

# Generating urban morphologies at large scales

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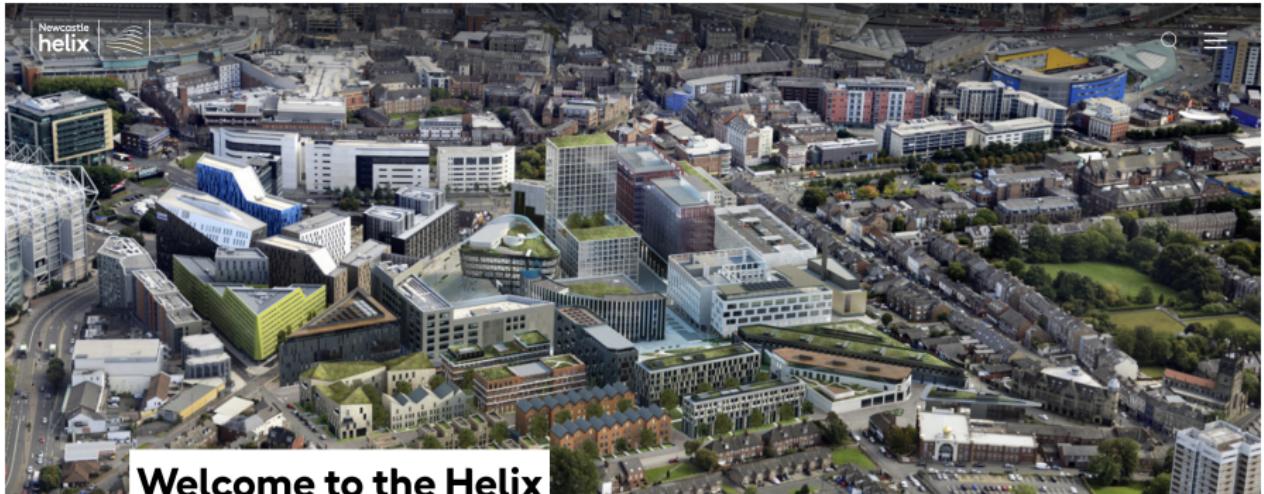
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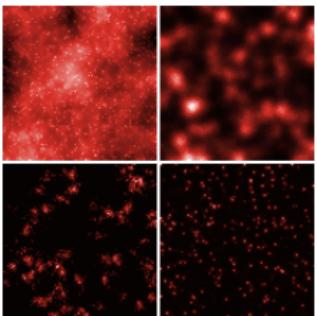
# Morphogenesis of Urban Systems



*"new innovation community, sustainable urban development, flourishing city, urban regeneration"*

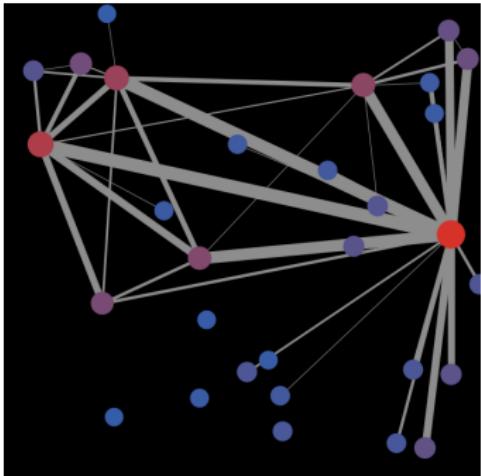
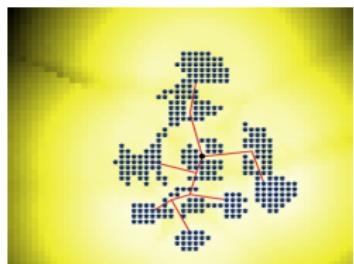
→ Are cities alive? Which morphogenetic processes?

# Urban Systems and Artificial Life



Raimbault, J. (2018). Calibration of a density-based model of urban morphogenesis. PloS one, 13(9), e0203516.

Raimbault, J. (2019). An urban morphogenesis model capturing interactions between networks and territories. In *The Mathematics of Urban Morphology* (pp. 383-409). Birkhäuser, Cham.



*Cities-network co-evolution model explored on synthetic systems of cities [?]*

Model studied by [?] : exploration and reinforcement by a slime mould searching for ressources



# Urban form from the bottom up

- emergence of the urban form from local processes
- 

**Research objective:**

# Generating building layouts

Complementary heuristics:

- random building blocks (modern urbanism)
- random population kernels (preferential attachment)
- percolation of roads through a compact urban core (transportation flows)

## Urban form indicators for building layouts:

- density, number of buildings, average area
- Moran index and average distance on rasterized representation
- average detour in the free space
- mathematical morphology indicators (steps for erosion and dilation)  
[?]

# Generators

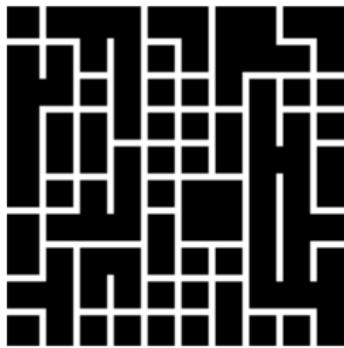
*Examples for each generator*



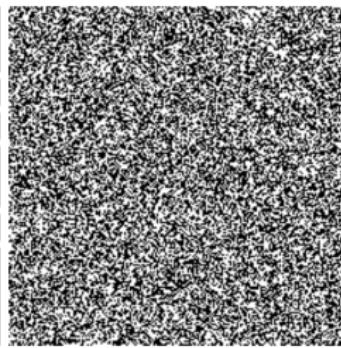
(a) Blocks



(b) Kernel mixture



(c) Network percolation



(d) Random

# Real configurations

*Sampled districts from OpenStreetMap*



# Classification of urban forms

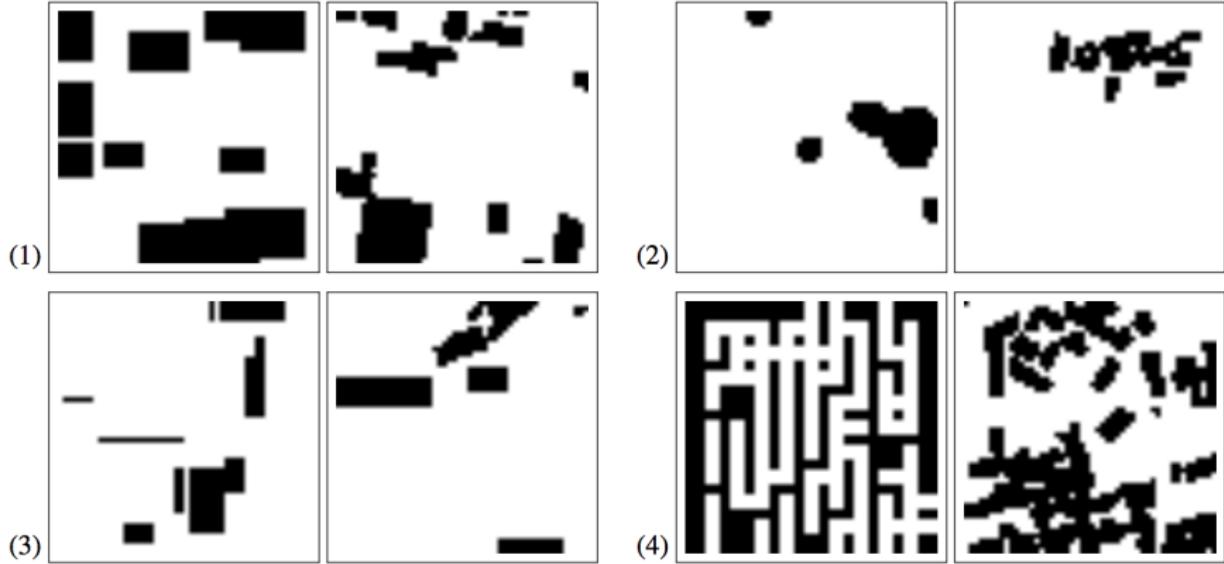


OpenMOLE software <https://next.openmole.org/>

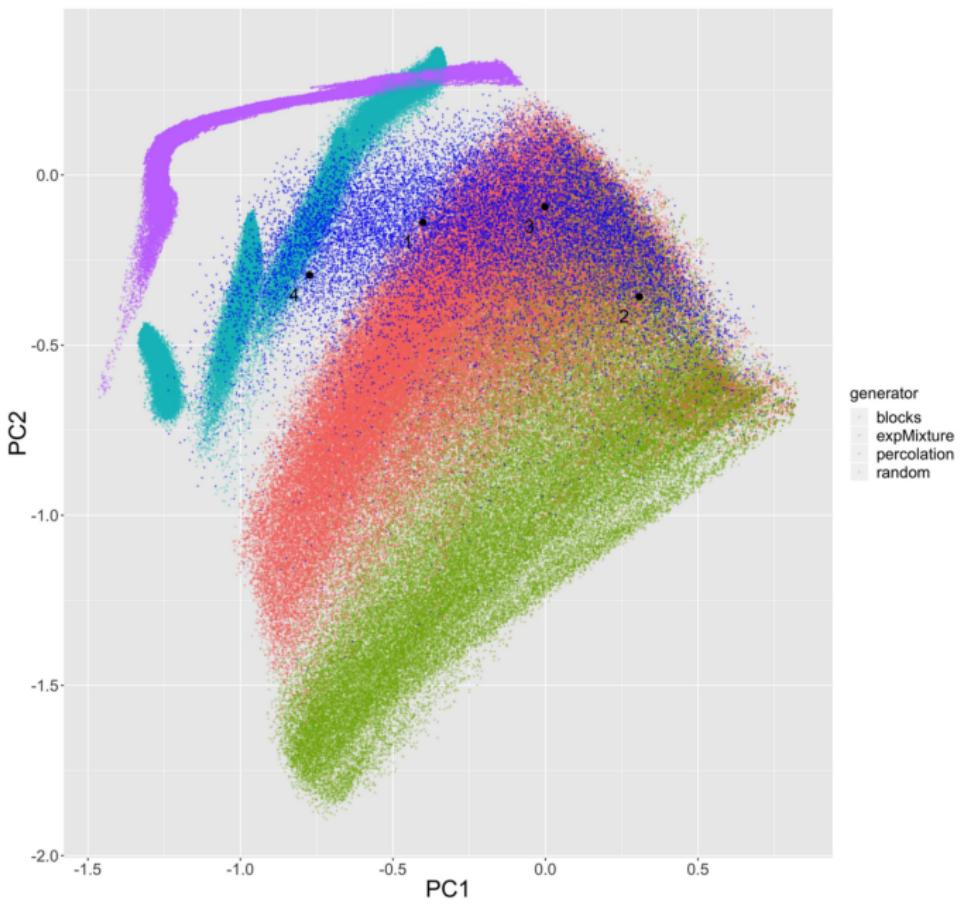


*OpenMOLE: (i) embed any model as a black box; (ii) transparent access to main High Performance Computing environments; (iii) model exploration and calibration methods.*

# Calibrated forms



# Point cloud



# Calibration

	Random	Blocks	Exp. Mixture	Percolation
Centroid 1	$0.424 \pm 0.011$	$0.106 \pm 0.063$	$0.303 \pm 0.101$	$0.325 \pm 0.019$
Centroid 2	$0.809 \pm 0.022$	$0.164 \pm 0.099$	$0.184 \pm 0.141$	$0.947 \pm 0.019$
Centroid 3	$0.428 \pm 0.019$	$0.095 \pm 0.054$	$0.109 \pm 0.064$	$0.541 \pm 0.019$
Centroid 4	$0.515 \pm 0.005$	$0.311 \pm 0.077$	$0.589 \pm 0.149$	$0.083 \pm 0.025$

*Why not use calibration heuristics? Open question of fitting a point cloud; issue of projecting in a reduced dimension space*

# Discussion

# Conclusion

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*Code and results at <https://github.com/openmole/spatialdata>*

## References I

-  Rimbault, J. (2018).  
Calibration of a density-based model of urban morphogenesis.  
*PloS one*, 13(9):e0203516.
-  Rimbault, J., Banos, A., and Doursat, R. (2014).  
A hybrid network/grid model of urban morphogenesis and optimization.  
In *4th International Conference on Complex Systems and Applications*, pages 51–60.