Building simplification using offset curves obtained from the straight skeleton

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TU Delft Delft University of Technology

Challenge the future

Building simplification using offset curves obtained from the straight skeleton

- Straight skeleton
- Offset curves
- Building simplification
- Results
- Discussion and Future work

Straight skeleton

- Polygon as input
- Shrink polygon inwards, with edges moving at constant speed
- Vertices move as well (some faster than others, depend on angle of the vertex)
- If moving vertex collides with non-adjacent edge: polygon is split and shrinking continues for each piece
- Moving vertices trace out set of curves: this is the straight skeleton

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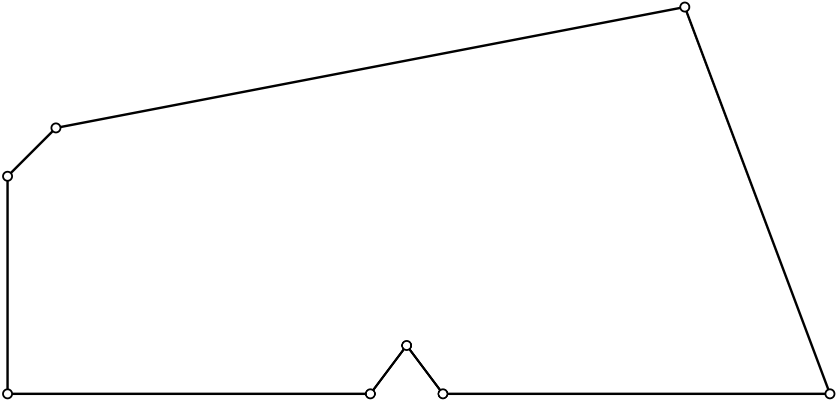
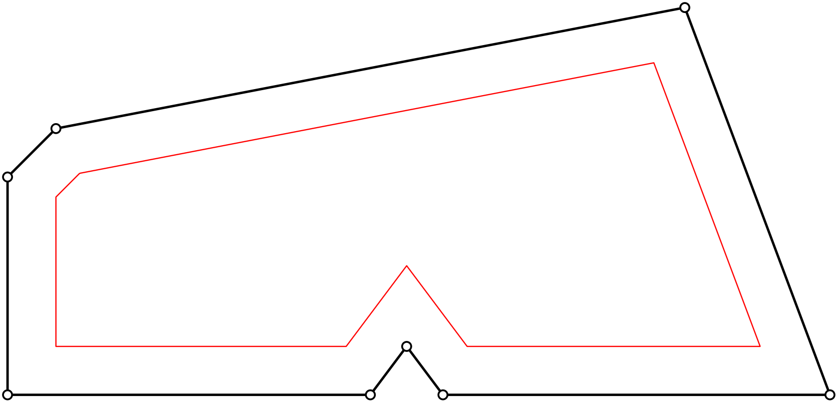
Straight skeleton



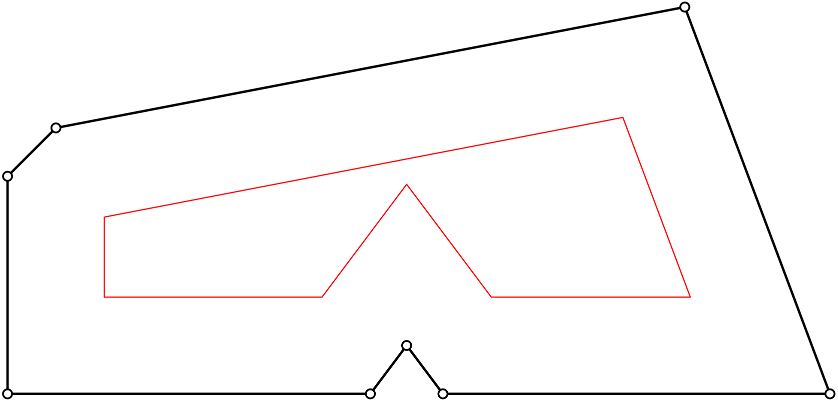
Edges move inward

Image after: Peter Palfrader, `http://www.palfrader.org/research/`

Straight skeleton



Straight skeleton



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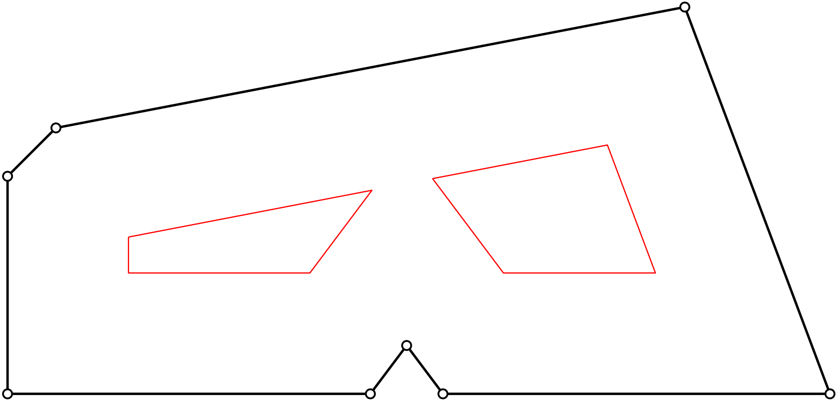

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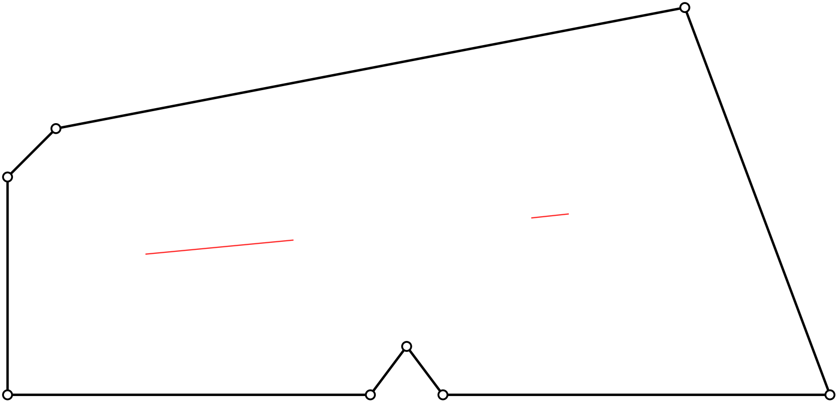
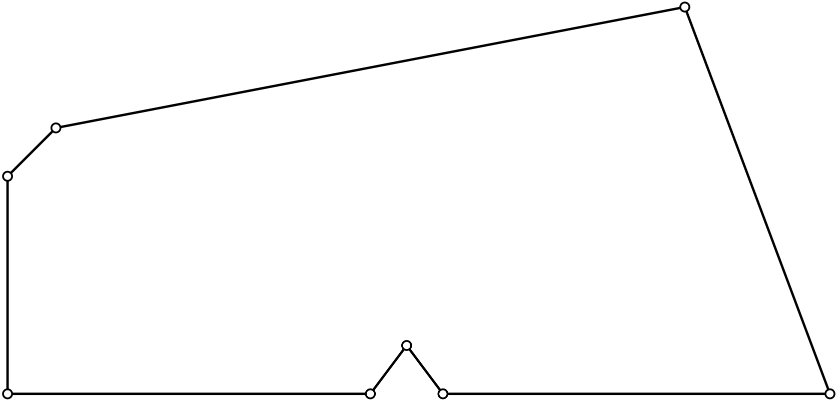
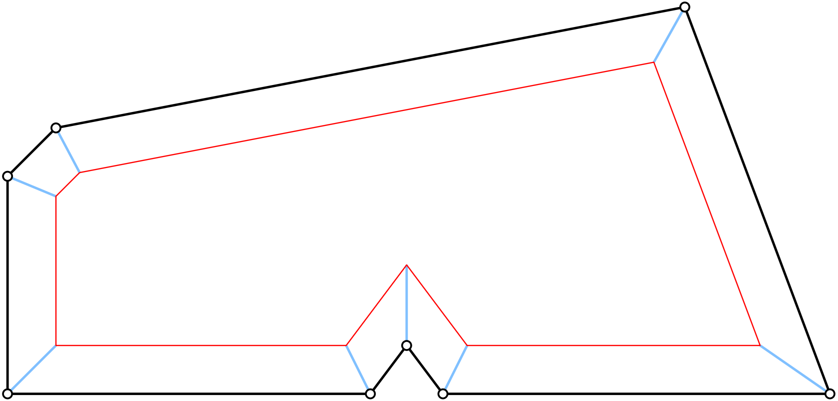


Straight skeleton

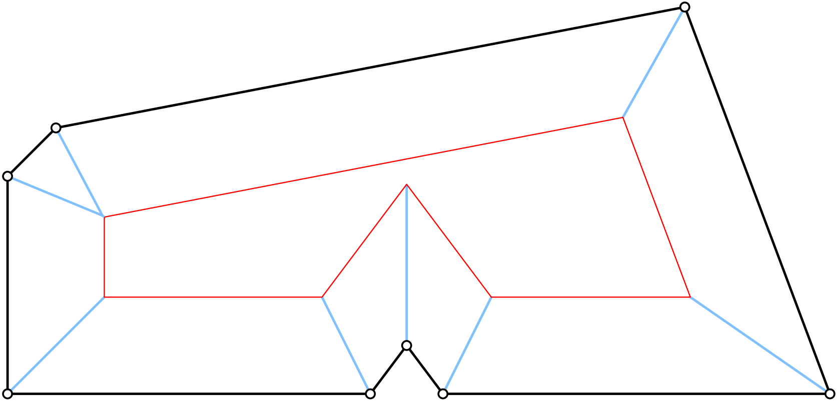


Vertices also move (some faster than others)

Straight skeleton

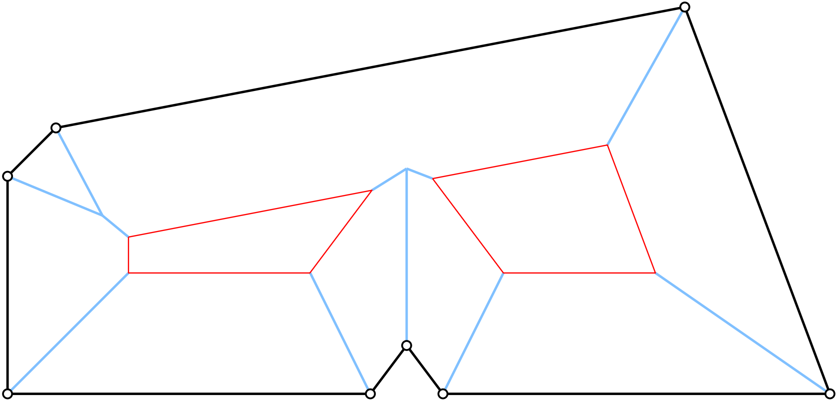


Straight skeleton



Polygon can be split, if vertex collides with non-adjacent edge

Straight skeleton



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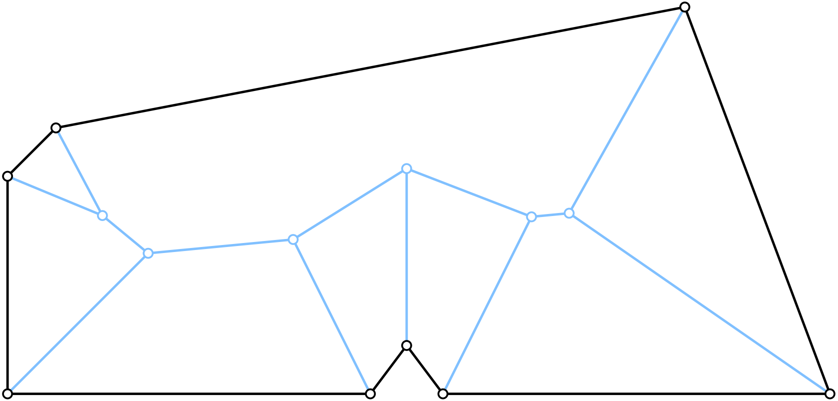


Straight skeleton

- Definition can be generalized for Planar Straight Line Graph (PSLG)
- Elegant algorithm for construction (Aichholzer and Aurenhammer, 1996; Palfrader, 2013):
  1. Triangulate regions between input segments
  2. Moving vertices does change size of triangles
  3. Triangle collapse (zero size) indicates change in structure of Straight Skeleton

Straight skeleton

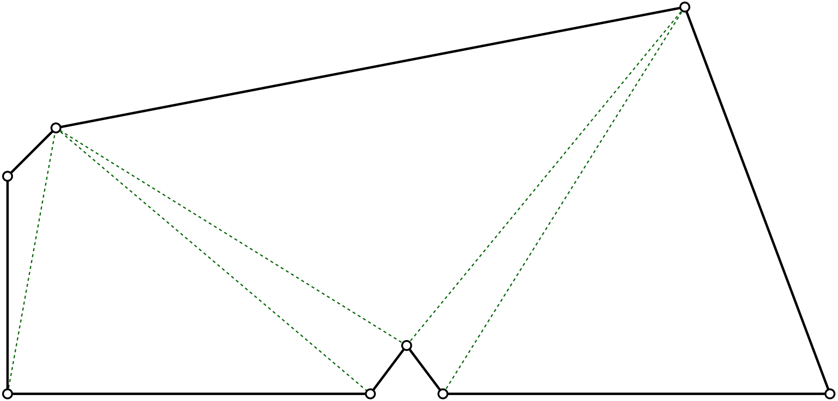
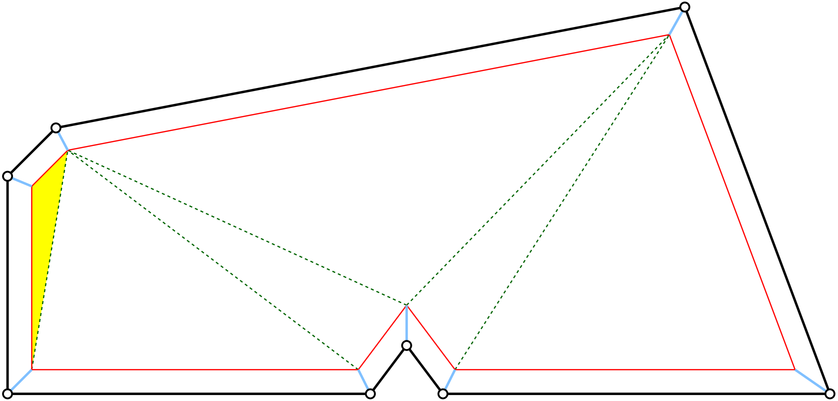


Image credit: Peter Palfrader

Straight skeleton



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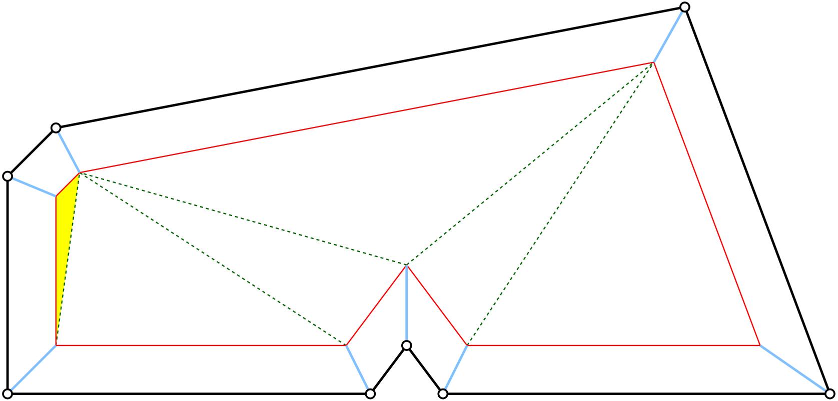

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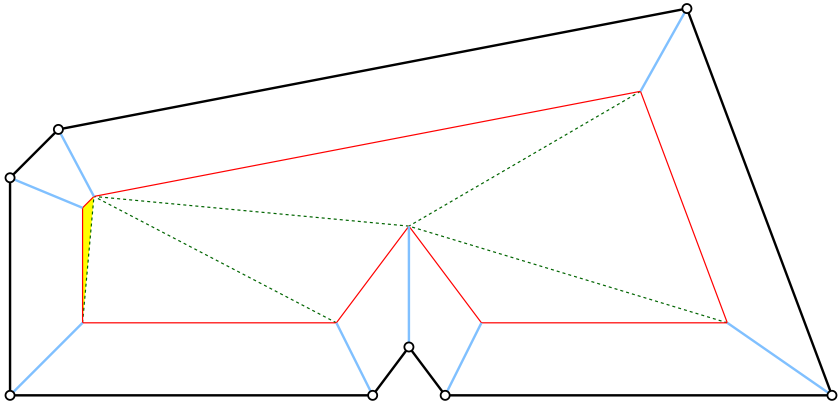
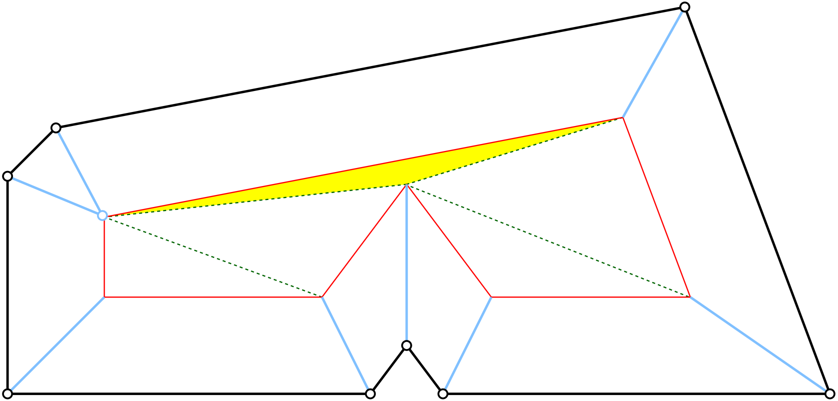


Straight skeleton



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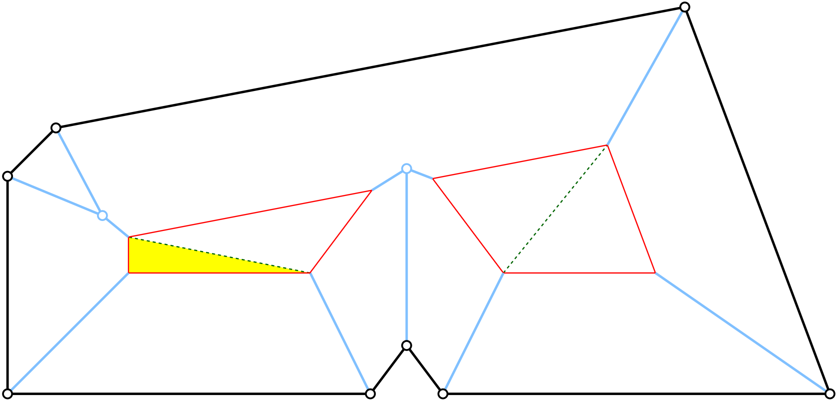

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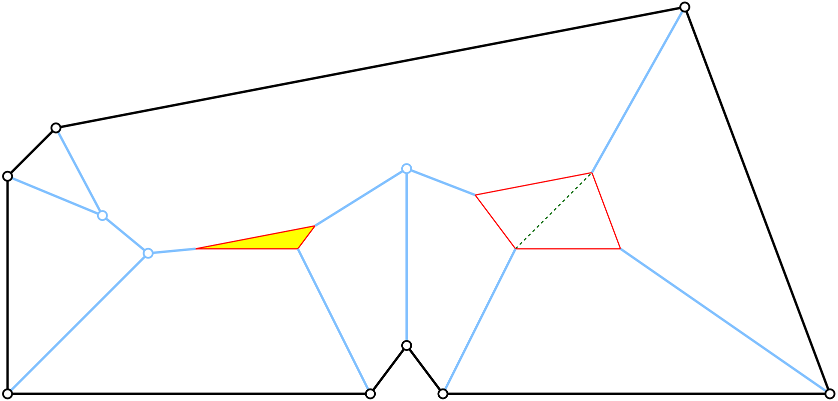

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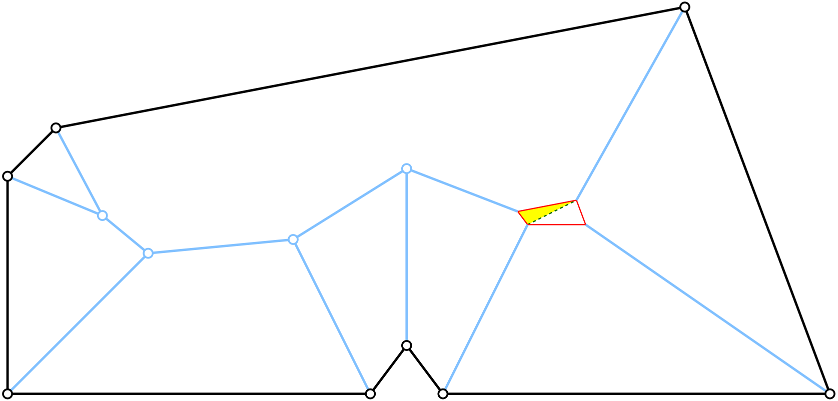

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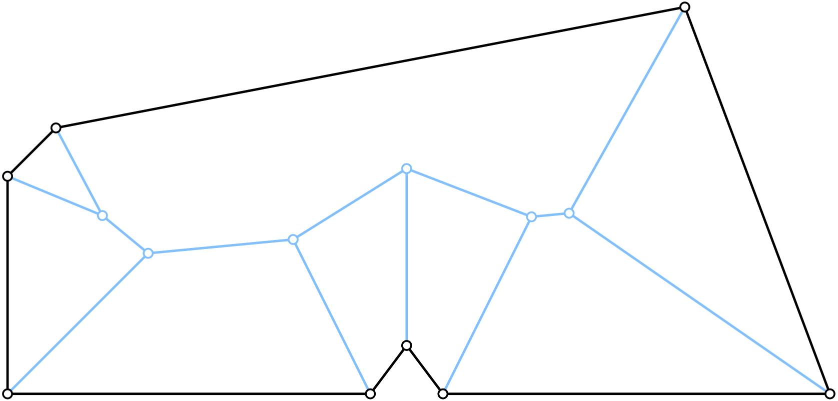

Offset curves

- Once traces of vertices are known, easy/cheap to generate offset curves (Palfrader and Held, 2015)
- For each vertex, keep track of neighbouring vertices at any time *t*

Offset curves

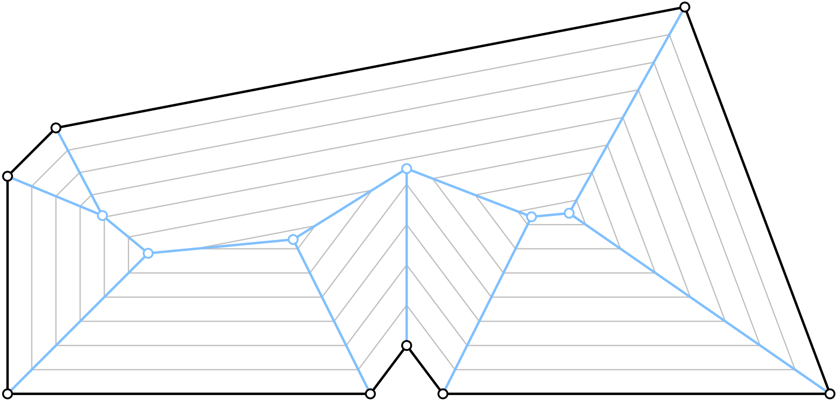

Image credit: Peter Palfrader

Building simplification

Algorithm for building simplification:

1. Compute straight skeleton
2. Generate offset curves — ϵ inwards
3. Compute straight skeleton, on resulting shape
4. Generate offset curves — ϵ outwards

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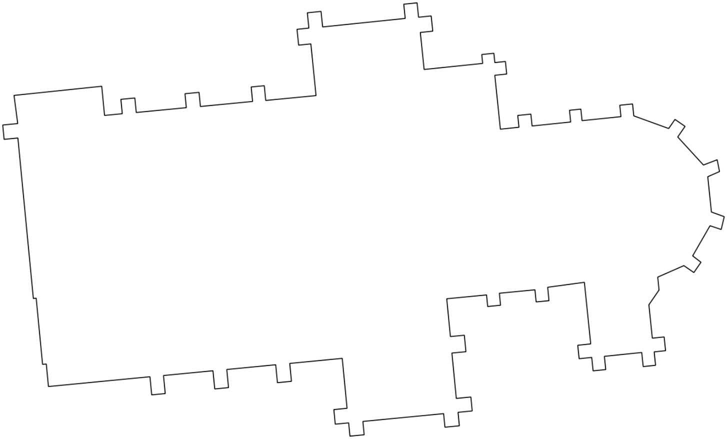
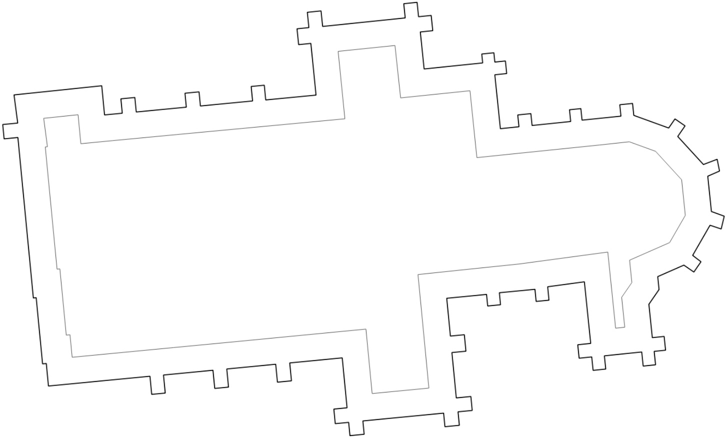
Order of inwards — outwards can be reversed (giving different results)

Building simplification



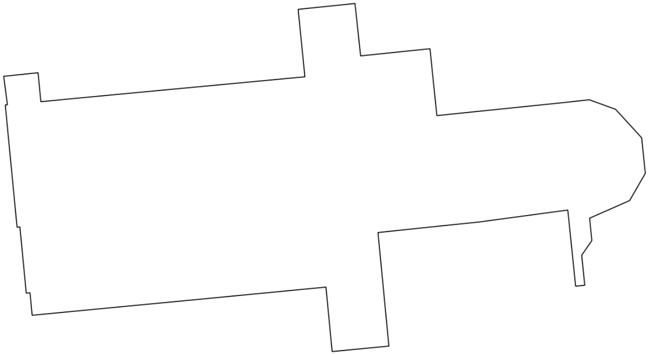
Input

Building simplification



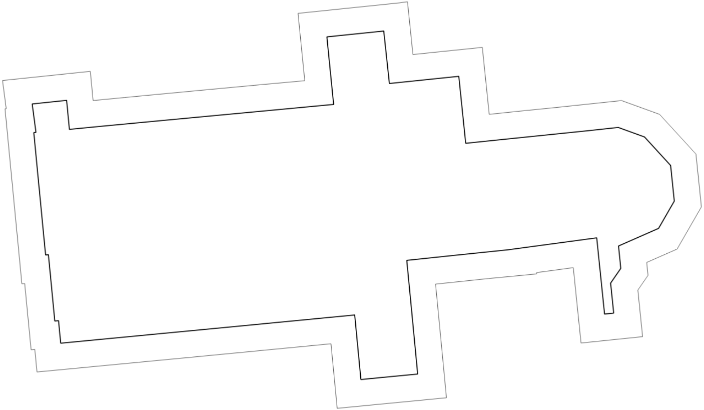
Offset curve inward

Building simplification



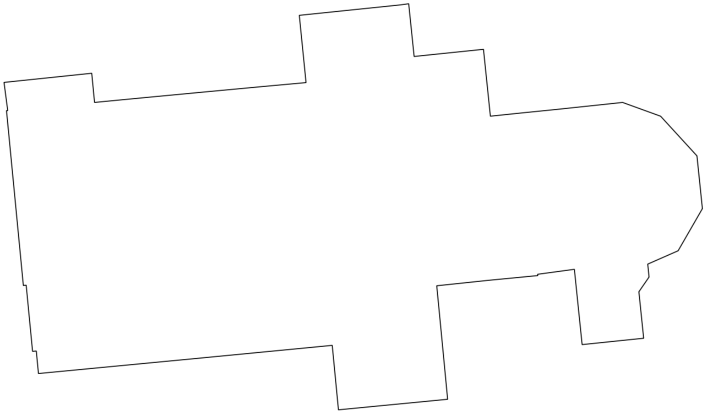
Input for 2nd step

Building simplification



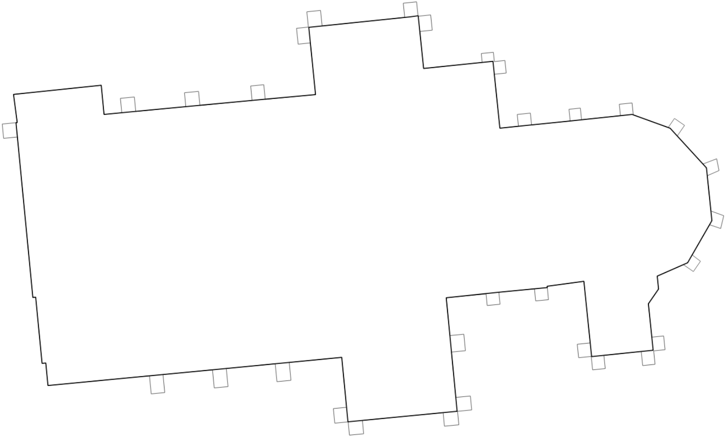
Offset curve outwards

Building simplification



Result

Building simplification



Result – Comparison with input

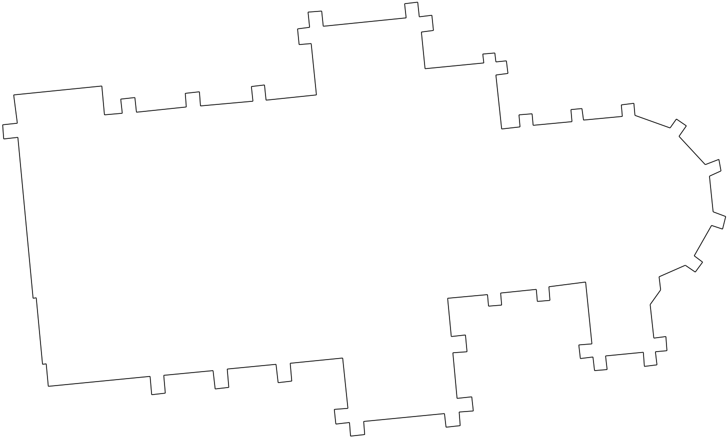
Building simplification

Algorithm for building simplification:

1. Compute straight skeleton
2. Generate offset curves — $\frac{1}{2}\epsilon$ inwards
3. Compute straight skeleton, on resulting shape
4. Generate offset curves — ϵ outwards
5. Compute straight skeleton, on resulting shape
6. Generate offset curves — $\frac{1}{2}\epsilon$ inwards

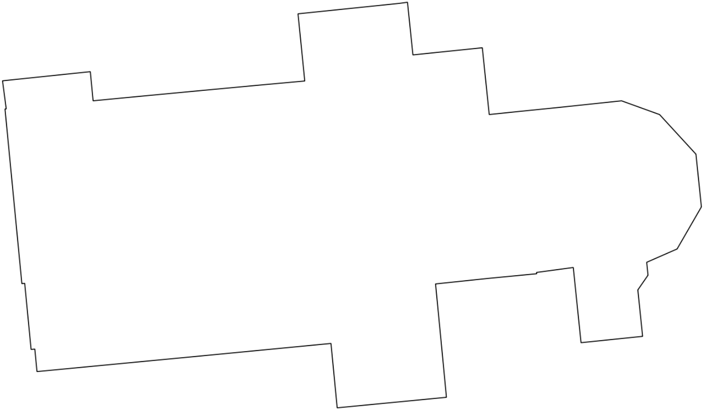
Note: $\frac{1}{2}\epsilon$ for outwards offsets
Order can be reversed again.

Results – One building



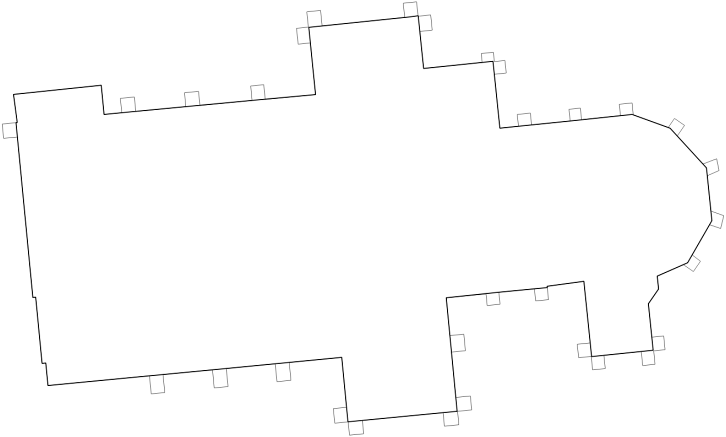
Input

Results – One building



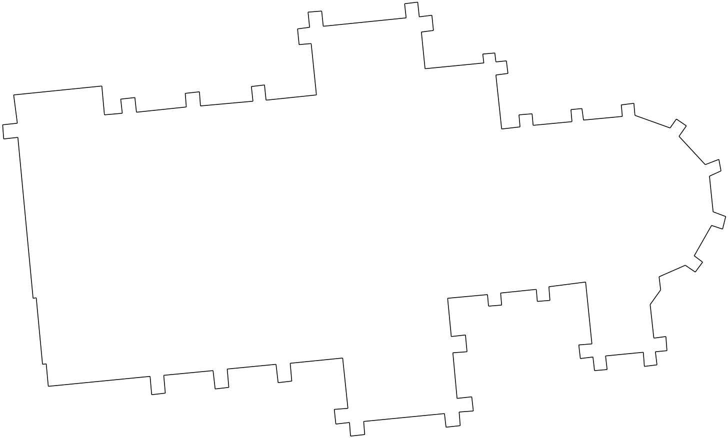
In–Out Result

Results – One building



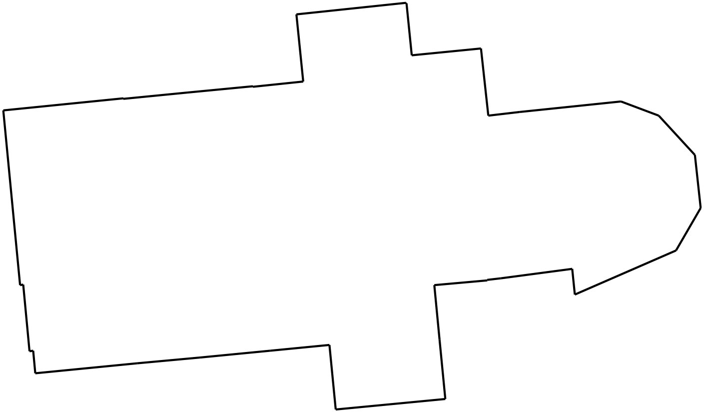
Result – Comparison with input

Results – One building



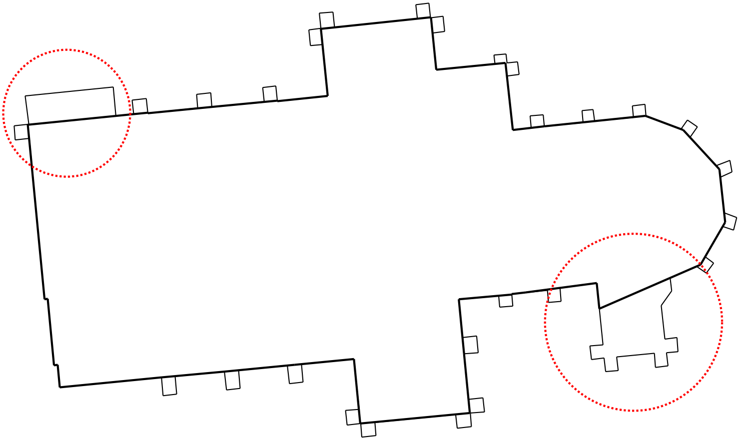
Input

Results – One building



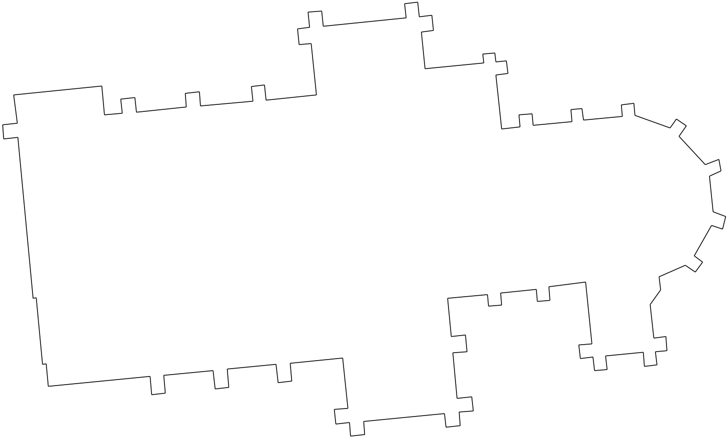
In–Out result, larger ϵ

Results – One building



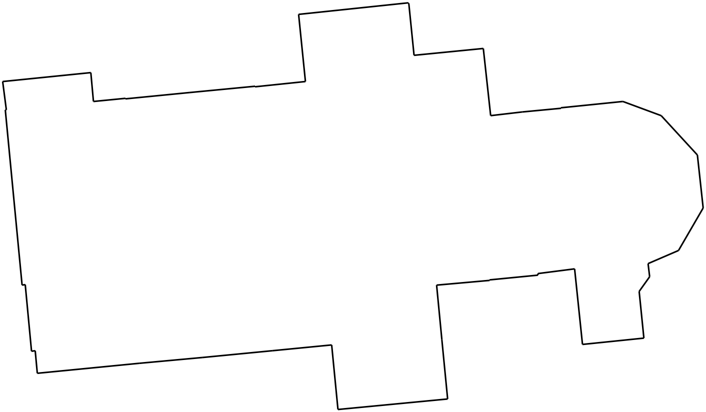
In–Out result, larger ϵ
(compare with input)

Results – One building



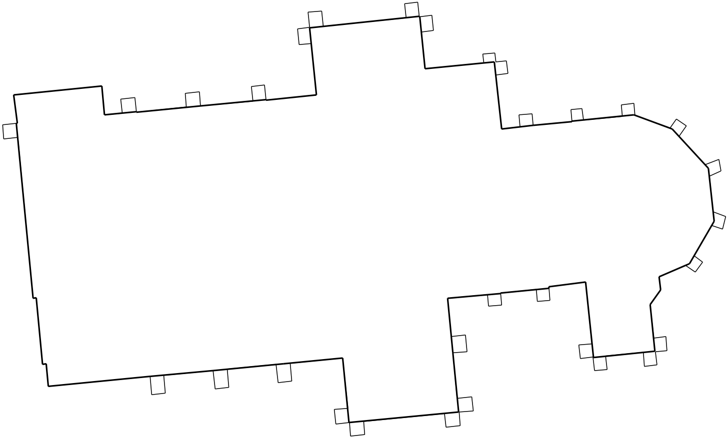
Input

Results – One building



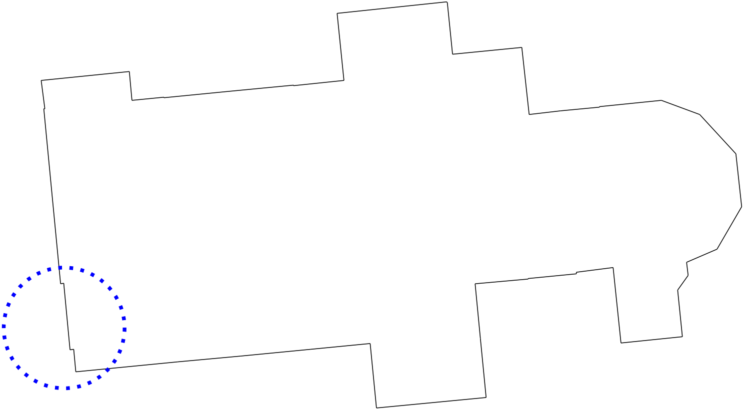
In–Out–In, result

Results – One building



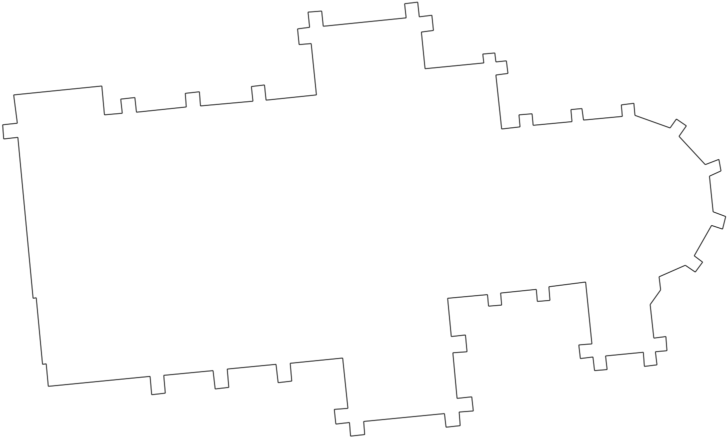
In–Out–In, result
(compare with input)

Results – One building



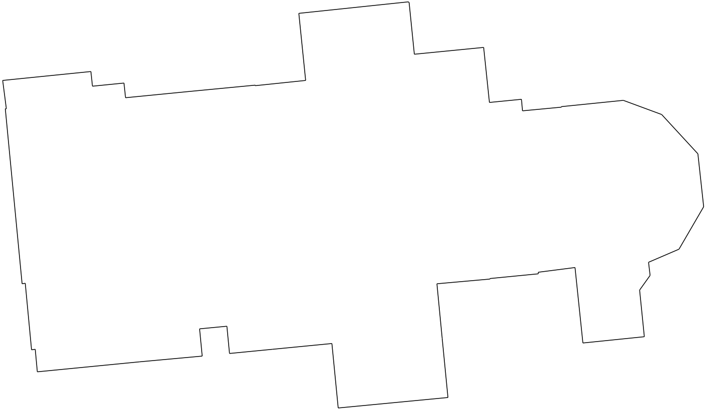
In–Out–In, result
Small edges still present

Results – One building



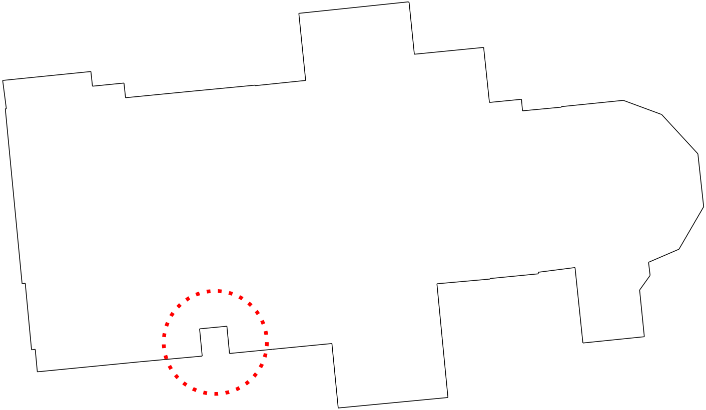
Input

Results – One building



Out–In–Out

Results – One building

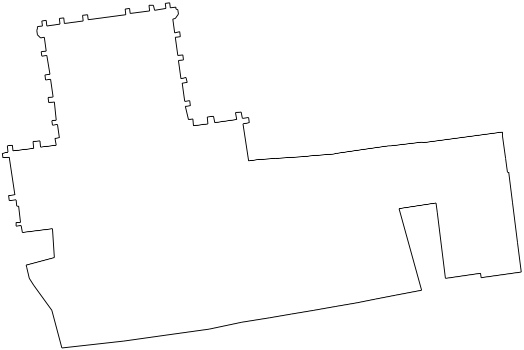


Out–In–Out
New created dent

Results – Multiple buildings

Input

Results – Multiple buildings

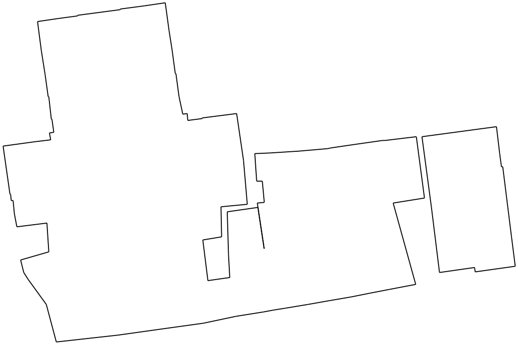


Out–In

Results – Multiple buildings

Input

Results – Multiple buildings

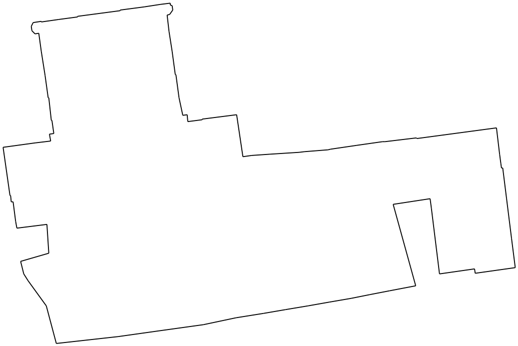


In–Out

Results – Multiple buildings

Input

Results – Multiple buildings

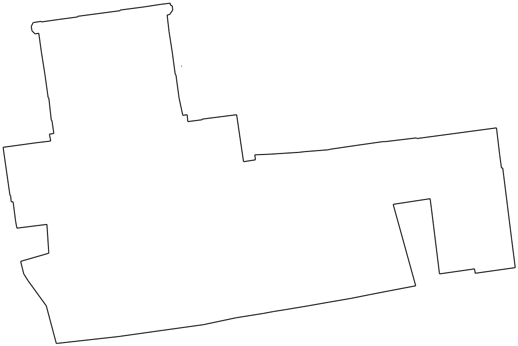


Out–In–Out

Results – Multiple buildings

Input

Results – Multiple buildings



In–Out–In

Results

- Straightforward algorithm
- Simplifies individual building outlines
- Amalgamates multiple buildings
- Still needs post-processing for small segments

Discussion

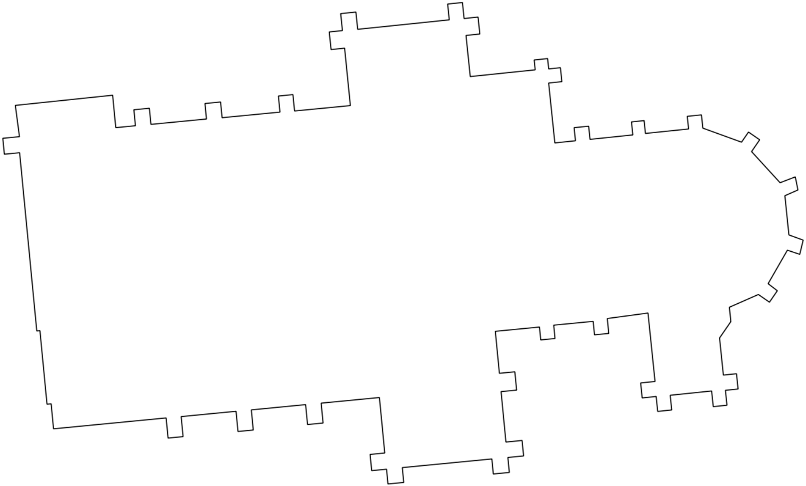
- Improve our implementation of straight skeleton, GrassFire[1]
- Difficult: determine correct ϵ
- No rotation needed for input (compare with Minkowski sum)

[1] https://bitbucket.org/bmmeijers/grassfire

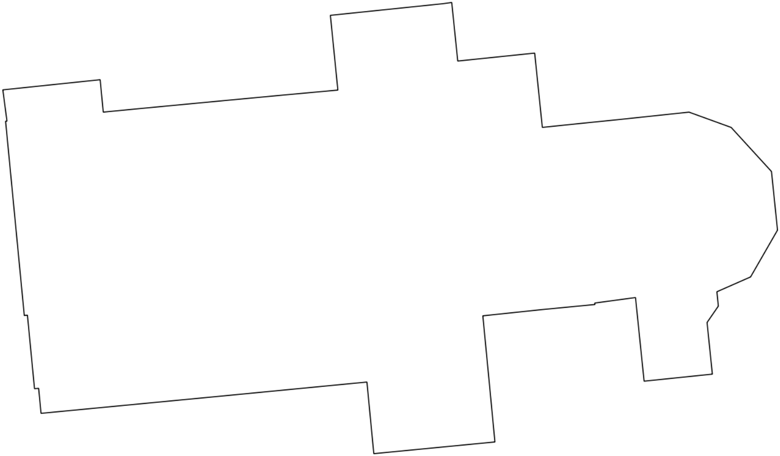
Future work

- Smooth transitions between the input and the output: interpolate what is in between (Barequet et al., 2004; Yakersberg, 2004)

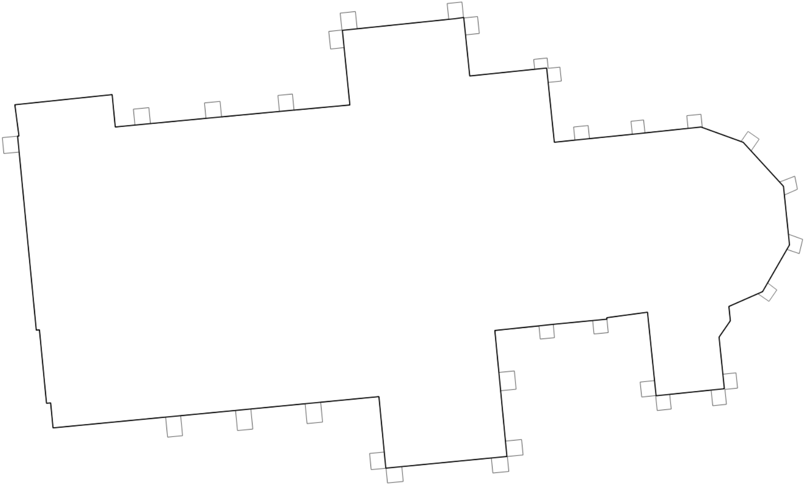
Smooth transitions



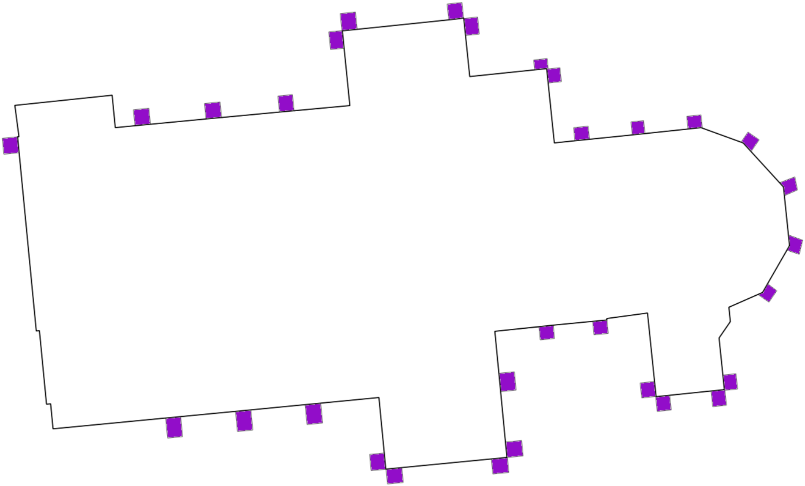
Smooth transitions



Smooth transitions



Smooth transitions



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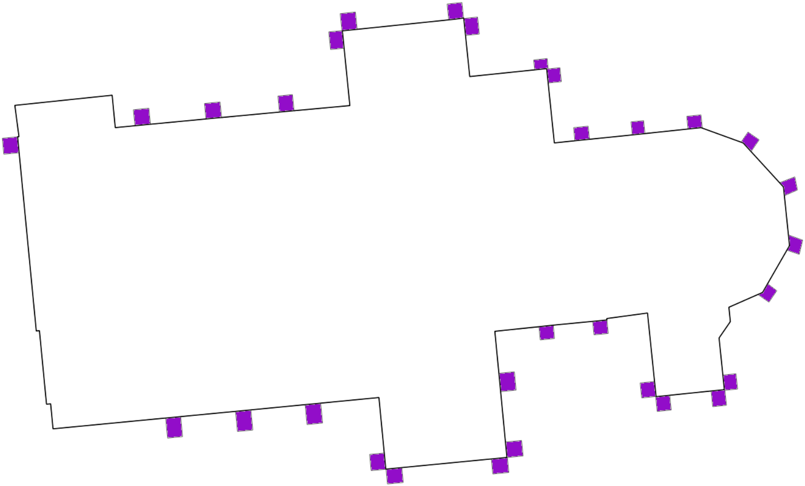

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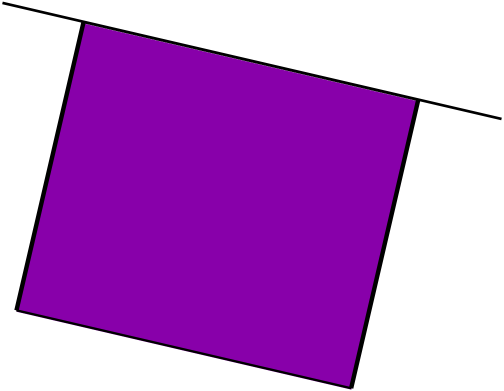

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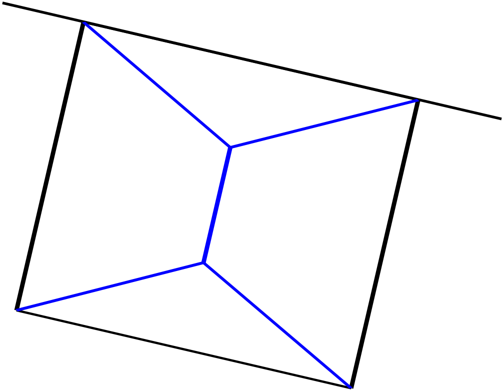

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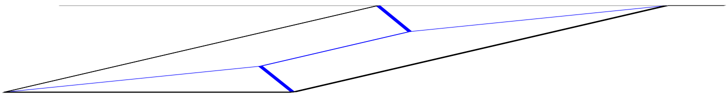

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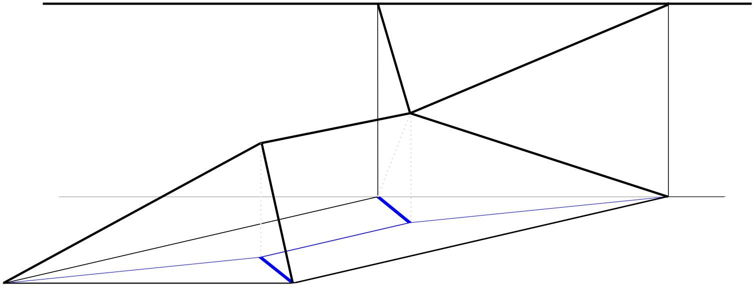

Thank you for your attention

- Questions?
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  Faculty of Architecture and the Built Environment
  OTB Research
  GIS Technology
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  tel. (+31) 15 27 856 42

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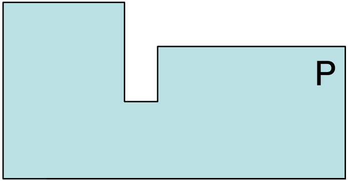
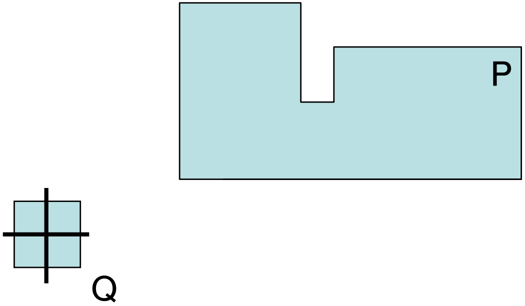
Minkowski sum (dilation–erosion) comparison



Input polygon *P*

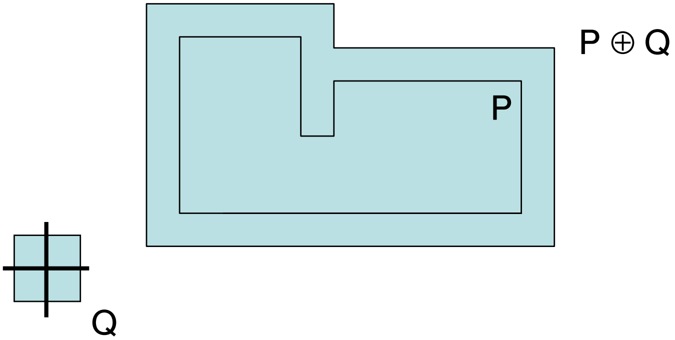
Image credit: Jonathan Damen (Damen et al., 2008)

Minkowski sum (dilation–erosion) comparison



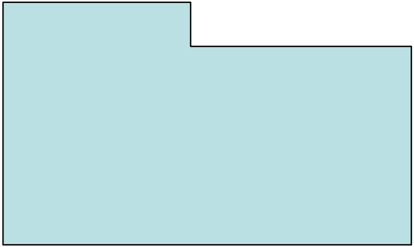
Q ‘traverses’ the boundary of P: adding Q to P

Minkowski sum (dilation–erosion) comparison



Dilation

Minkowski sum (dilation–erosion) comparison



Dilation

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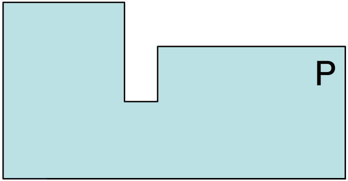
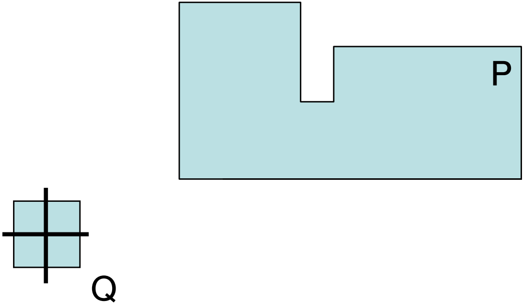


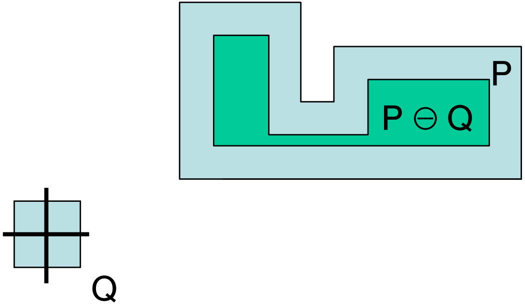
Input polygon P

Minkowski sum (dilation–erosion) comparison



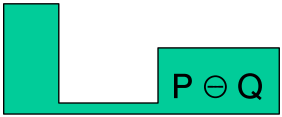
Q ‘traverses’ the boundary of *P*: subtracting *Q* from *P*

Minkowski sum (dilation–erosion) comparison



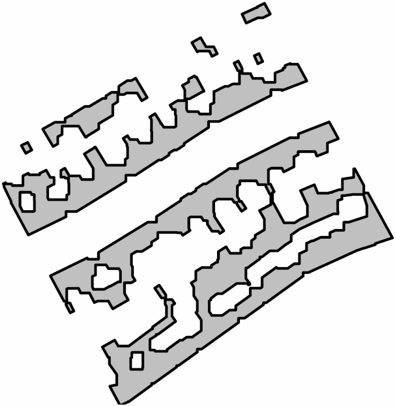
Dilation

Minkowski sum (dilation–erosion) comparison



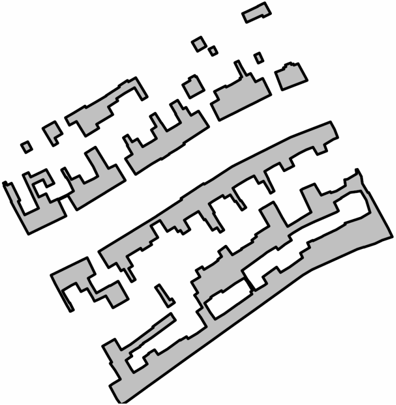
Dilation

Minkowski sum (dilation–erosion) comparison



Dilation-Erosion, axis-aligned buildings

Minkowski sum (dilation–erosion) comparison

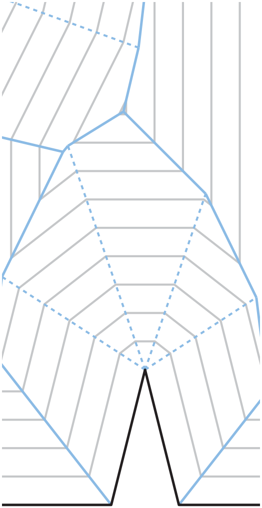


Dilation-Erosion, rotated buildings (main direction axis of building)

Linear axis around vertices with sharp angles

Image credit: Palfrader and Held (2015)

Linear axis around vertices with sharp angles



Linear axis