High Quality Building Generalization by Extending the Morphological Operators

Jonathan Damen Marc van Kreveld Bert Spaan

Department of Information and Computing Sciences
Utrecht University

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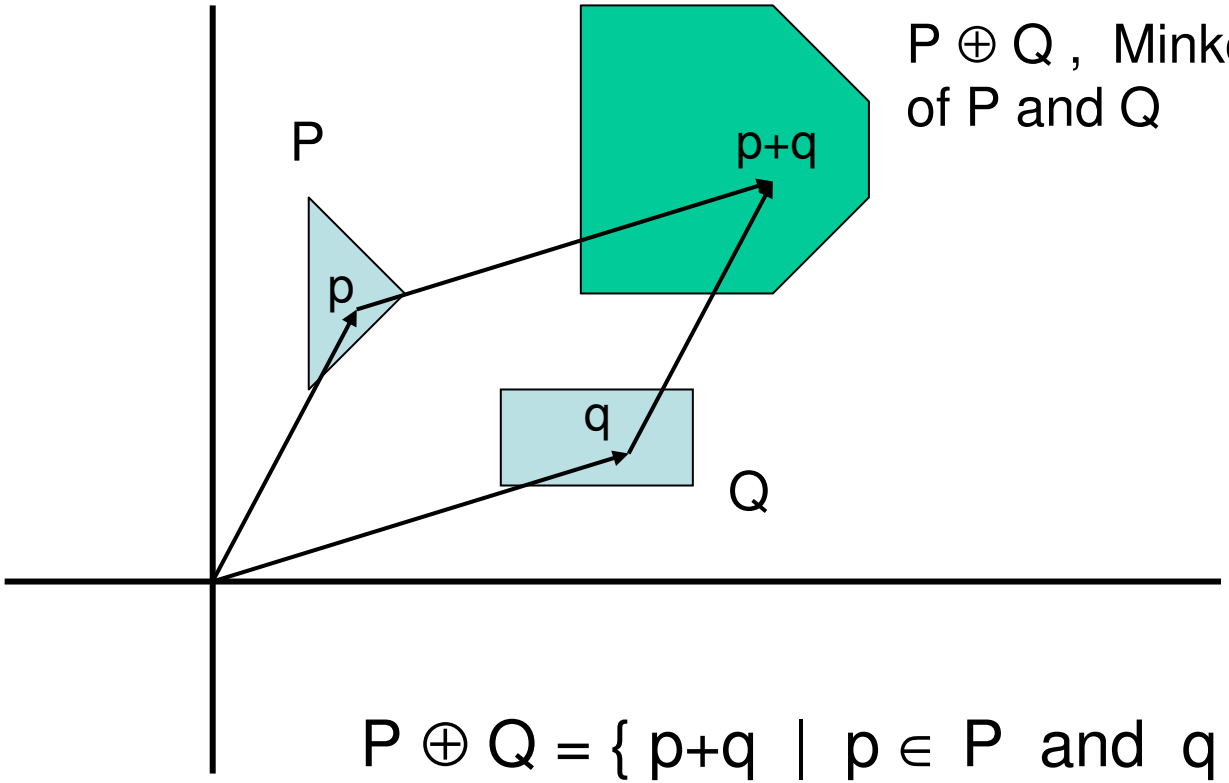
Morphological operators

- Erosion, dilation, opening, closure

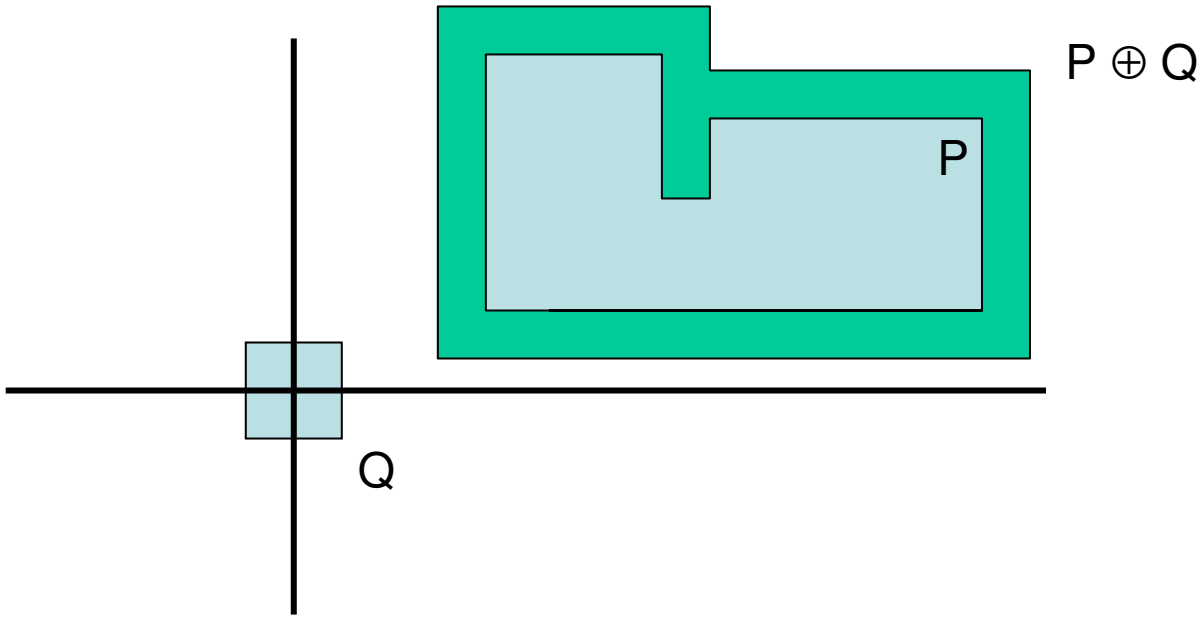


$P \oplus Q$, Minkowski sum of P and Q

$$P \oplus Q = \{ p+q \mid p \in P \text{ and } q \in Q \}$$

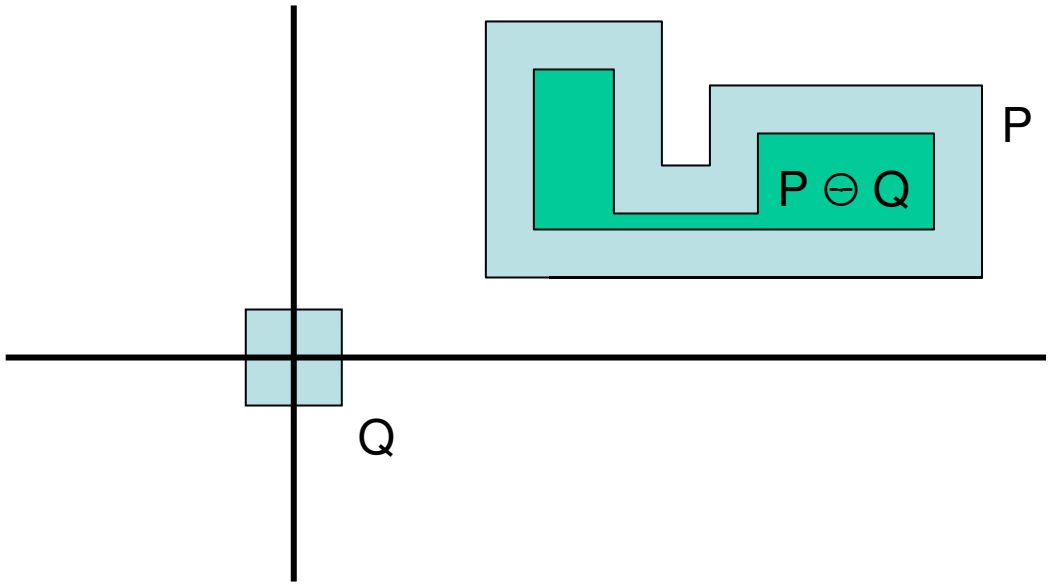
Morphological operators

- **Dilation**: Minkowski sum of a polygon P with a fixed element like a circle or a square centered at the origin



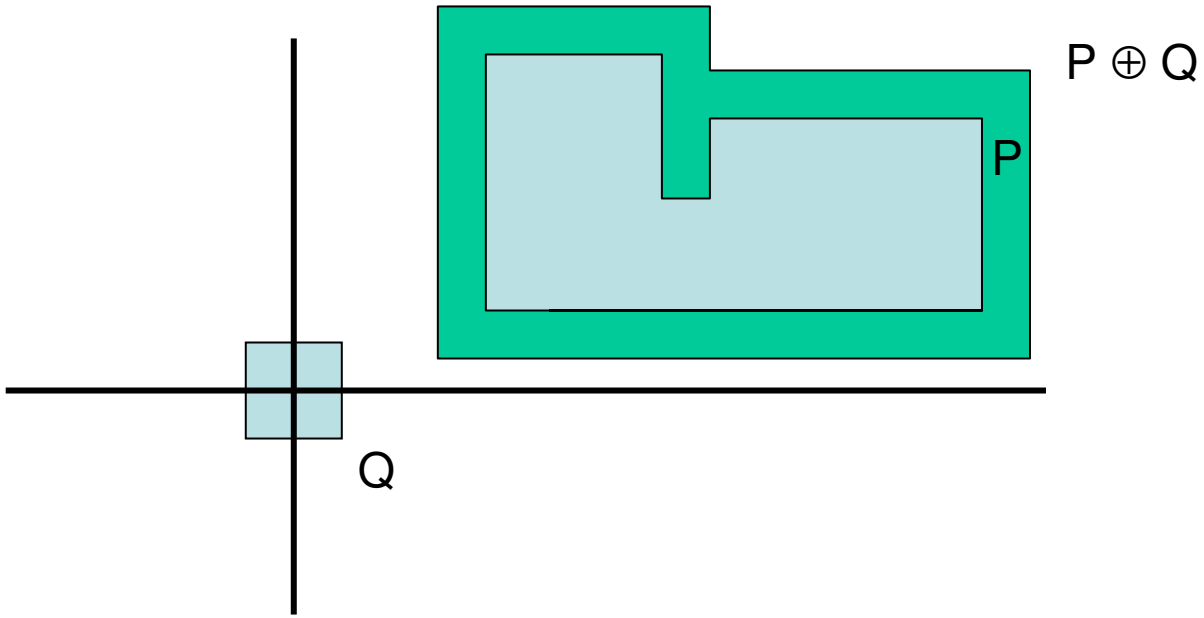
Morphological operators

- **Erosion**: complement of Minkowski sum of complement of a polygon P with a fixed element like a circle or a square centered at the origin



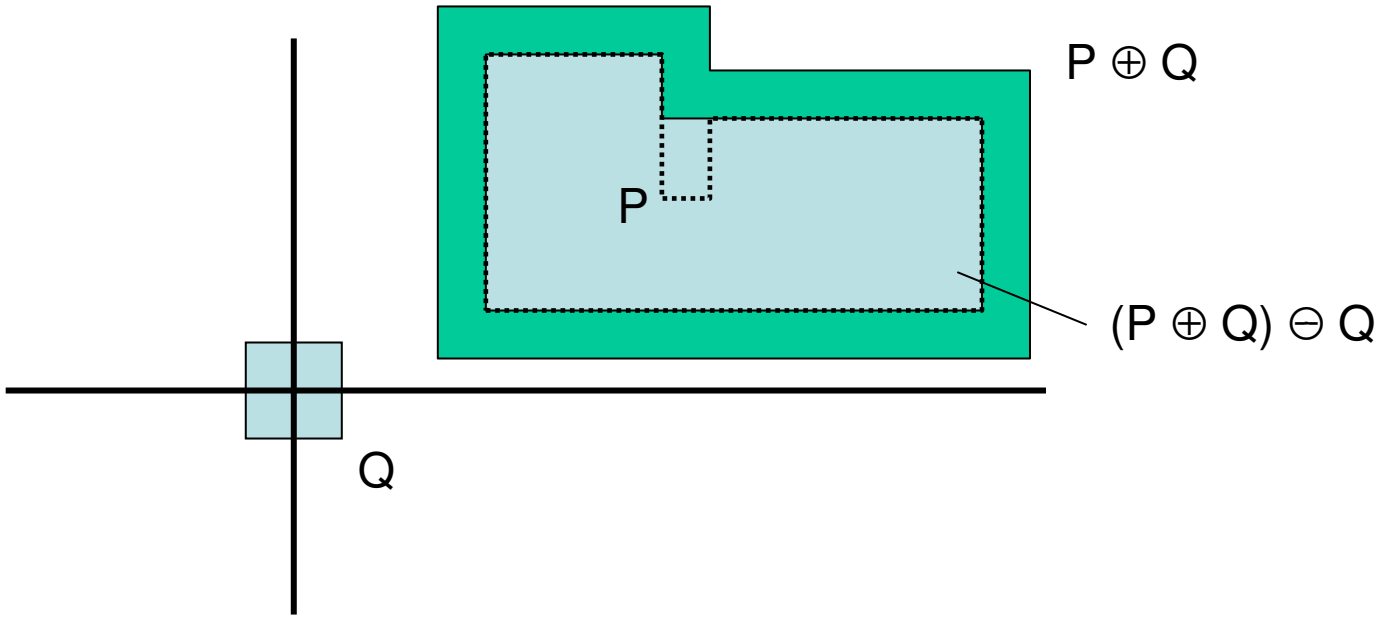
Morphological operators

- **Closure**: dilation followed by erosion



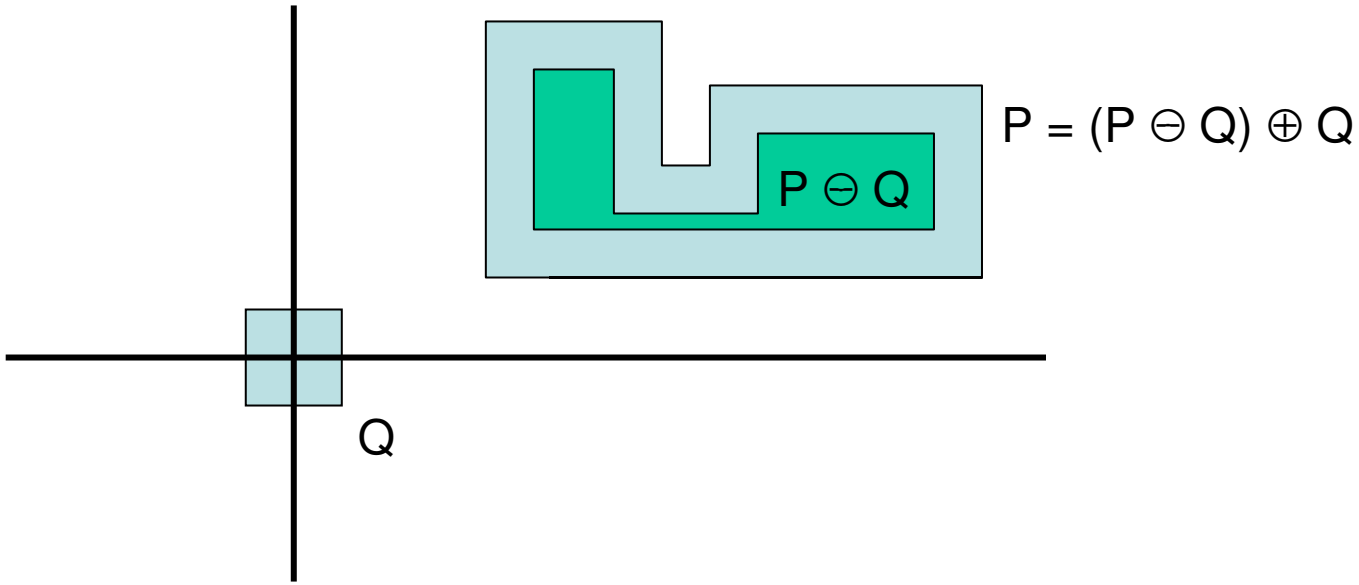
Morphological operators

- **Closure**: dilation followed by erosion



Morphological operators

- **Opening**: erosion followed by dilation



Morphological operators

- Always:

  erosion(P) $\subseteq$ opening(P) $\subseteq$ P $\subseteq$ closure(P) $\subseteq$ dilation(P)

Building generalization

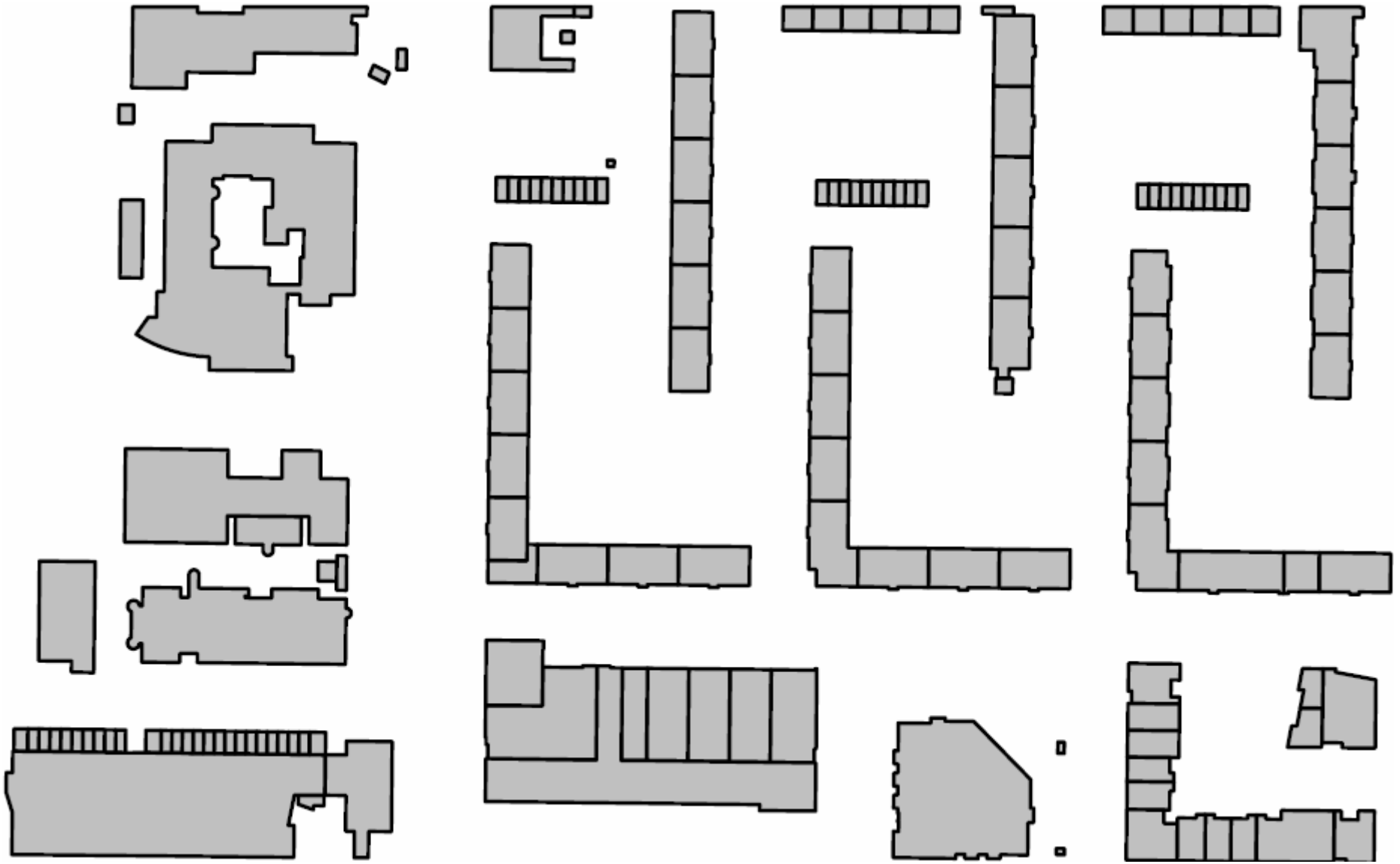
- Building generalization by morphological operators:

  Su, Li, Lodwick, and J.-C. Müller (1997), Li, Yan, Ai, and Chen (2004), Cámara and López (2005), Mayer (2005)

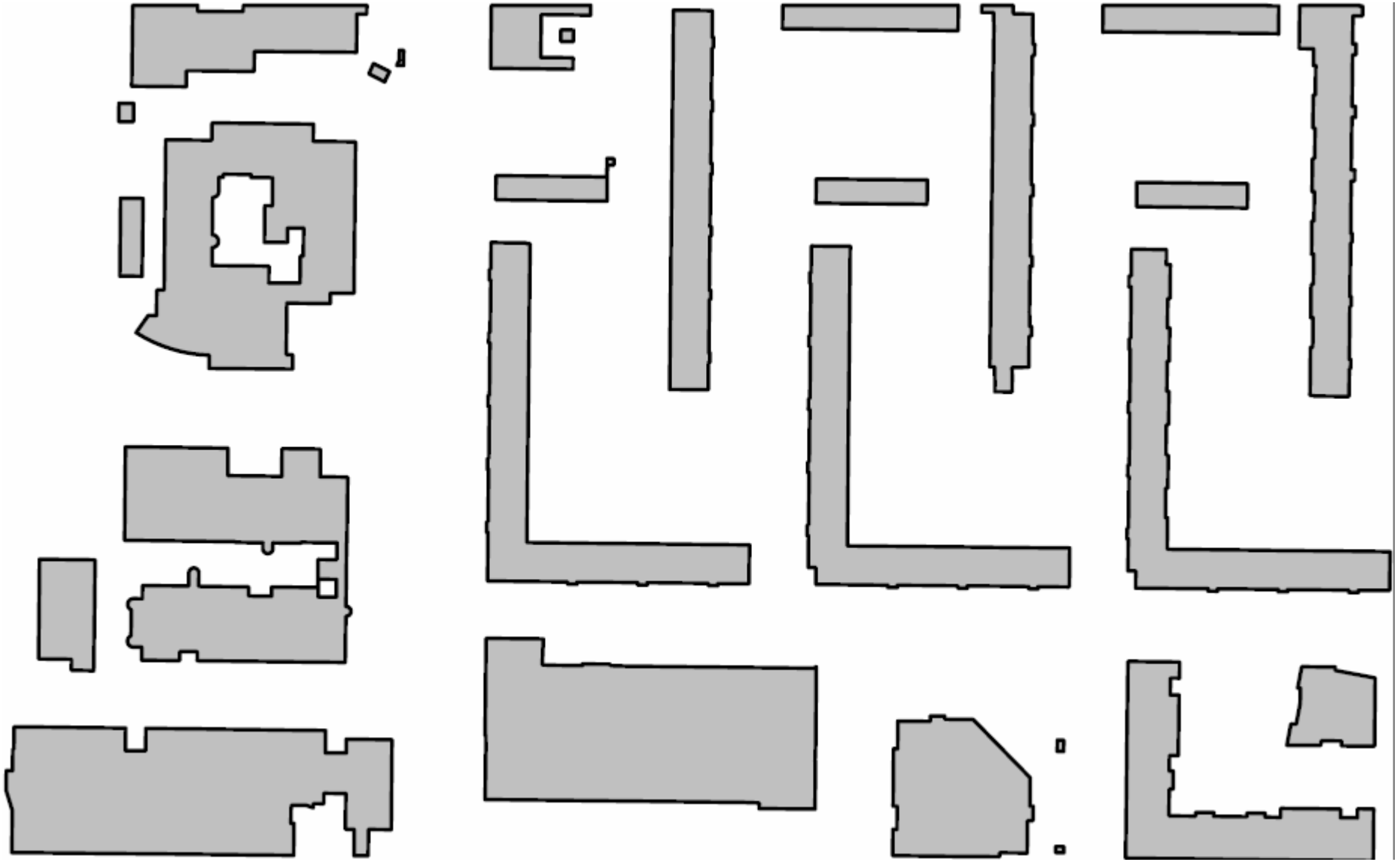
- Other research on building generalization:

  Bader, Barrault, Weibel, Burghardt, Cecconi, Duchêne, Bard, Barillot, Ruas, Trévistan, Holzapfel, Jones, Bundi, Ware, Lamy, Demazeau, Jackson, Mackaness, Lonergan, Purves, Rainsford, Revell, Regnauld, Edwardes, Sester, Brenner, Klein, Yan, Yang

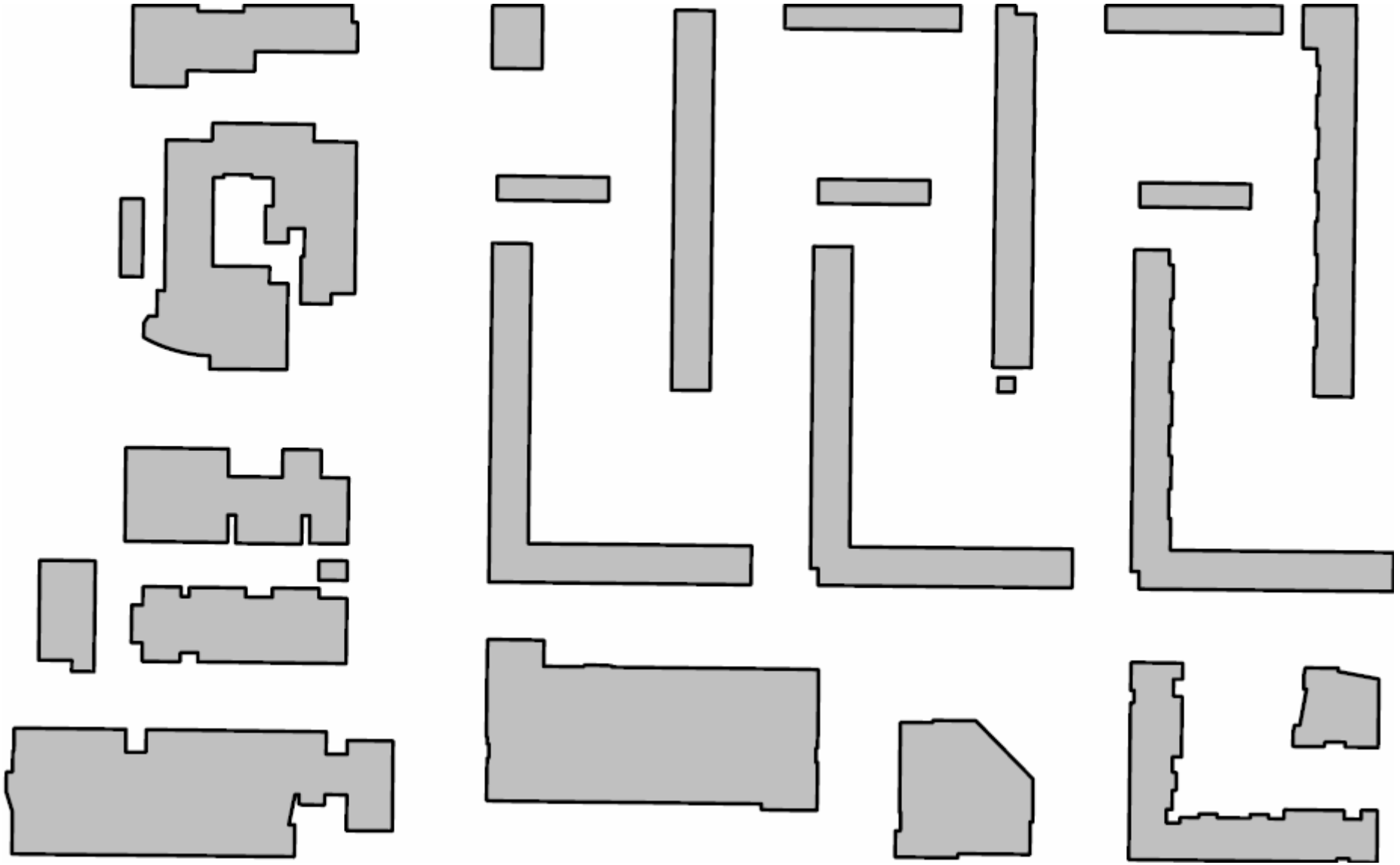
Original



Closure

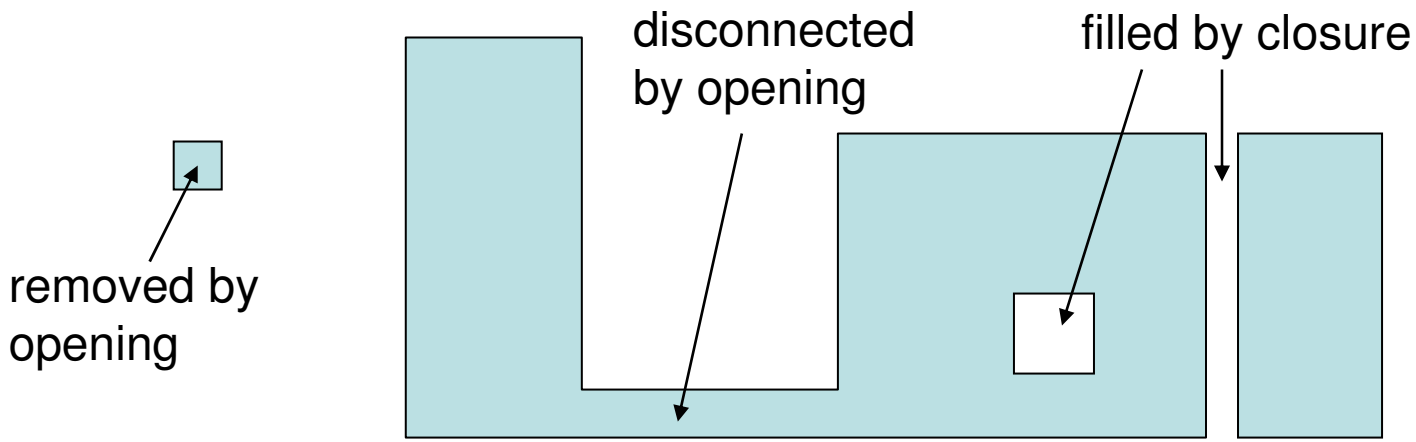


Opening



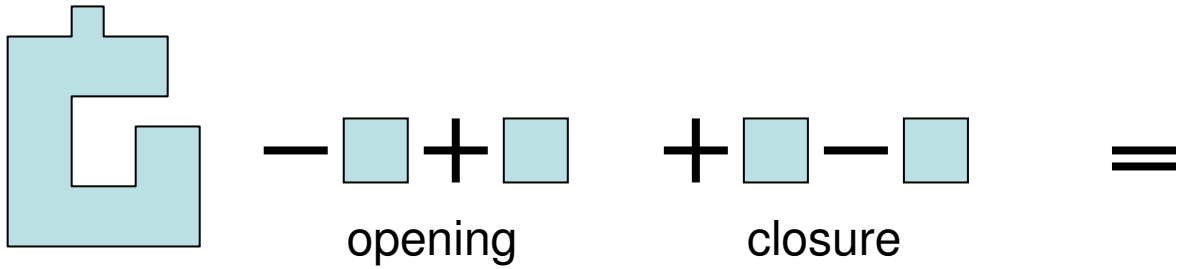
After opening or closure

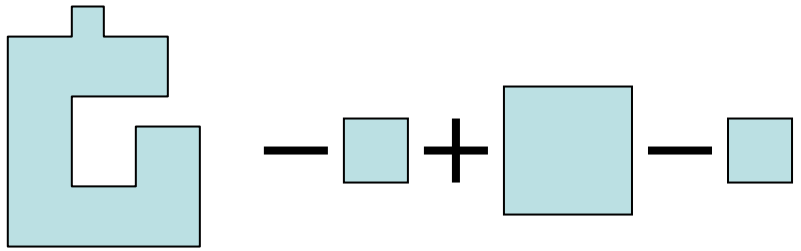
- Opening does not aggregate and does not close holes
- Closure does not remove small buildings or narrow connections
- Both may leave details (short edges)



Obvious idea

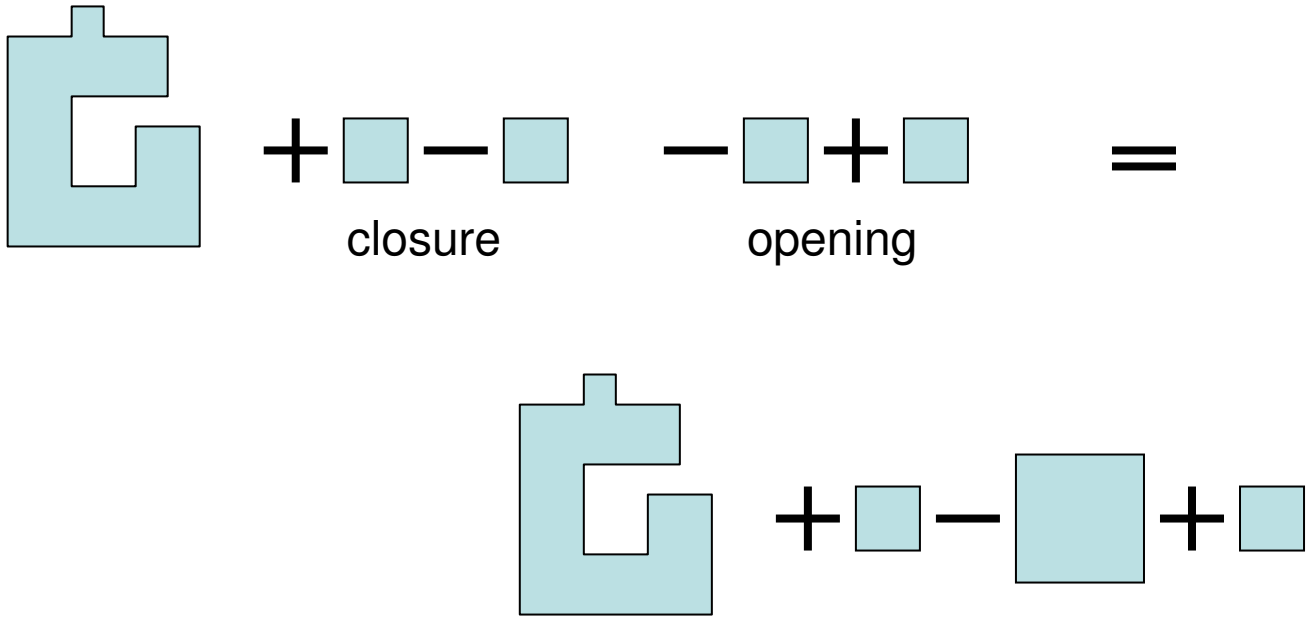
- Try opening and then closure



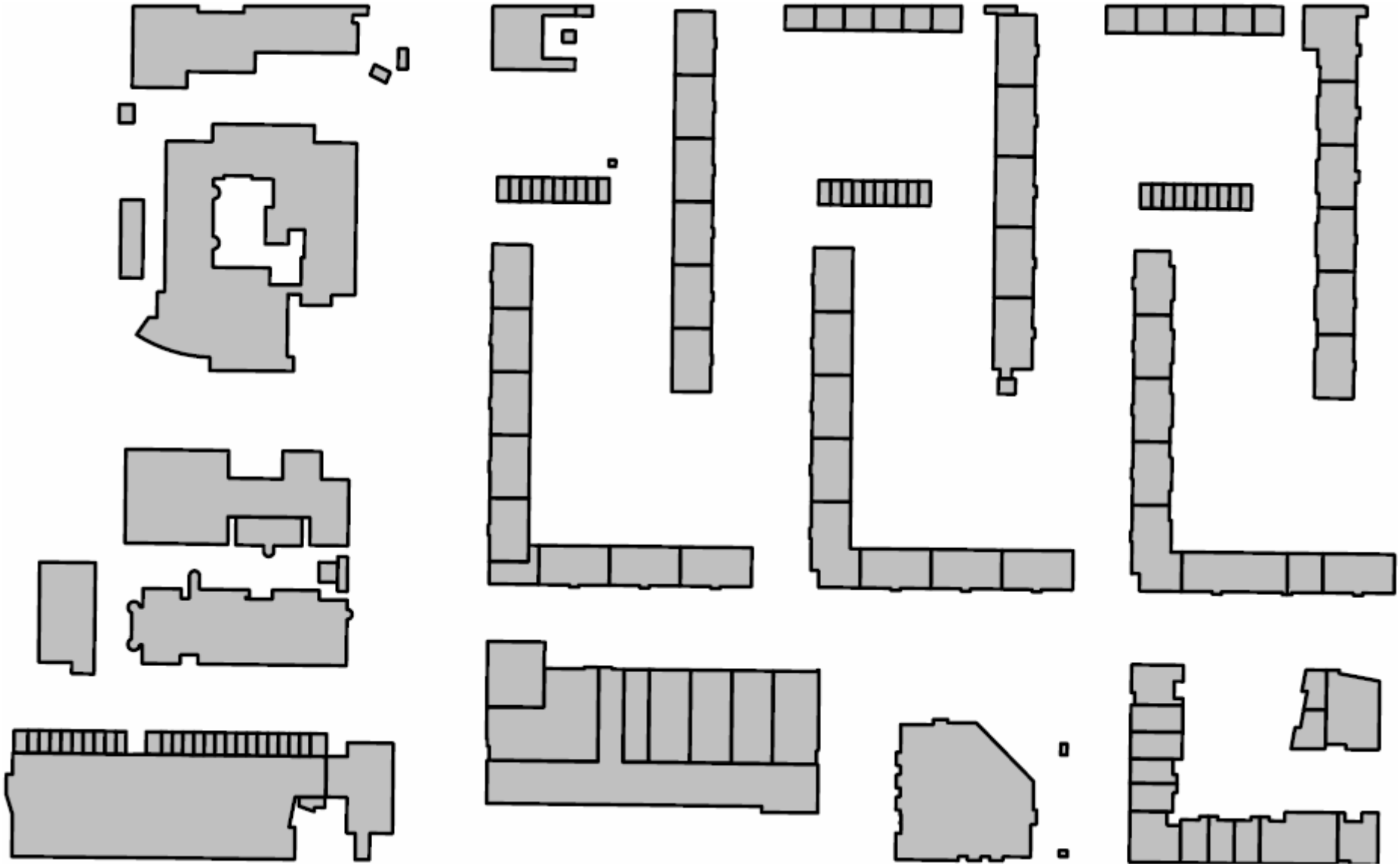


Obvious idea

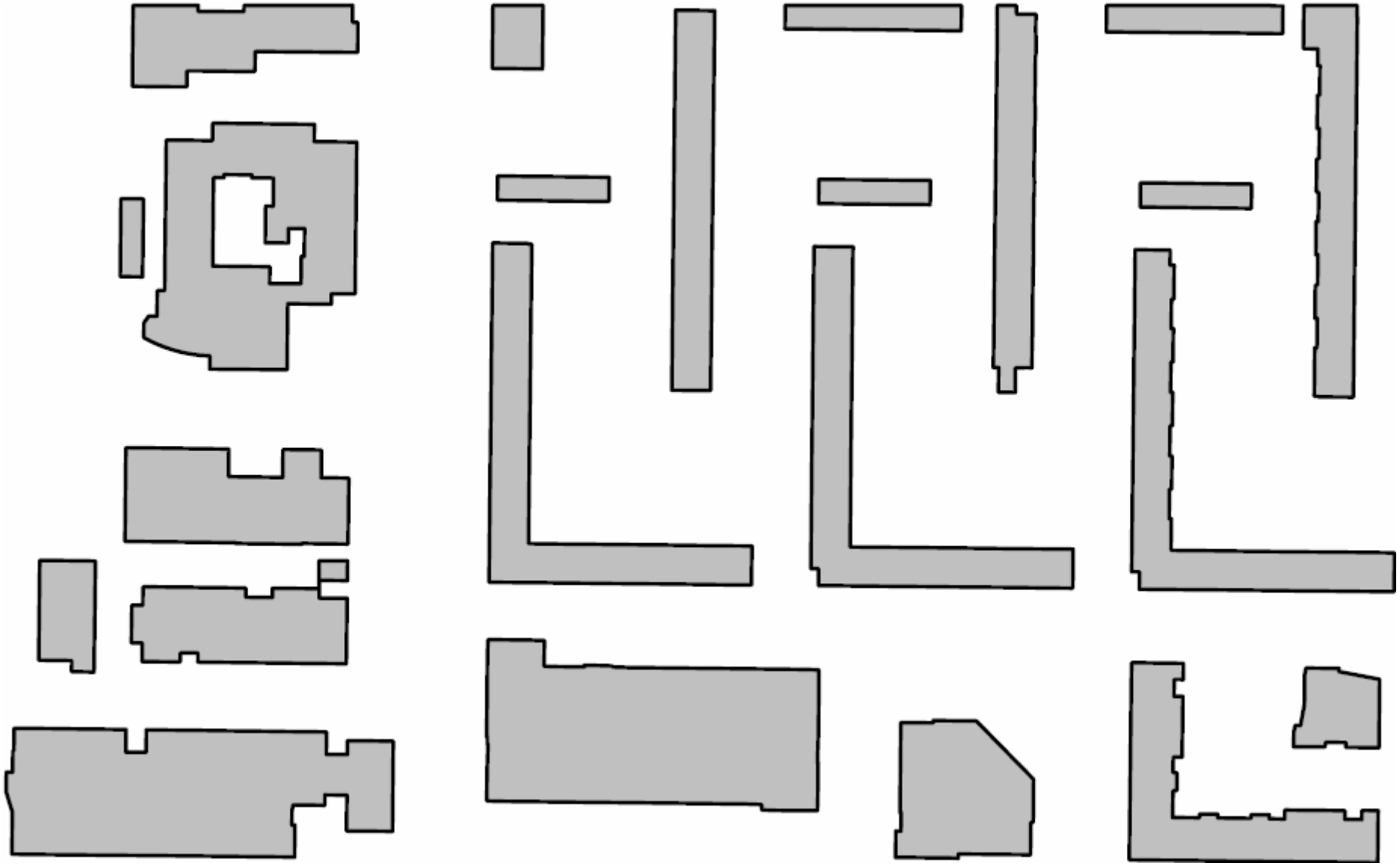
- Try opening and then closure, or vice versa



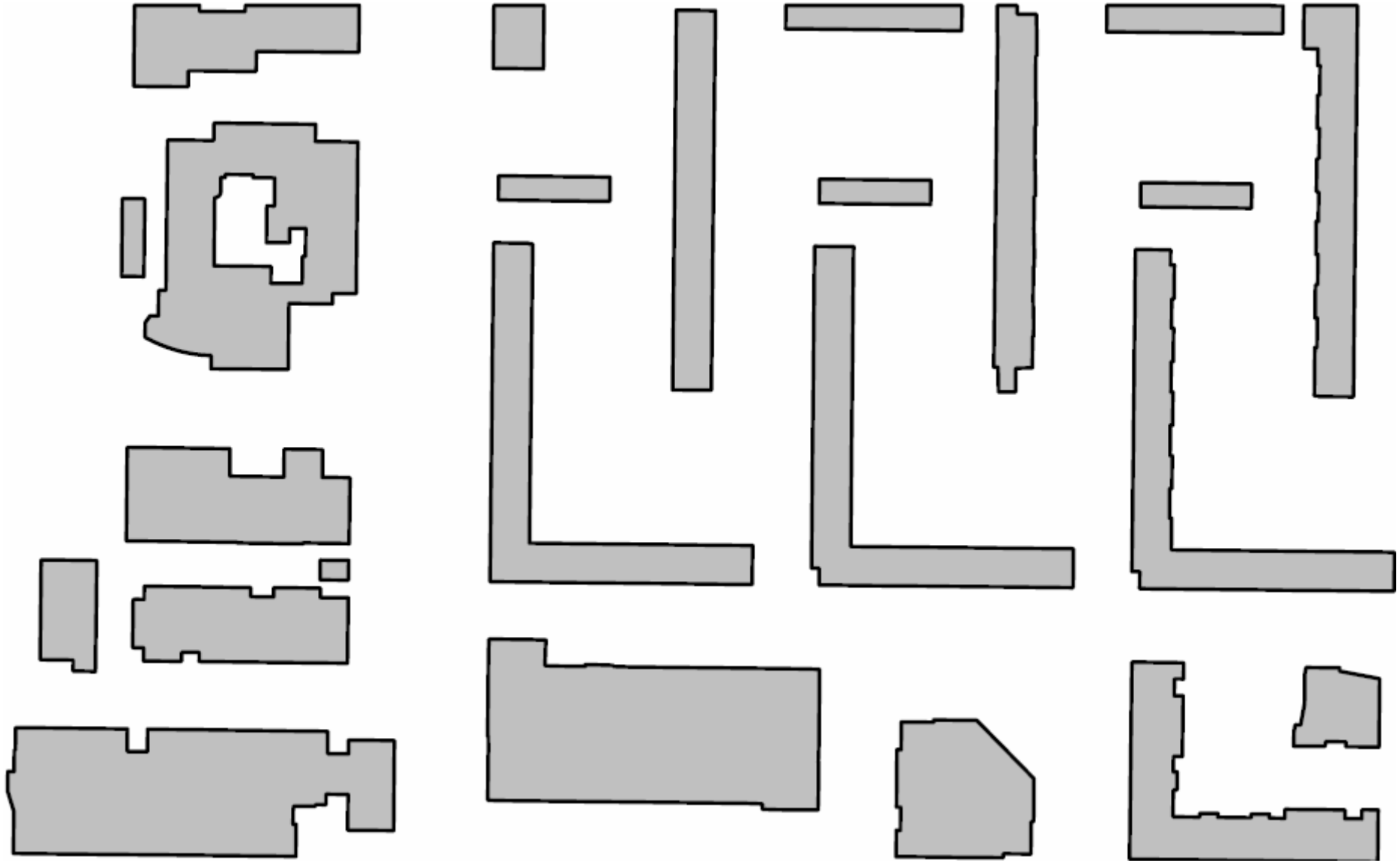
Original



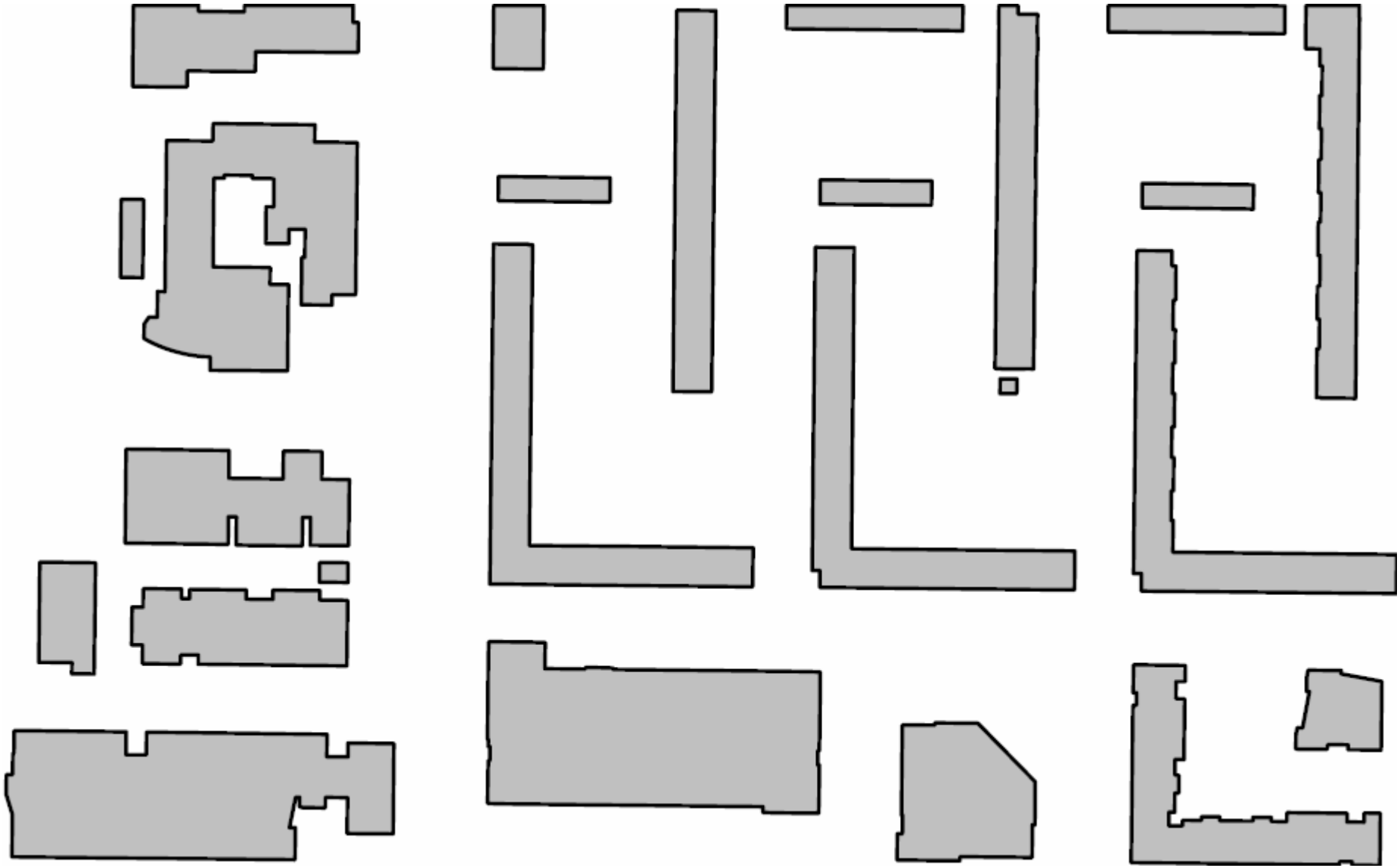
Opening and then closure



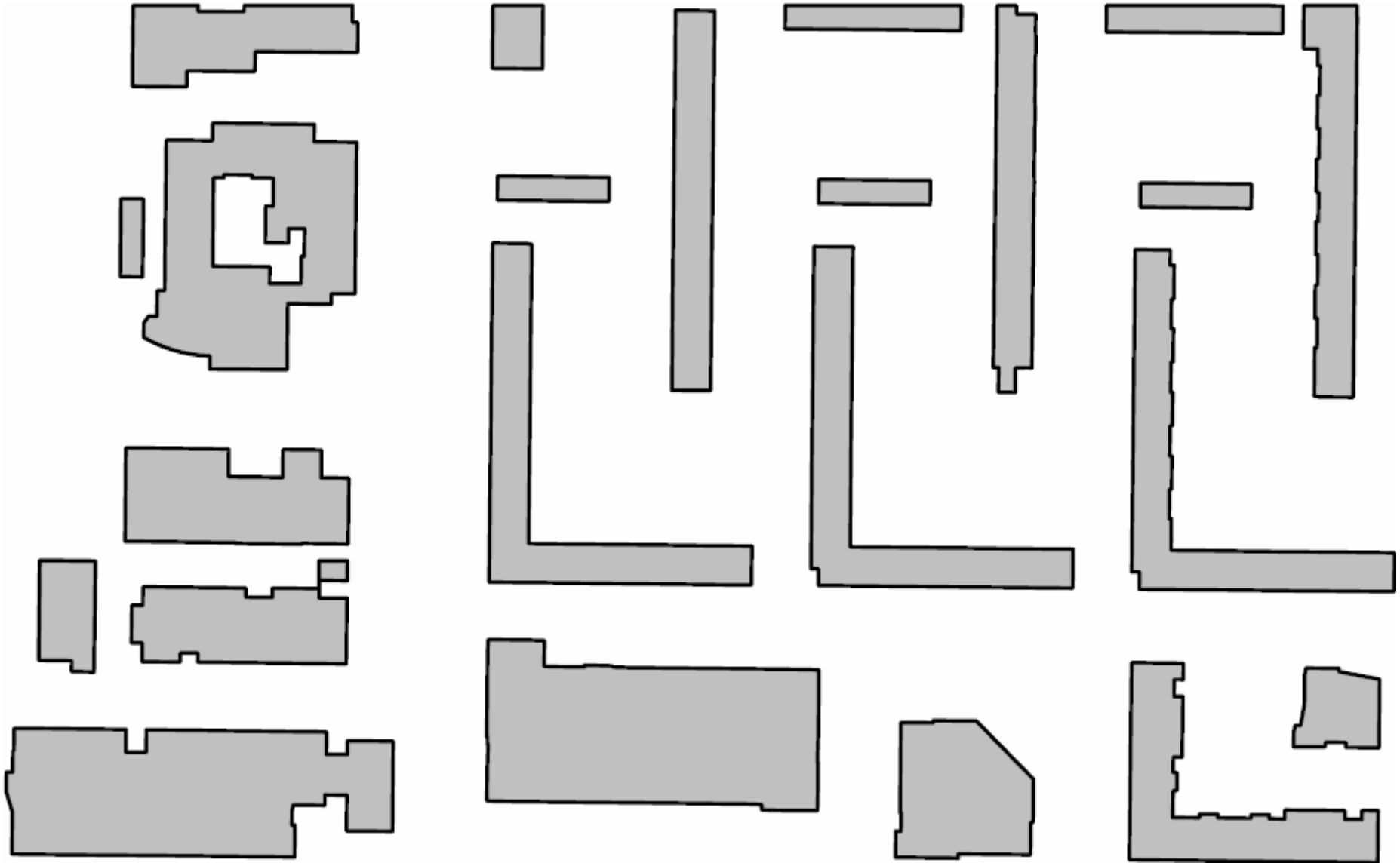
Closure and then opening



Opening

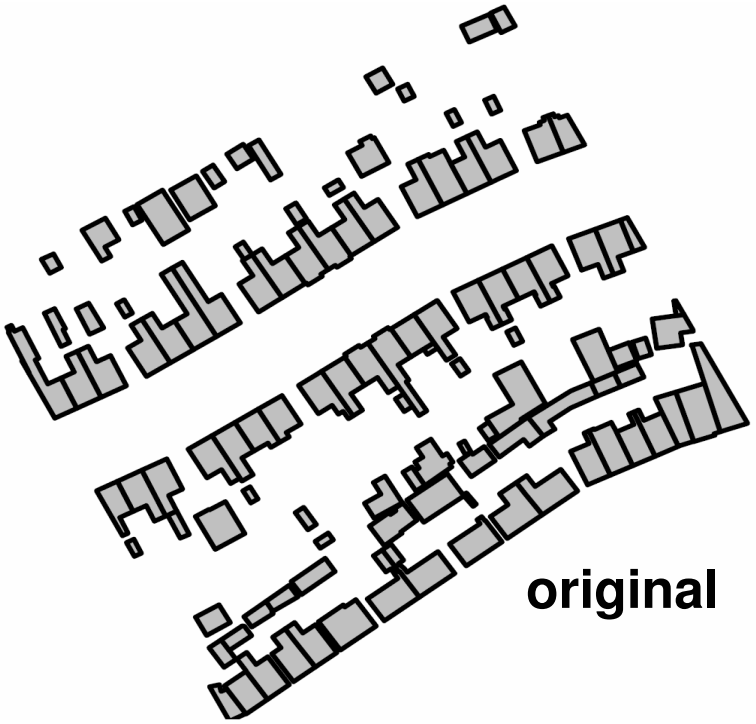


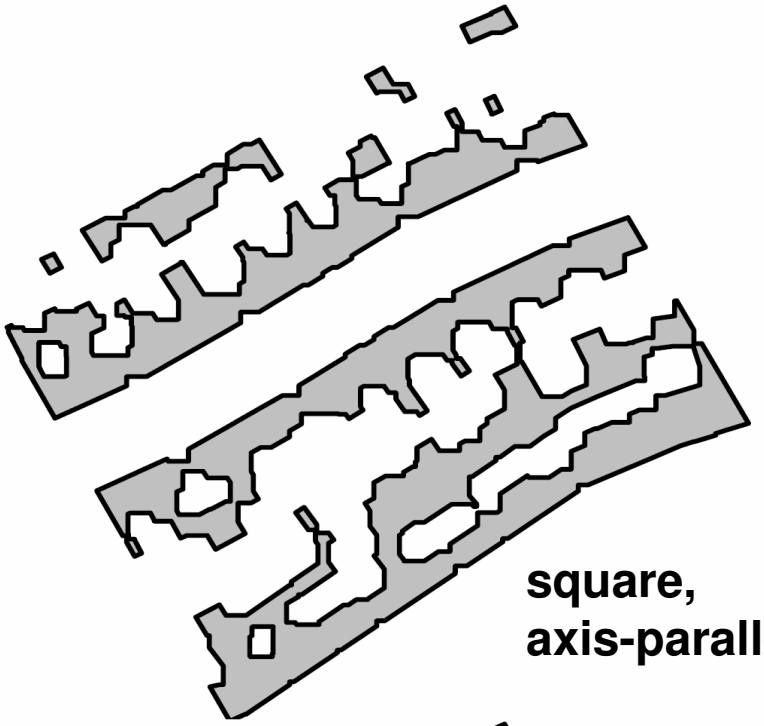
Opening and then closure

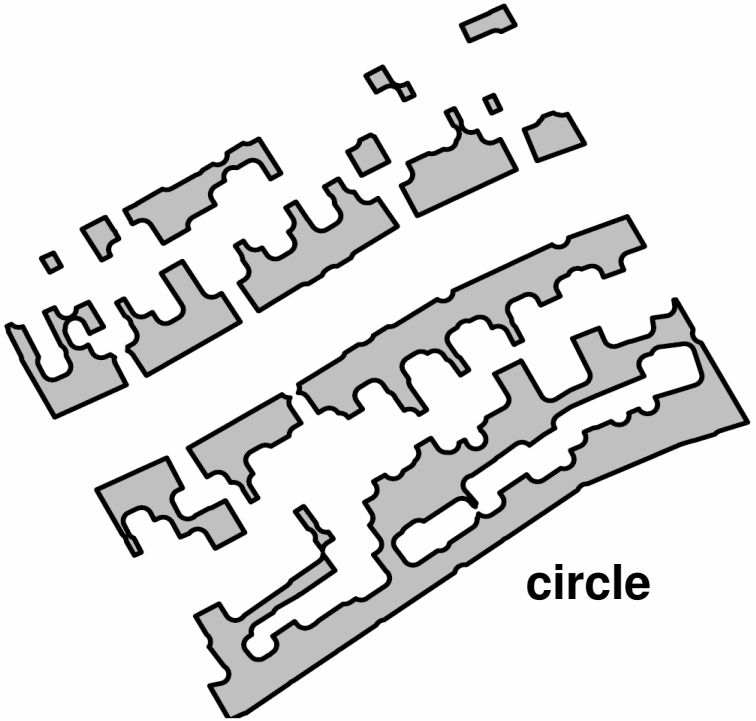


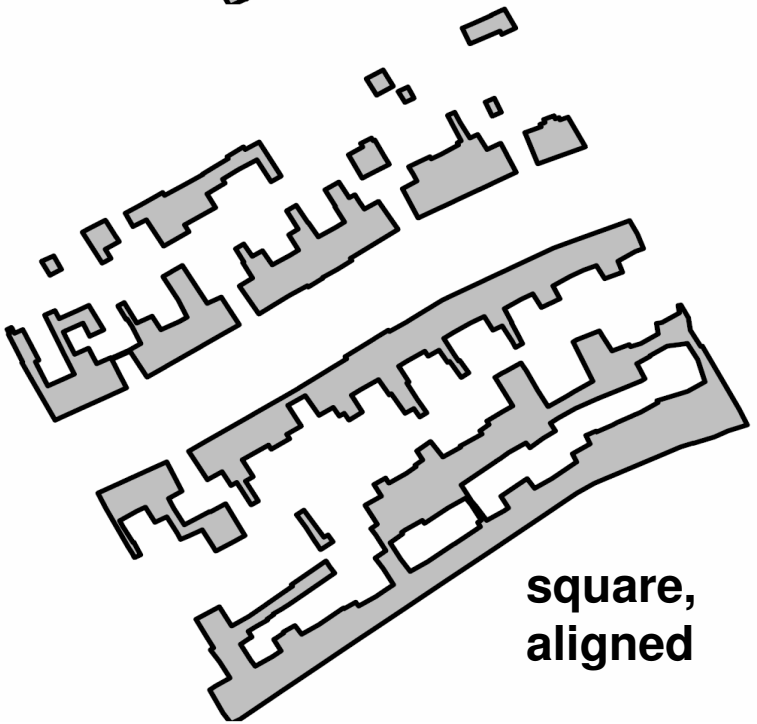
Size, shape, orientation of the element

- Larger element → more elimination, more aggregation, more simplification
- Square element is better than circle to keep orthogonal character of buildings
- Orientation of square should correspond to orientation of most edges


original


square,
axis-parallel


circle


square,
aligned

Conclusions & further research

- Elegant, global solution
- Opening-Closure and Closure-Opening are both better than opening or closure individually

- Short edges remain; post-simplification desirable
- Best orientation of square may not be the same throughout whole building