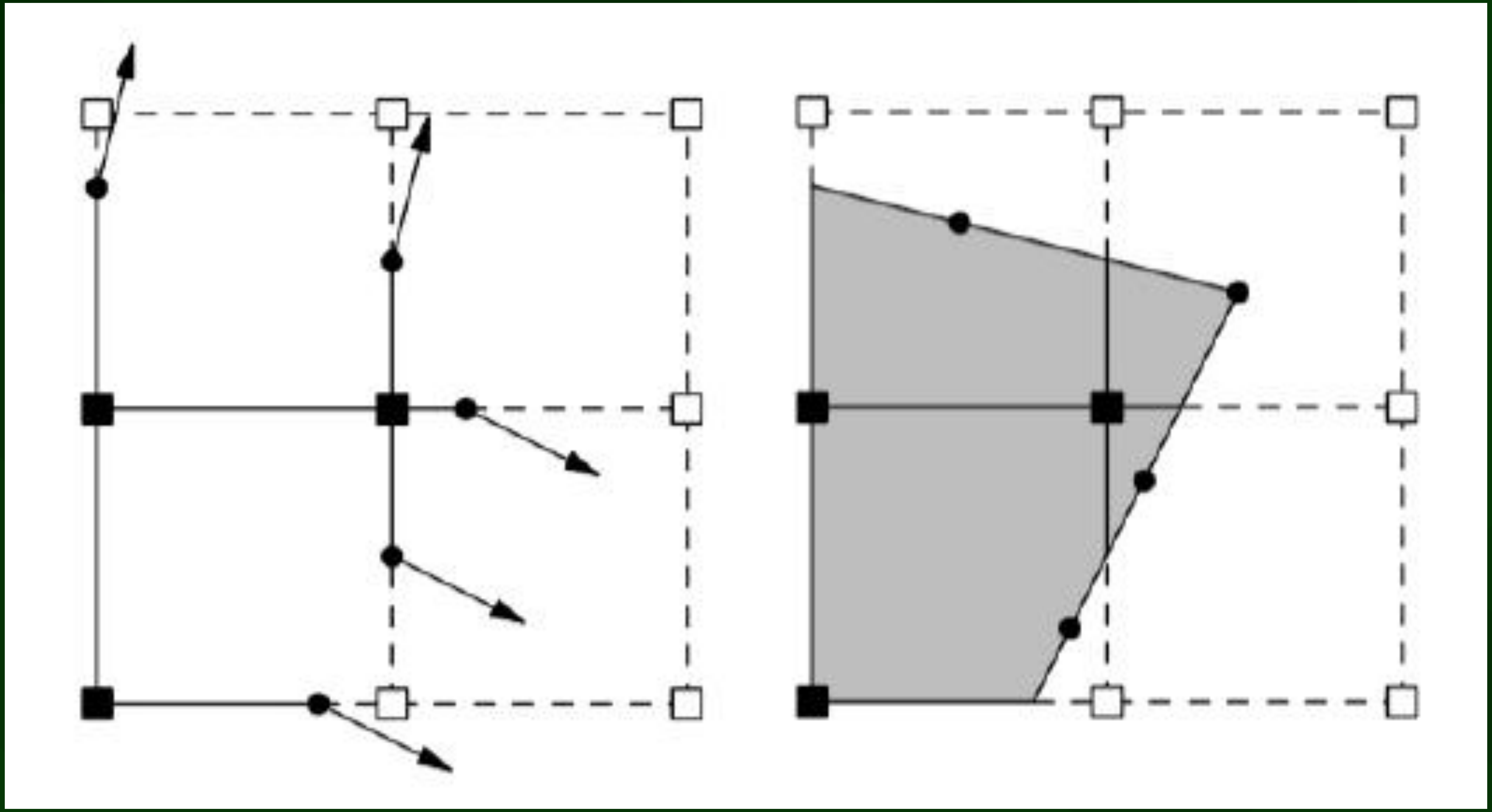
Dual contouring



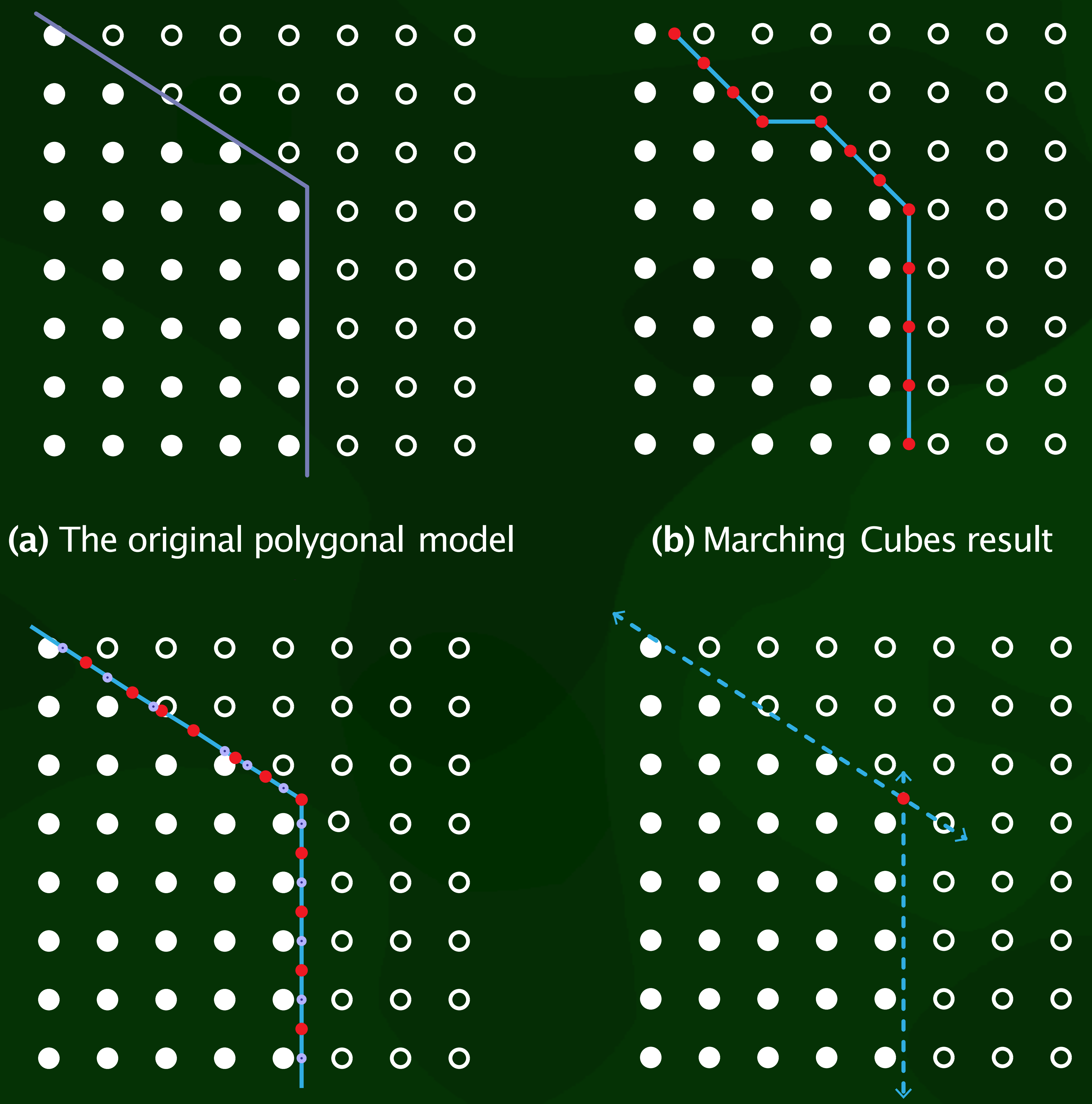
Dual contouring



Dual contouring

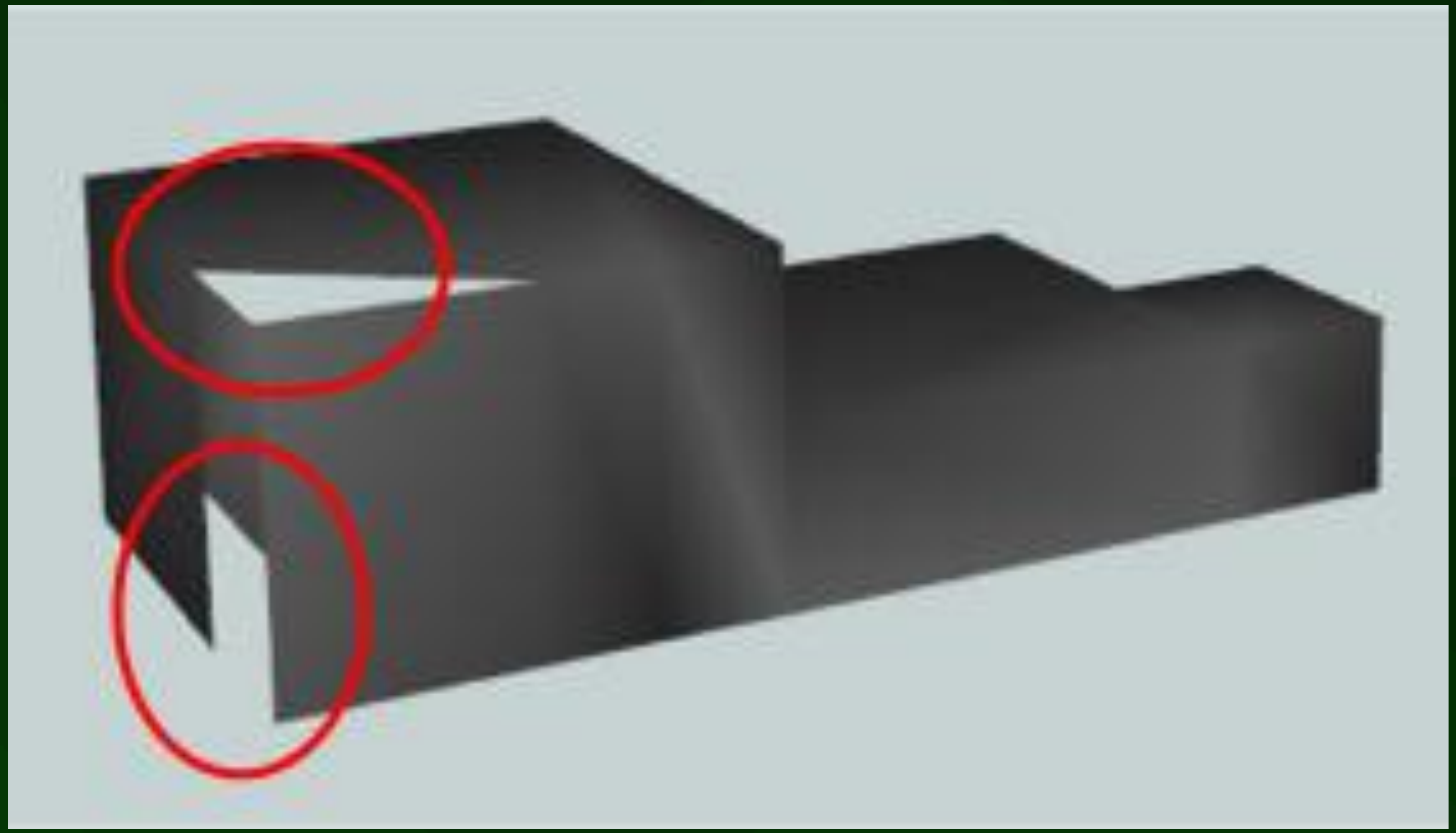


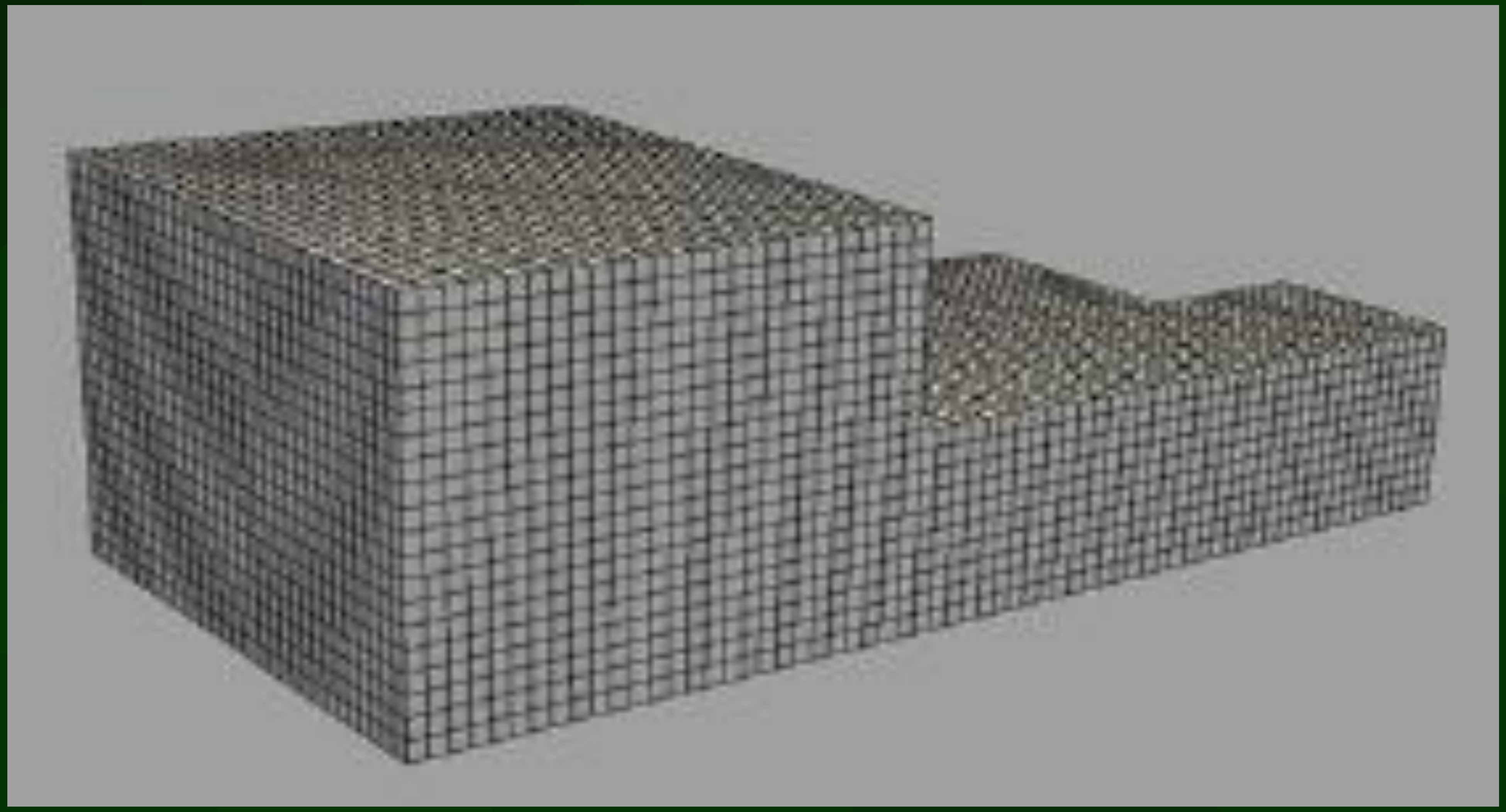
Full process



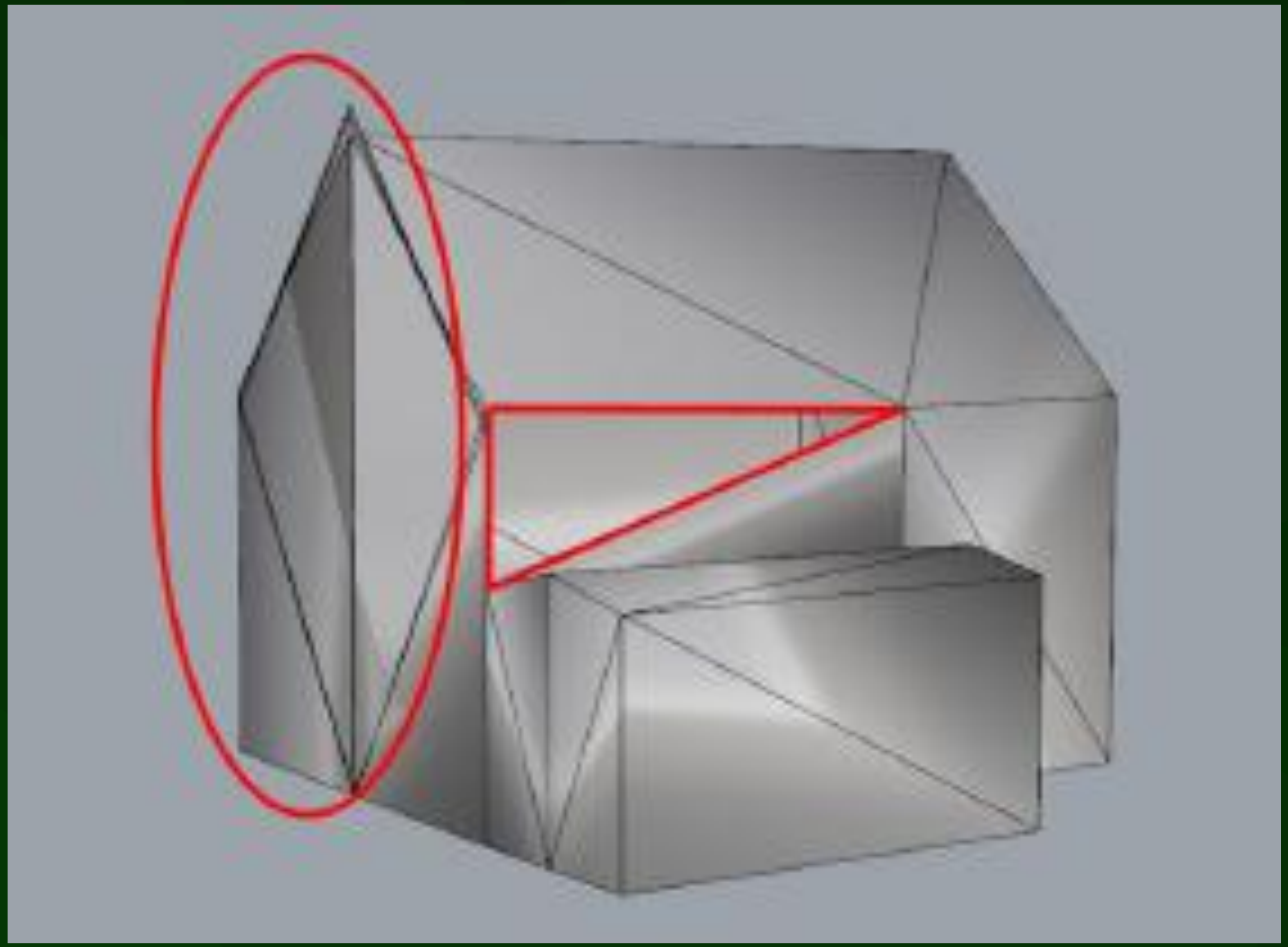
(a) The original polygonal model
(b) Marching Cubes result
(c) Dual Contouring result
(d) Pressing result

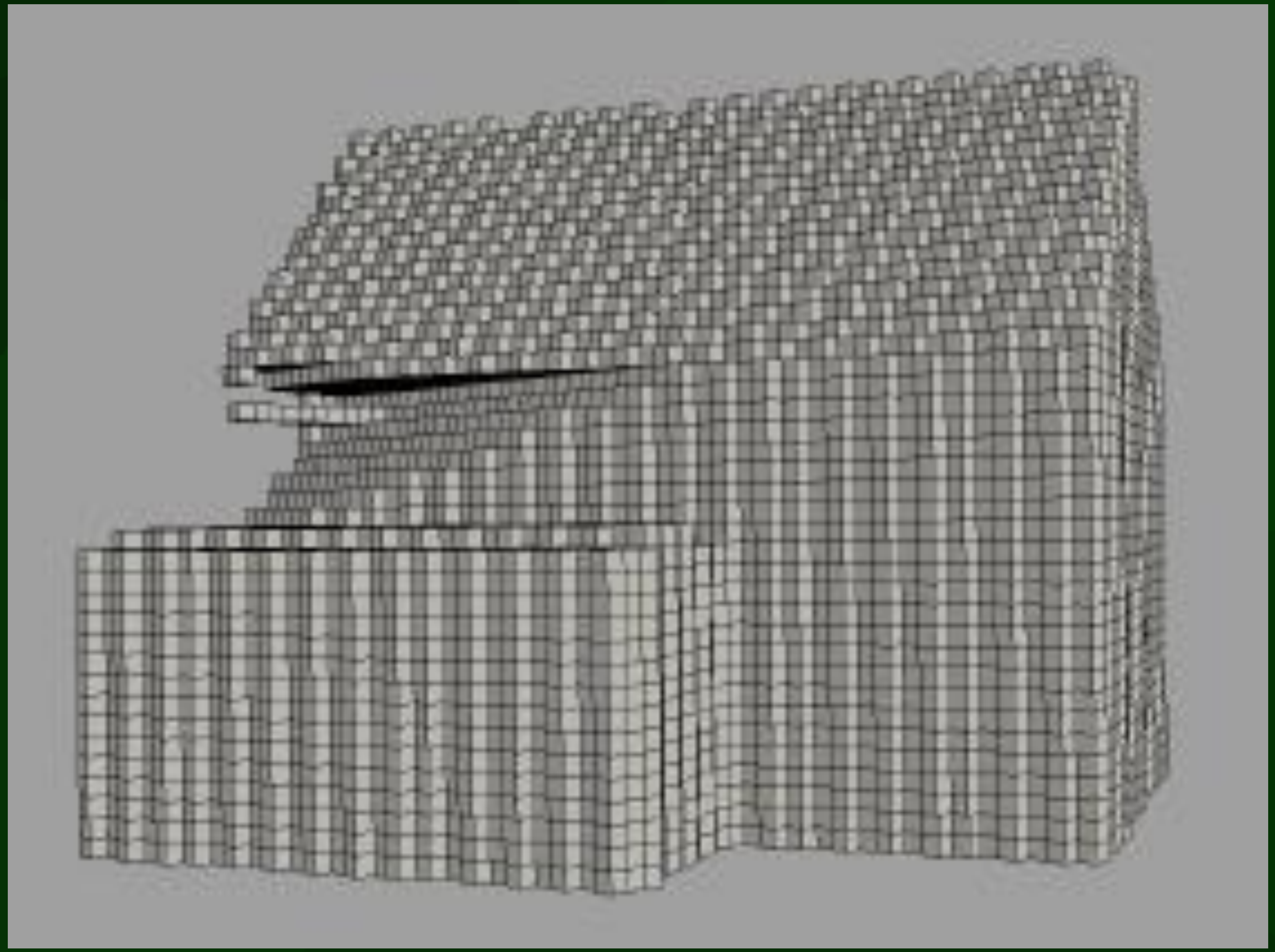
Results



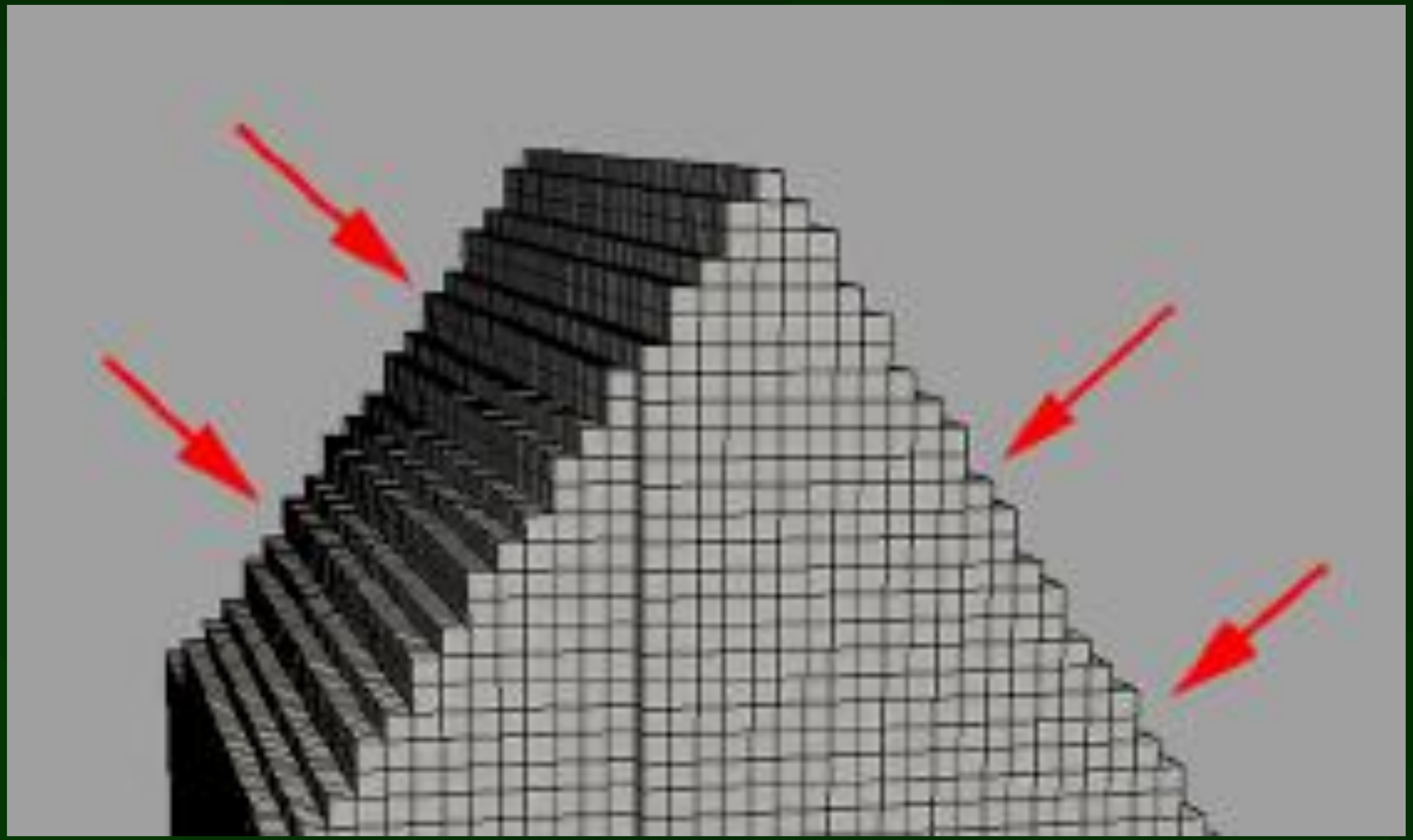


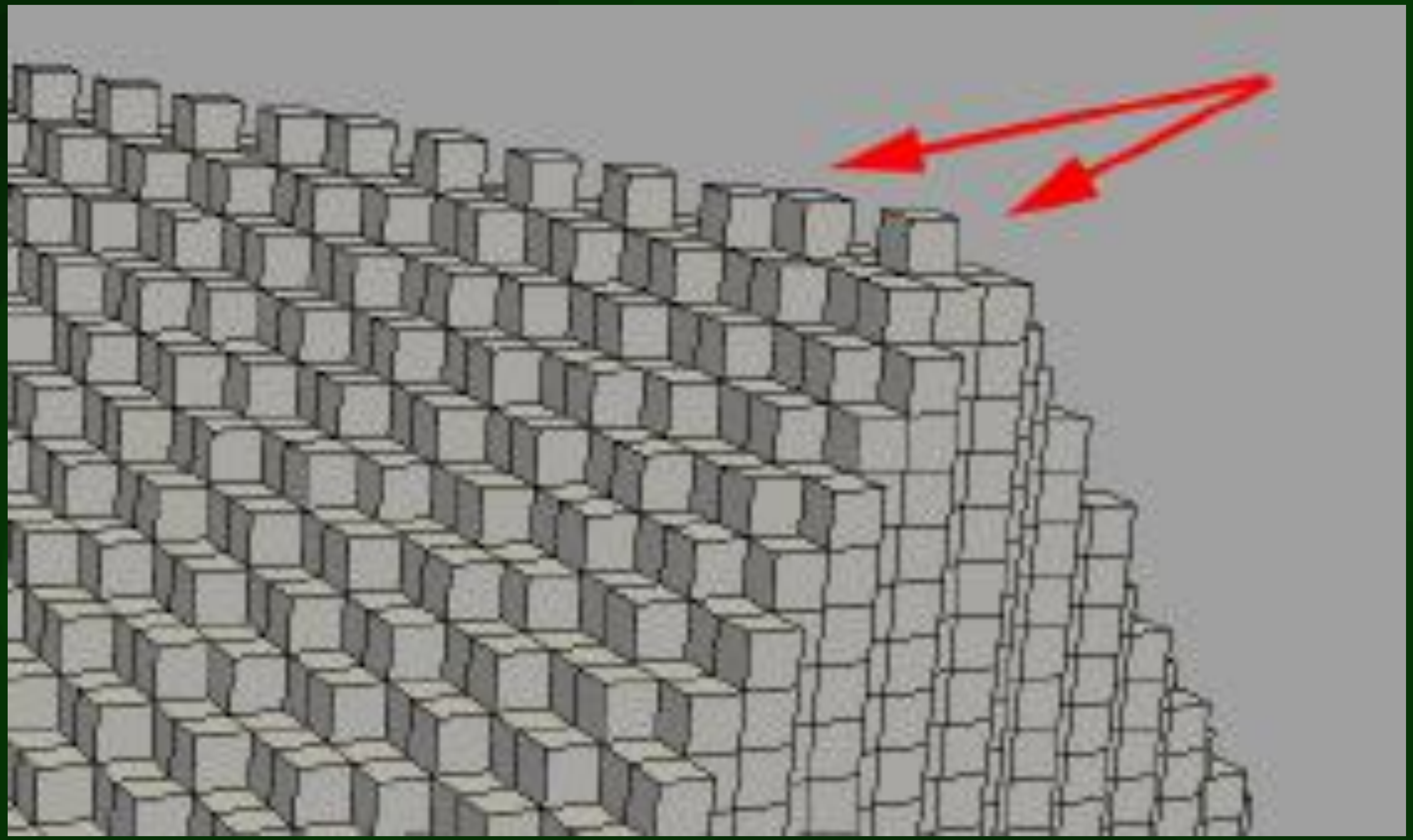
Results



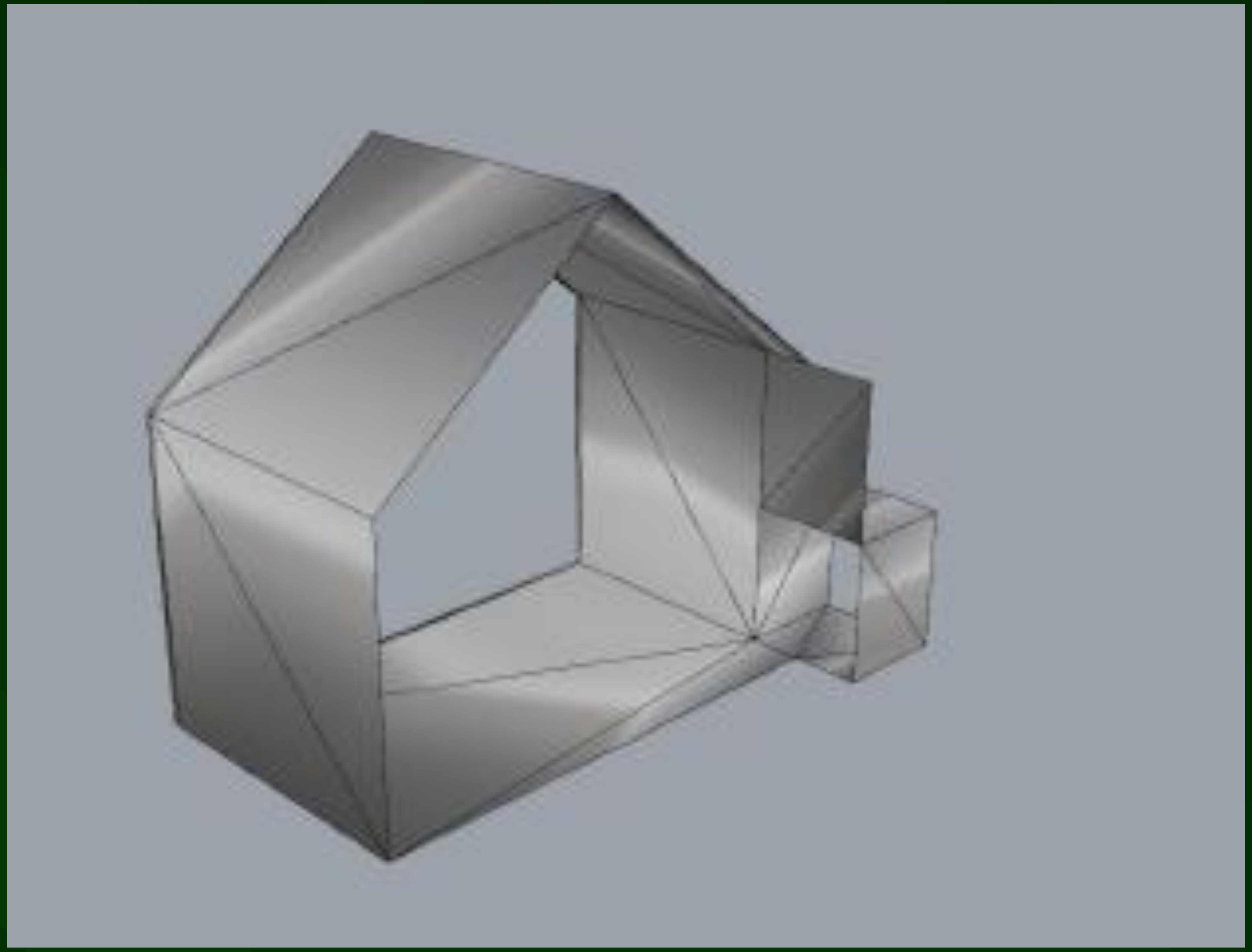


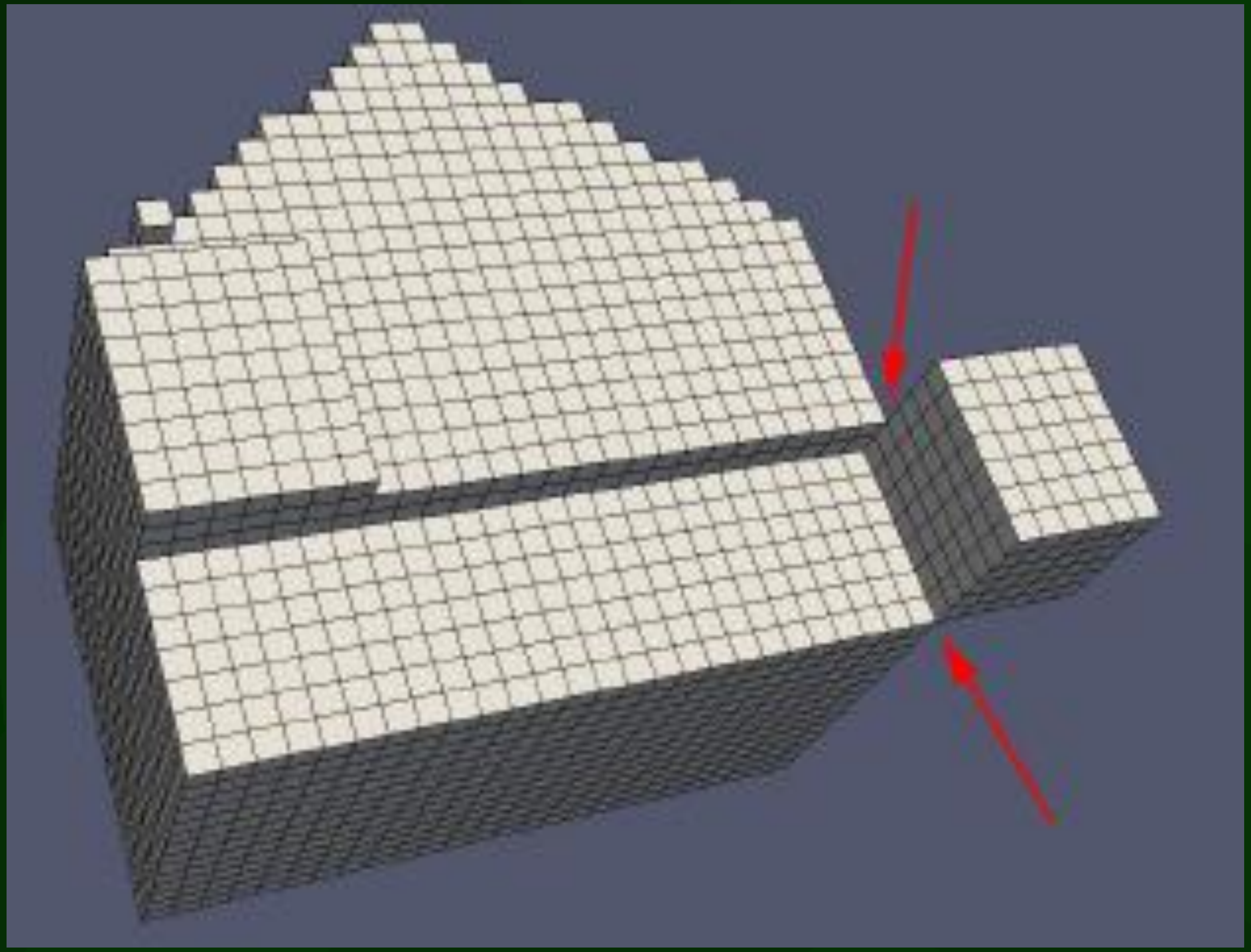
Artefacts



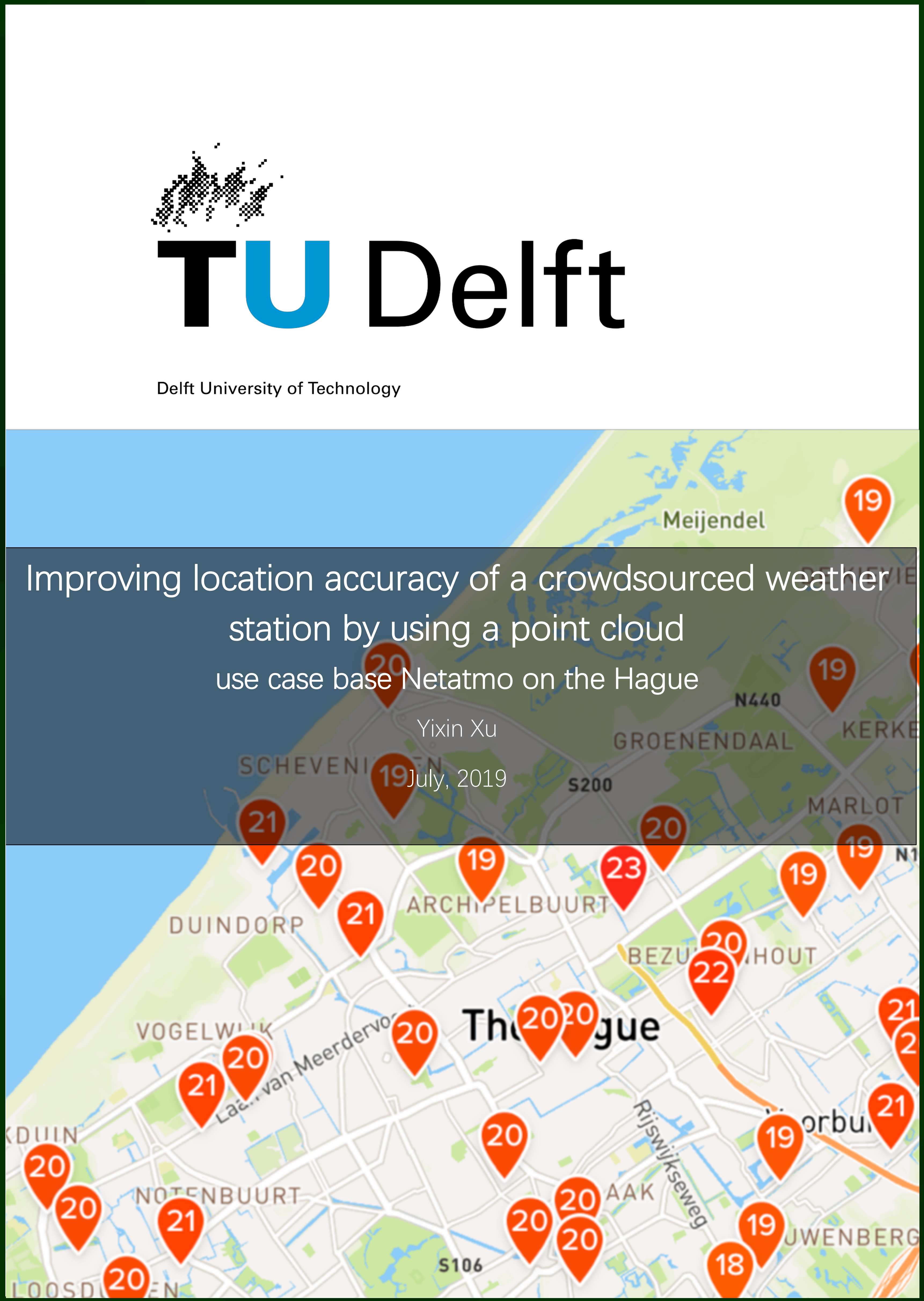


Results



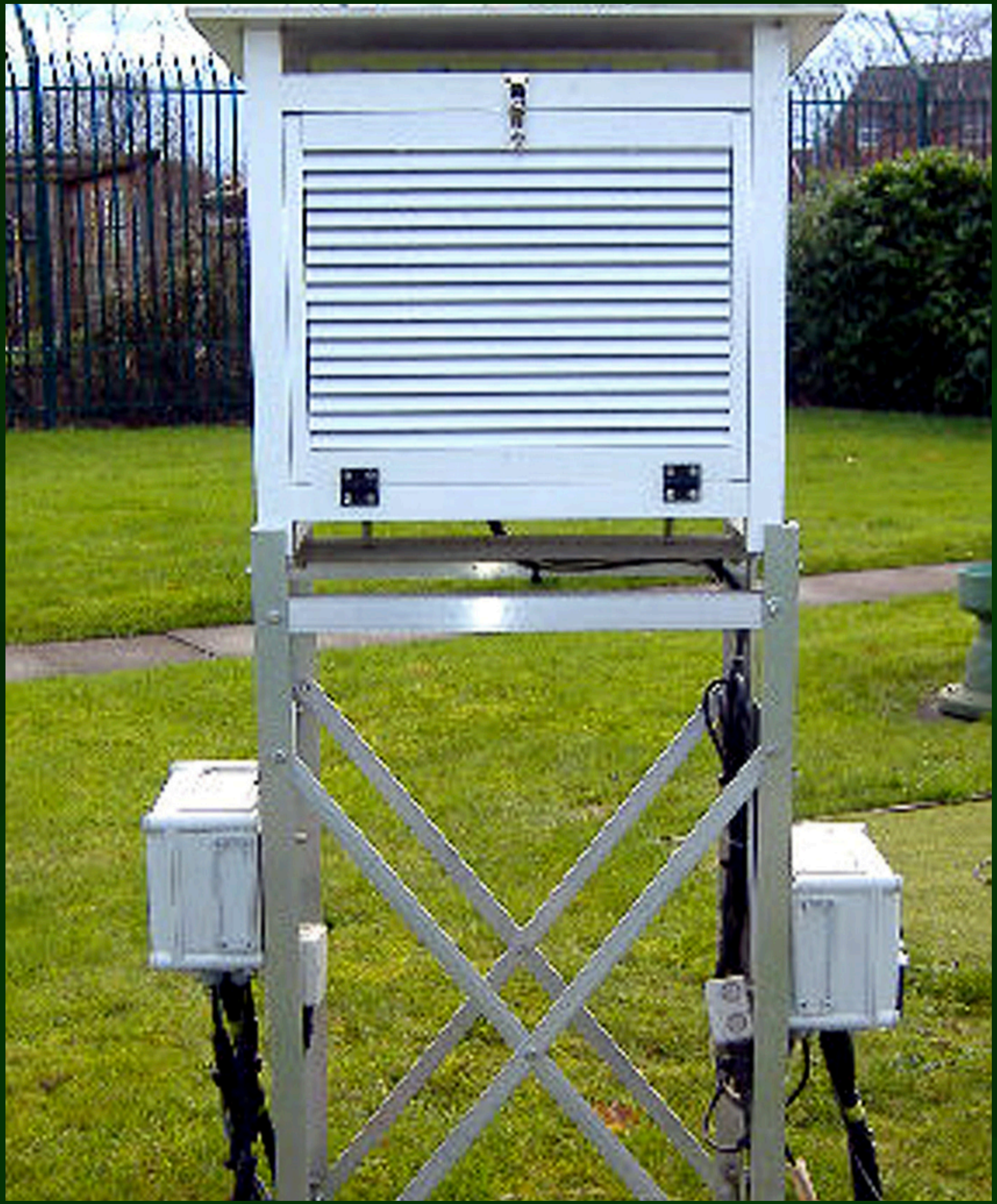


- Motivation: improving the accuracy of the location of personal weather stations for urban heat island research
- Generate potential locations
- Evaluate them through skyview + solar modelling



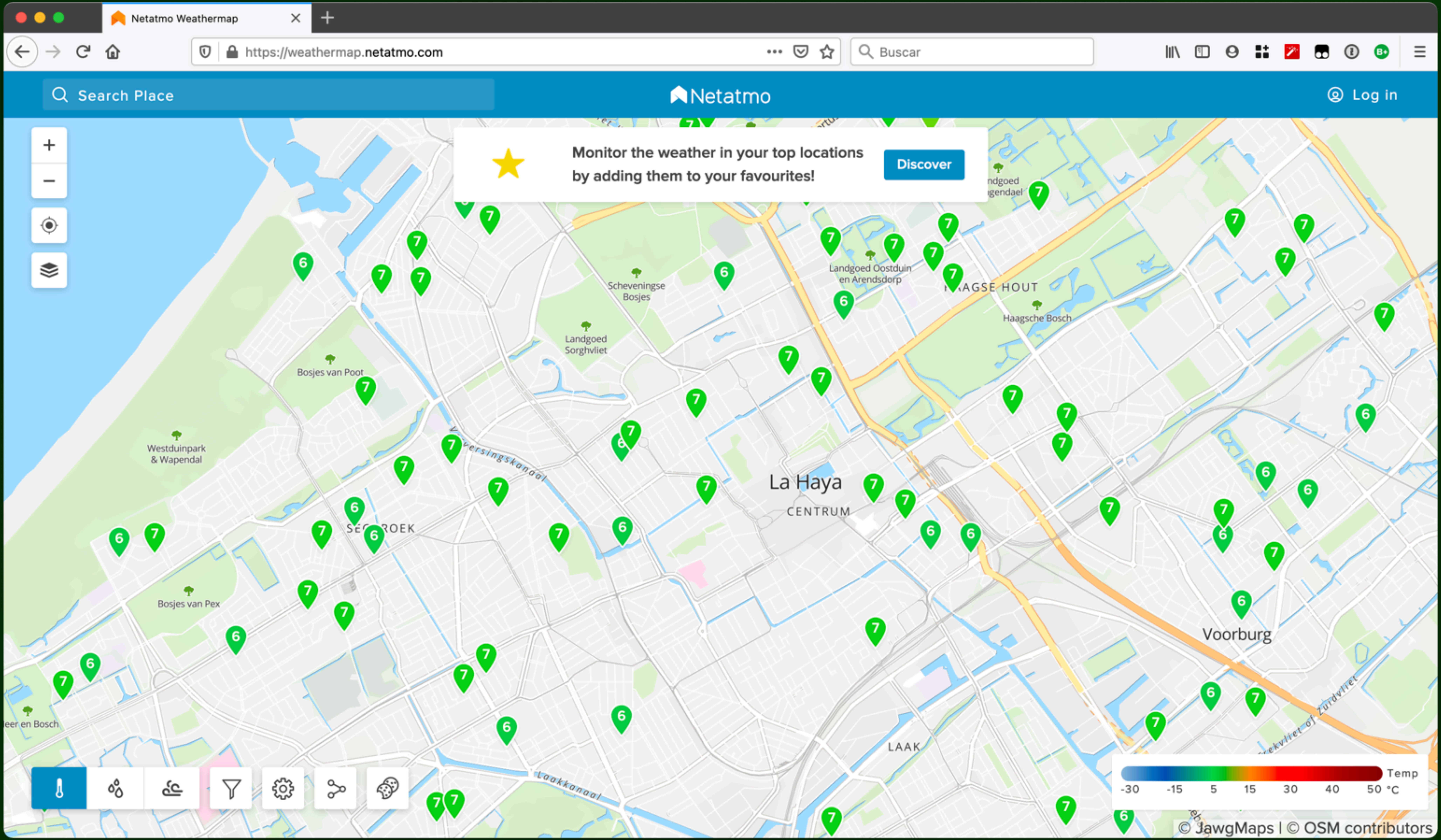
Urban heat island

Traditional weather stations

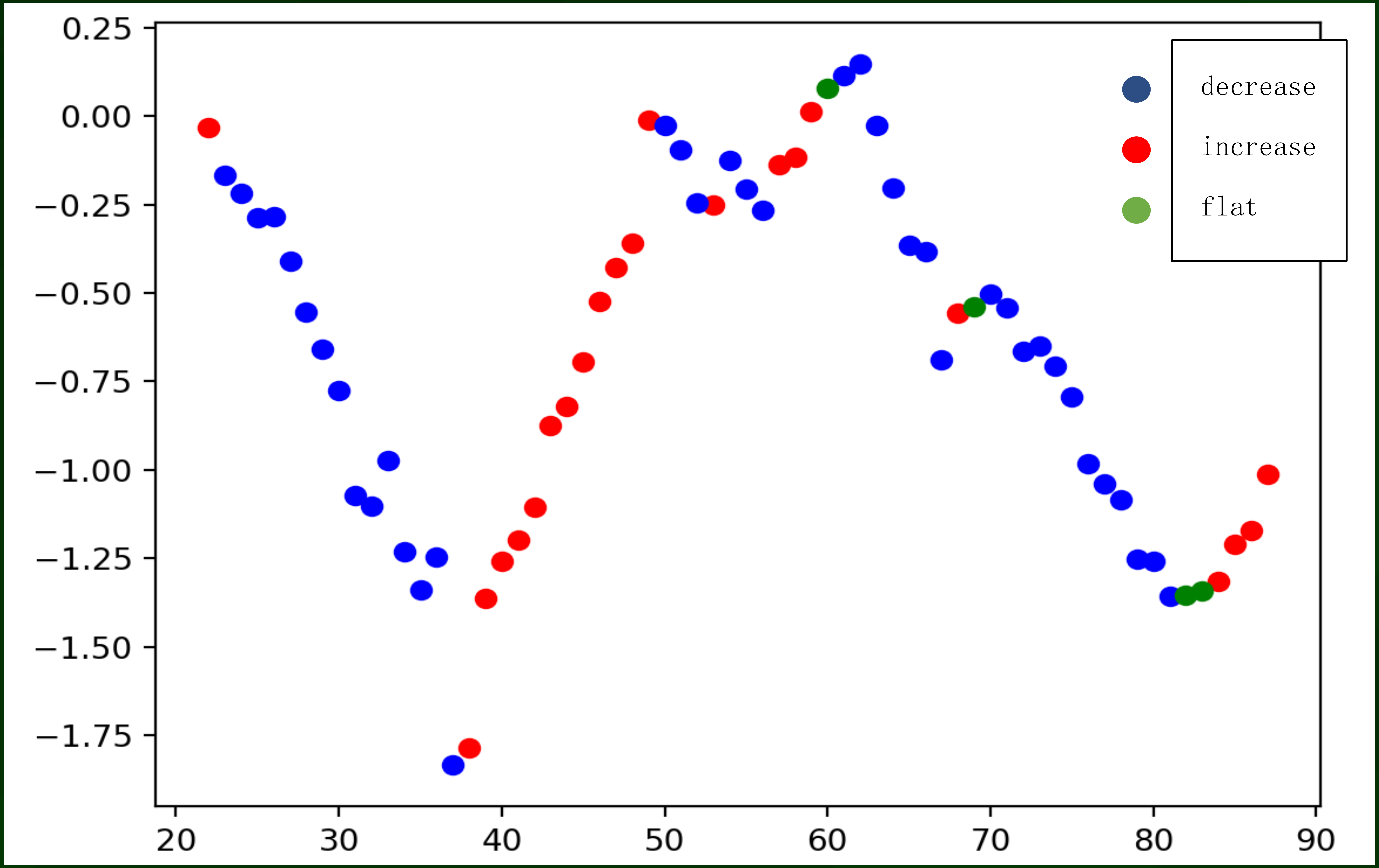


Personal weather stations

Crowdsourced weather data



Behaviour



0.25
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decrease
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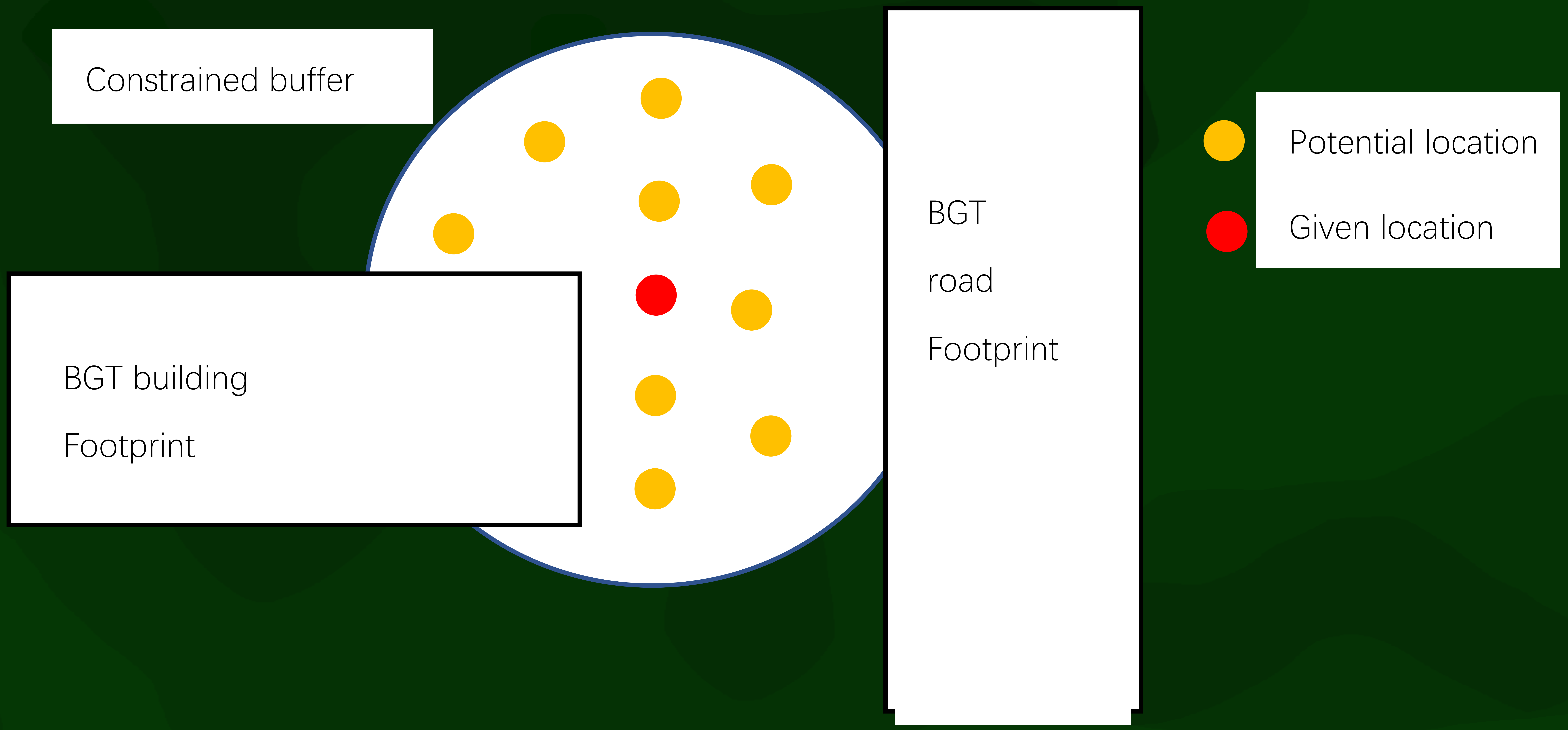
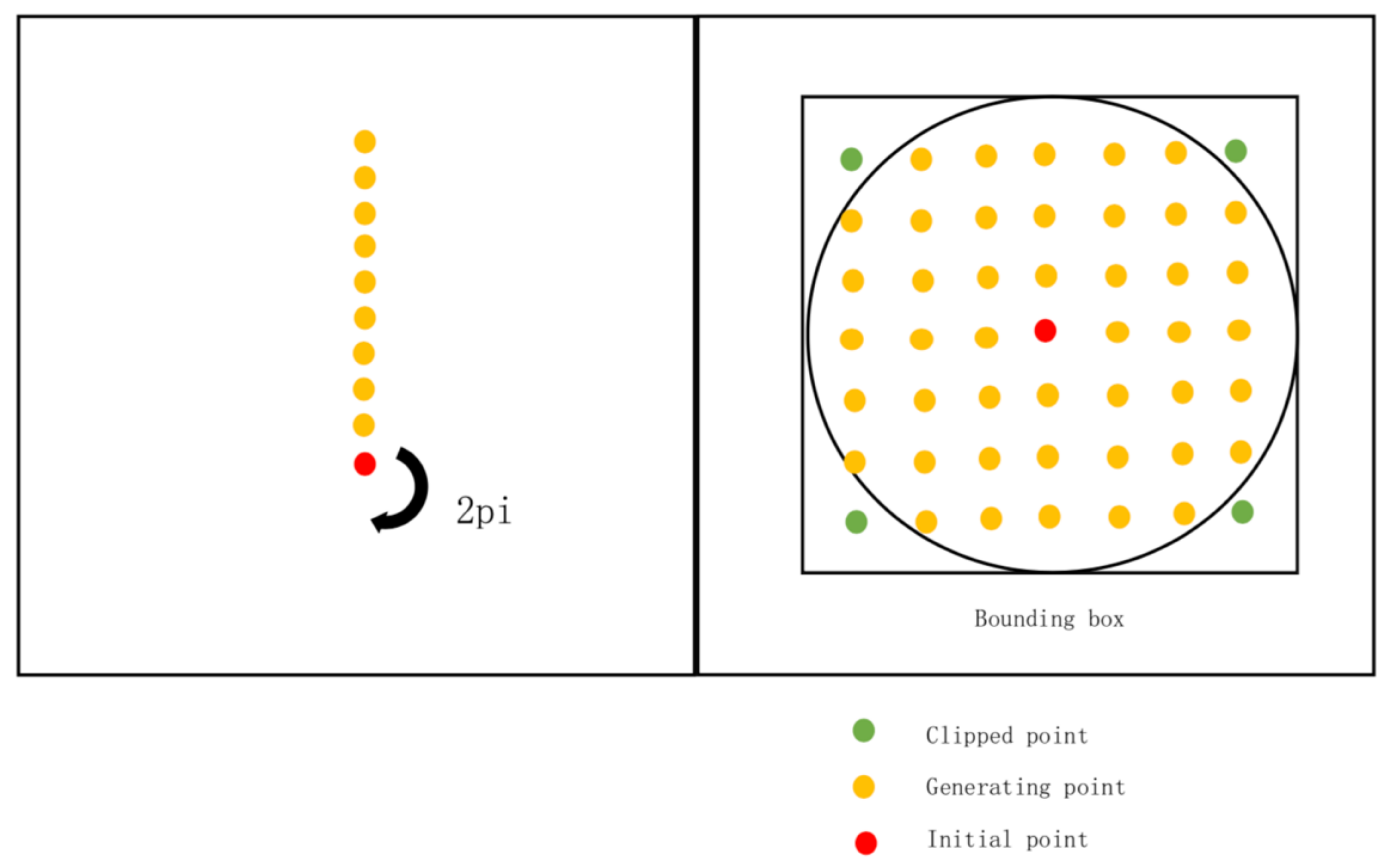
flat

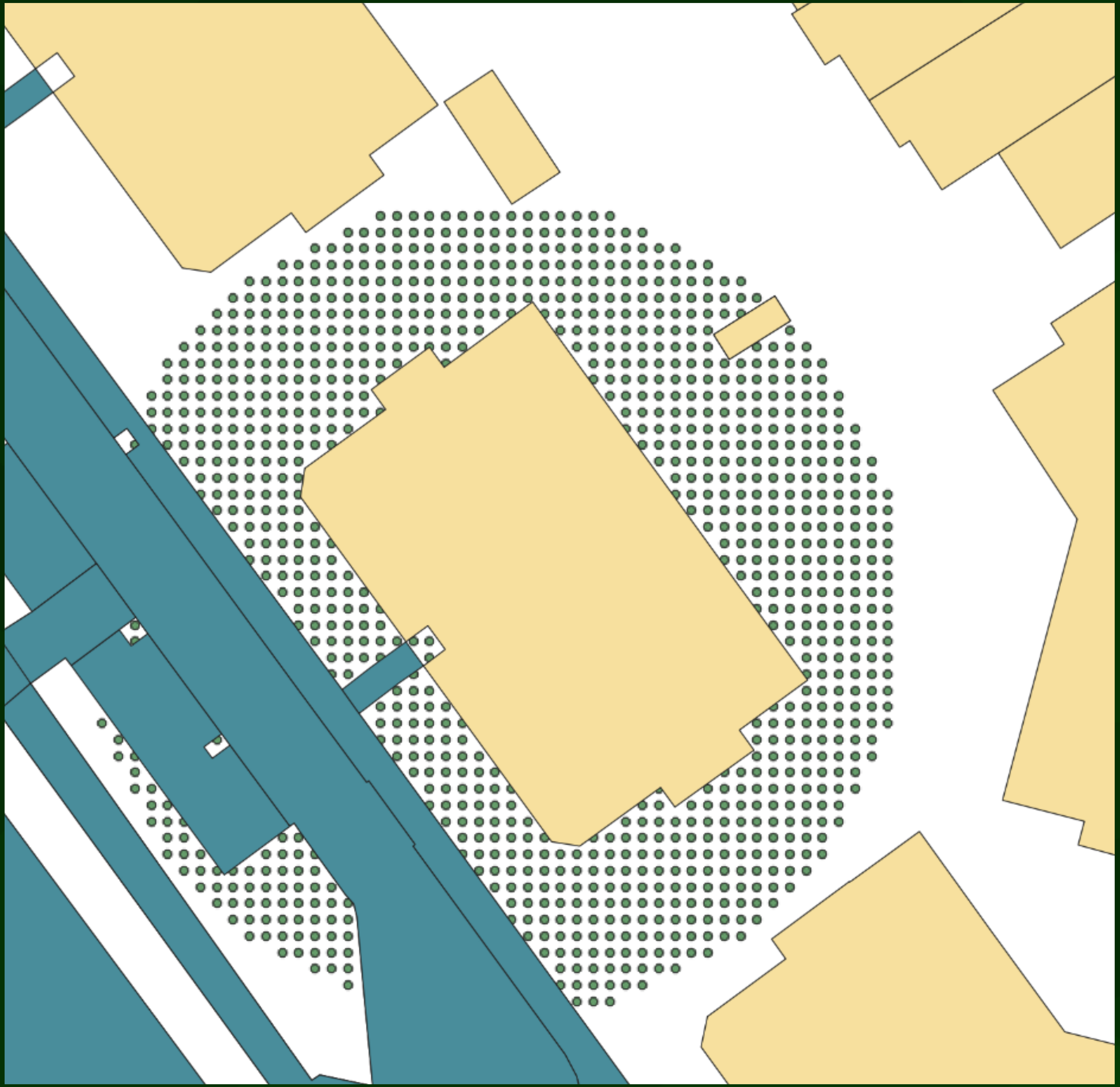
Potential locations



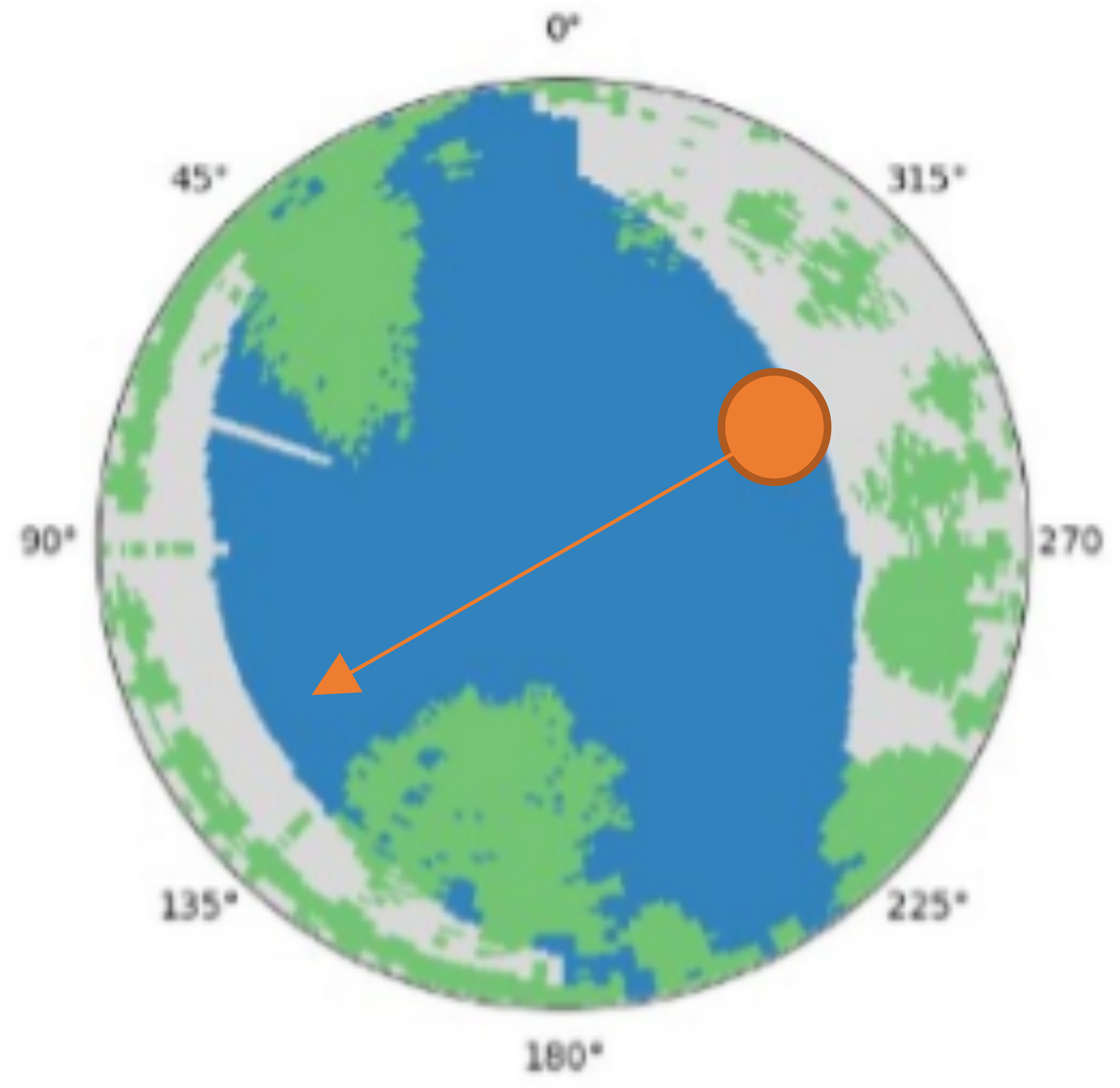
Potential locations



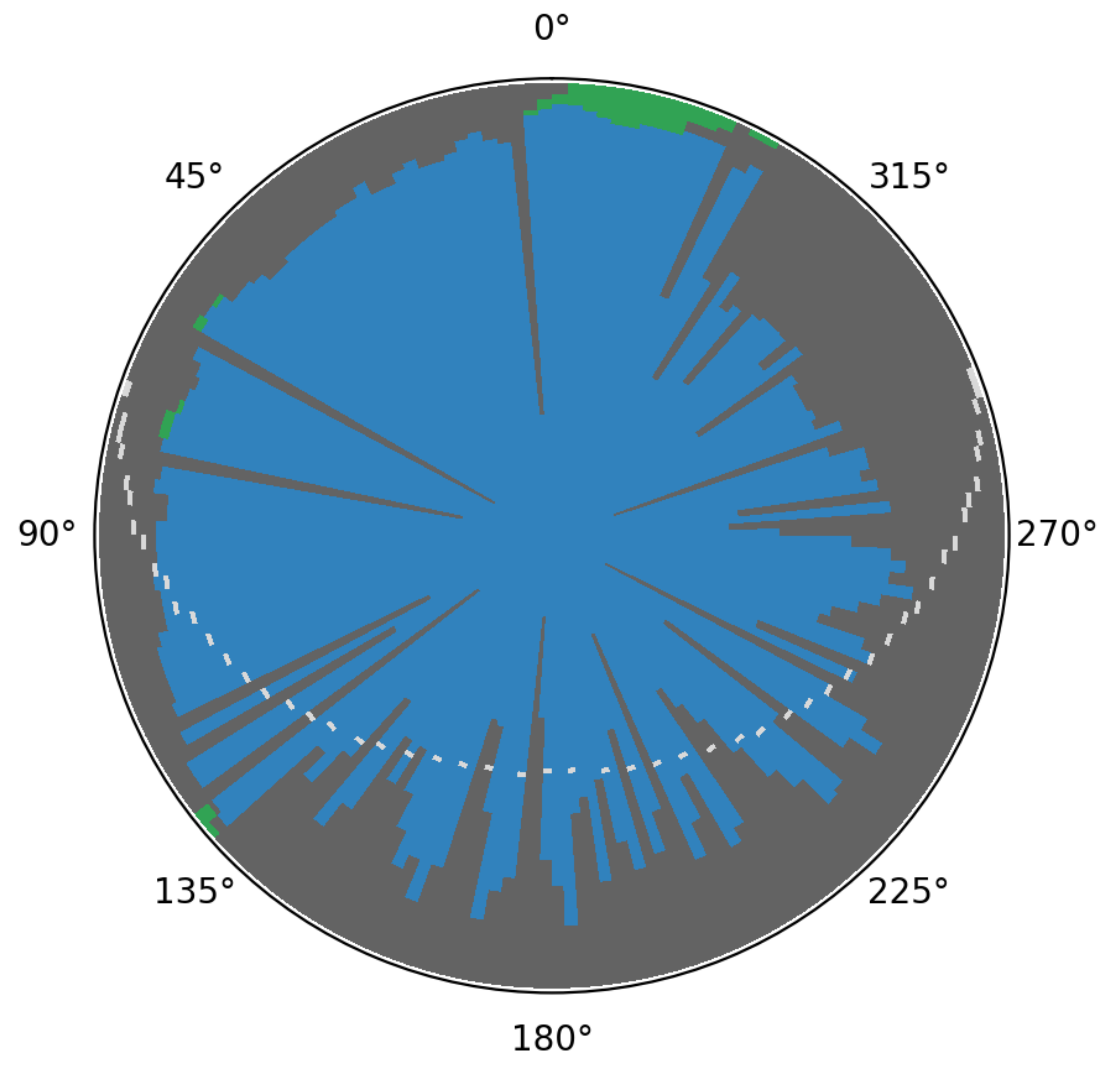
Potential locations



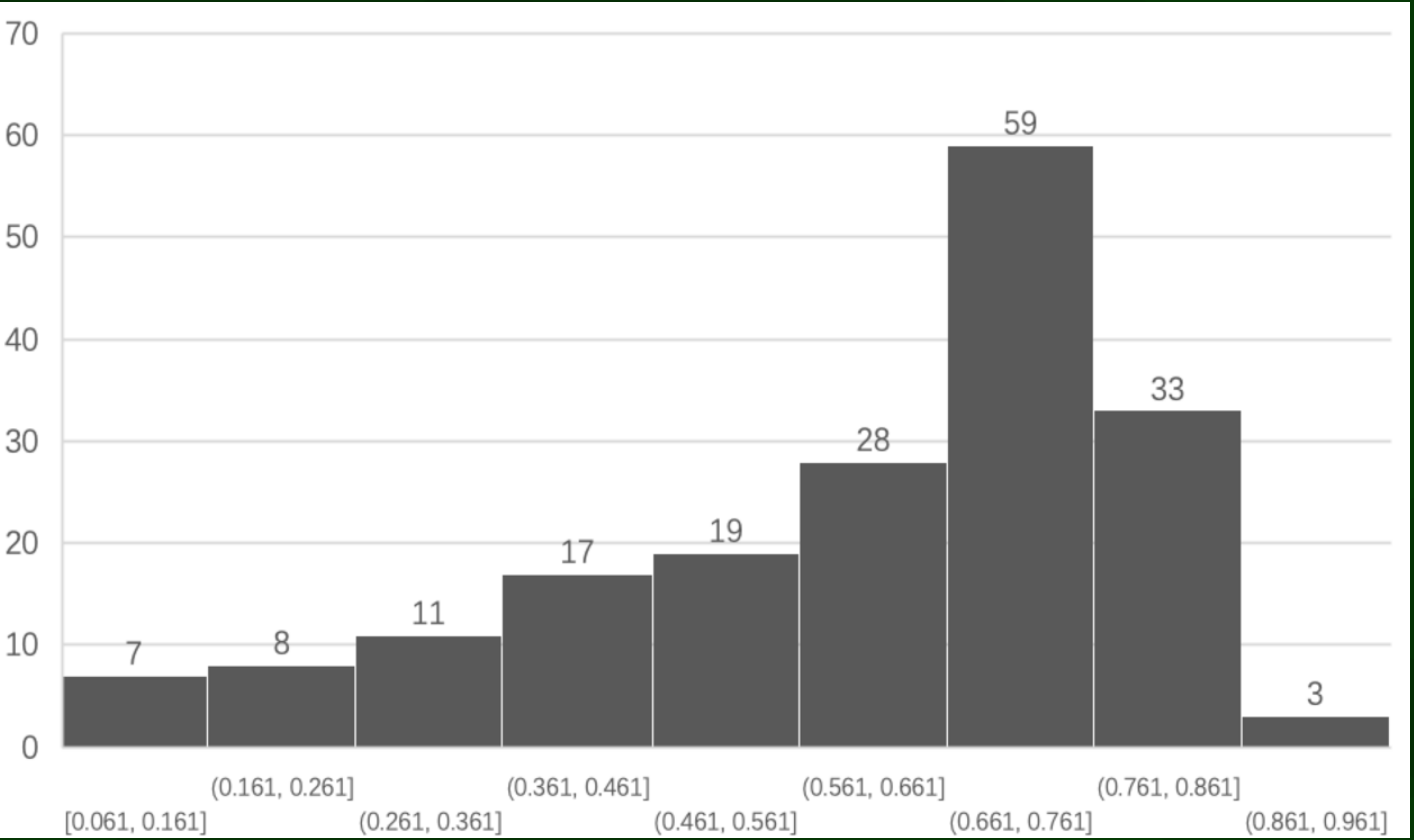
Skyview computation



Analysis



Results



70
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(0.461, 0.561]
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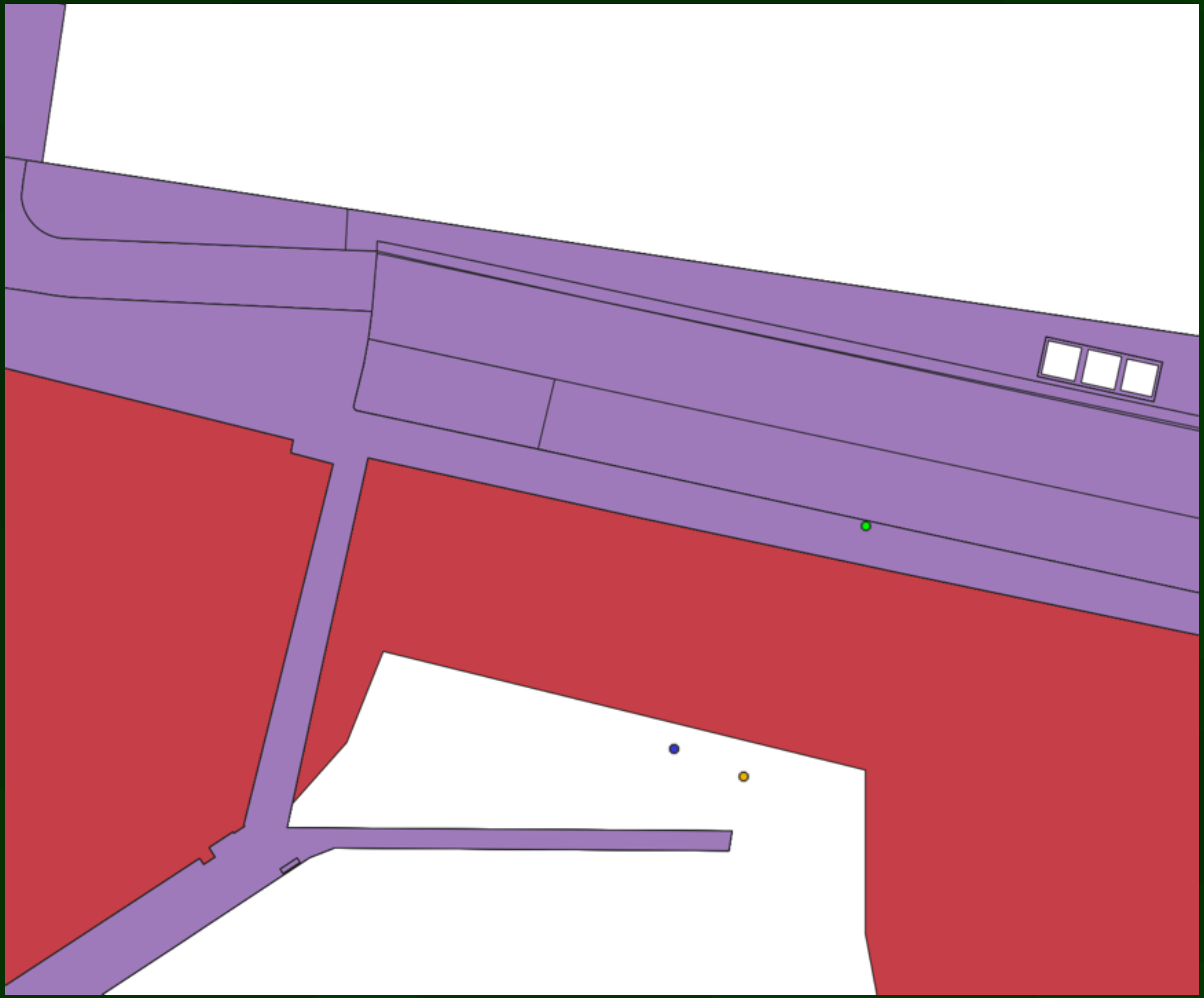
(0.661, 0.761]
(0.761, 0.861]
(0.861, 0.961]

Experiment

Experiment



Recommendations

- GEO5014: Geomatics as support for energy applications
- GEO5015: Modelling wind and dispersion in urban environments
- Your own MSc thesis

Sources of images

- [2-6]: Filip Biljecki (paper on application of 3D city models and PhD thesis)
- [9-20]: Roeland Boeters (MSc thesis and related paper)
- [21-29]: Sjors Donkers (MSc thesis and related paper)
- [30-48]: Damien Mulder (MSc thesis)
- [49, 51-62]: Yixin Xu (MSc thesis)
- [50]: Anna-Maria Ntarladima (MSc thesis)