

Spatial Computing

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Spatial Computing Workshop
@ IEEE SASO 2009

Previous Meetings

- Computing Media and Languages for Space-Oriented Computation (Dagstuhl, 2006)
- French Workshop on Amorphous Computing (Paris, 2007)
- From Amorphous to Spatial Computing Workshop (Paris, 2008)
- Spatial Computing Workshop (SASO, 2008)

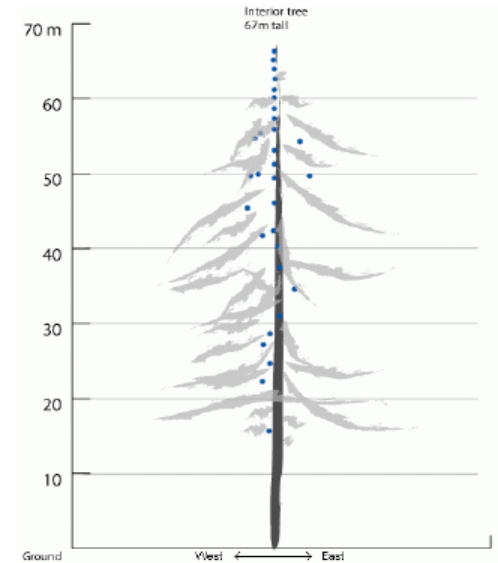
Spatial Computers



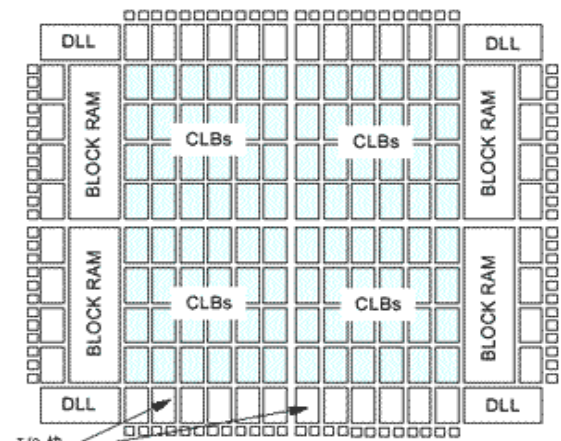
Robot Swarms



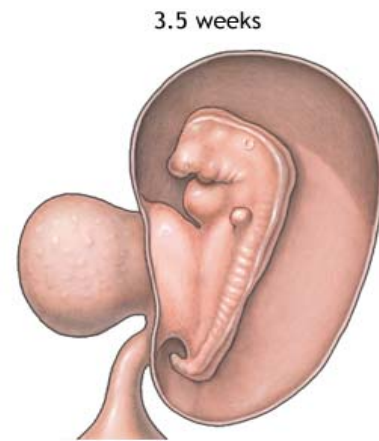
Biological Computing



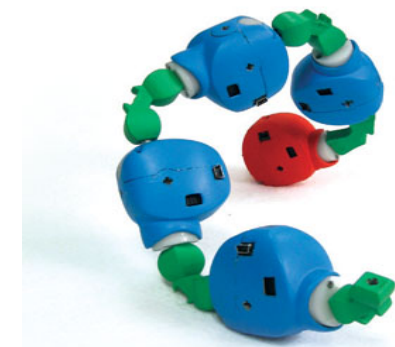
Sensor Networks



Reconfigurable Computing



Cells during Morphogenesis



Modular Robotics

More formally...

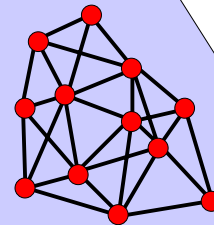
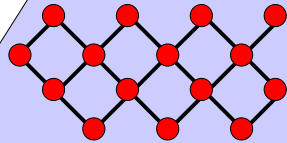
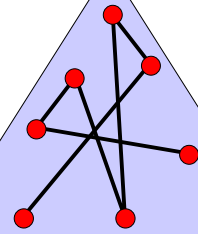
- A spatial computer is a collection of computational devices distributed through a physical space in which:
 - the difficulty of moving information between any two devices is strongly dependent on the distance between them, and
 - the “functional goals” of the system are generally defined in terms of the system's spatial structure

More formally...

- A spatial computer is a collection of computational devices **distributed through** a physical space in which:
 - the difficulty of moving information between any two devices is **strongly dependent on the distance** between them, and
 - the “functional goals” of the system are **generally defined** in terms of the system's spatial structure

Notice the ambiguities in the definition

Graphs

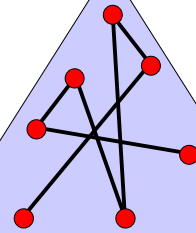


Crystalline
(e.g. CAs)

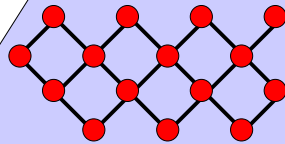
**Amorphous/
Continuous**

(w. Dan Yamins)

Graphs

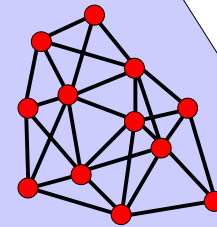


density
↑
↓
space complexity



jitter

← grain size →

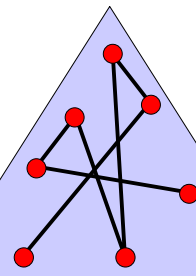


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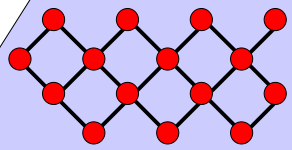
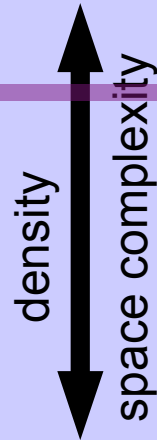
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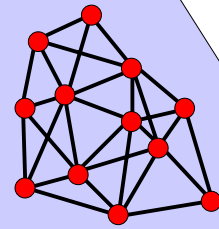


spatial computing



jitter

grain size



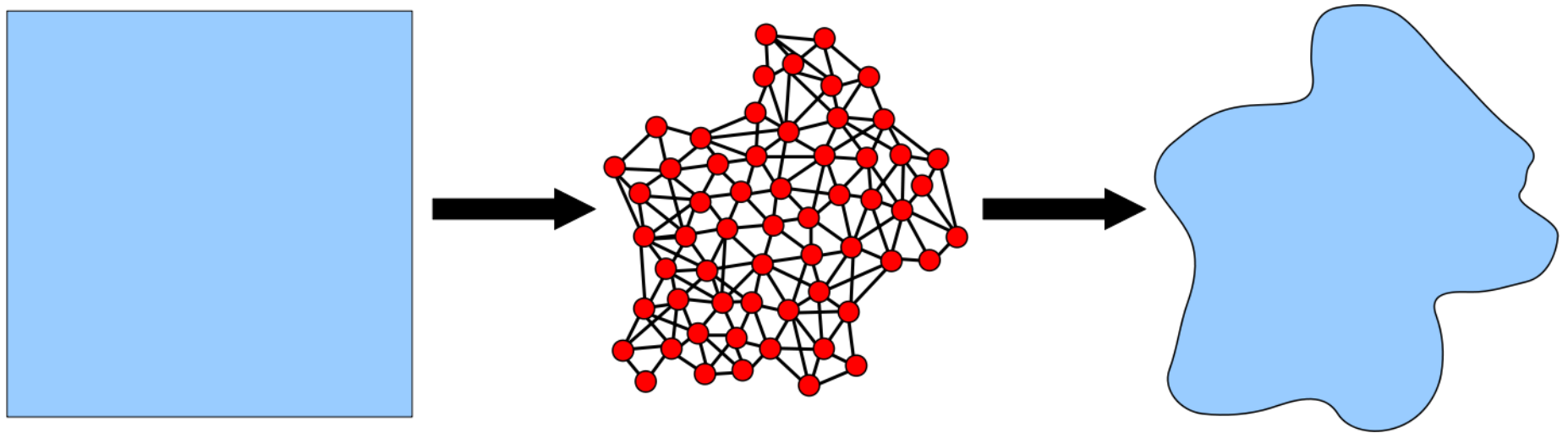
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(w. Dan Yamins)

Space/Network Duality

How well does the network cover space?



What space is covered well by the network?

Tentative Mathematical Definition

- A spatial computer is any set of n devices s.t.
 - Graph $\{V, E\}$ with edge weights $w(v_1, v_2)$
 - Manifold M , with distance function d
 - M is compact, Riemannian *(may be stronger than needed)*
 - Position function $p: V \rightarrow M$
 - $w(v_1, v_2) = O(1/d(p(v_1), p(v_2)))$

Examples: unit disc network, chemical diffusion

Questions for the Workshop

- What is special about computation over space?
- What techniques or metrics do we share?
- How can a spatial view help us move results and algorithms from one domain to another?
- How do we apply spatial insights?

Schedule

- Introduction & Opening Discussion
- "Spatial Computing as Intentional Data Parallelism" (Spicher et al.)

15 minute break

- Dynamically Defined Processes for Spatial Computers (Beal)
- Spatial Coordination of Pervasive Systems through Chemical-inspired Tuple Spaces (Viroli et al.)
- Discussion: Theory & Unifying Frameworks

lunch (ends at 1:30pm)

- Molecular Self-assembly for Nanoscale Spatial Computation (Dwyer)

15 minute break

- A Biologically Inspired Spatial Computer that Learns to See and Act (Robertson & Laddaga)
- Discussion: Applications & Future Directions