

Skeletal Descriptors

These set of slides show how to calculate skeletal descriptors for a two-phase microstructure

What do we do

Given a segmented microstructure, we compute a set of 10 skeletal descriptors per phase : 20 descriptors

- **List of descriptors**
 - d1 Fraction of skeletal pixels
 - d2 Number of end pixels
 - d3 Number of intersection pixels
 - d4 Number of end pixels on the top and bottom boundary
 - d5 Number of branches
 - d6 Average branch length
 - d7 Number of cycles
 - d8 Max distance from the skeleton to the opposite phase
 - d9 Min distance from the skeleton to the opposite phase
 - d10 Average distance to opposite phase



Descriptor naming in the package – note the order of the descriptors

d1 SKEL_f_<phase>

d2 SKEL_n_end_<phase>

d3 SKEL_n_intS_<phase>

d4 SKEL_boundary_END_n_<phase>

d5 SKEL_nB_<phase>

d6 SKEL_lB_<phase>

d7 SKEL_n_cycles_<phase>

d8 SKEL_max_width_<phase>

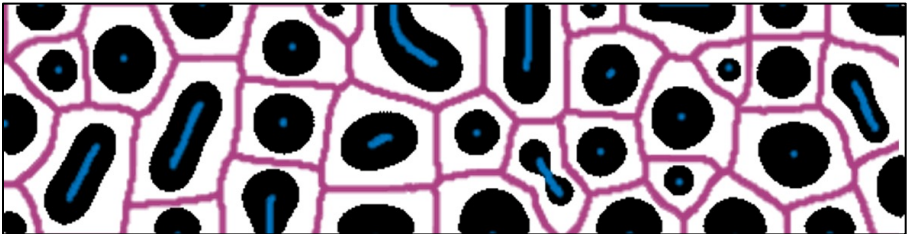
d9 SKEL_min_width_<phase>

d10 SKEL_f_width_<phase>

Number of skeletal pixels	835
	711
Fraction of skeletal pixels	0.0410622
	0.0352574
Number of end pixels	15
	18
Number of intersection pixels	7
	2
Number of branch pixels	813
	691
Number of branches	9
	13
Average branch length	94.1111
	54.8462
Number of cycles	1
	1
Max. distance to the opp. phase	18.5
	19.54
Min. distance to the opp. phase	1.5
	5.12
Avg. distance to the opp. phase	11.1958
	11.7675



Number of skeletal pixels	1952
	240
Fraction of skeletal pixels	0.077
	0.015
Number of end pixels	18
	24
Number of intersection pixels	31
	0
Number of branch pixels	1903
	216
Number of branches	32
	13
Average branch length	61.06
	18.30
Number of cycles	14
	0
Max. distance to the opp. phase	17.68
	15.5
Min. distance to the opp. phase	2.5
	0.5
Avg. distance to the opp. phase	8.00
	9.18

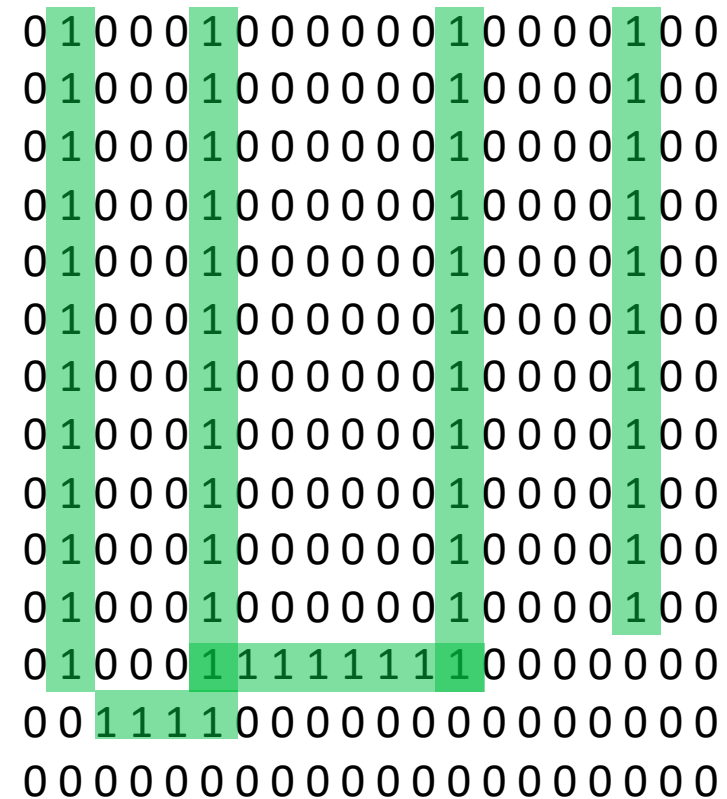


Illustrative examples

Step 1 : Skeletonize



Input microstructure (marked red is the phase we skeletonize)

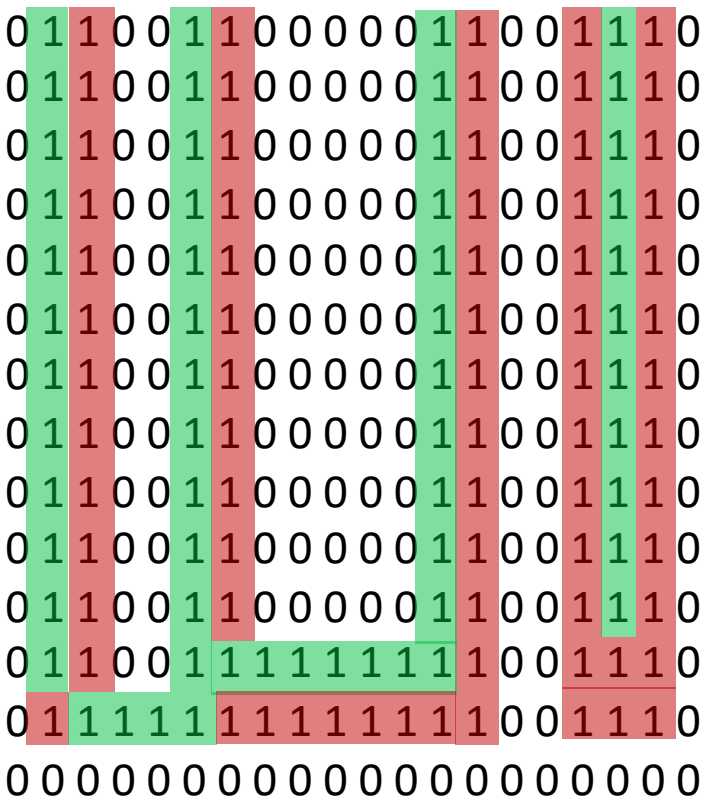


Skeleton of the input phase
(marked green is the skeleton)

Basic descriptors for white phase (marked as 1)

Number of white skeletal pixels : 57

d1. Fraction of skeletal pixels (Number of white skeletal pixels /
Number of white pixels) : 0.46



Definitions:

Skeletal Pixels : The pixels of the input morphology that correspond to the skeleton/medial axis after the erosion process

Fraction of skeletal pixels : The ratio of the skeletal pixels to the total number of pixels of the phase of interest

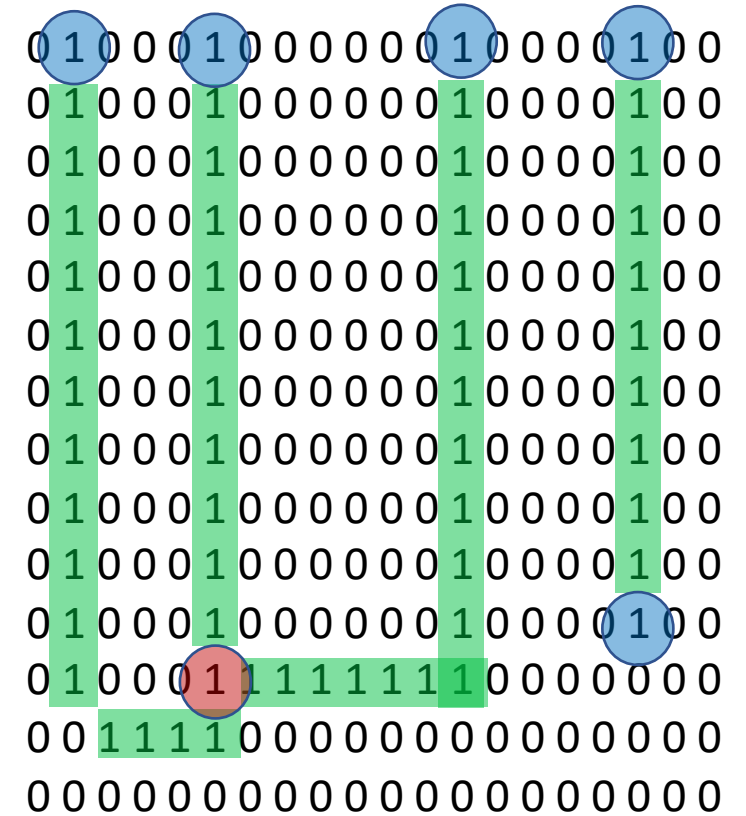
[Note : In the attached figure :
Number of skeletal pixels are highlighted in green and
Fraction of skeletal pixels is : number of green pixels/ number of (green + red) pixels]

We segment skeletal pixels into three categories : intersection pixels, end pixels, and branch pixels

d3. Number of intersection pixels : 1

d2. Number of End Pixels : 

Number of Branch Pixels : 51



Definitions:

Intersection pixels: Junction points in the skeleton between three or more branches

End pixels: The end/ultimate pixels of skeletal branches (also defined as the pixels that have exactly one neighbor in the 8-neighborhood)

Branch pixels : pixels that belong to skeleton but are not intersection or ends

d5. Number of branches : 4

Array of intersections : White 3 1

<color of phase> <degree of the vertex> <occurrence>

Array of branch lengths : 17

12

19

11

d6. Average branch length : 14.75

Definitions:

Branches : A group of voxel separated by intersection/end pixels.

Degree of vertex : Number of branches connected to the vertex (intersection pixels)

Occurrence : The number of intersection vertices with a degree value for the morphology under inspection



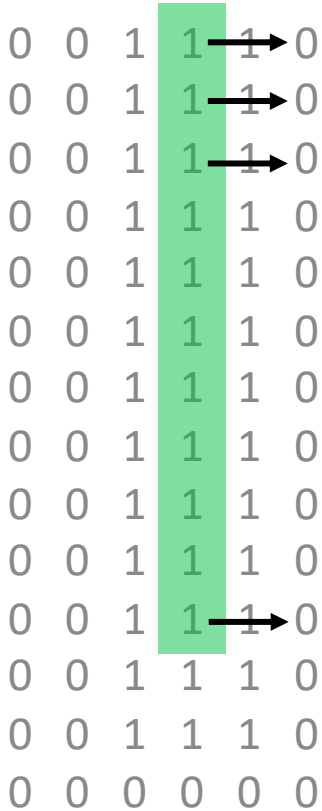
d8, d9, d10. Area through the network : Max, min and avg. distance fromt eh skeleton to the opposite phase

d7. Number of cycles : 0

Definitions:

Area through the network : Shortest distance from each pixel of the skeleton to the opposite phase (Figure).

Cycles : Number of closed loops or closed chains in a morphology. In graph theory, this can be defined as a non-empty trail in which the only repeated vertices are the first and last vertices.



Examples of the shortest distance from the skeletal pixel to the opposite phase illustrated as arrows

