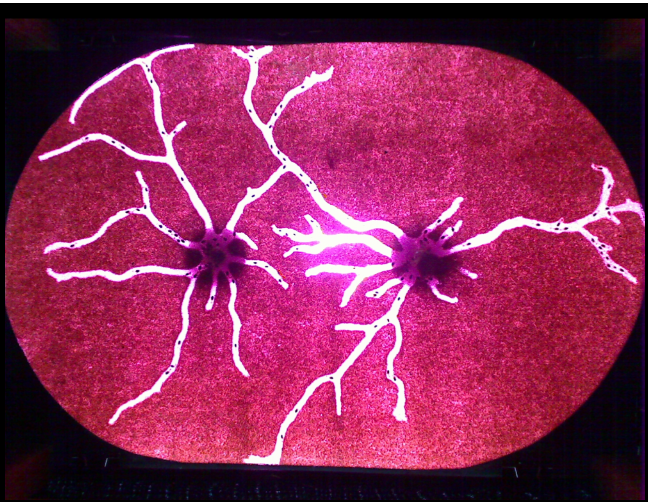
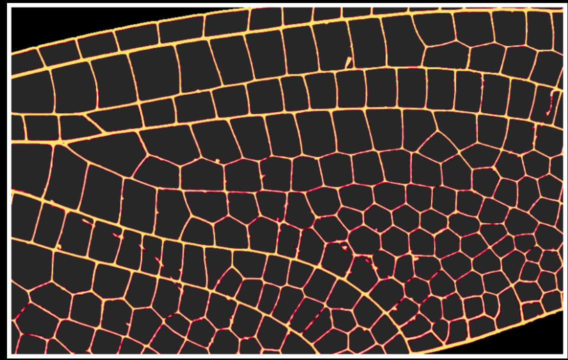
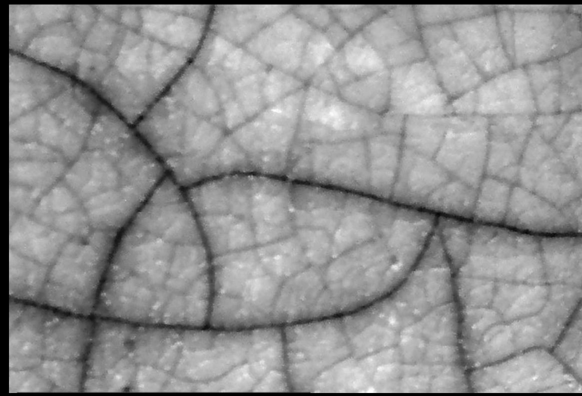
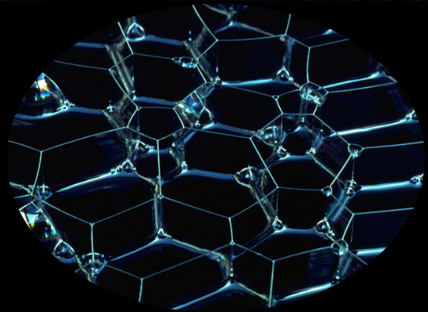
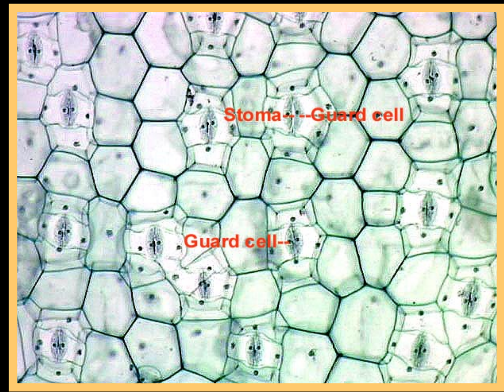








Two classes of real world net-like patterns identified by angles at junctions



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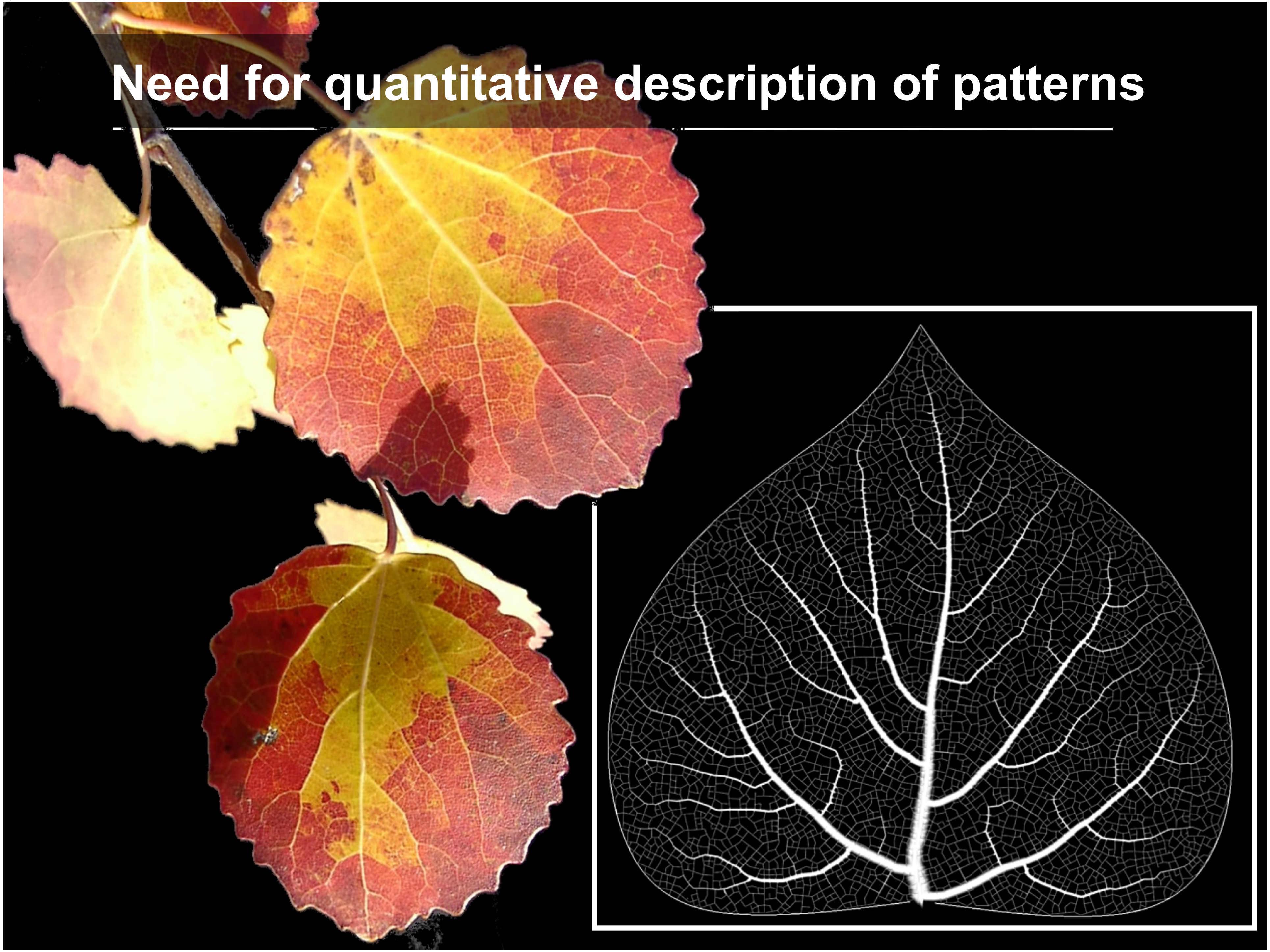
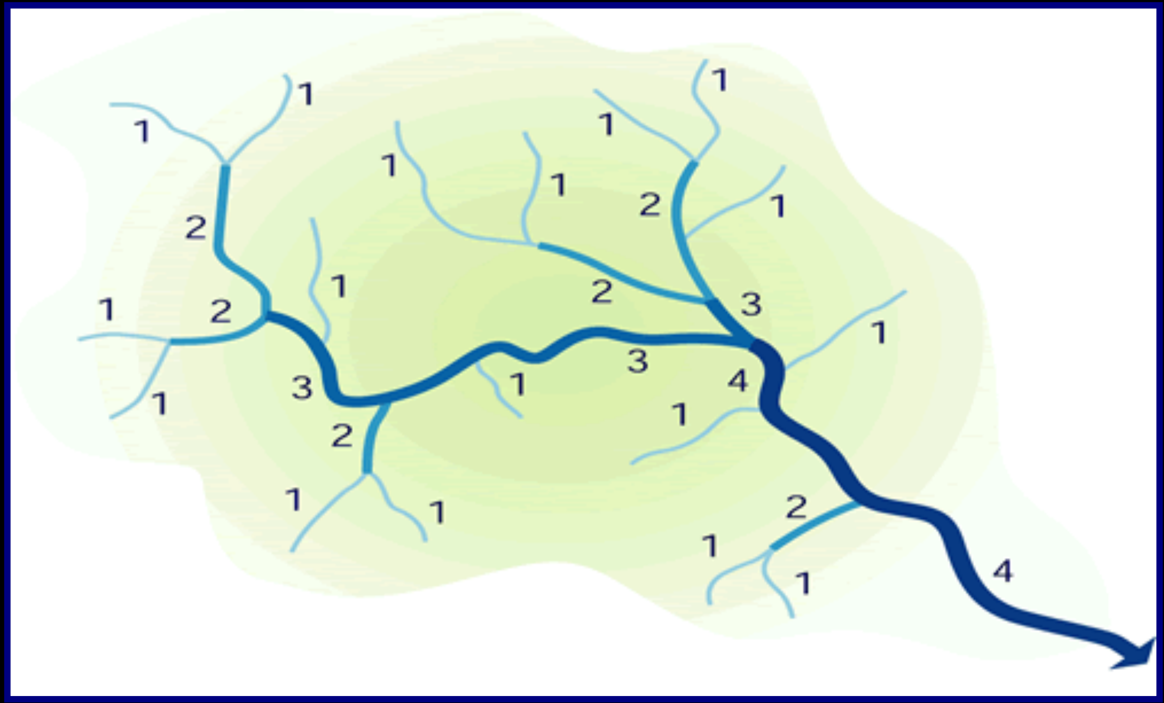
isc
CNRS CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE

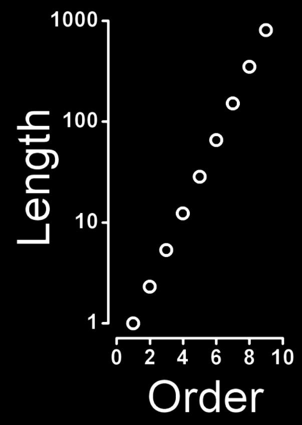
Need for quantitative description of patterns

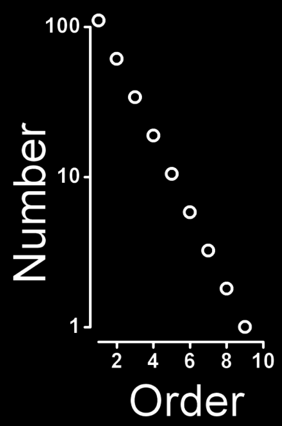


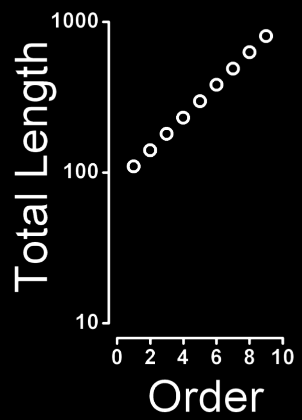
Difficulty in describing hierarchical patterns



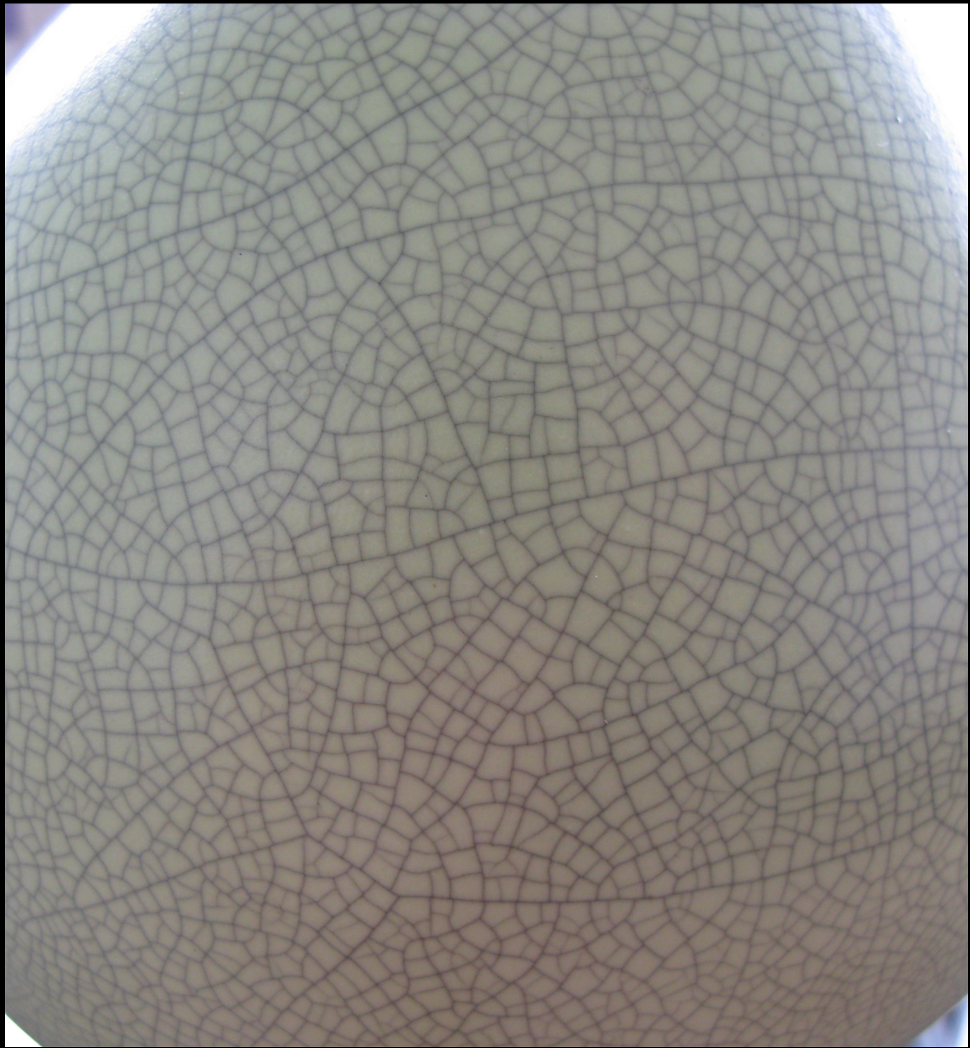
Horton-Strahler classification systems for river networks







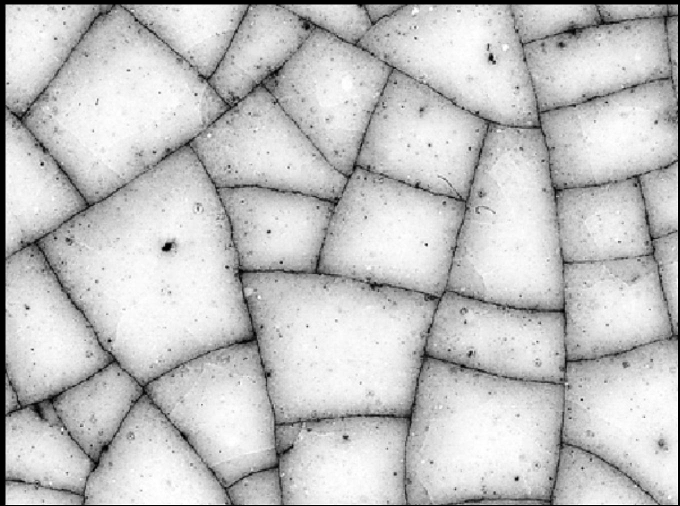
Difficulty in describing hierarchical patterns

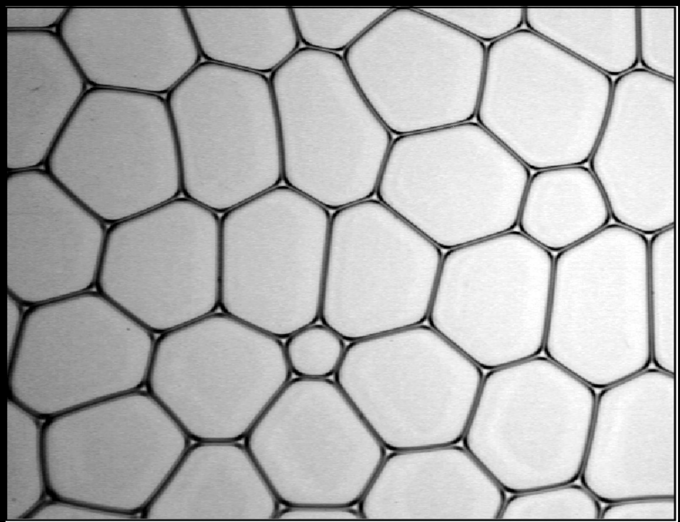


Loops!

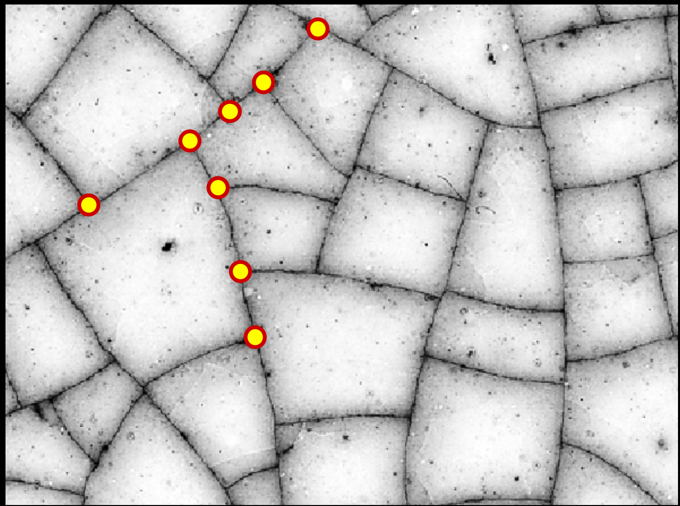
Mangroves

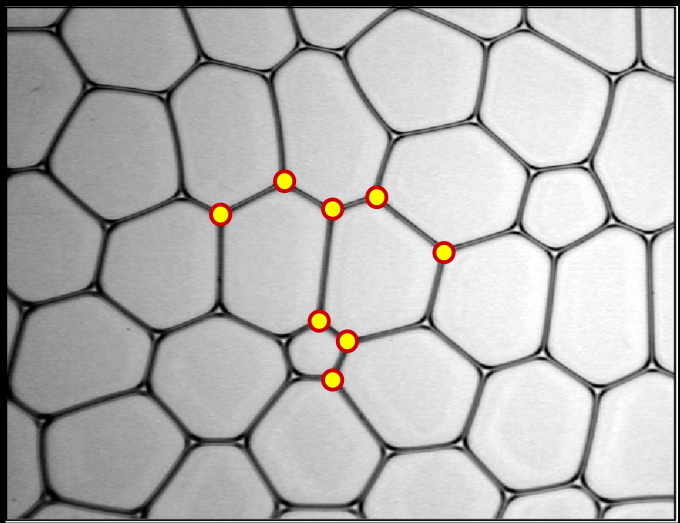
Describe them in terms of graphs



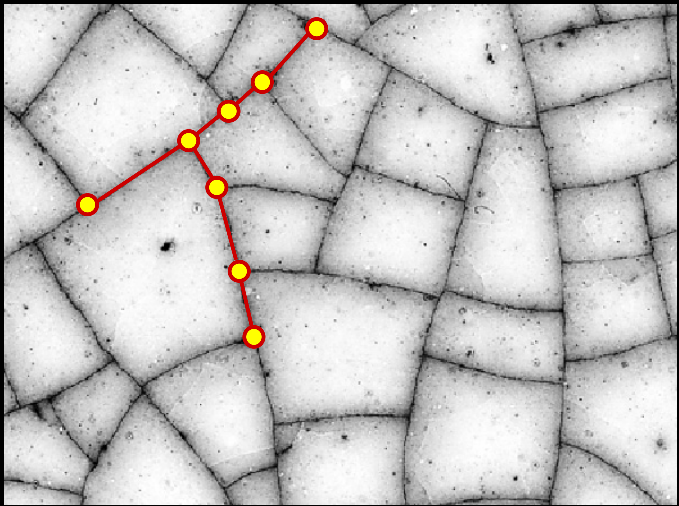


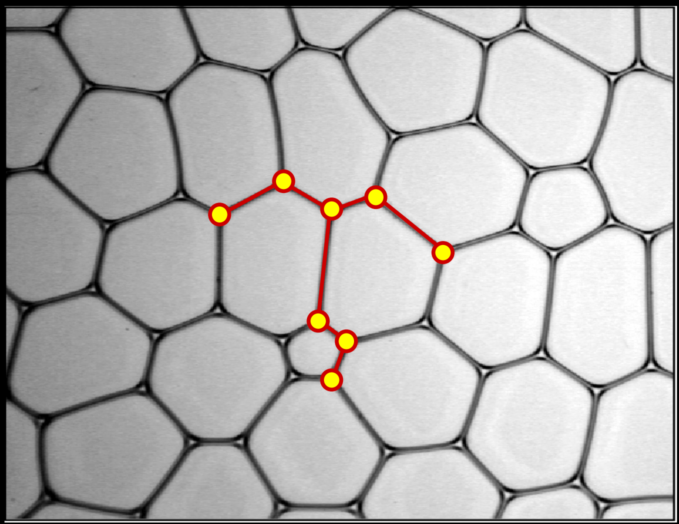
Describe them in terms of graphs



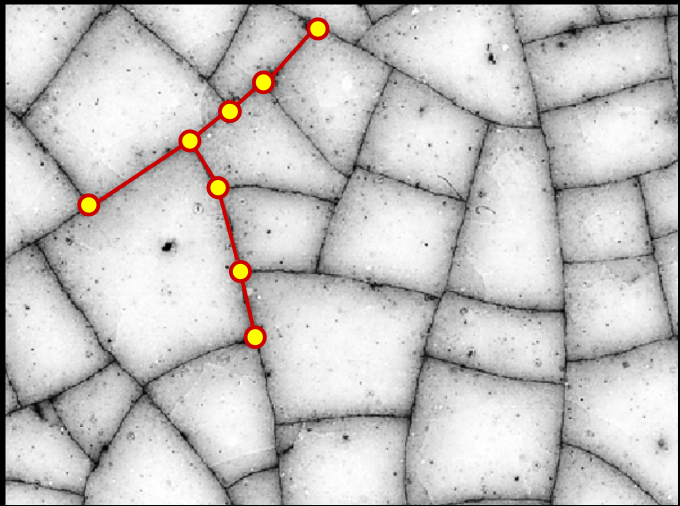


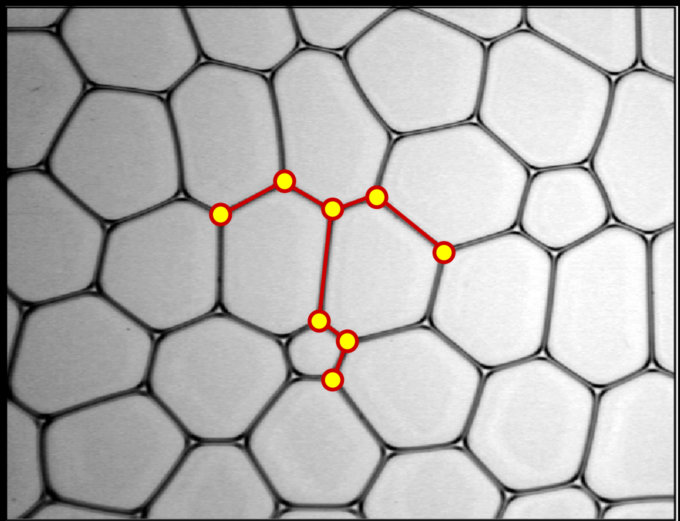
Describe them in terms of graphs





The topology is similar





Euler formula states that

$N - E + F = 2$

From which follows that

$E \leq 3N - 6$

and

$\langle k \rangle < 6$

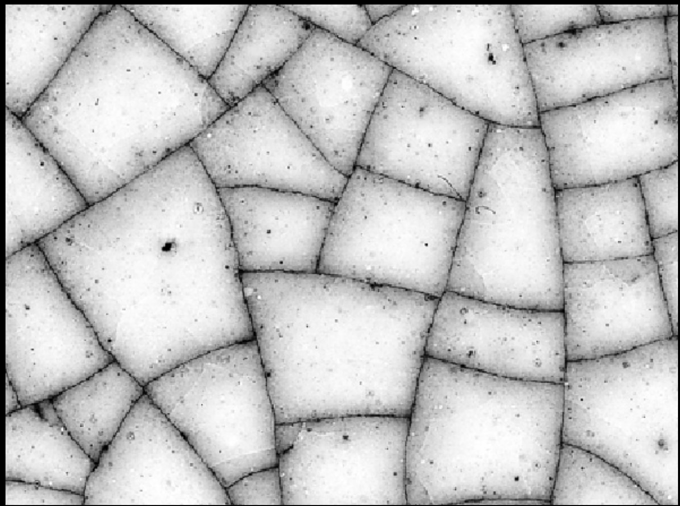
But here in particular:

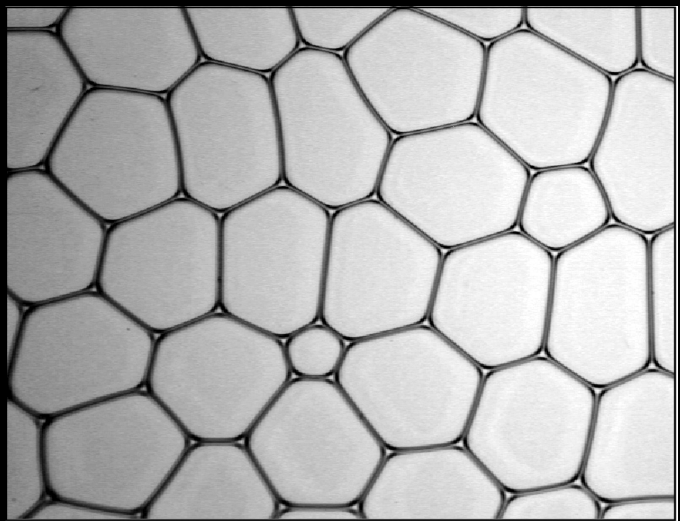
$\langle k \rangle \approx 3$

Cycles length ≈ 6

$\langle L \rangle \propto \sqrt{N}$

The geometry is different





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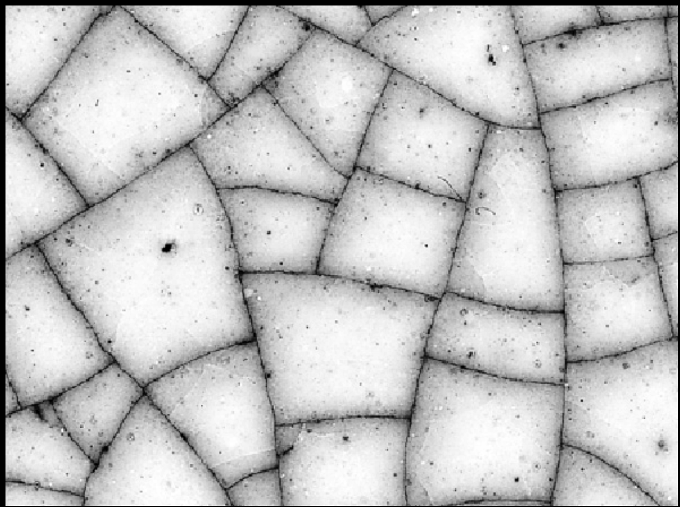

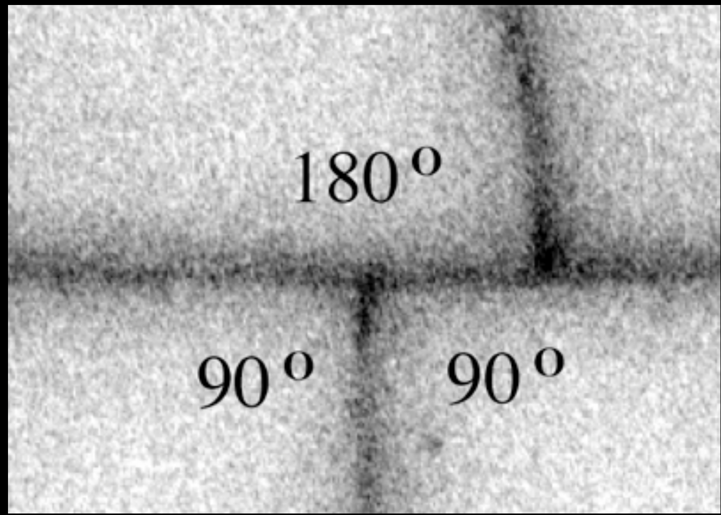

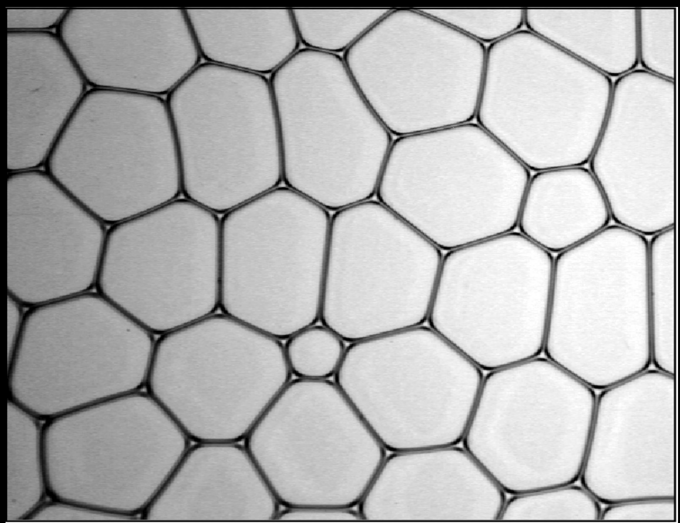

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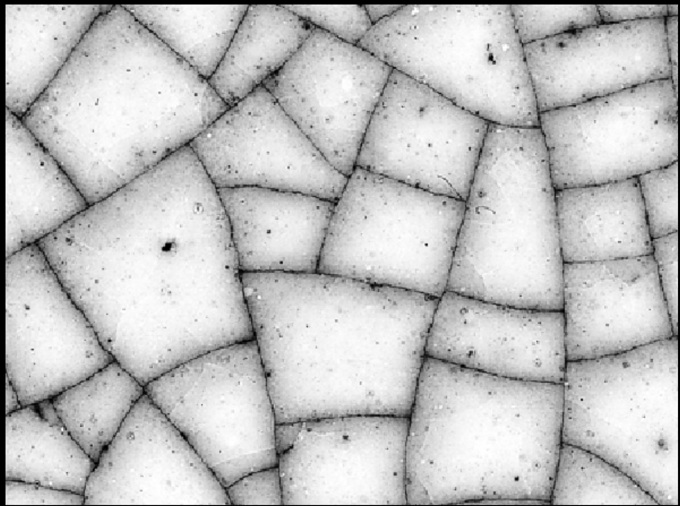
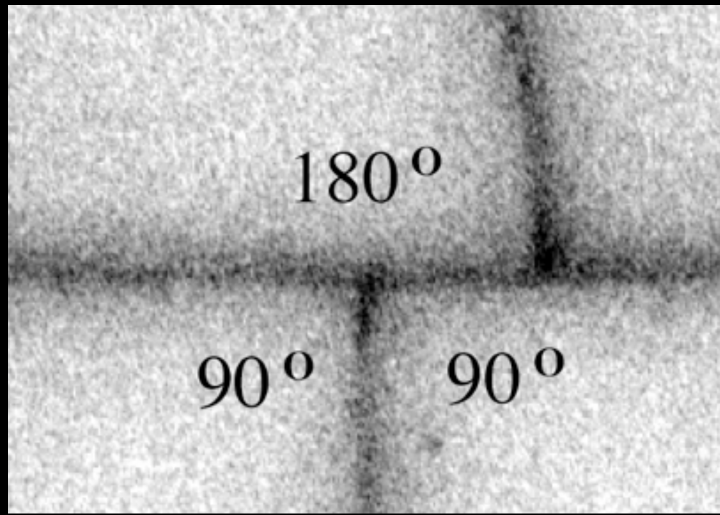
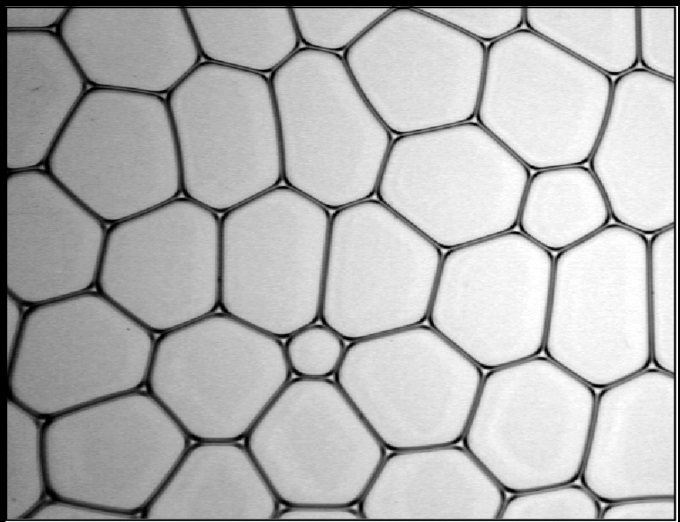
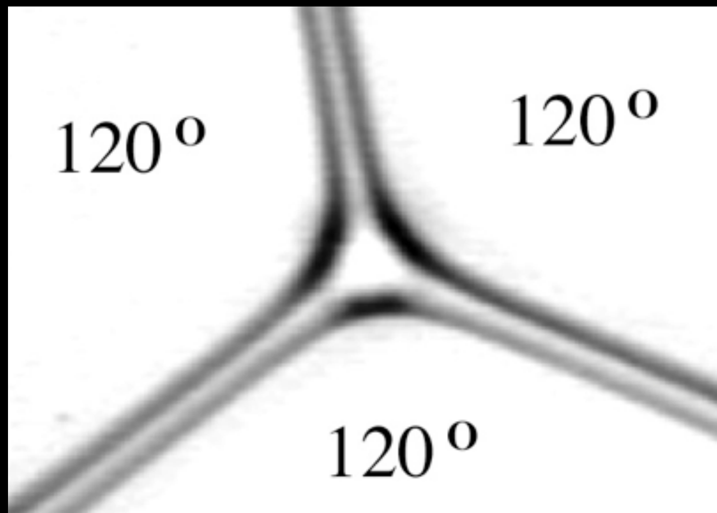




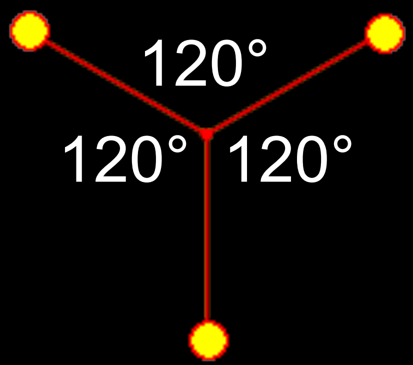


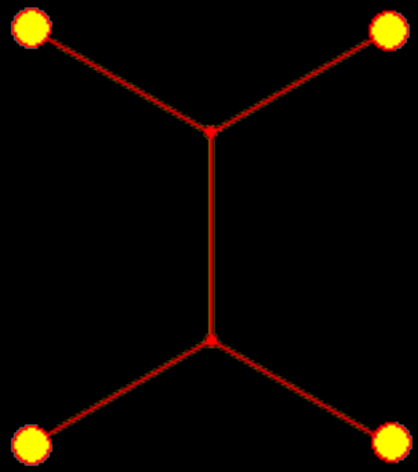


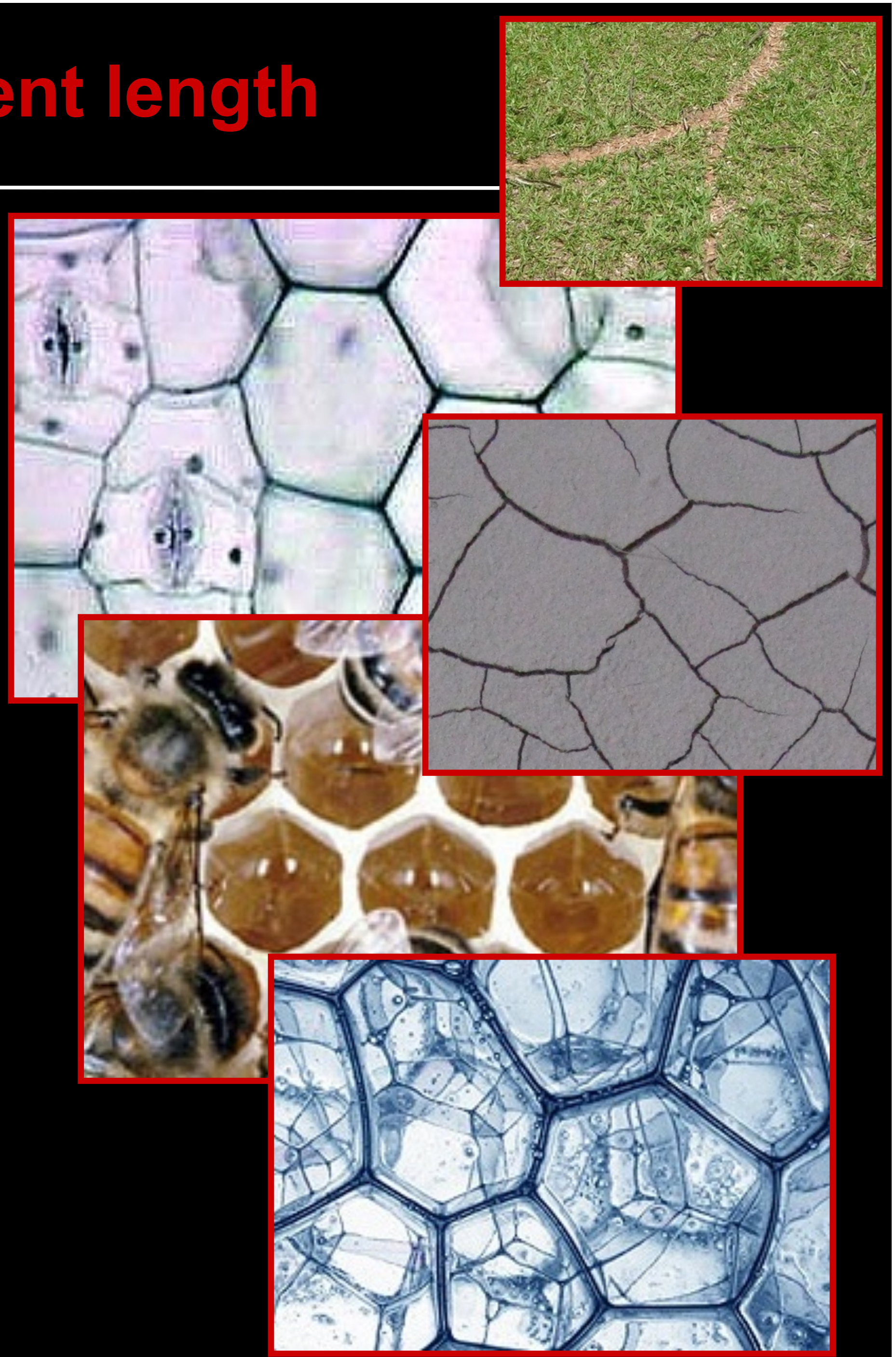
Locally minimal segment length

Euclidean Steiner tree problem:

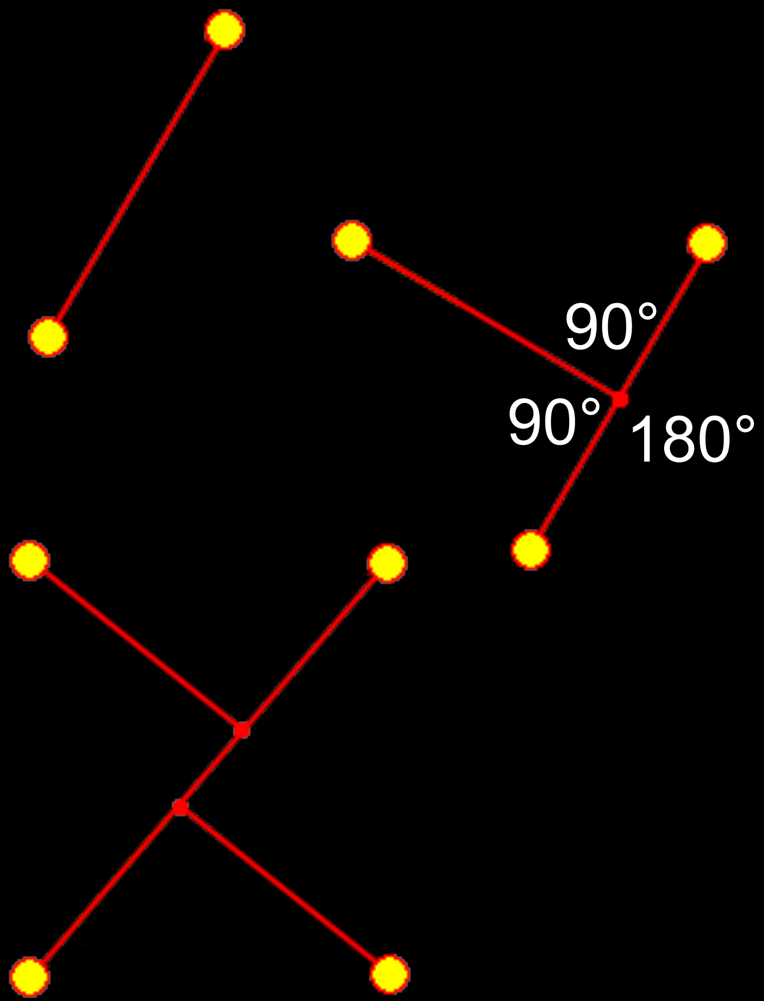
Given N points in the plane, connect them by lines of minimum total length in such a way that any two points may be interconnected by line segments either directly or via other points and line segments.



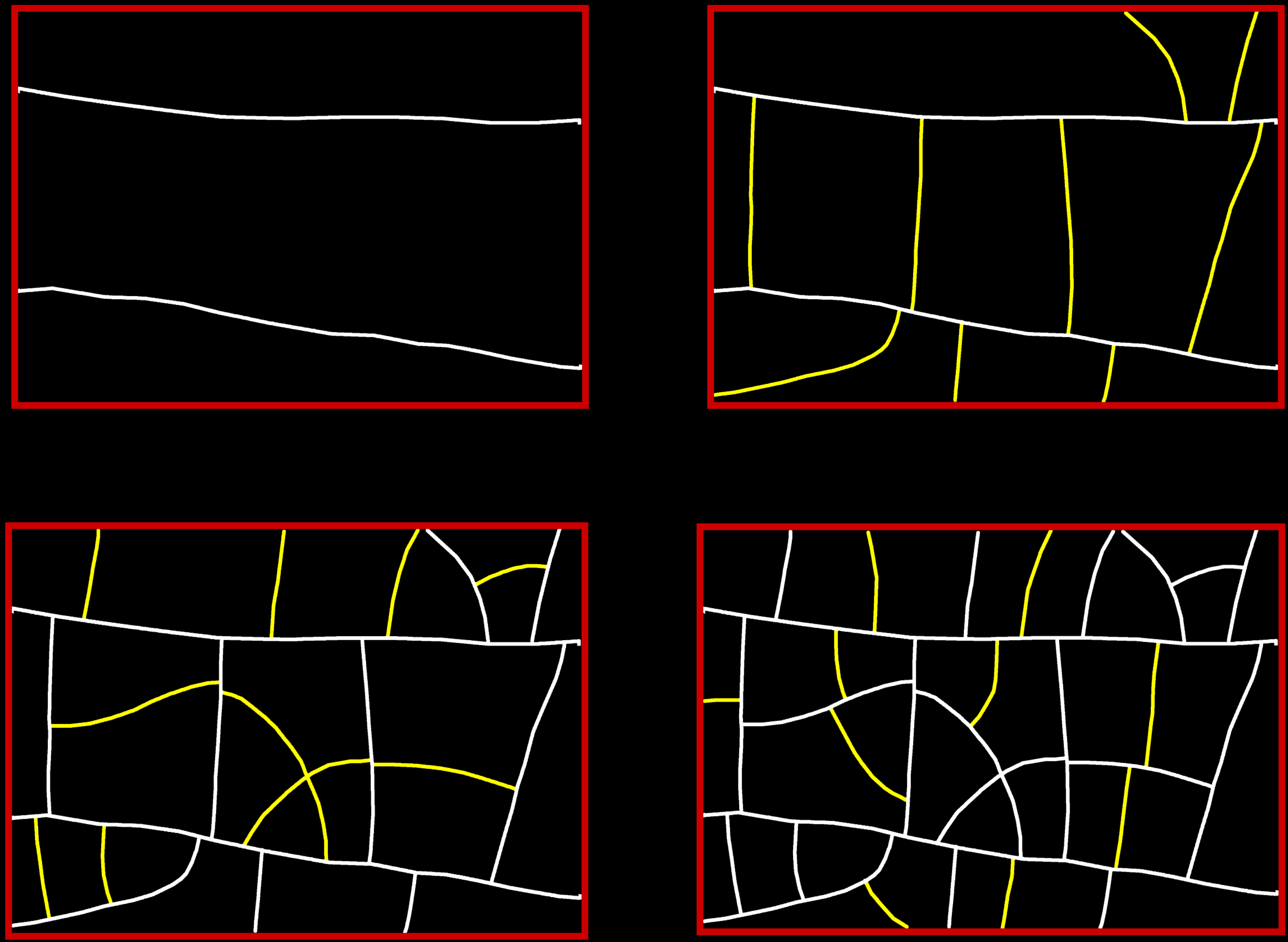




Minimal length, but sequential construction



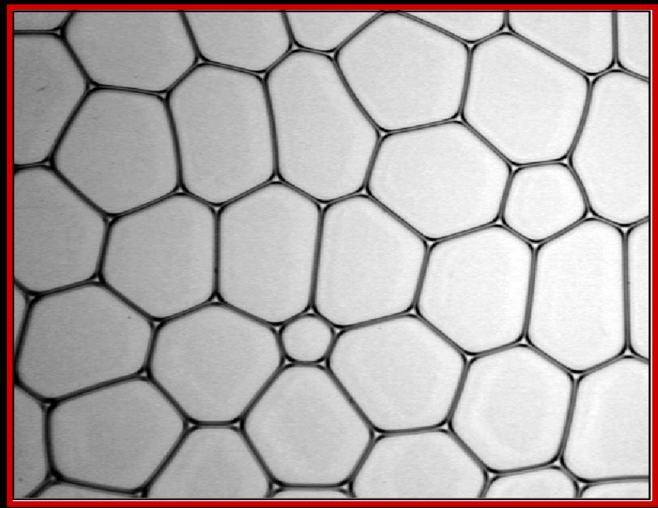
Temporal and spatial hierarchy

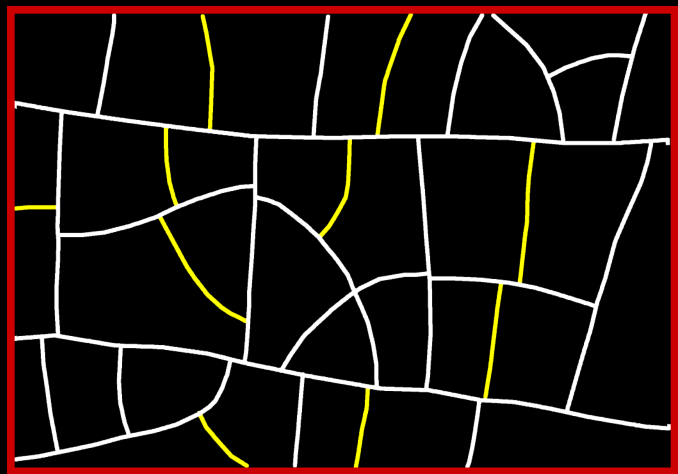


Temporal and spatial hierarchy

We want a method that:

1) Gives different description of “hierarchical” and “equilibrium” patterns (e.g. of froths and ceramics fractures)





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We want a method that:

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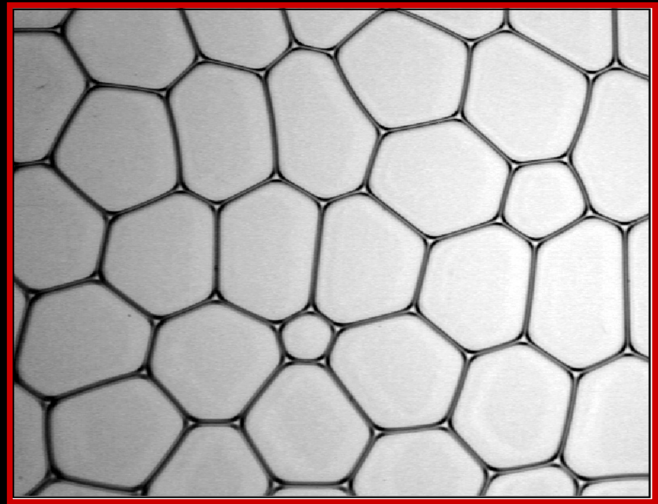
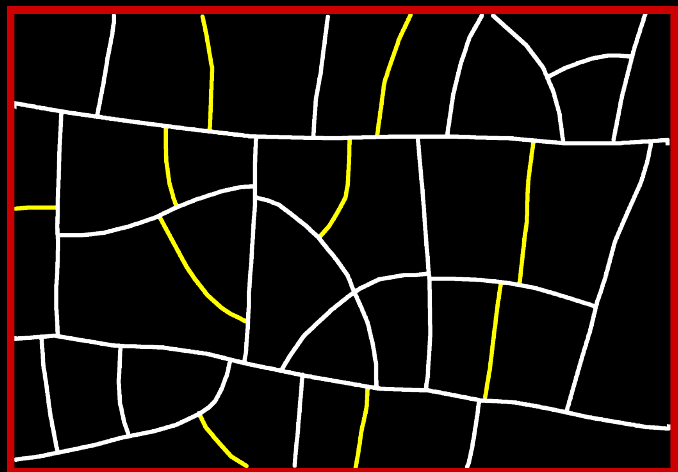
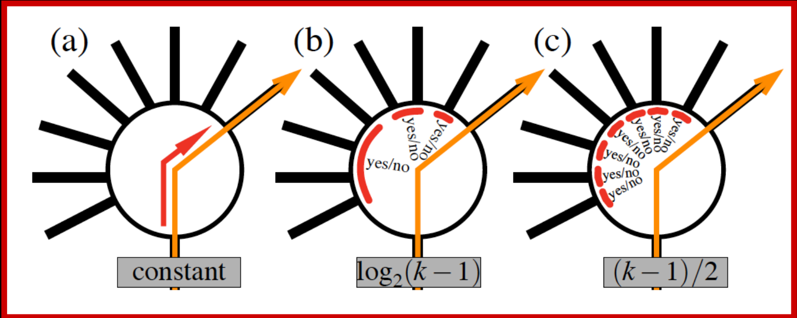
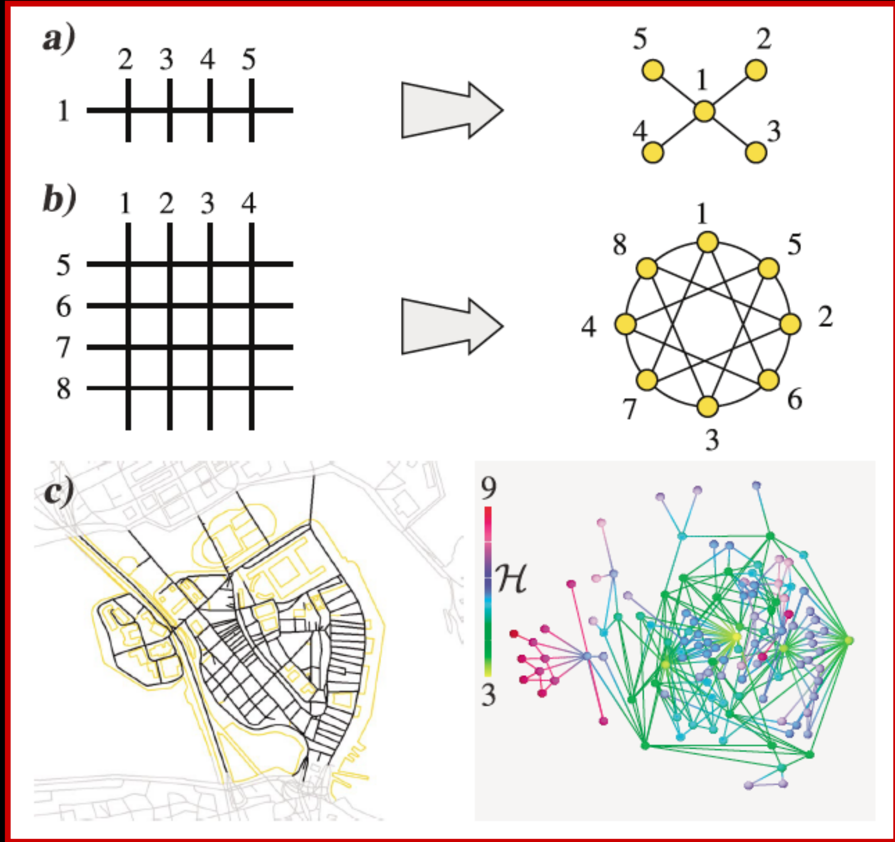




Geometry of spatial networks, a review

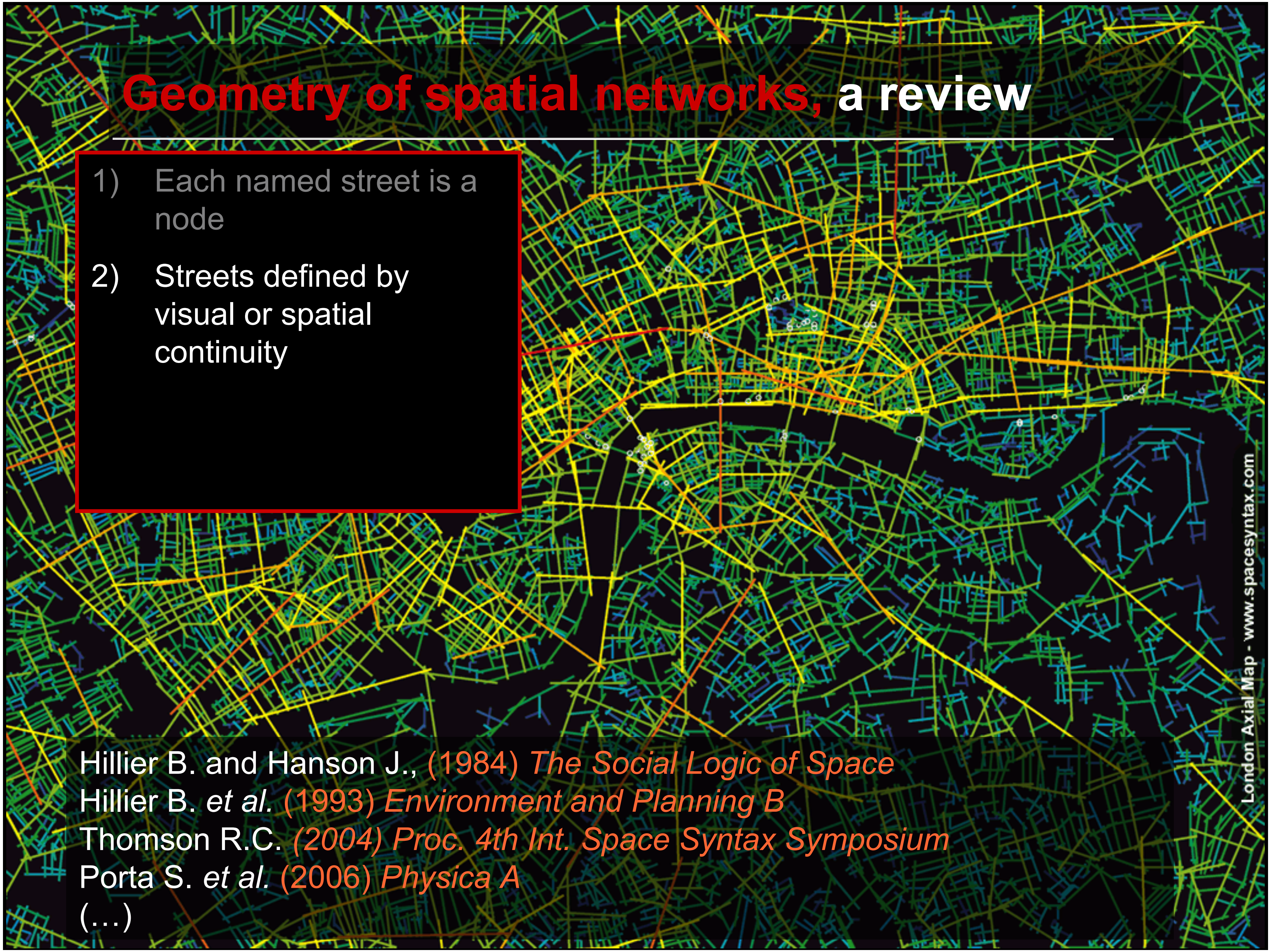
1) Each named street is a node





Jiang B. and Claramunt C., (2004) *Environment and Planning B*
Kalapala V. *et al.* (2006) *Physical Review E*
Rosvall M. *et al.* (2005) *Physical Review Letters*
(…)

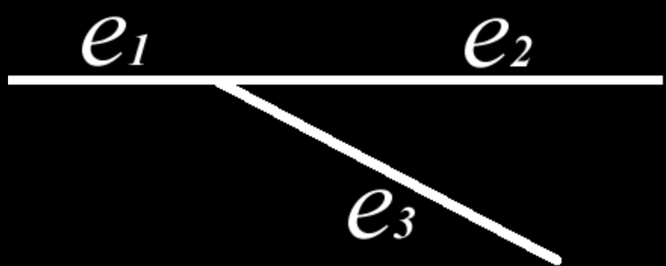
Geometry of spatial networks, a review



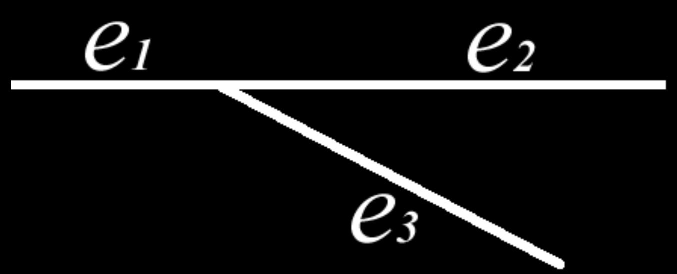
1) Each named street is a node
2) Streets defined by visual or spatial continuity

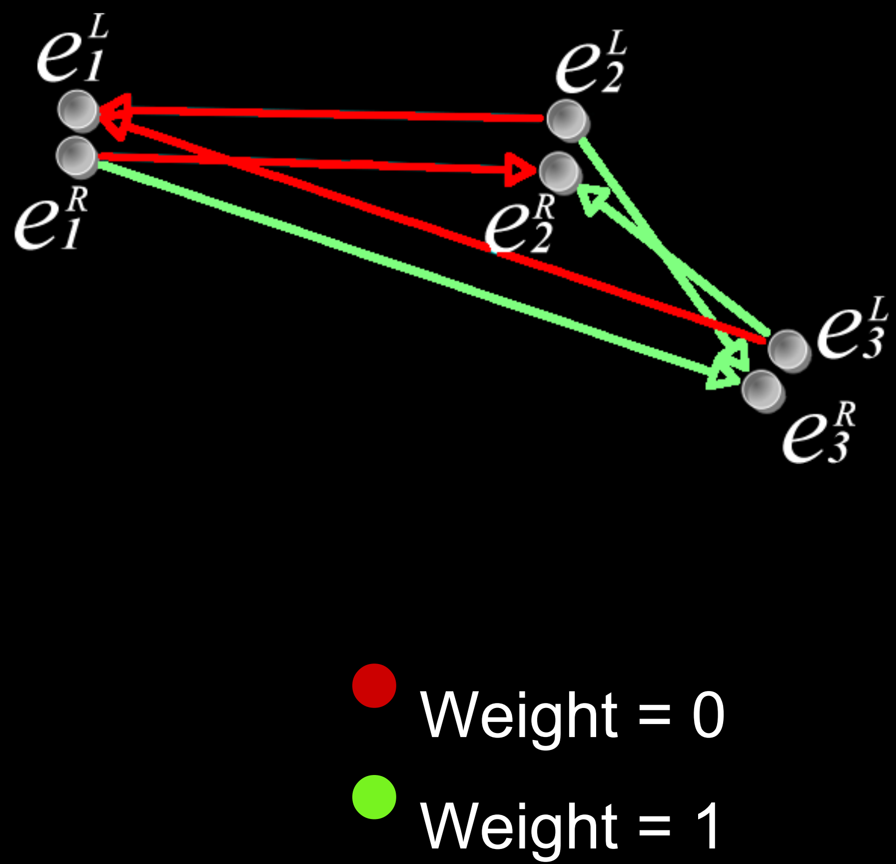
Hillier B. and Hanson J., (1984) *The Social Logic of Space*
Hillier B. *et al.* (1993) *Environment and Planning B*
Thomson R.C. *(2004) Proc. 4th Int. Space Syntax Symposium*
Porta S. *et al.* (2006) *Physica A*
(…)

Our approach



Our approach: a weighted directed line graph





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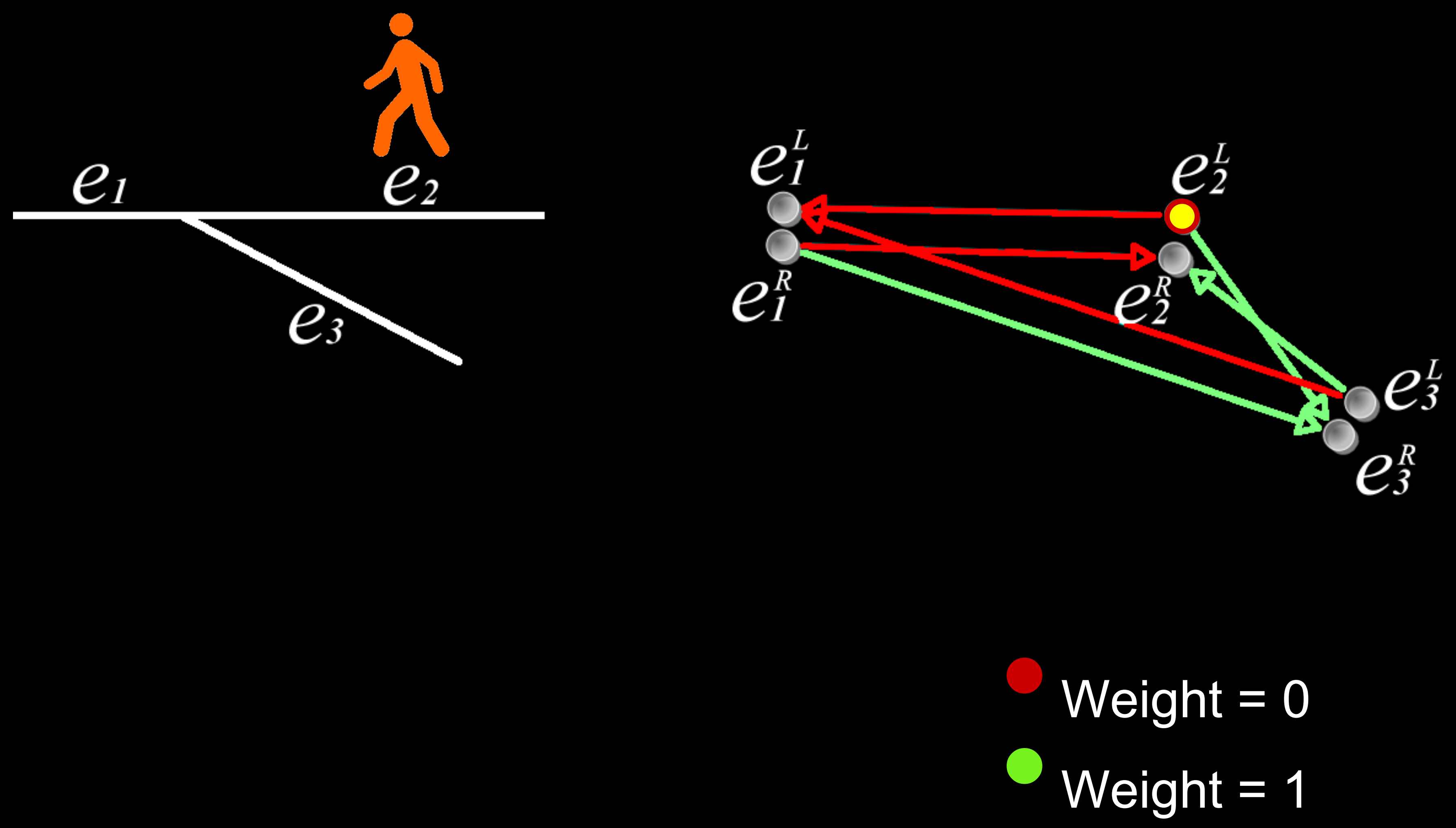

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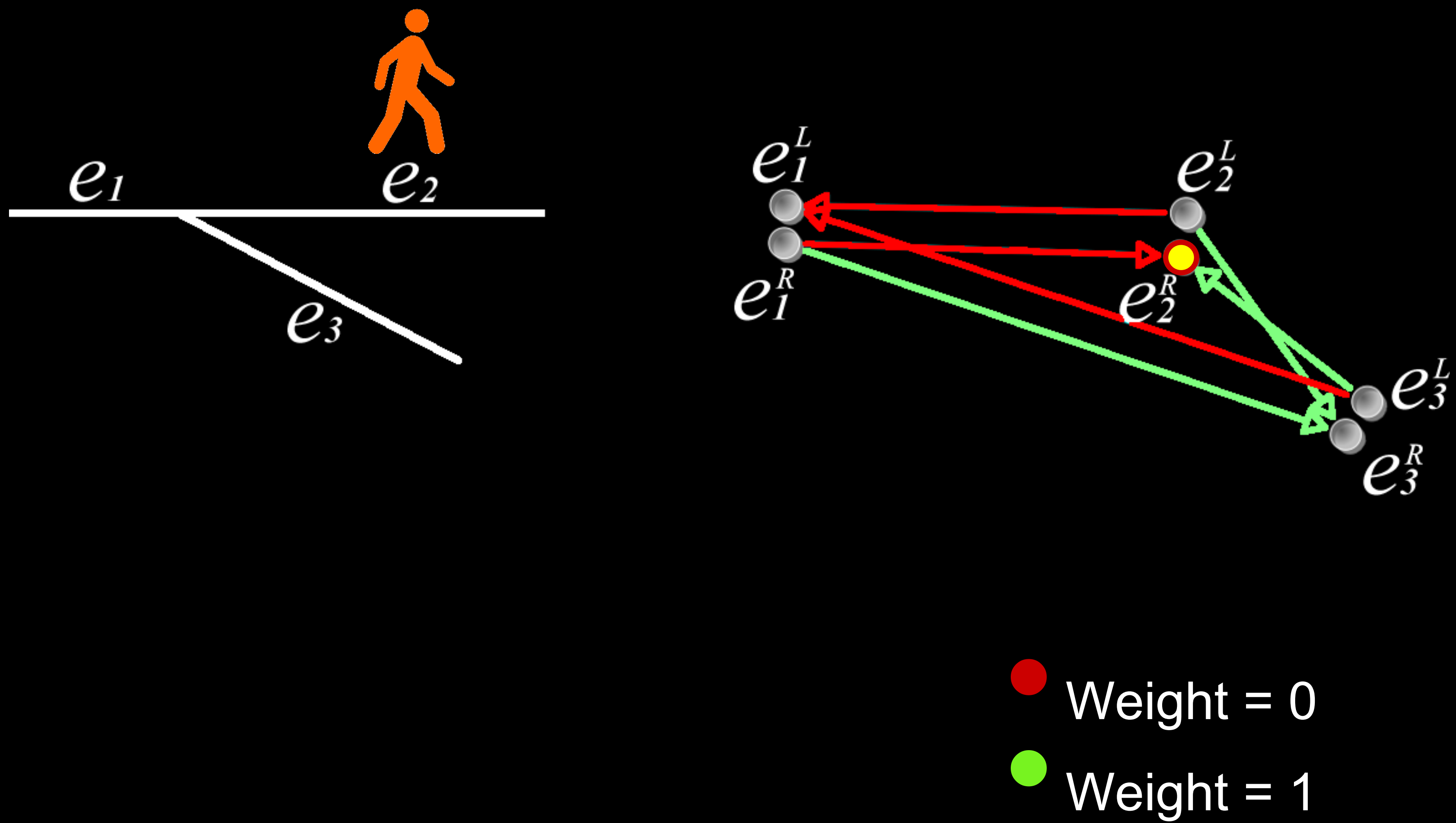

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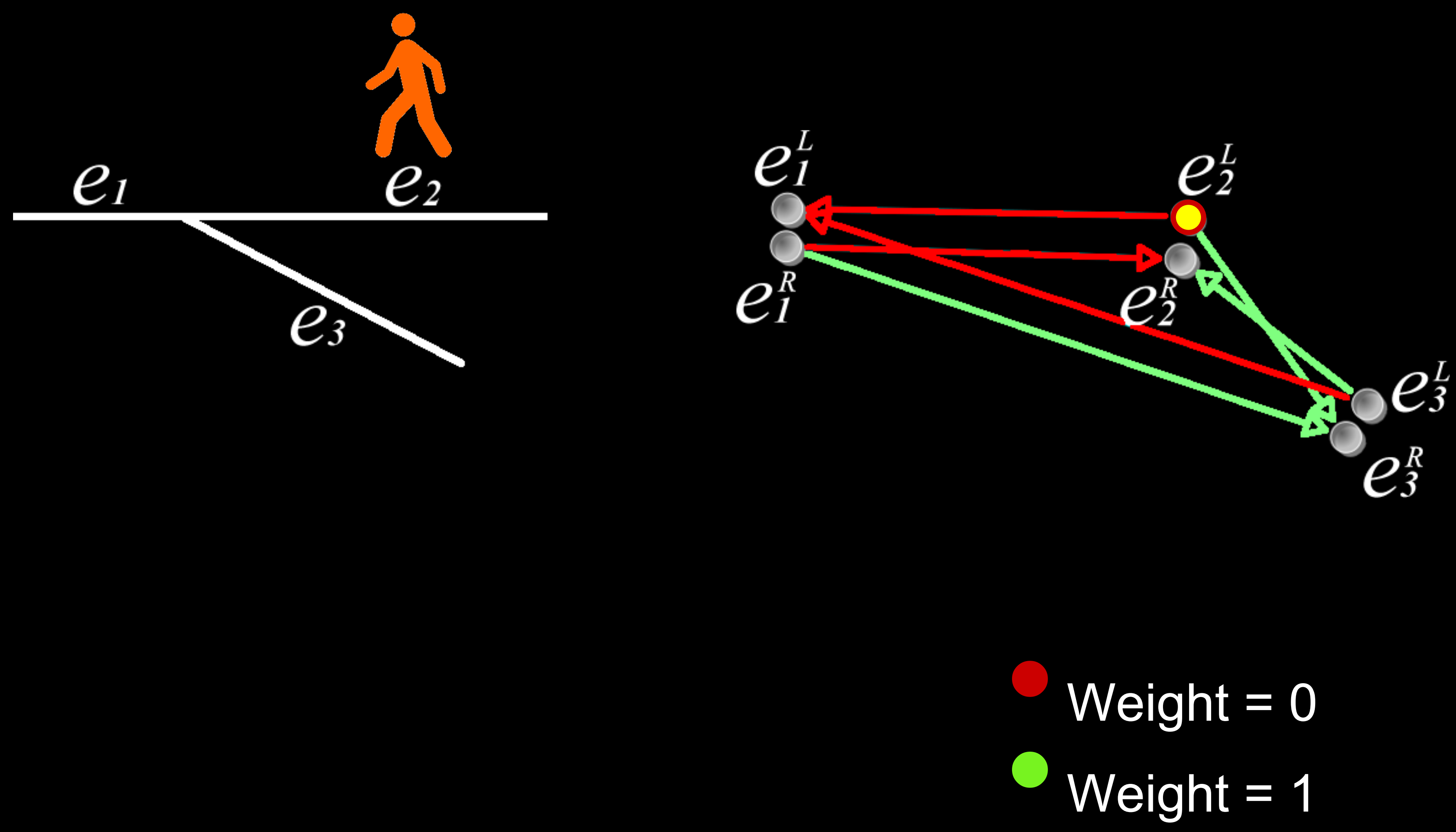

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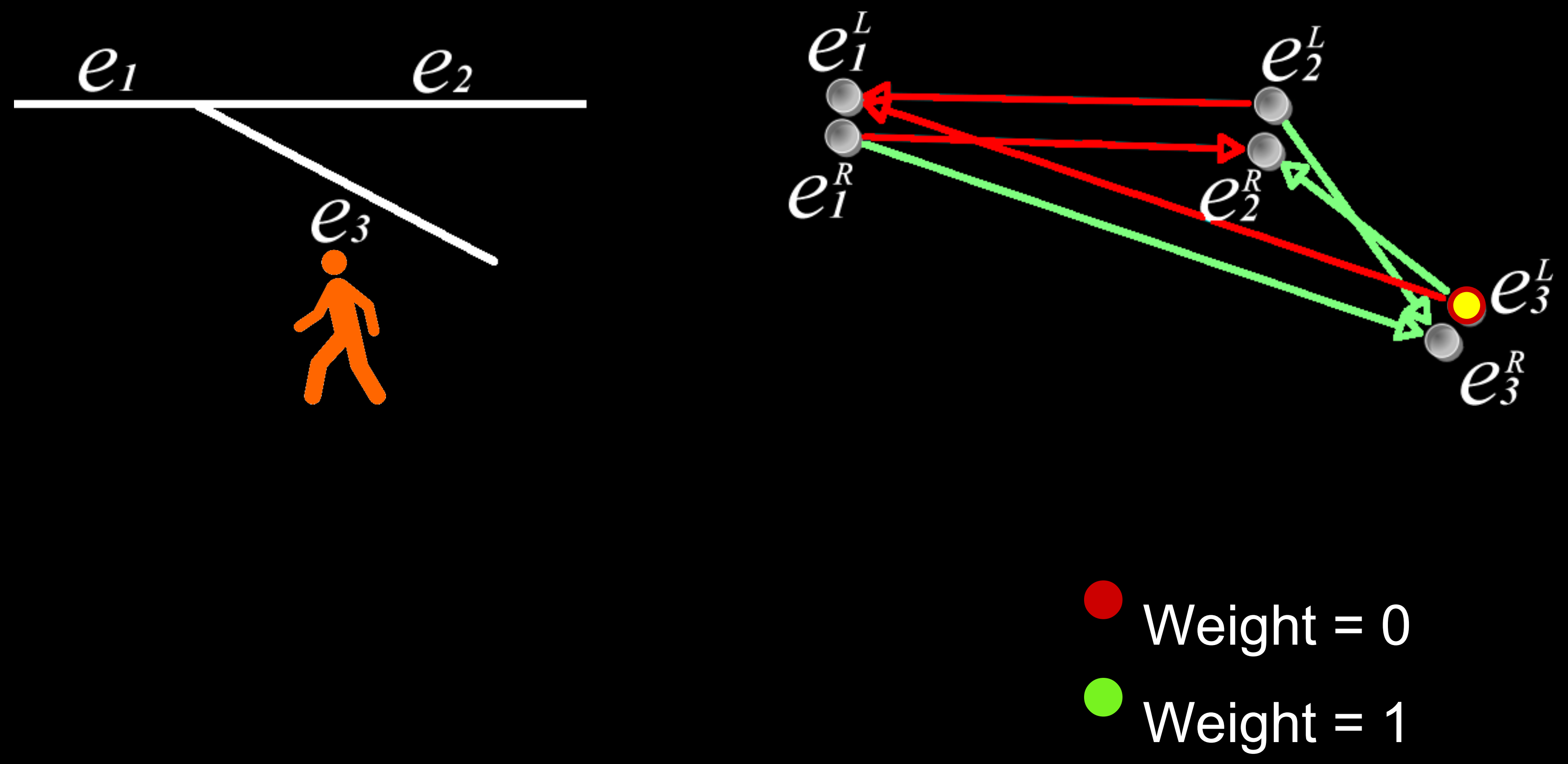

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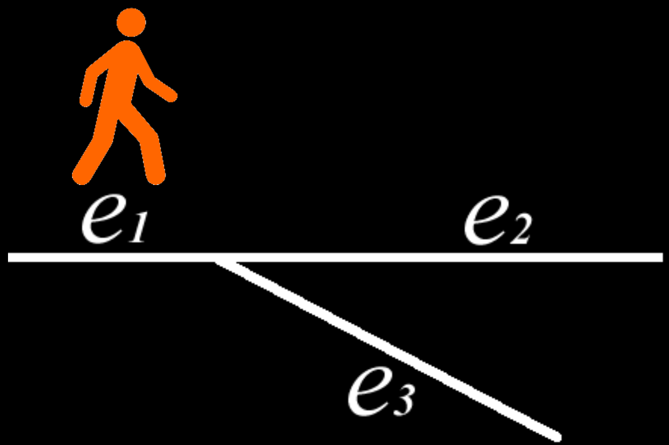
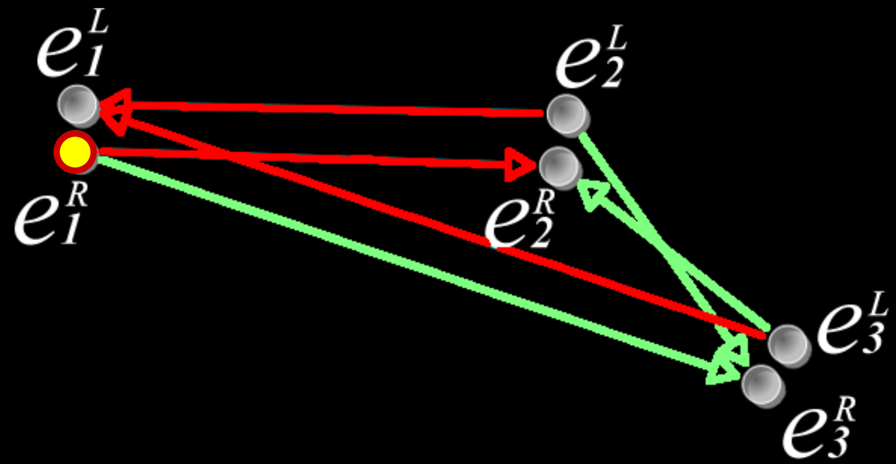
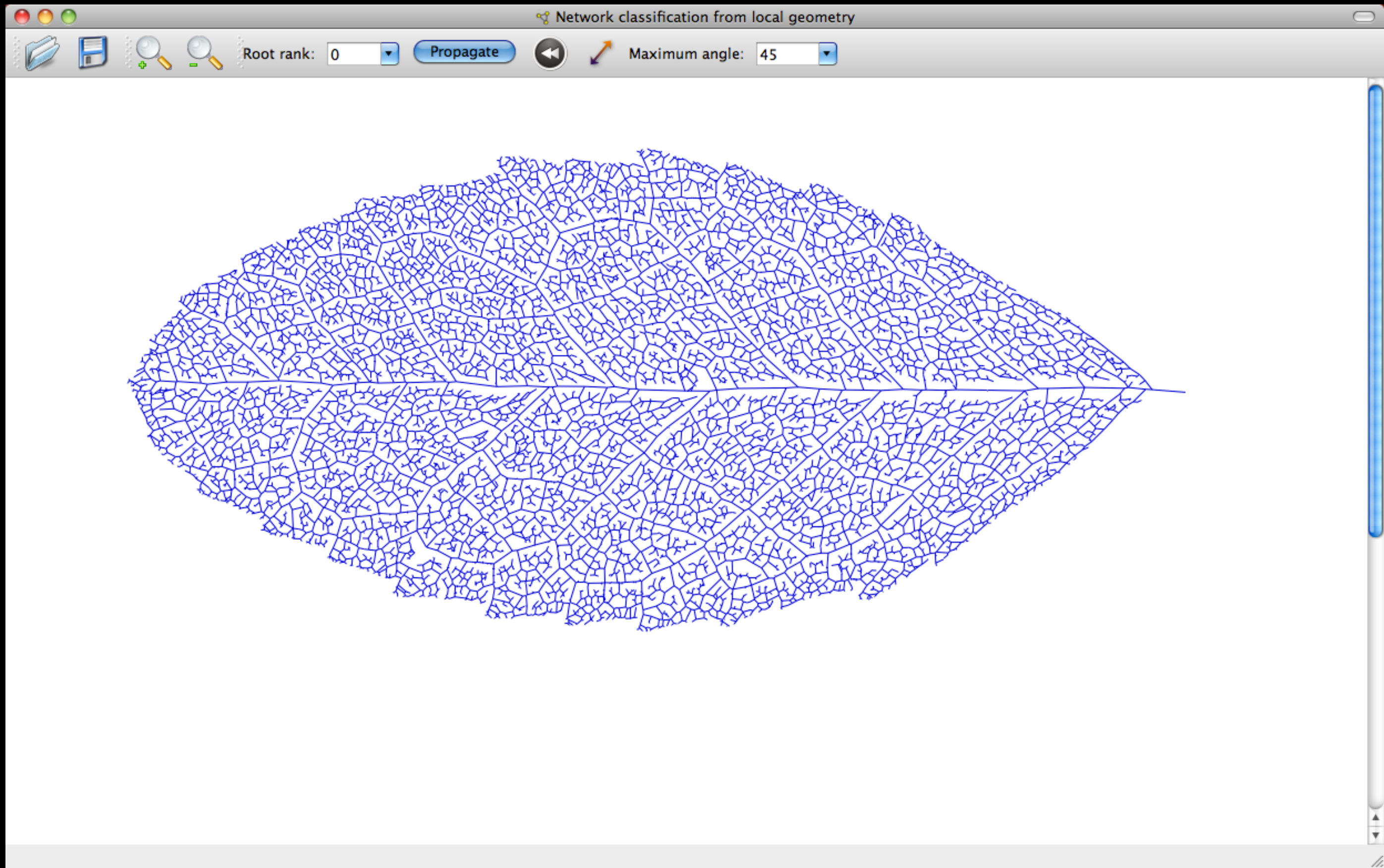




Weight = 0

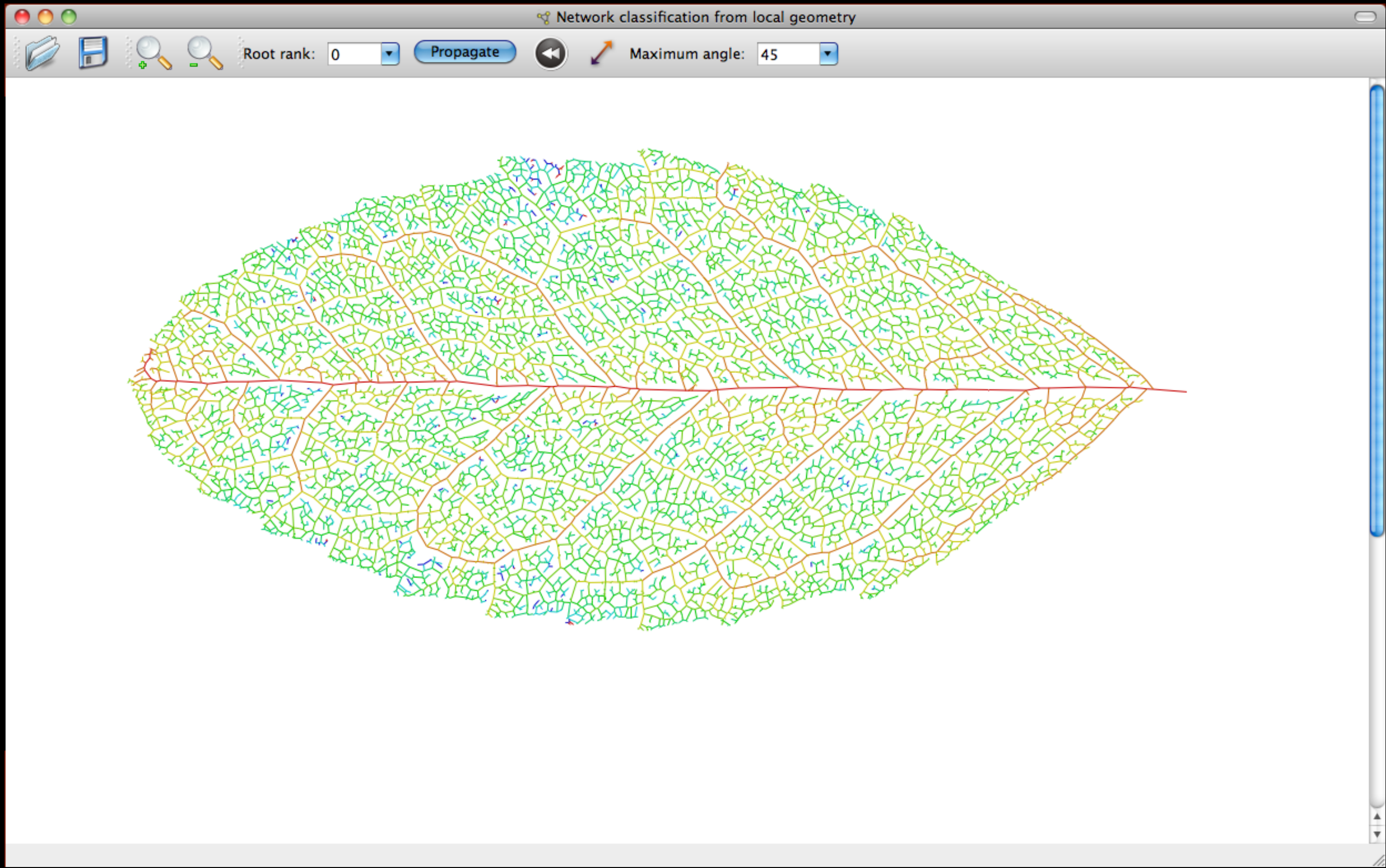
Weight = 1

Let's try!



Free download from http://dx.doi.org/10.1103/PhysRevE.83.066106

Let’s try!



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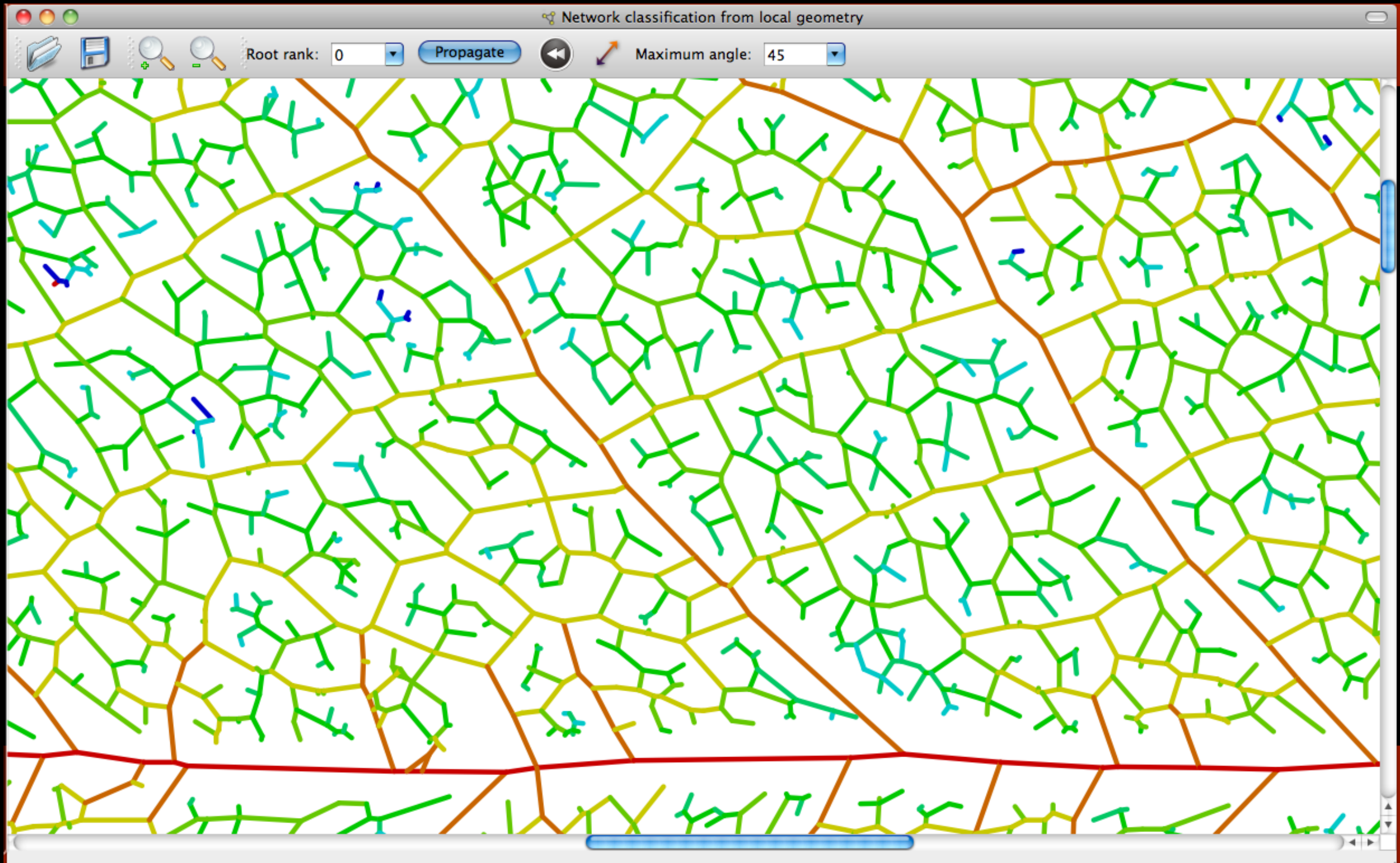


Free download from http://dx.doi.org/10.1103/PhysRevE.83.066106

Inferred orders vs. "age"

The diameter of leaf veins is roughly proportional to vein age (because veins keep growing continuously since they first appear)

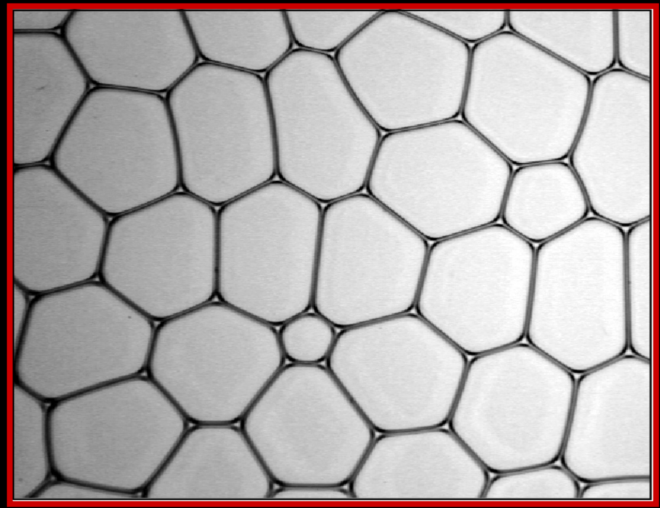
We can compare the rank assigned to veins by our algorithm (which is based only on junction angles, not on the size of the veins) with the vein diameter to assess to what extent the classification recovers the temporal information.

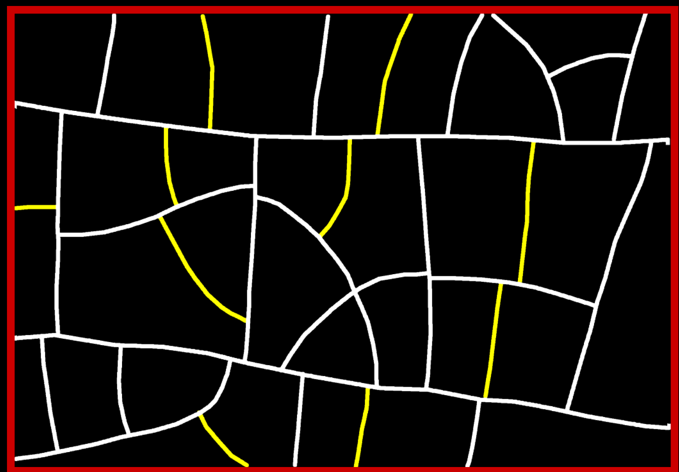
Temporal and spatial hierarchy

We want a method that:

1) Gives different description of “hierarchical” and “equilibrium” patterns (of froths and ceramics fractures)

2) Provides some approximation of the order of appearance of network segments





Temporal and spatial hierarchy

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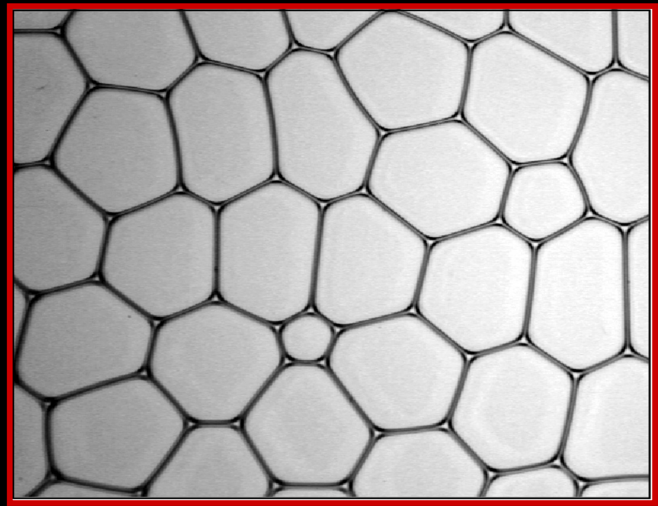
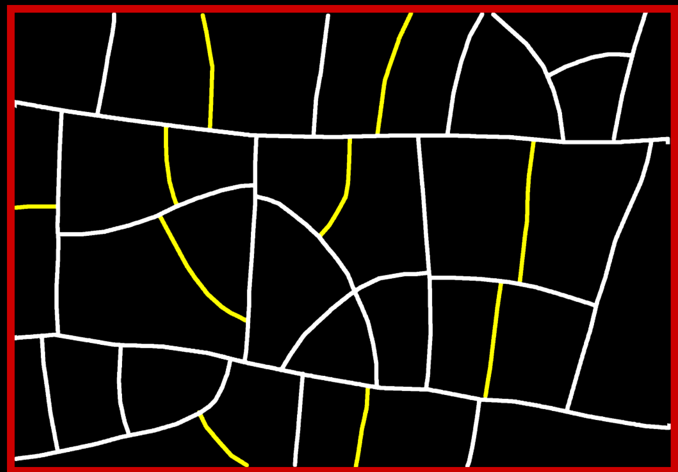
OK!

but not perfectly

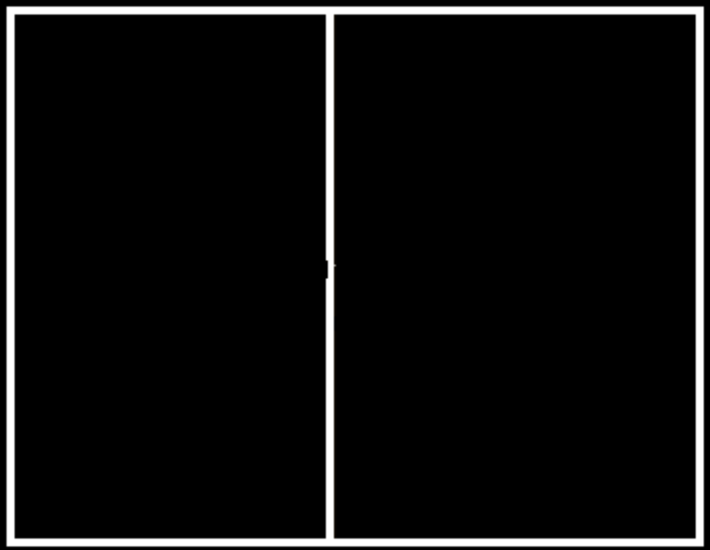




Lattice models for hierarchical networks

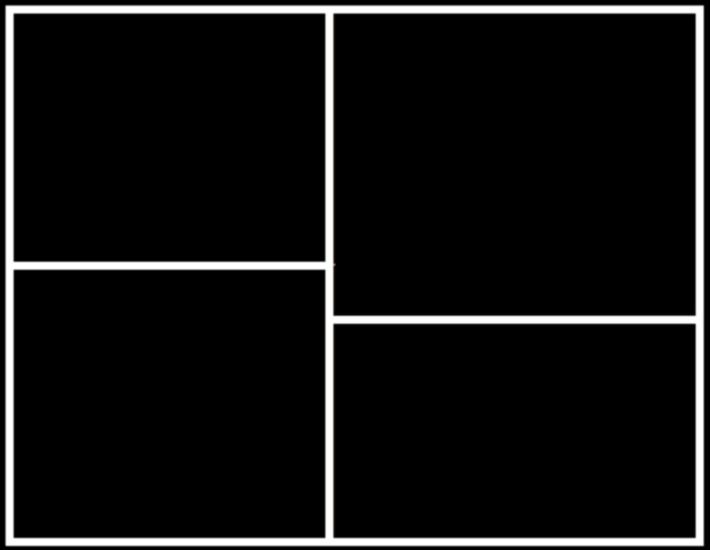
Introducing "Mondrian" lattices

Lattice models for hierarchical networks



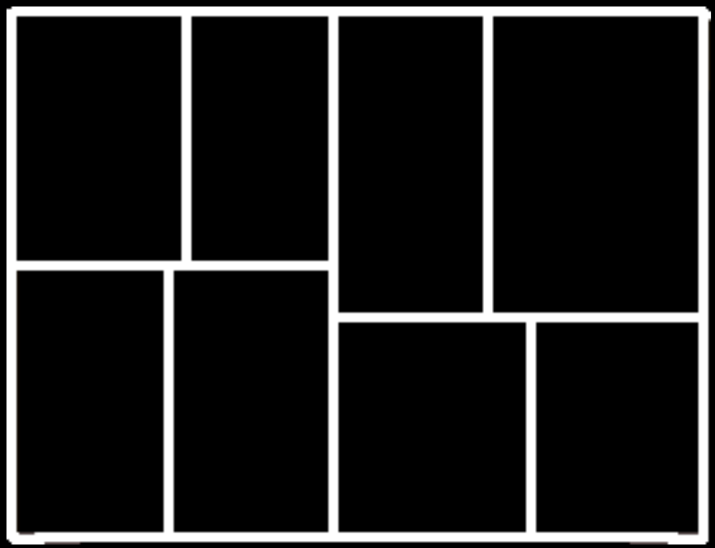
Introducing “Mondrian” lattices

Lattice models for hierarchical networks



Introducing “Mondrian” lattices

Lattice models for hierarchical networks



Introducing “Mondrian” lattices

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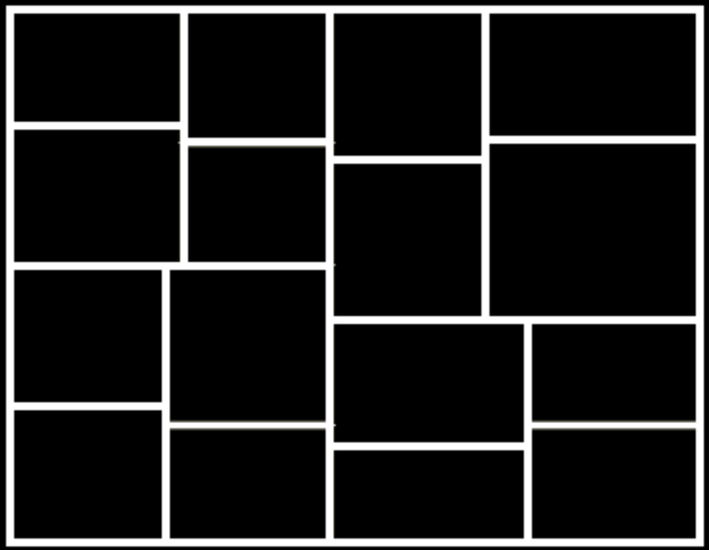

Introducing "Mondrian" lattices

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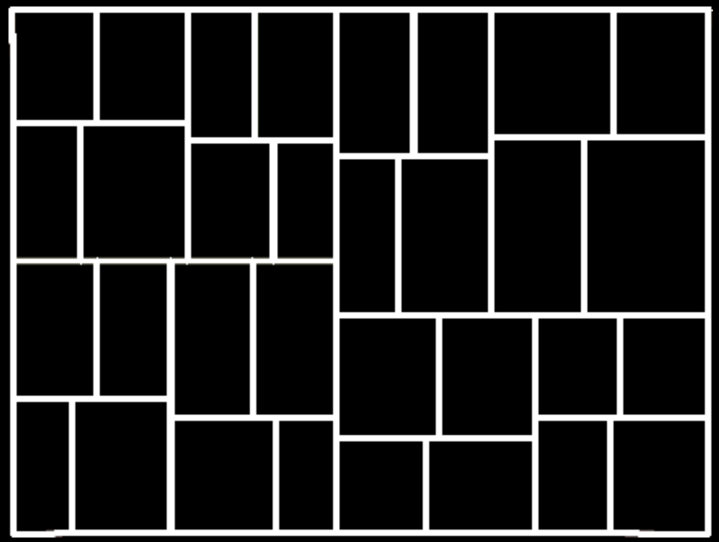

Introducing “Mondrian” lattices

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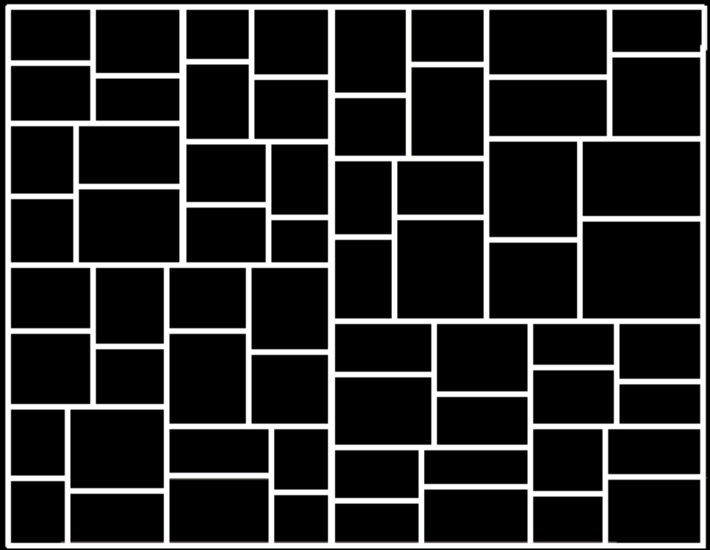
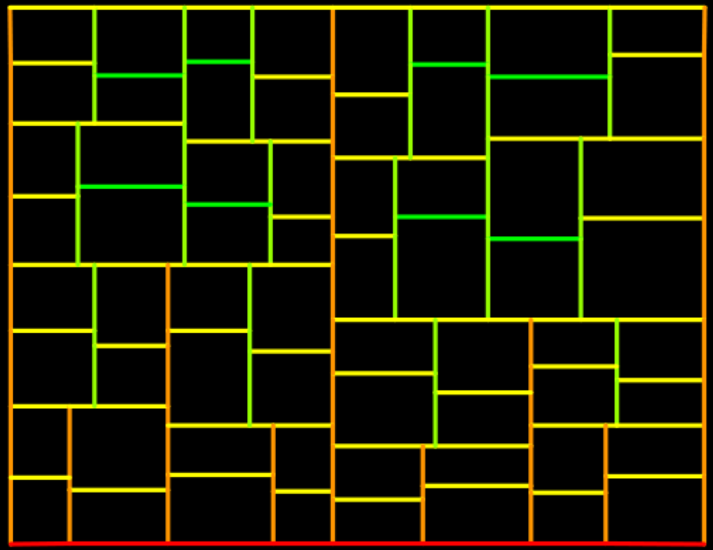


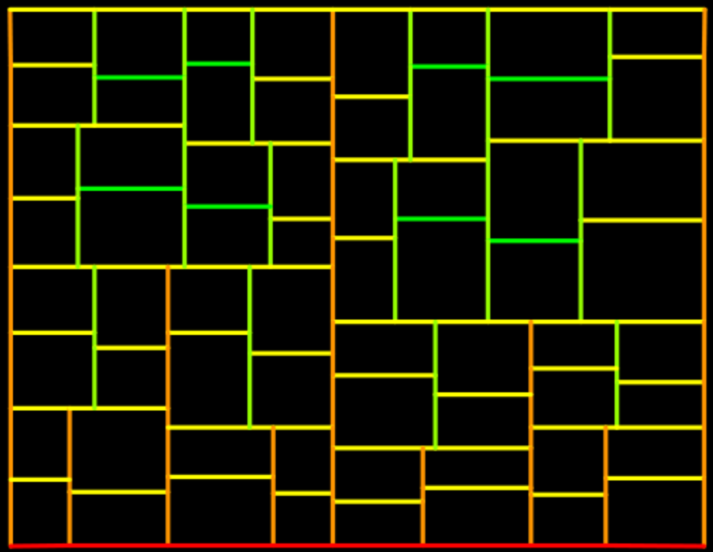
Introducing "Mondrian" lattices

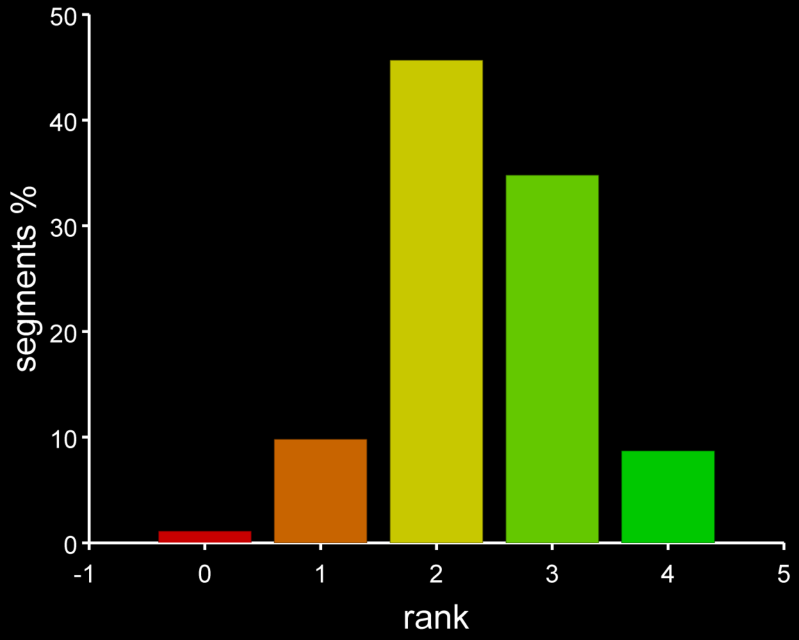
Lattice models for hierarchical networks



Introducing "Mondrian" lattices

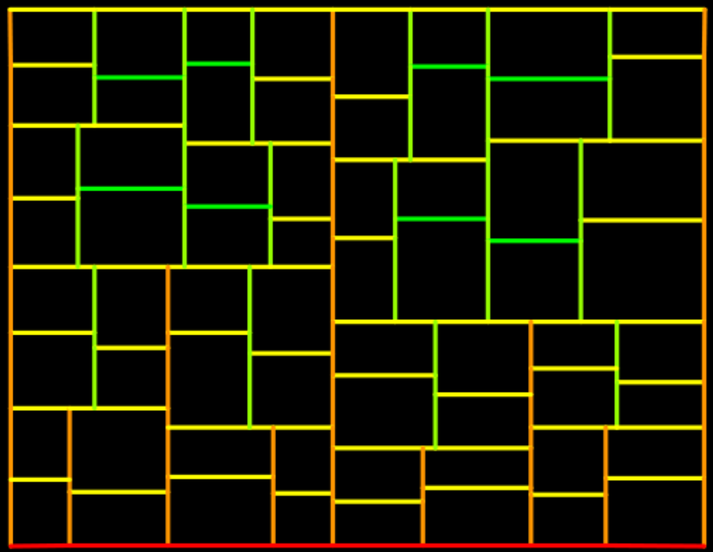
Lattice models **for hierarchical networks**

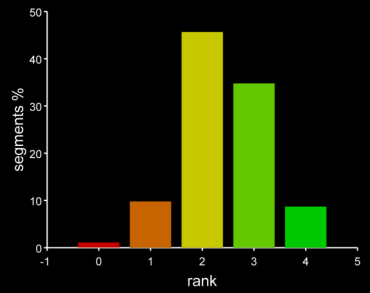




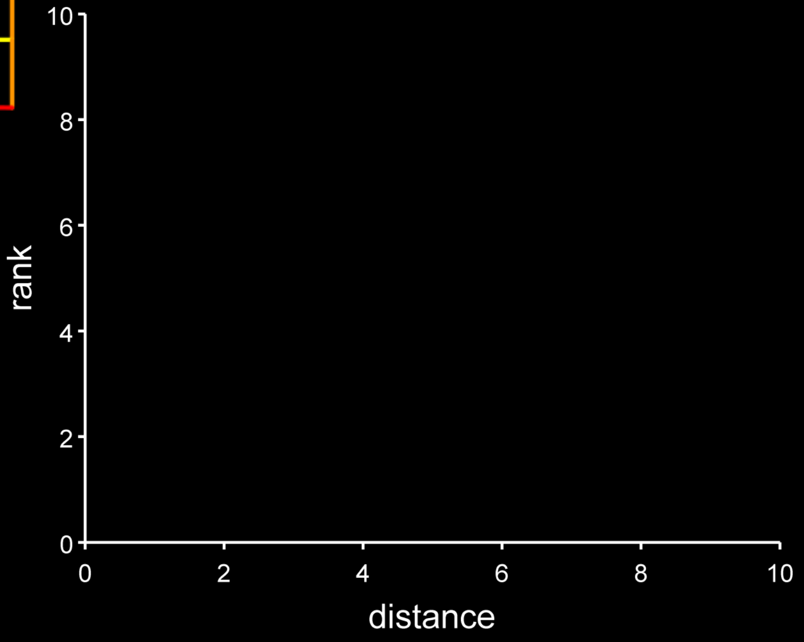
- Segment histogram

Lattice models for hierarchical networks

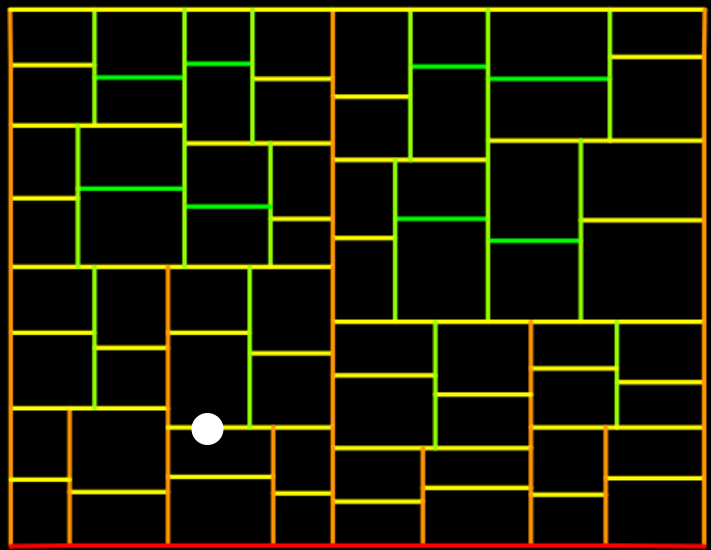


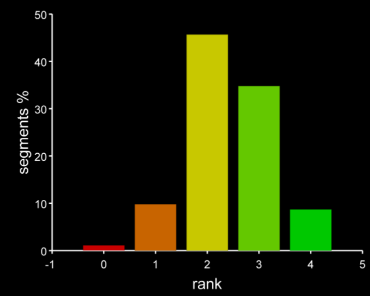


- Segment histogram
- Edge rank vs. distance



Lattice models **for hierarchical networks**





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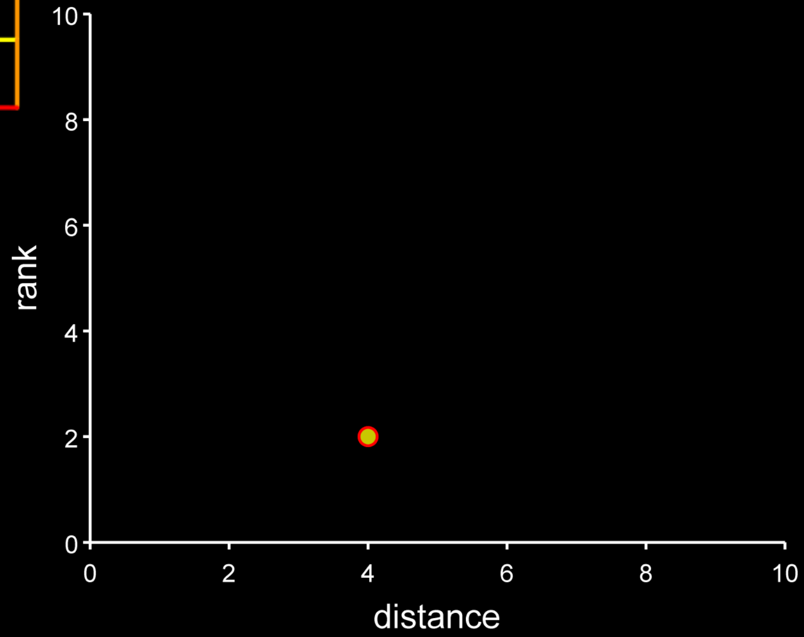

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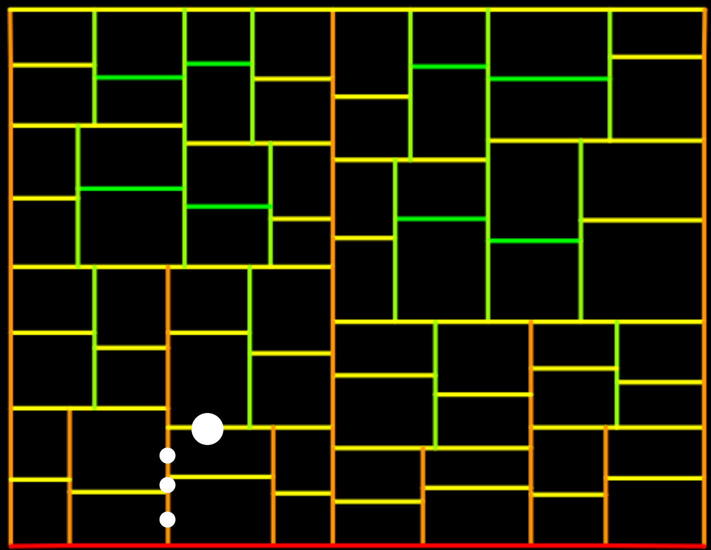

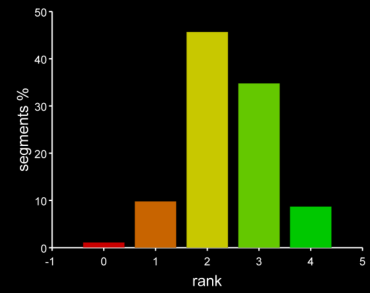

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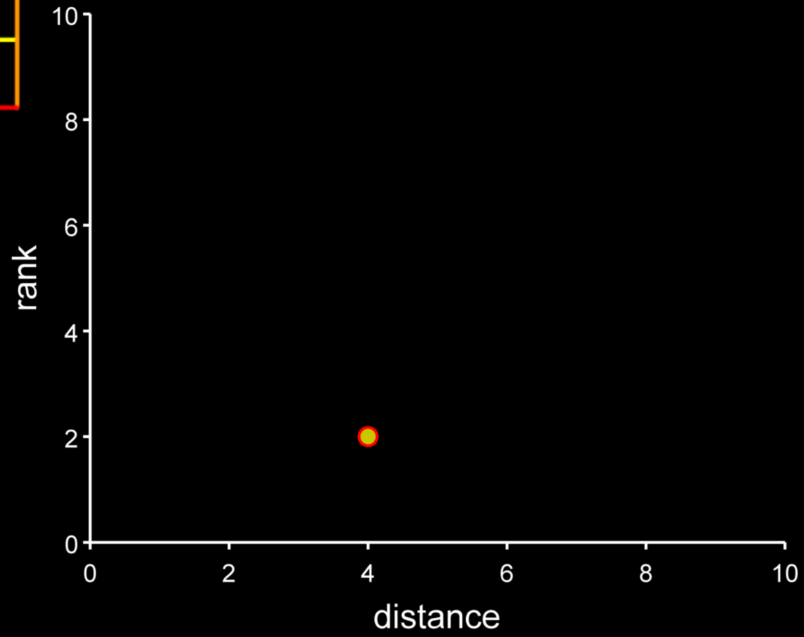
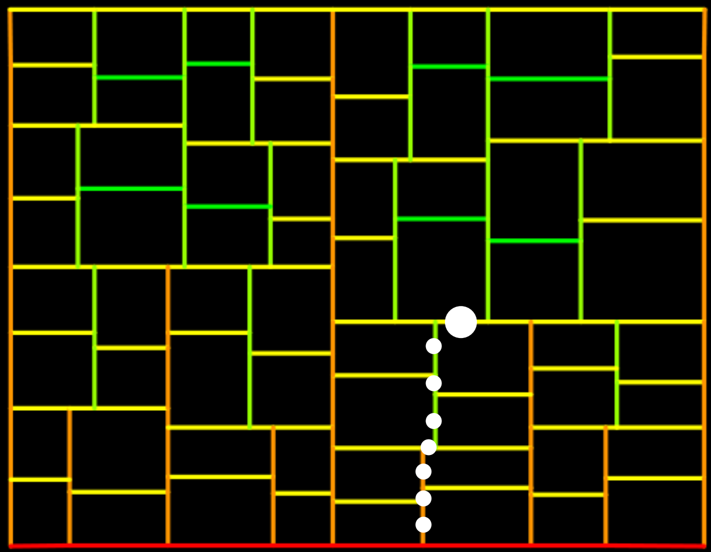
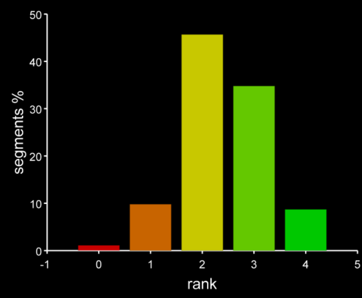


Lattice models for hierarchical networks





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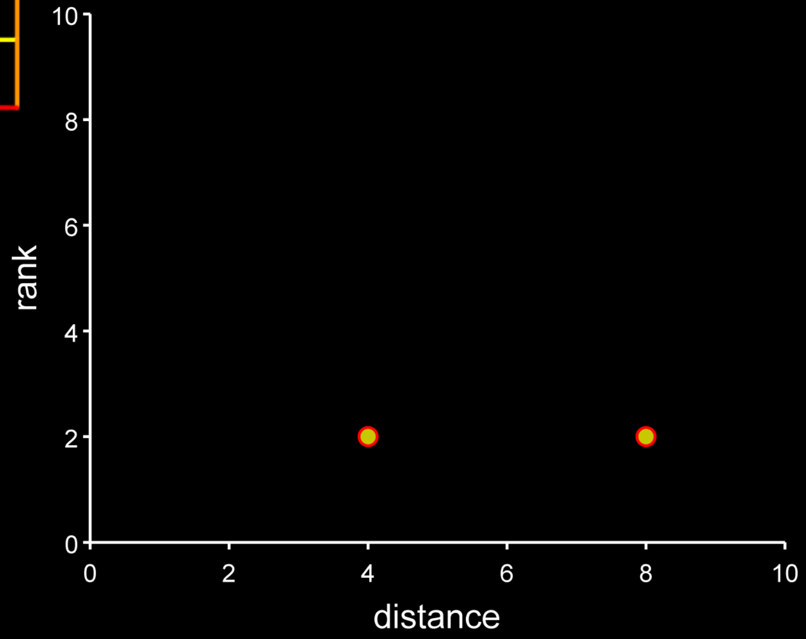
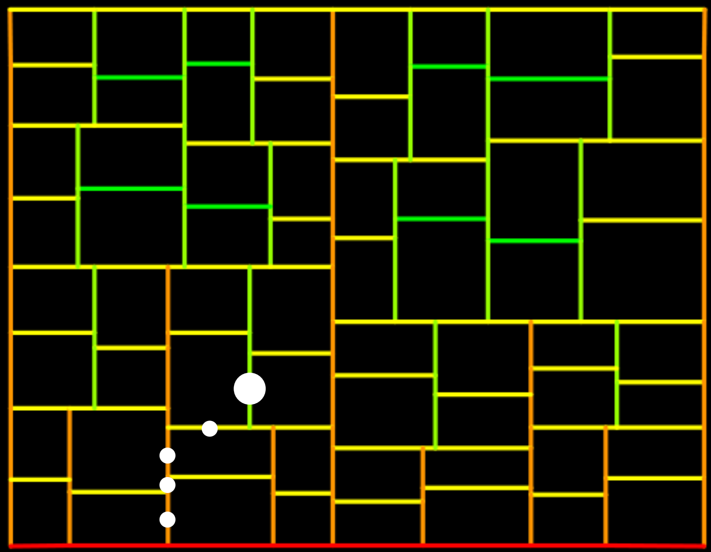
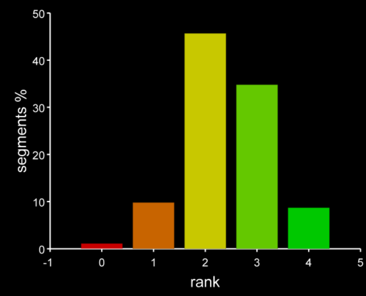


Lattice models for hierarchical networks





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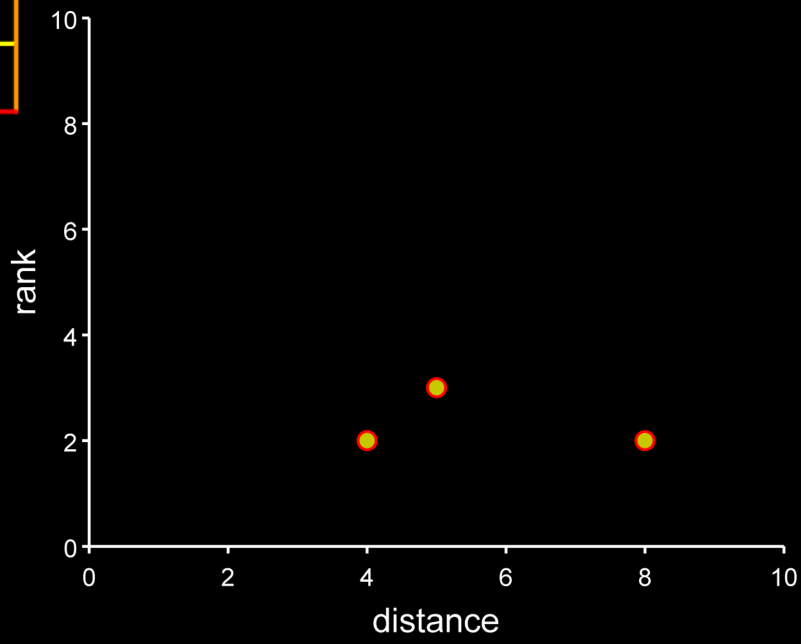
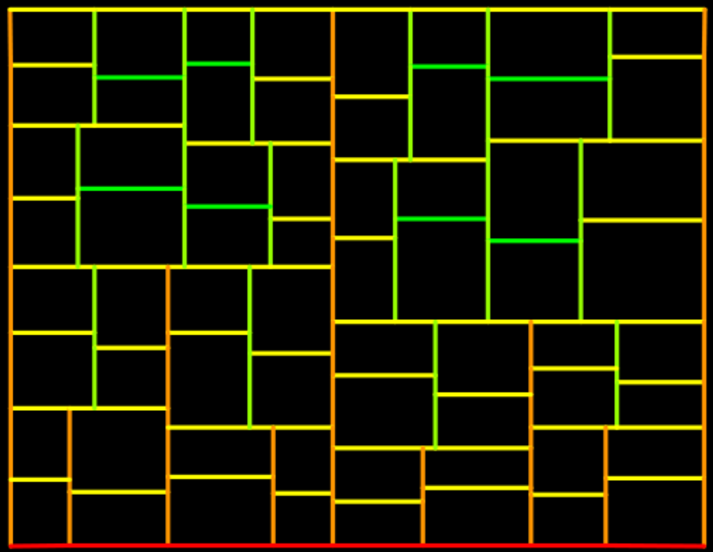


Lattice models for hierarchical networks



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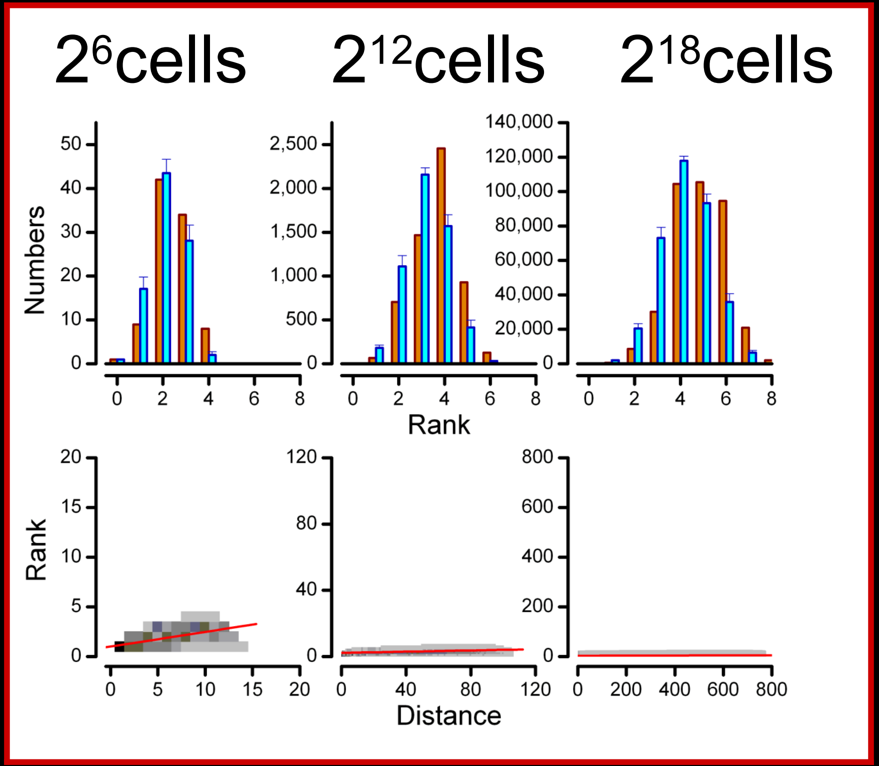
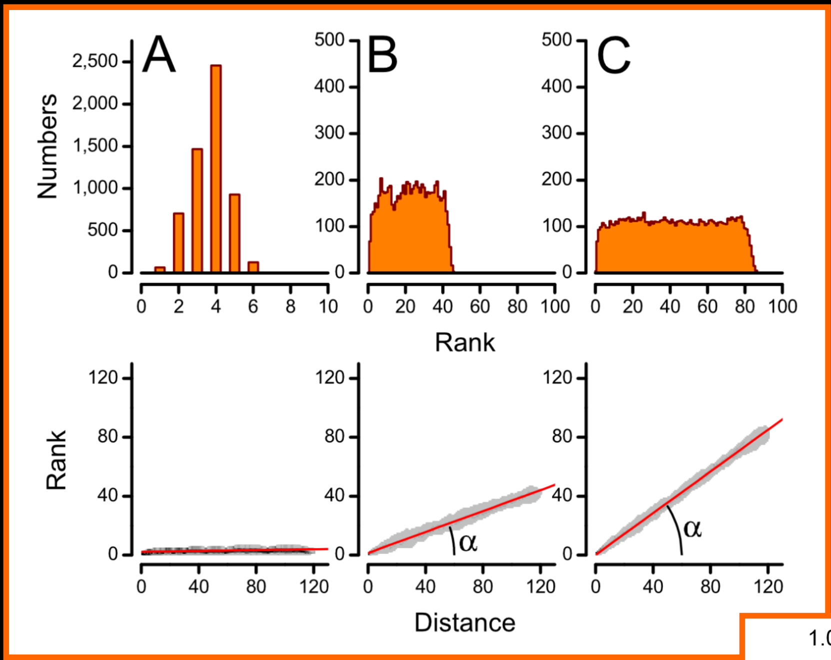
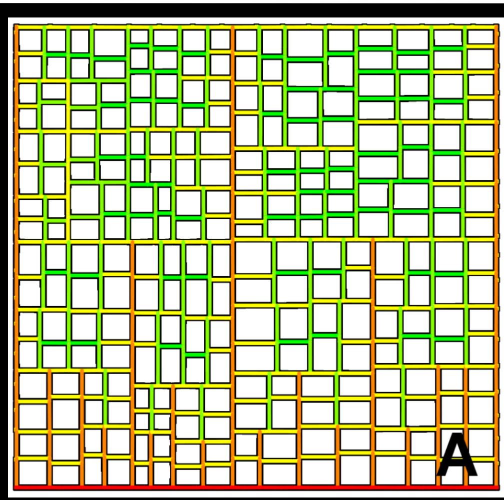
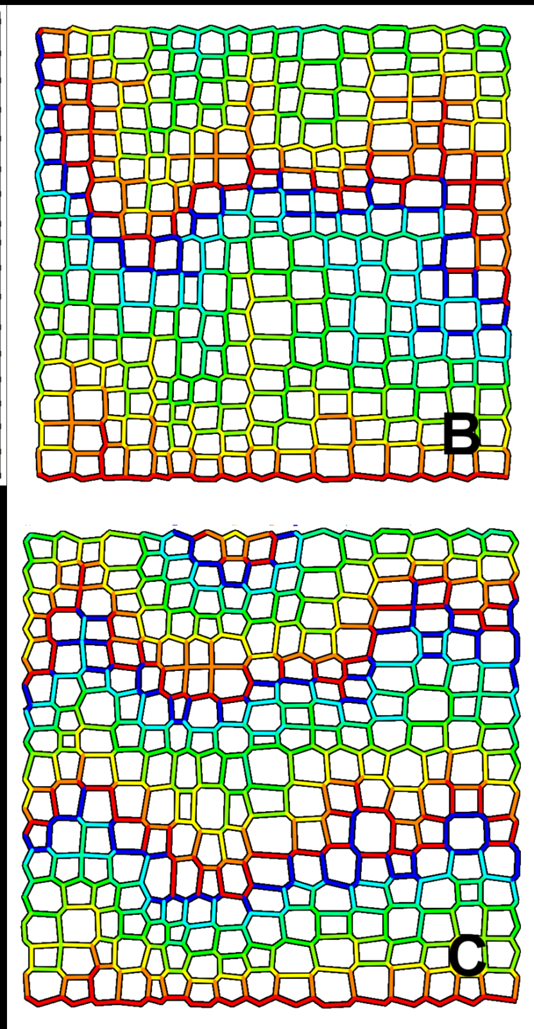
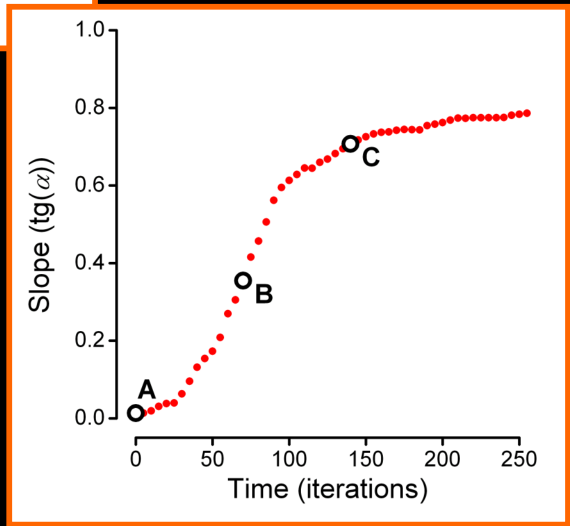


Forces applied to the nodes

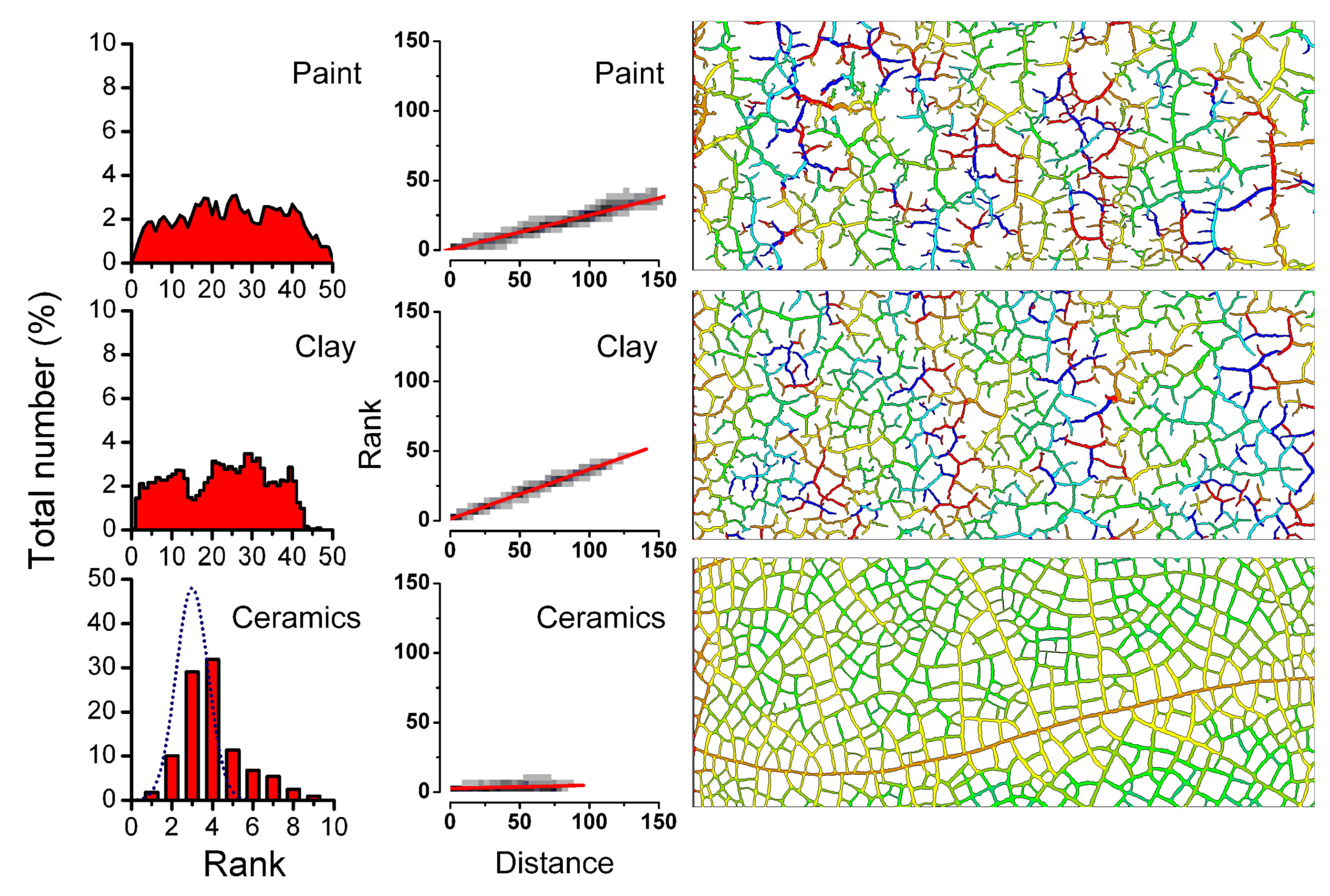




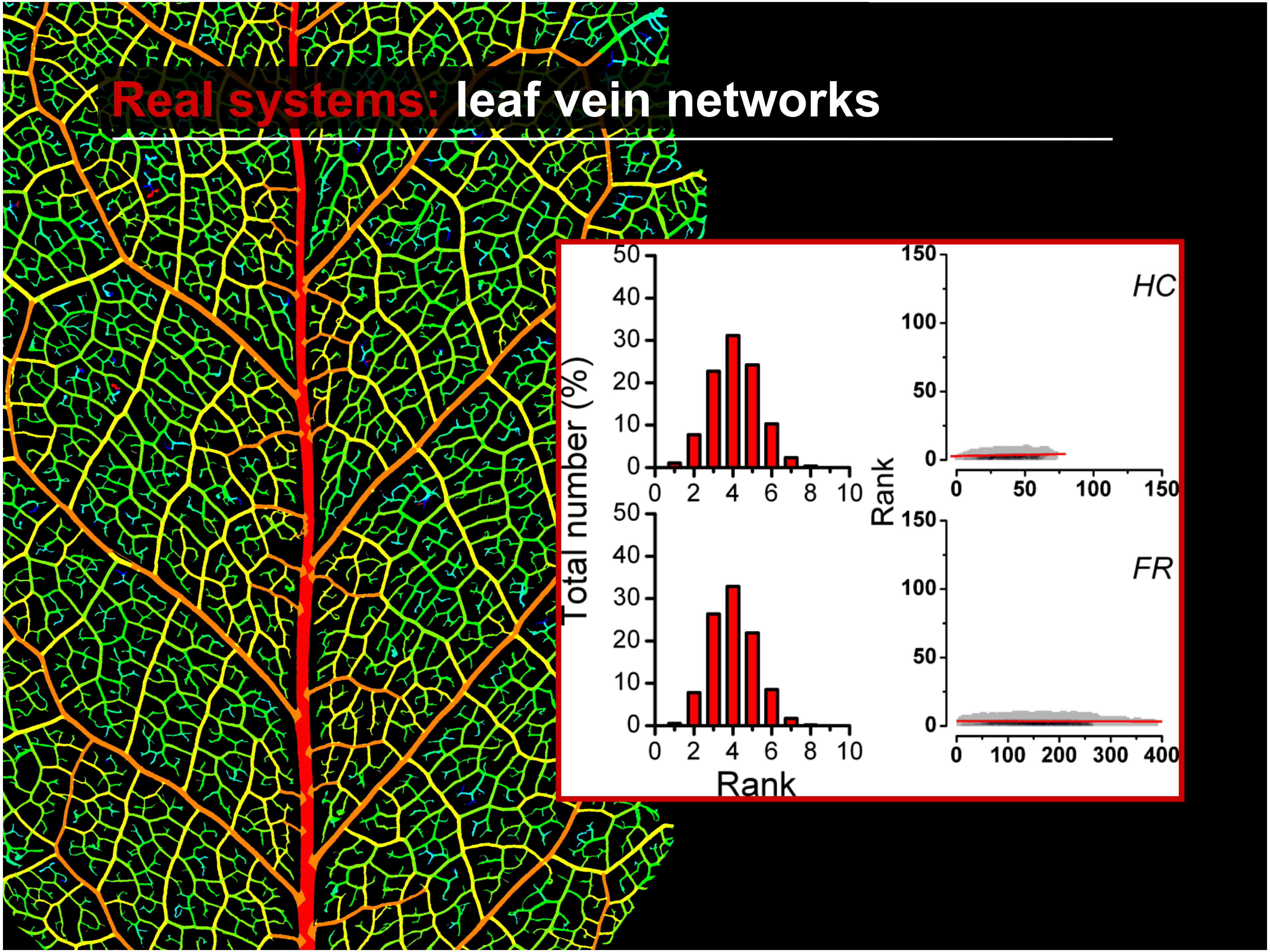




Real systems: crack patterns



Real systems: leaf vein networks



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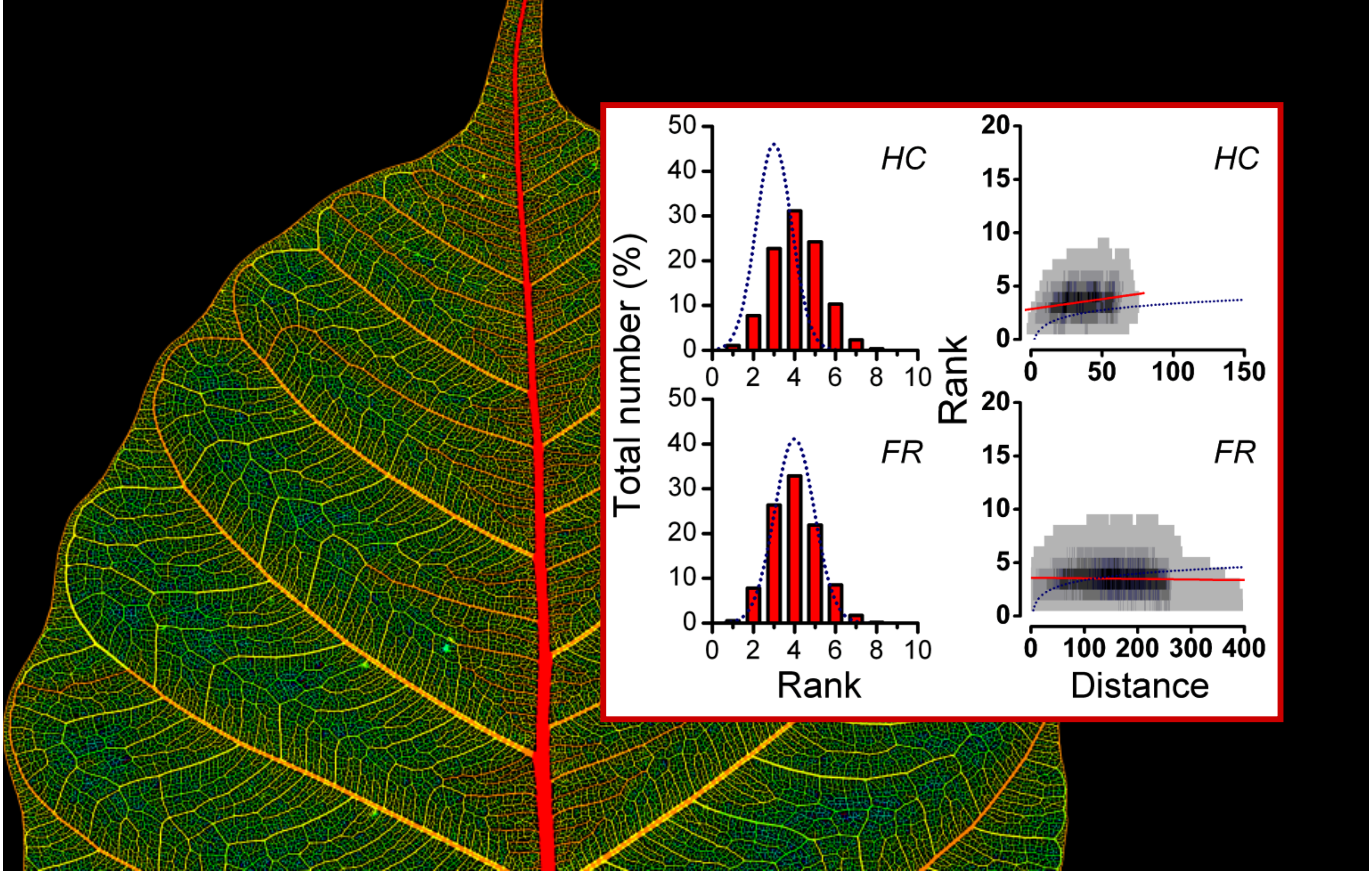
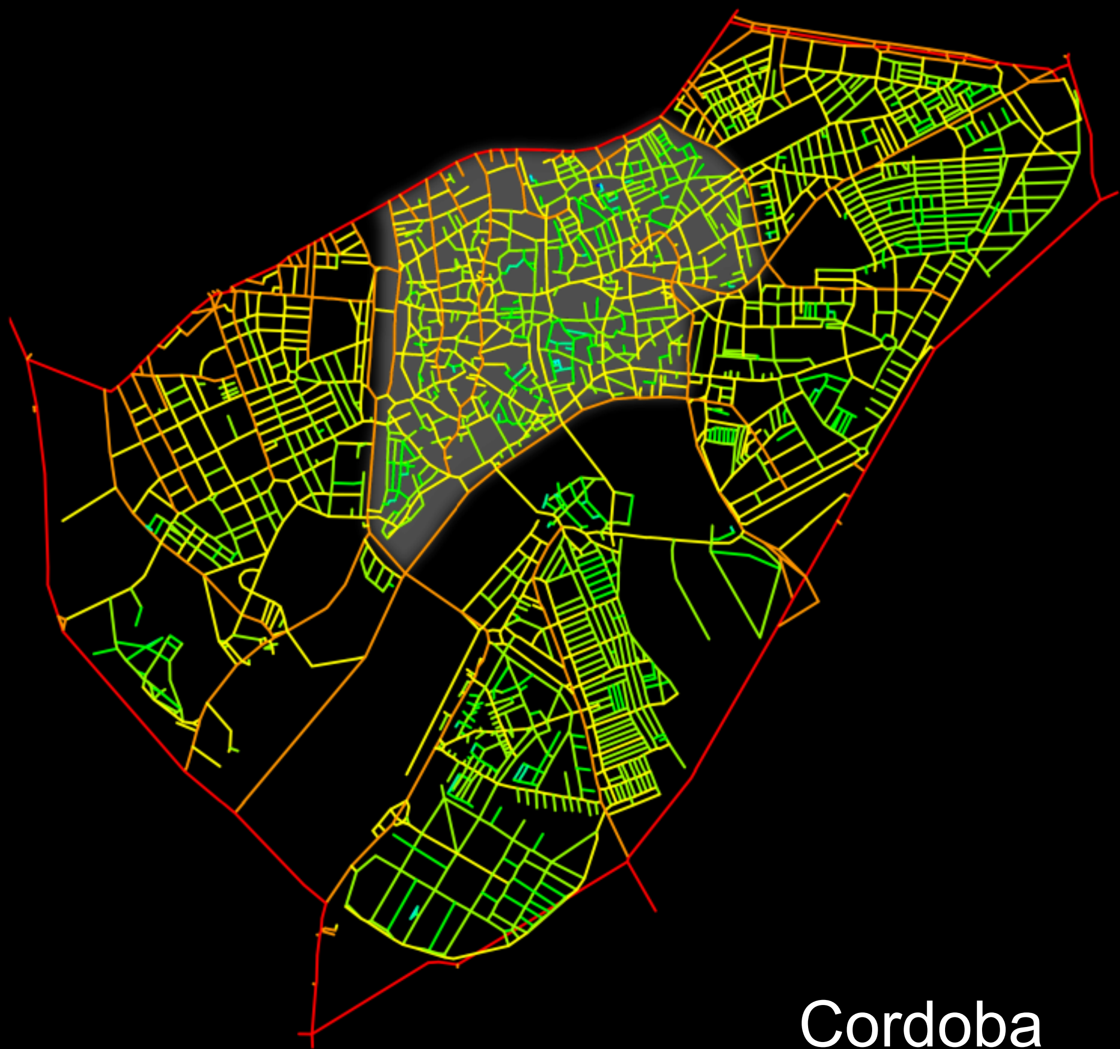
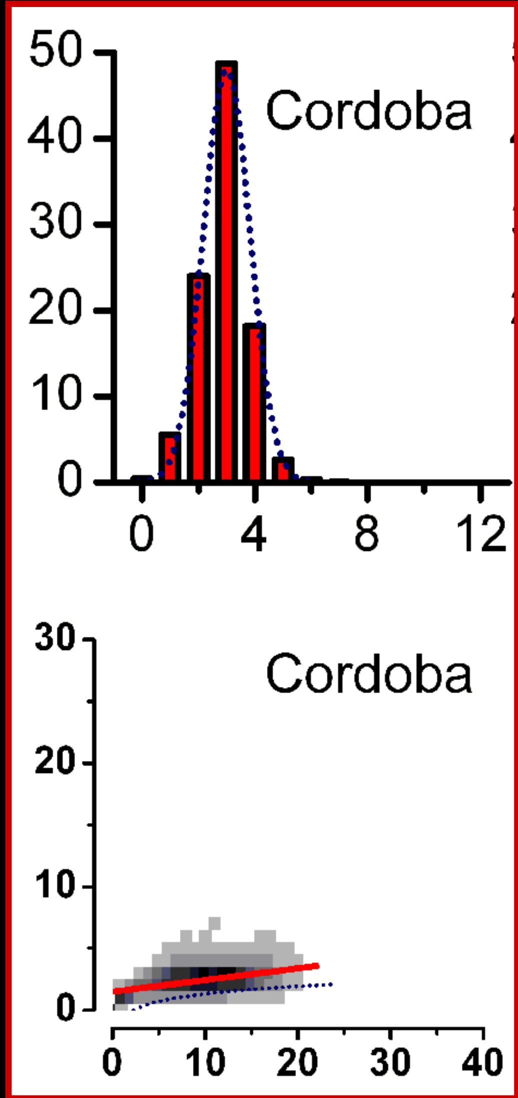


Real systems: urban street patterns





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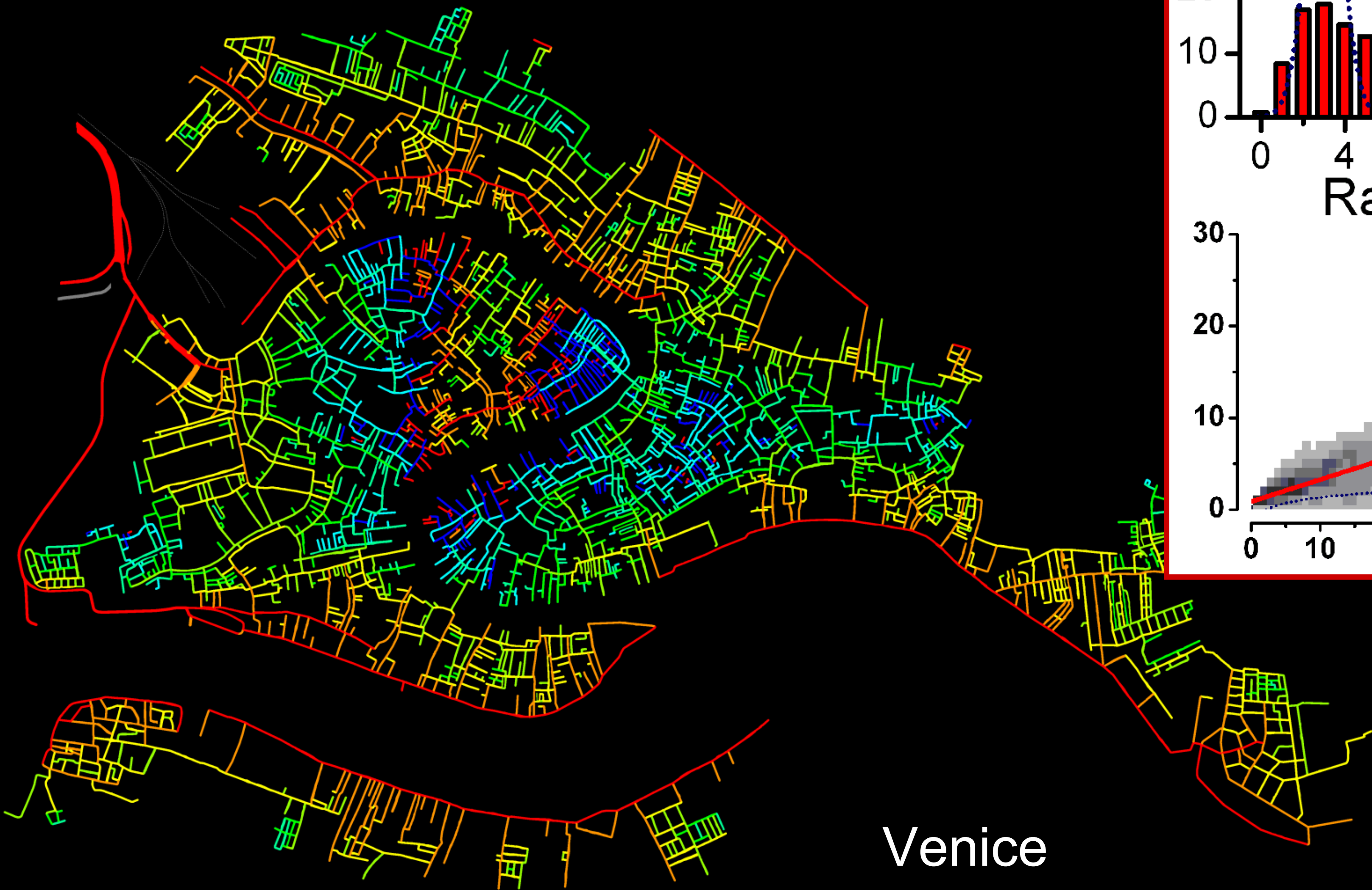

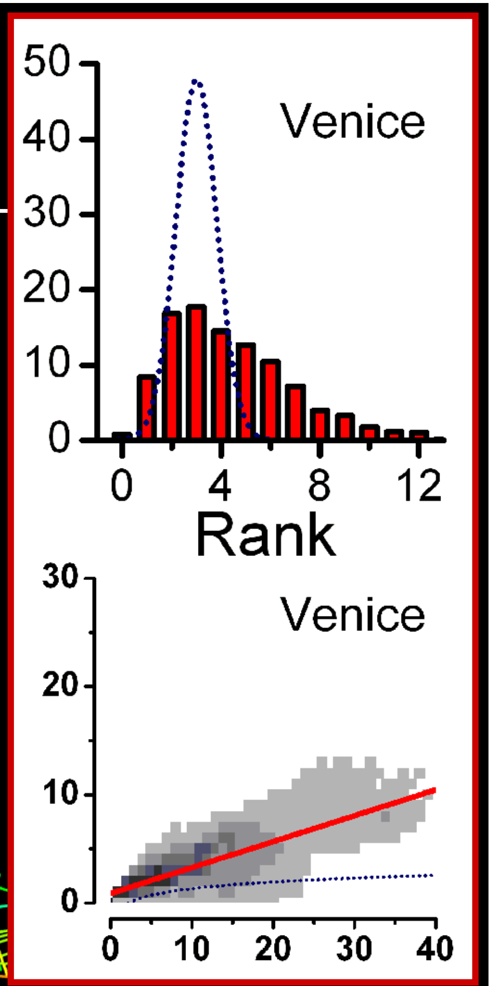

Real systems: urban street patterns

Venice


More...
Map
Satellite
Terrain
50 ft
20 m
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Real systems: urban street patterns

Main entrance on canal

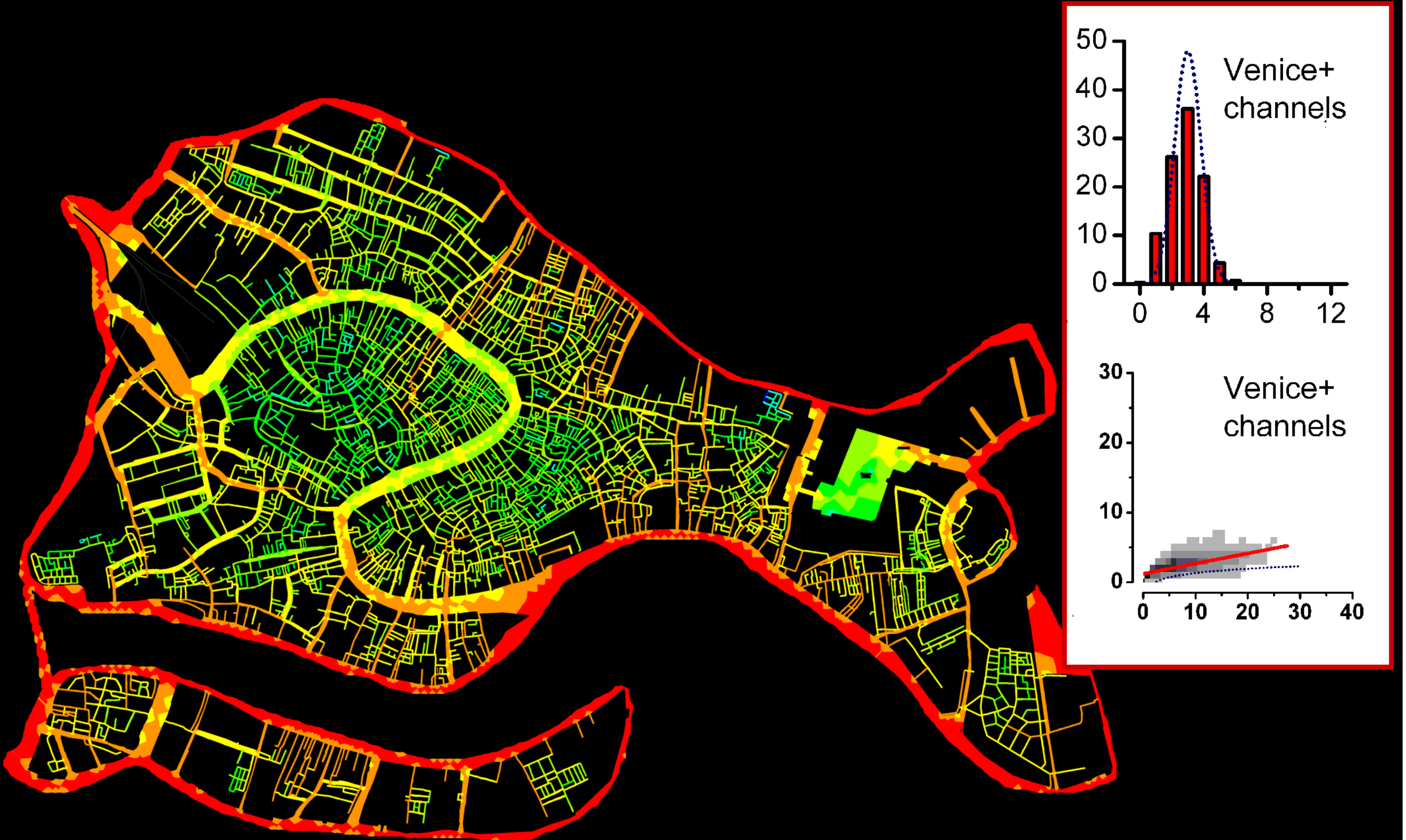
reconnection

Walking space
= space left free…

Real systems: urban street patterns

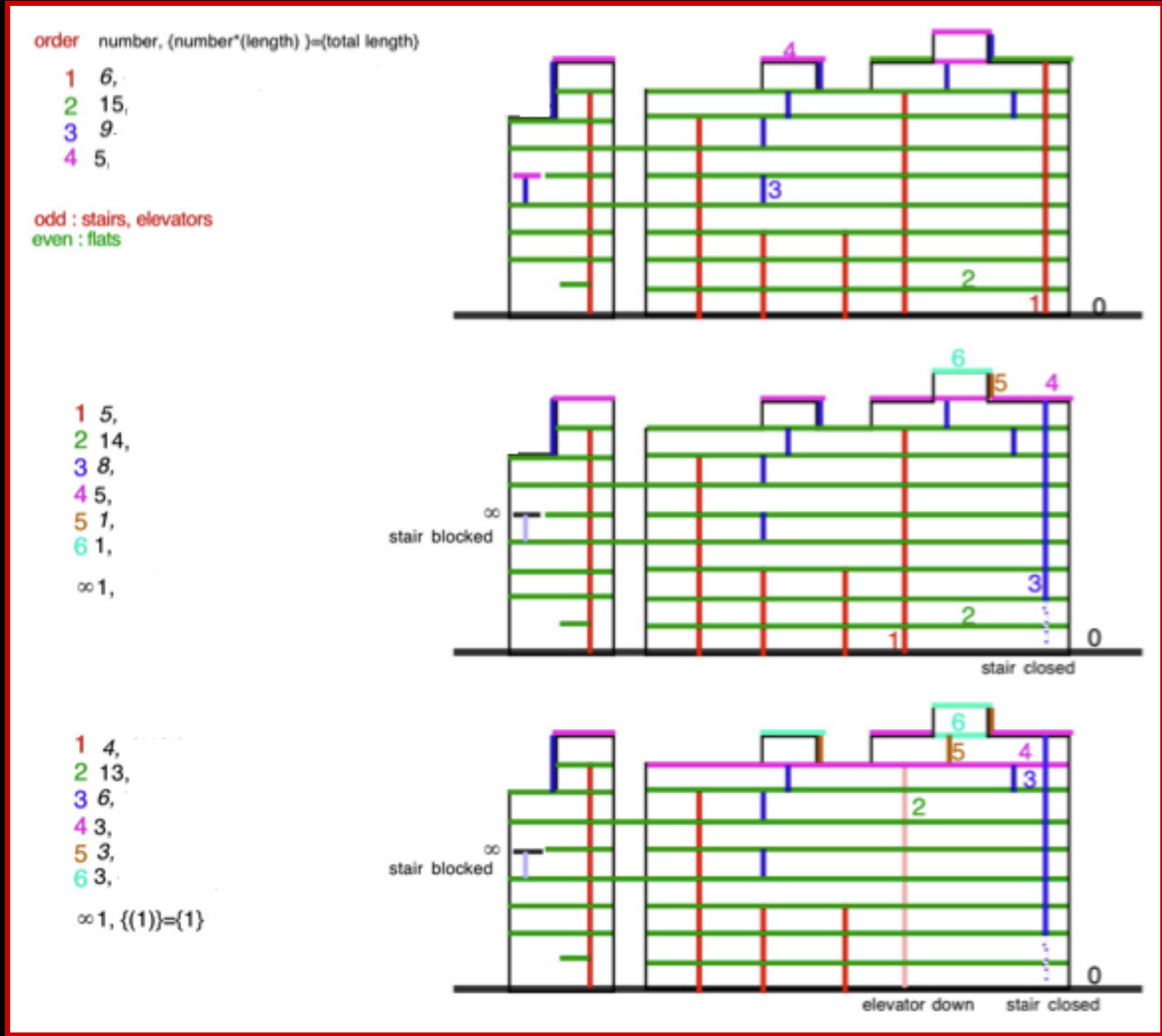
Channels are normal city

Real systems: urban street patterns



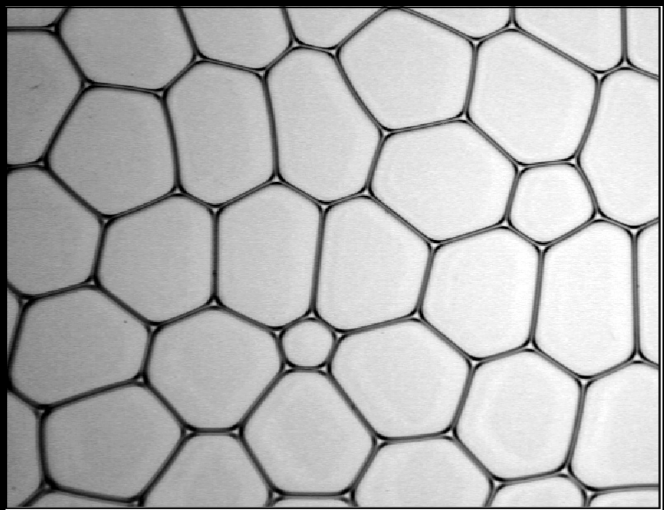
Three dimensional spatial networks

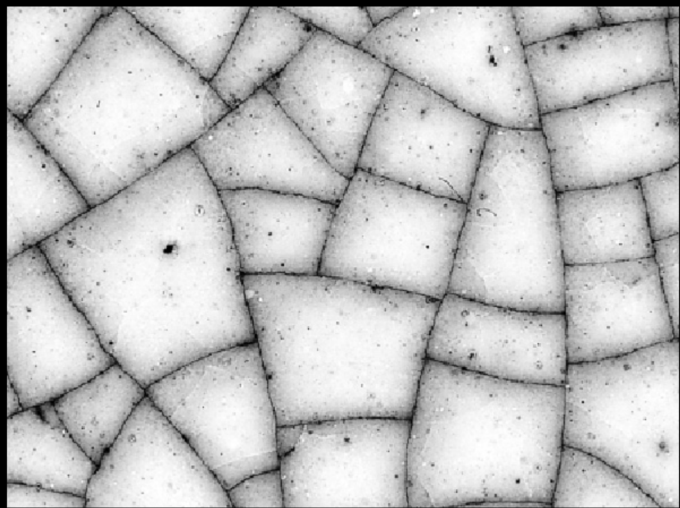
Three dimensional spatial networks



Conclusions

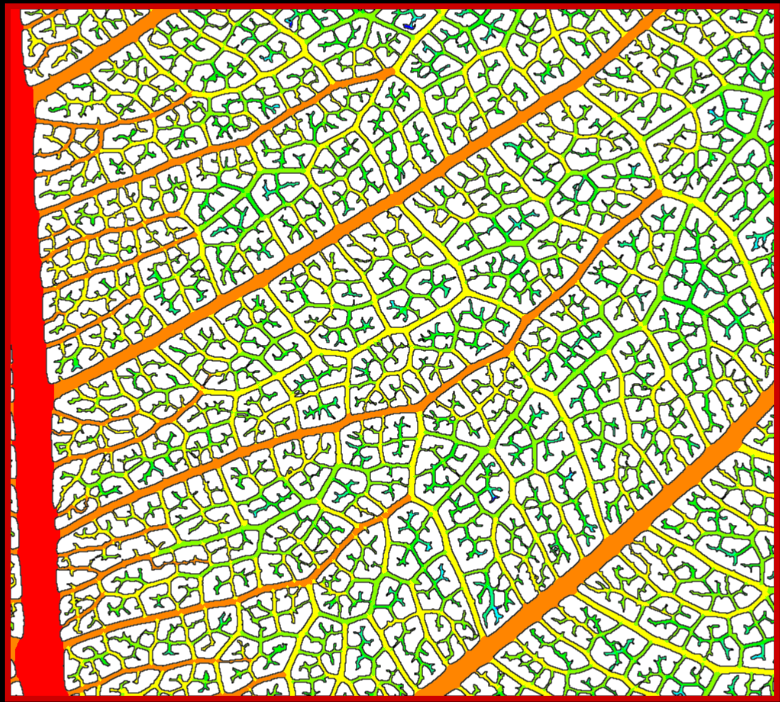
1. Local geometry allows to discriminate between two classes of network-like patterns





Conclusions

1. Local geometry allows to discriminate between two classes of network-like patterns
2. And to reconstruct the temporal order of appearance of different network segments



Conclusions

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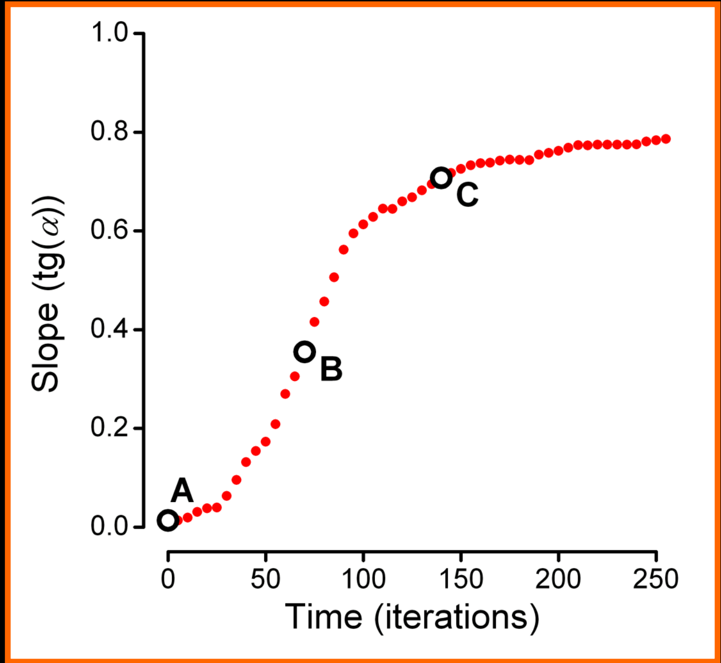
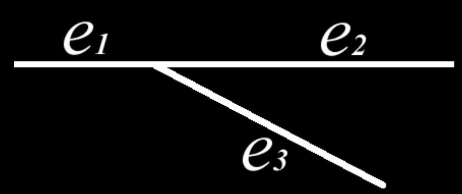
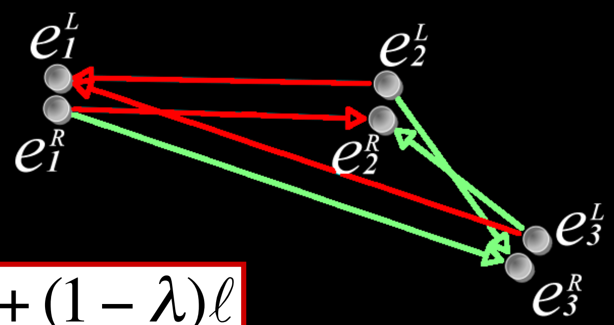
3. With our algorithm we can quantify the scale over which the spatial organization persists.



Conclusions

1. Local geometry allows to discriminate between two classes of network-like patterns
2. And to reconstruct the temporal order of appearance of different network segments
3. With our algorithm we can quantify the scale over which the spatial organization persists.
4. Future work might associate (geometric) distances to the edges of the line directed graph, to explore the trade-offs between ease of orientation and short paths in different networks





$$d = \lambda w + (1 - \lambda)\ell$$

The Mesomorph project

CRCA Toulouse

Christian Jost

Jacques Gautrais

Vincent Fourcassié

Guy Theraulaz

MSC Paris

Stéphane Douady

LINA Nantes

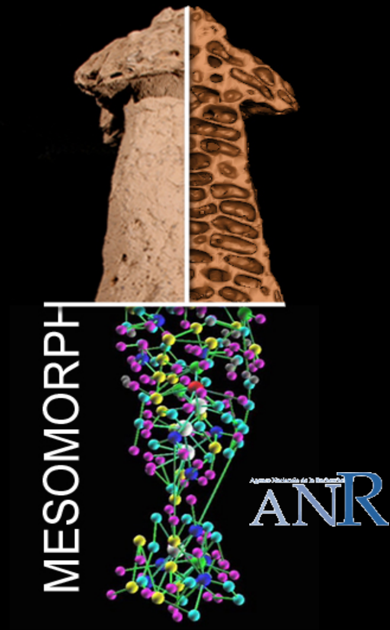
Pascale Kuntz

Fabien Picarougne

CSL Barcelona

Sergi Valverde

Ricard Solé



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