Lecture 9 – Information theory wrap-up

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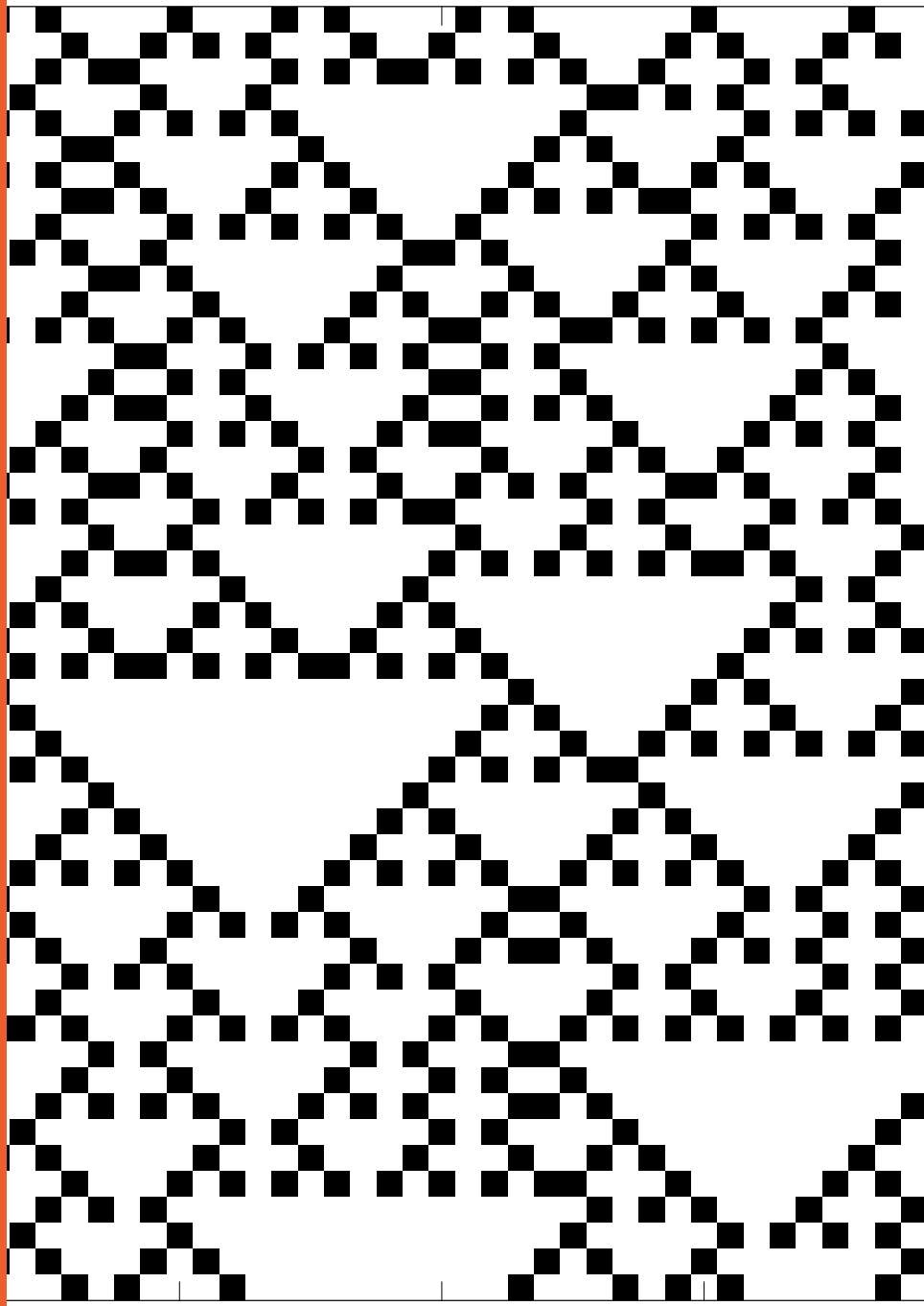

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Learning outcomes

1. Capacity to **critically evaluate** investigations of self-organisation and criticality in complex systems, and the insights provided
2. To be able to **apply** a series of 'computational experiments' on complex systems in order to **understand** their dynamics and to **interpret** the result in a technically correct manner. This includes researching and implementing techniques not covered in class.
3. Develop scientific programming skills which can be **applied** in complex system analysis and design
4. Ability to **apply** and make informed decisions in selecting and using information-theoretic measures and software tools to analyse complex systems
5. Ability to **create** information-theoretic analyses of real-world data sets, in particular in a student's domain area of expertise
6. To be able to use the computational and mathematical tools that are appropriate for the analysis of systems that are in a 'critical' or 'complex' state.
7. **Understand** basic information-theoretic measures, and advanced measures for time-series, and how to use these to **analyse** and **dissect** the nature, structure, function and evolution of complex systems
8. Understand, and successfully use in analysis, the concepts of percolation, chaos theory, phase transitions and fractals.
9. To be able to **understand** the design of and to extend the design of a piece of software using techniques from class and your own readings

Information theory: what we covered

Lectures/activities

1. Introduction to information theory
2. What is information?

3a. Introduction to JIDT

3b. Information-theoretic estimators and JIDT

4. Self-organisation and case studies
5. Statistical significance and undersampling
6. Information dynamics I (storage)
7. Information dynamics II (transfer)
8. Effective network inference

Assessments

1. Literature review

2. Information theory project

Resources:

- Texts: Cover and Thomas, Mackay, Bossomaier et al., Lizier (JIDT)
- Software: JIDT

Final messages: info theory, questions and answers

- Information theory is all about questions and answers.
  - Your estimator will always give you an answer. But is it answering the same question that you think you are asking?
  - Think hard about the question you want to ask of the data, and whether and how information theory can help you get an answer to that question.

Final messages: what we've left out

- There are many perspectives on information theory.
- I've given you mine, focussing on empirical analysis of complex systems.
- We've necessarily left out a lot, including:
  - Traditional use of information theory and coding
  - Information theory and thermodynamics
  - Partial information decomposition (still evolving …)

Final messages: info theory and complex systems

- Information theory is a very powerful approach for investigating dynamics of and relationships in complex systems
  - Many pros: nonlinear, data-type agnostic, mathematically rigorous.
  - And many features of complex systems that we're interested in can be measured by information theory!

- Shannon famously argued to restrict the application of information theory to communications engineering though.
- What do you think?

C. E. Shannon, "The Bandwagon", IRE Transactions on Information Theory, vol. 2(1), p. 3, 1956

Questions

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