Topology preserving parallel thinning

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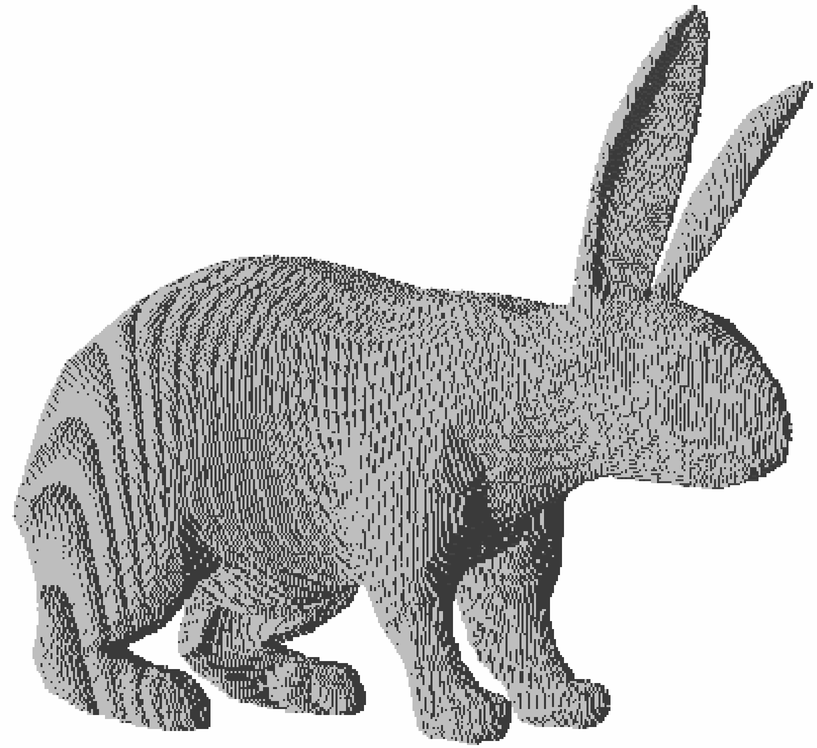
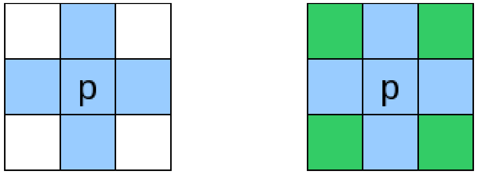
Binary images in 2D and 3D



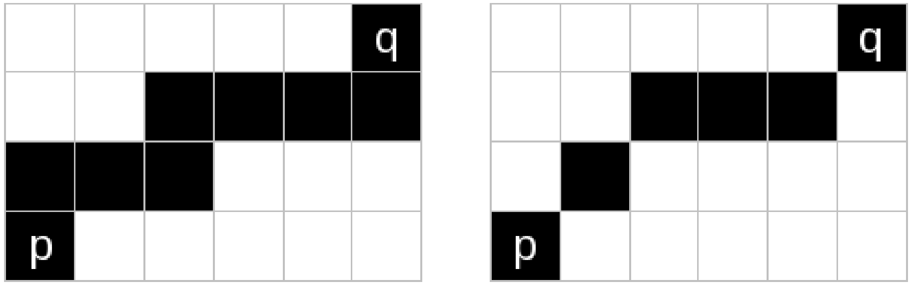
background: 0 (white)
object: 1 (black)

Adjacencies and connectedness

- 4- and 8-adjacency



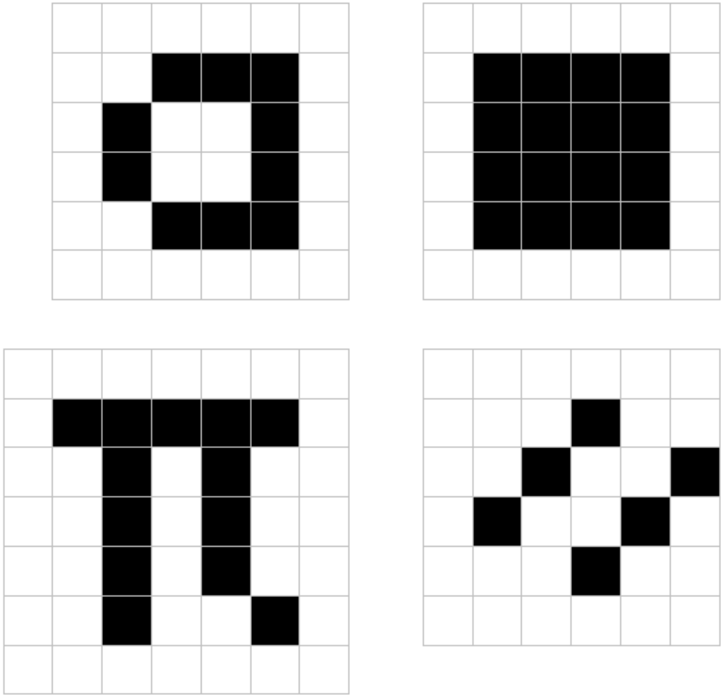
Two points *p* and *q* are *j*-connected (*j*=*4*,*8*), if there is a *j*-path between them.



4-path 8-path

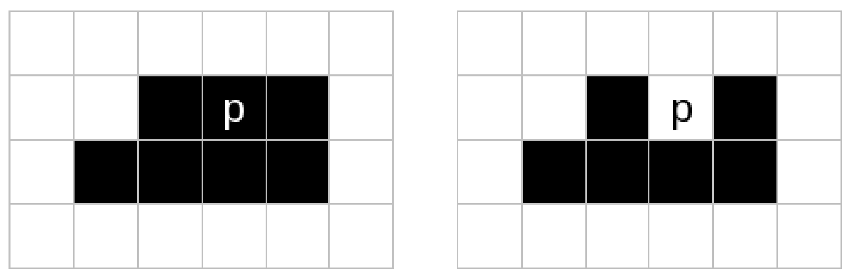
A (8,4) binary picture

- Foreground is 8-connected
- Background is 4-connected



Reduction Operations

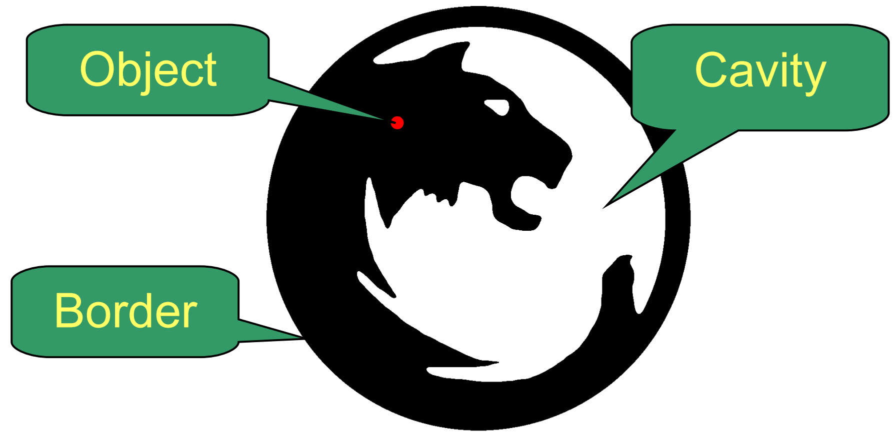
- Reduction: some change a black points are changed to white

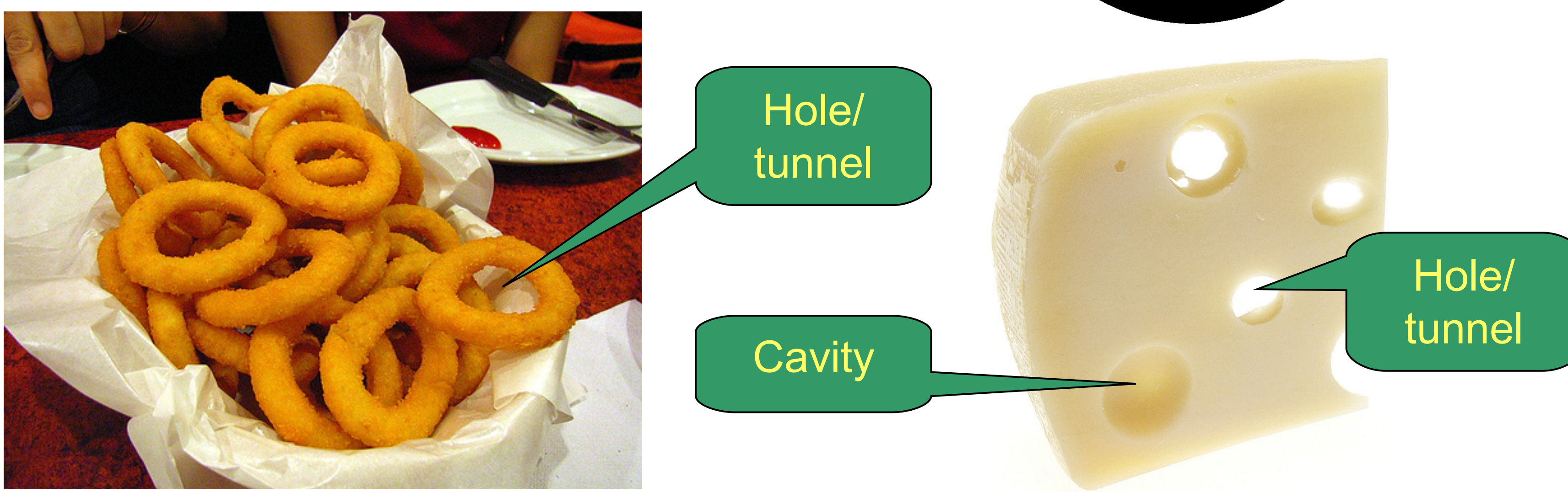


- Thinning: iterative object reduction

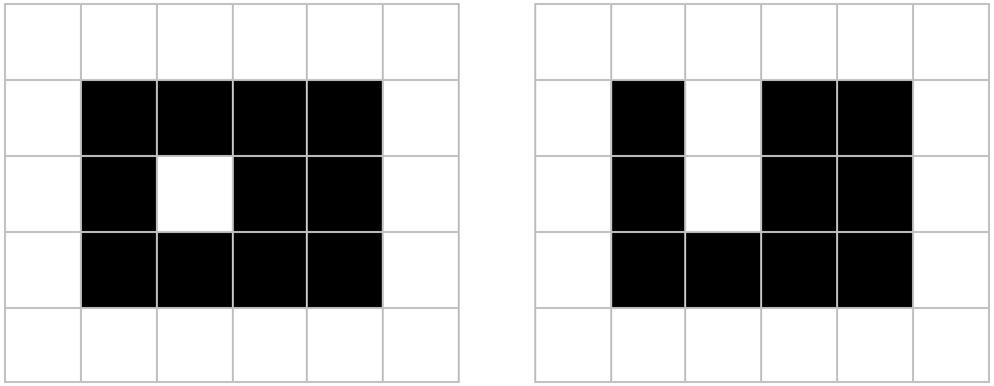
Digital topology

- Object
- Cavity
- Hole/tunnel (3D)



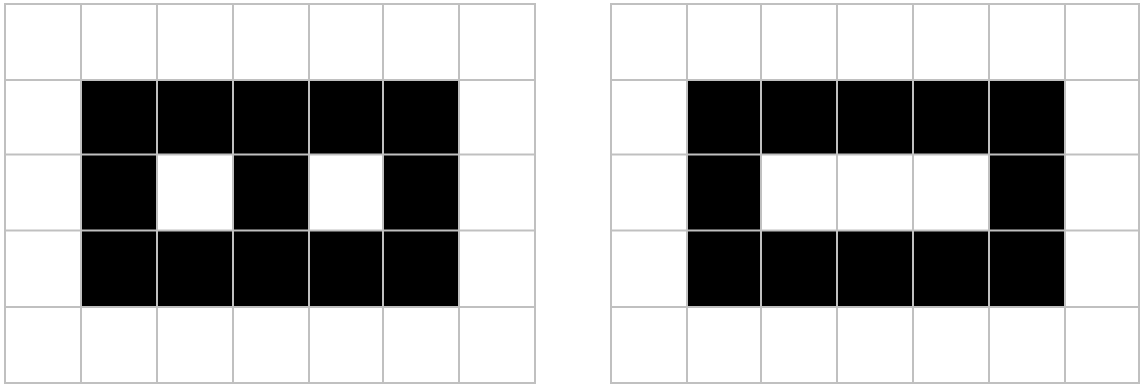


Example for non-topology preserving reduction



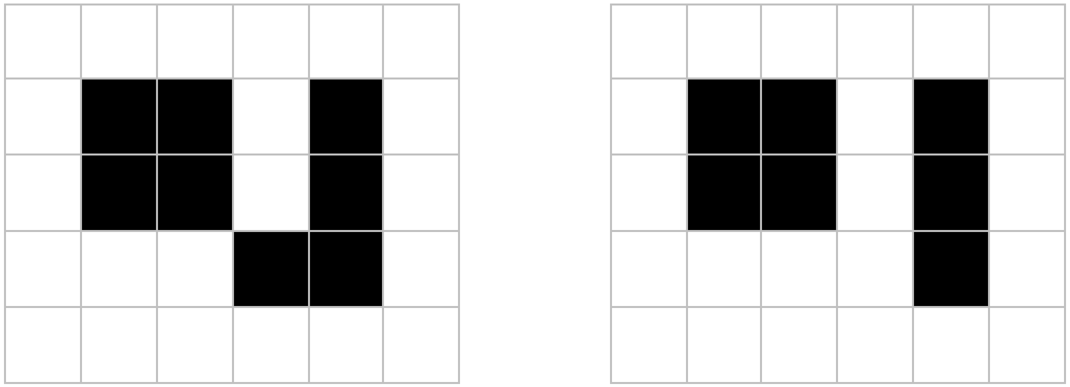
a cavity is eliminated

Example for non-topology preserving reduction



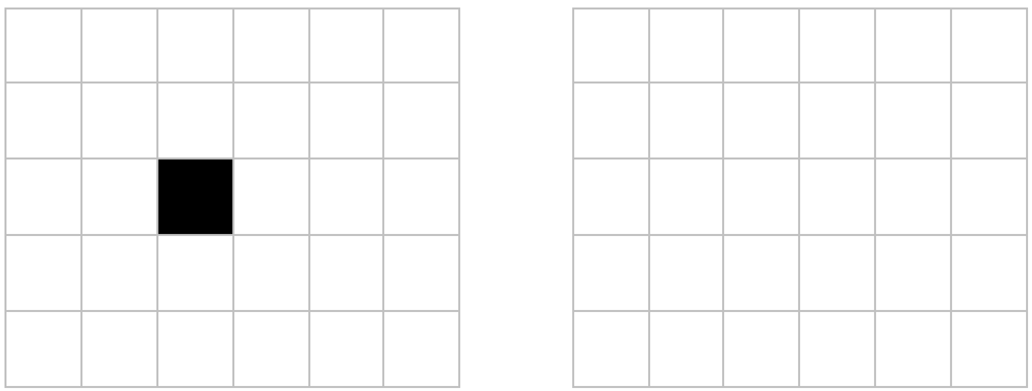
two cavities are merged

Example for non-topology preserving reduction



an object is split

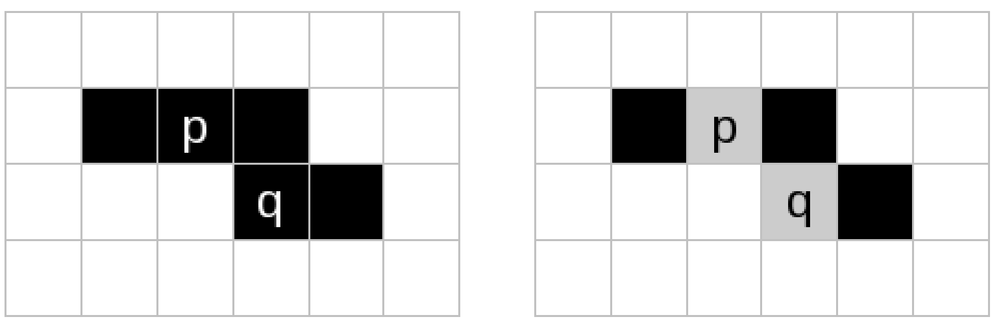
Example for non-topology preserving reduction



an object is completely deleted

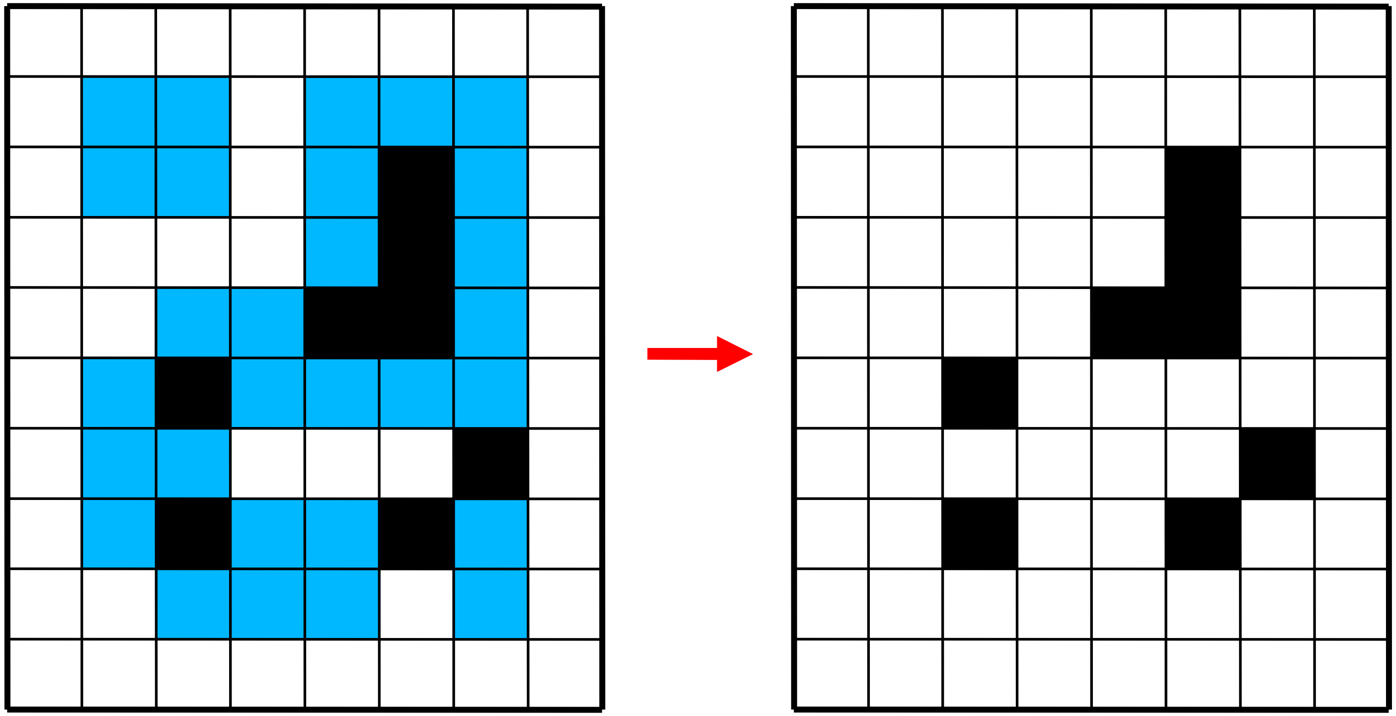
Border points and simple points

- Border point: black point, which has at least one white 4-neighbor.
- Simple point: black point, whose reduction doesn't alter the topology



q is simple, but *p* is not.

Parallel reduction



simple
non-simple

topology is altered

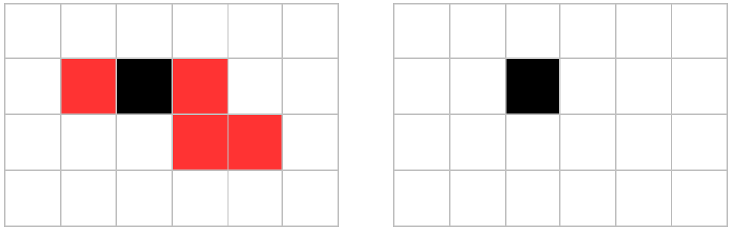
Ronse’s sufficient condition (2D)

A parallel reduction operator T is topology preserving for (8,4) pictures if all the three conditions hold:

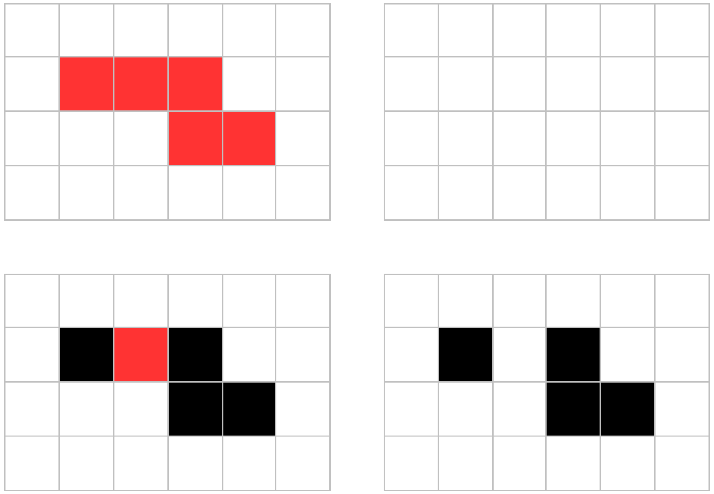
- Only simple points are deleted by T.
- For any two 4-adjacent points p and q are deleted by T, p is simple after deletion of q, or q is simple after p is removed.
- No „small” black component in a 2x2 square is deleted completely by T.

Ronse's sufficient condition 1

- Only simple points are deleted by T.



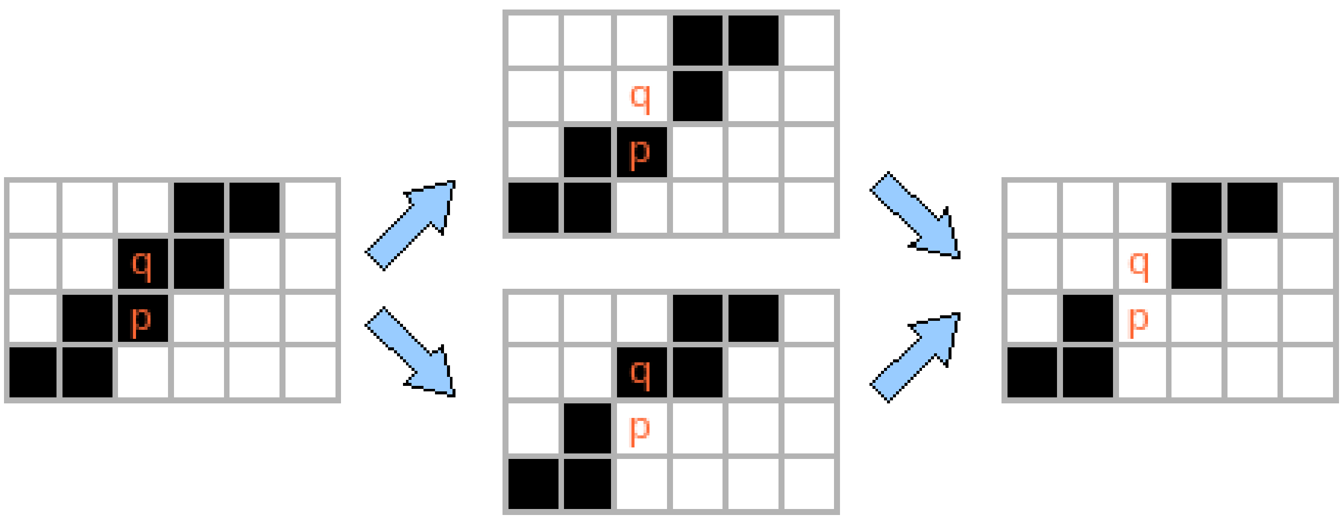
Topology is preserved



Topology is altered

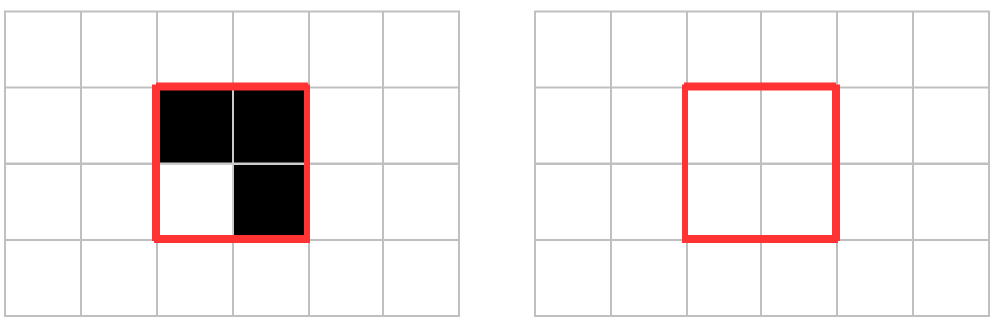
Ronse’s sufficient condition 2

- For any two 4-adjacent points p and q are deleted by T, p is simple after deletion of q, or q is simple after p is removed.



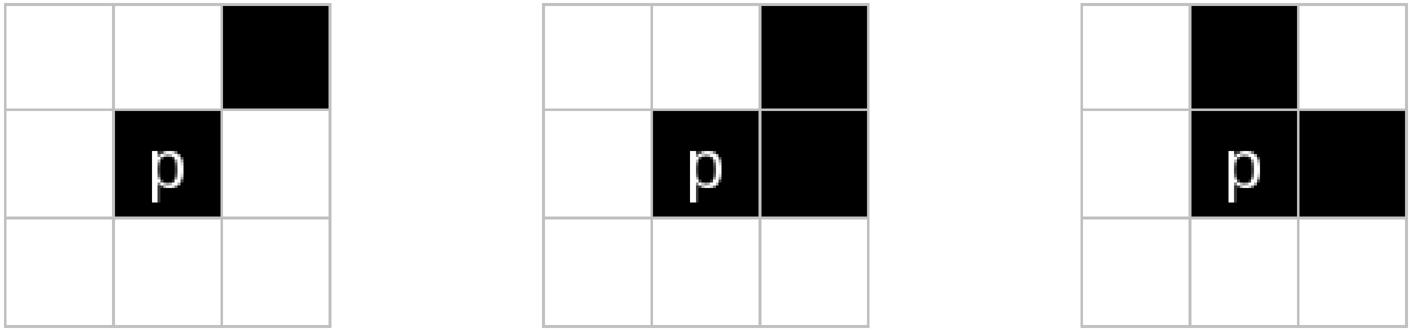
Ronse’s sufficient condition 3

- No „small” black component in a 2x2 square is deleted completely by T.



End points

- Three types of end points



E1 E2 E3

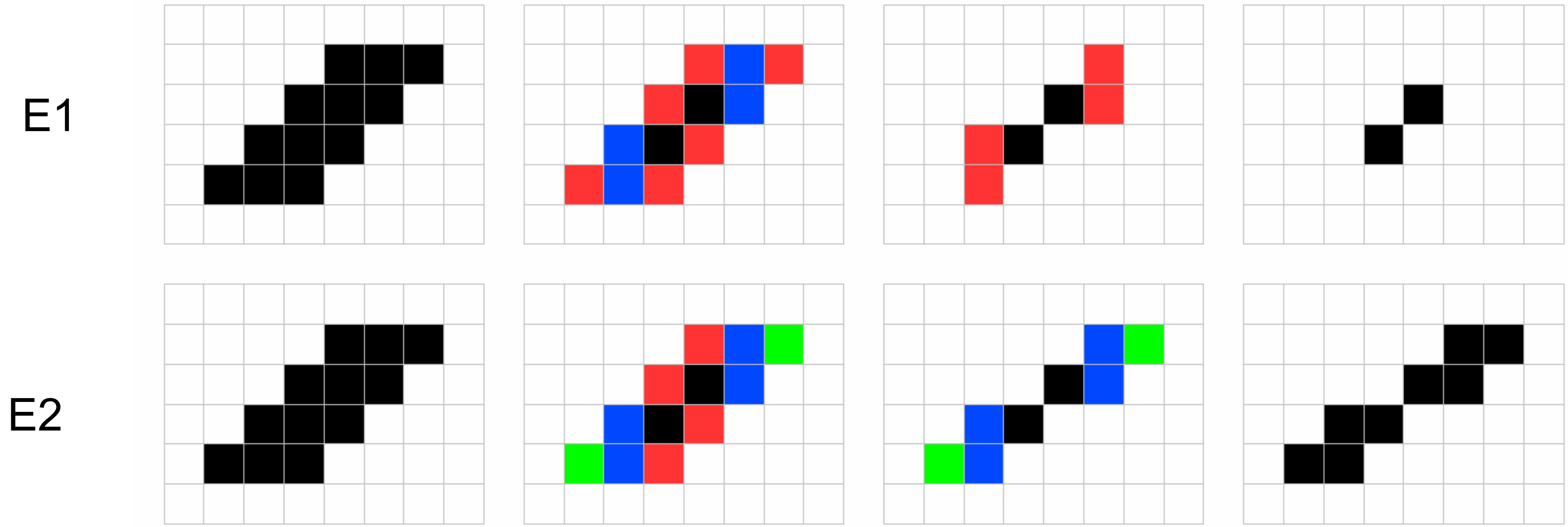
2D thinning algorithms

Input:set of object points X
type of endpoints t

Output: set of skeletal points Y

```
Y = X
repeat
    D = { all points that are not endpoints of type t
          and satisfy Ronse's condition}
    Y = Y - D
until  D=Ø
```

Example

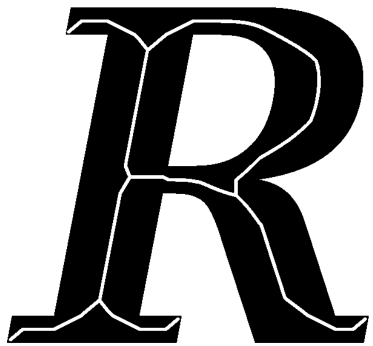


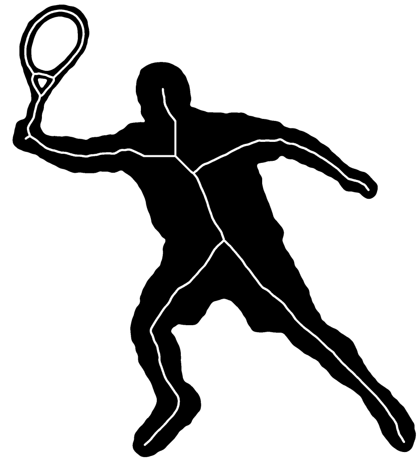
Some technical details...

- Support: 5x5 neighborhood of the visited visited point.
- 2^{24} cases necessary to check
- Precalculated LUT for decision of deletability

Results

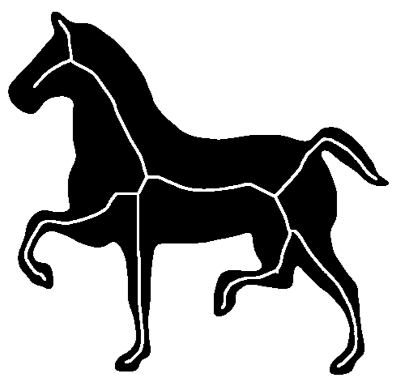
600x557
0,15 s

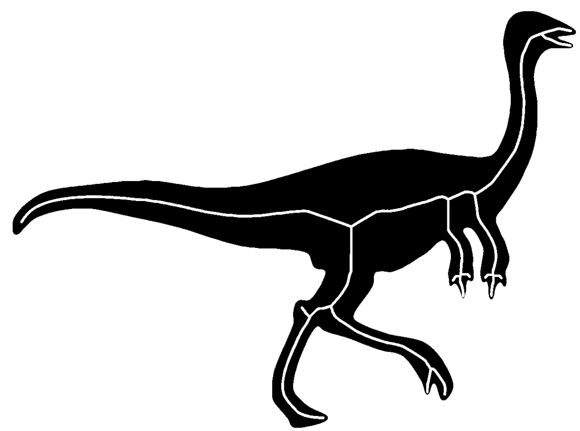




1832x2054
1,17 s

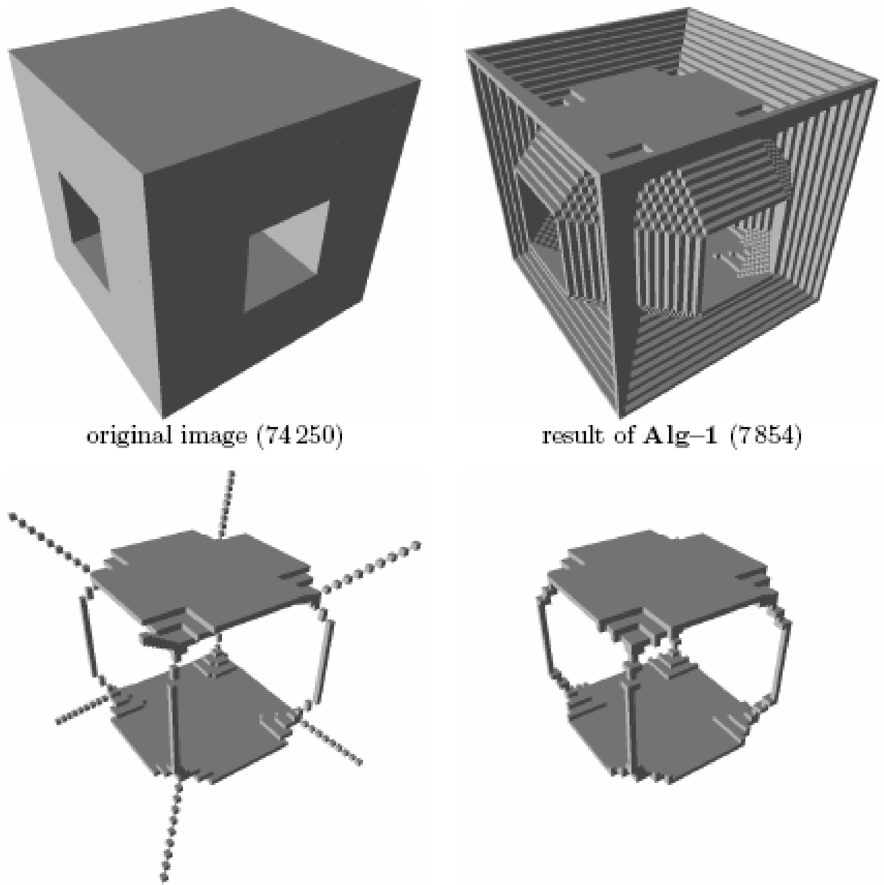
473x451
0,08 s





1188x811
0,28 s

Results of a 3D method based on topology preserving



original image (74 250)

result of **Alg–1** (7 854)

result of **Alg–2** (2 102)

result of **Alg–3** (2 126)

Thank you for your attention!