Lecture 4 – Self-organisation

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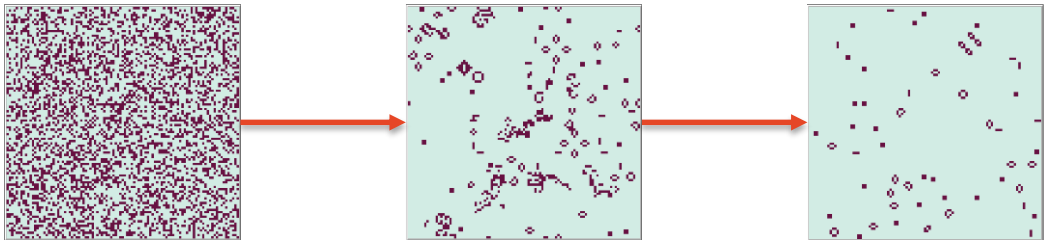
Self-organisation: session outcomes

- Understand concept of self-organisation, and possible methods to measure it

- Primary references:
  - J.T. Lizier, "The local information dynamics of distributed computation in complex systems", Springer, Berlin/Heidelberg, 2013. Section 2.1.2

Self-organisation



- Game of Life?
  - Describe the final state in contrast to the initial random state?
  - Did it organise? In what way?
  - How did that happen? Was there any central control?
  - What happens to the density, and does the original density matter?
- Sayama, p. 6: "*Self-organization is a dynamical process by which a system spontaneously forms nontrivial macroscopic structures and/or behaviors over time.*"
- More specifically [2,3 in 4], must have 2 key features:
  - "*An increase in organisation over time*"
  - "*Dynamics not guided by any centralised or external control agent*"
- Other examples of self-organisation?

[1] H. Sayama, "*Introduction to the Modeling and Analysis of Complex Systems*", Geneseo, NY: Open SUNY Textbooks, 2015; chapter 1
[2] C.R. Shalizi, K.L. Shalizi, R. Haslinger, "*Quantifying self-organization with optimal predictors*", Phys. Rev. Lett. 93(11), 118701 (2004)
[3] D. Polani, "*Foundations and formalizations of self-organization*", in Advances in Applied Self-organizing Systems, ser. Advanced Information and Knowledge Processing, ed. by M. Prokopenko (Springer, London, 2008), pp. 19–37
[4] J.T. Lizier, "*The local information dynamics of distributed computation in complex systems*", Springer: Berlin/Heidelberg, 2013

How to measure order/organisation?

Several options:

1. Complement of randomness / entropy [1]
2. Mutual information between parts of the system [2]†
3. Statistical complexity* [3]

– For more details I recommend ref. [2]

[1] C. Gershenson, N. Fernández, "*Complexity and information: Measuring emergence, self-organization, and homeostasis at multiple scales*", Complexity, 18(2), pp. 29-44, 2012
[2] D. Polani, "*Foundations and formalizations of self-organization*", in Advances in Applied Self-organizing Systems, ser. Advanced Information and Knowledge Processing, ed. by M. Prokopenko (Springer, London, 2008), pp. 19–37
[3] C.R. Shalizi, K.L. Shalizi, R. Haslinger, "*Quantifying self-organization with optimal predictors*", Phys. Rev. Lett. 93(11), 118701 (2004)
† Ref [2] mainly considers higher order mutual information (i.e. multi-information or integration).
* Not covered in this course!

Self-organisation: summary

- Self-organisation is an increase in order over time (without external control).
  - The key to measuring it is measuring order in the system;
  - There are several options for doing so.

- *Next lecture*: Information processing in complex systems.

Questions

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