Complex Systems

- What is a complex system and what is complex systems or complexity science about?

- Are there specific methods for the analysis of complex systems?

- What are typical problems in complex systems science?

What is a complex system?

- Many interacting elements – emergent properties on the system level

- Selforganization paradigm from physics: simple elements with simple but nonlinear interactions, e.g. Cellular automata, deterministic low-dimensional chaos

- Biological and social systems: complex elements, which are adaptive, e.g. neurons, cells individuals
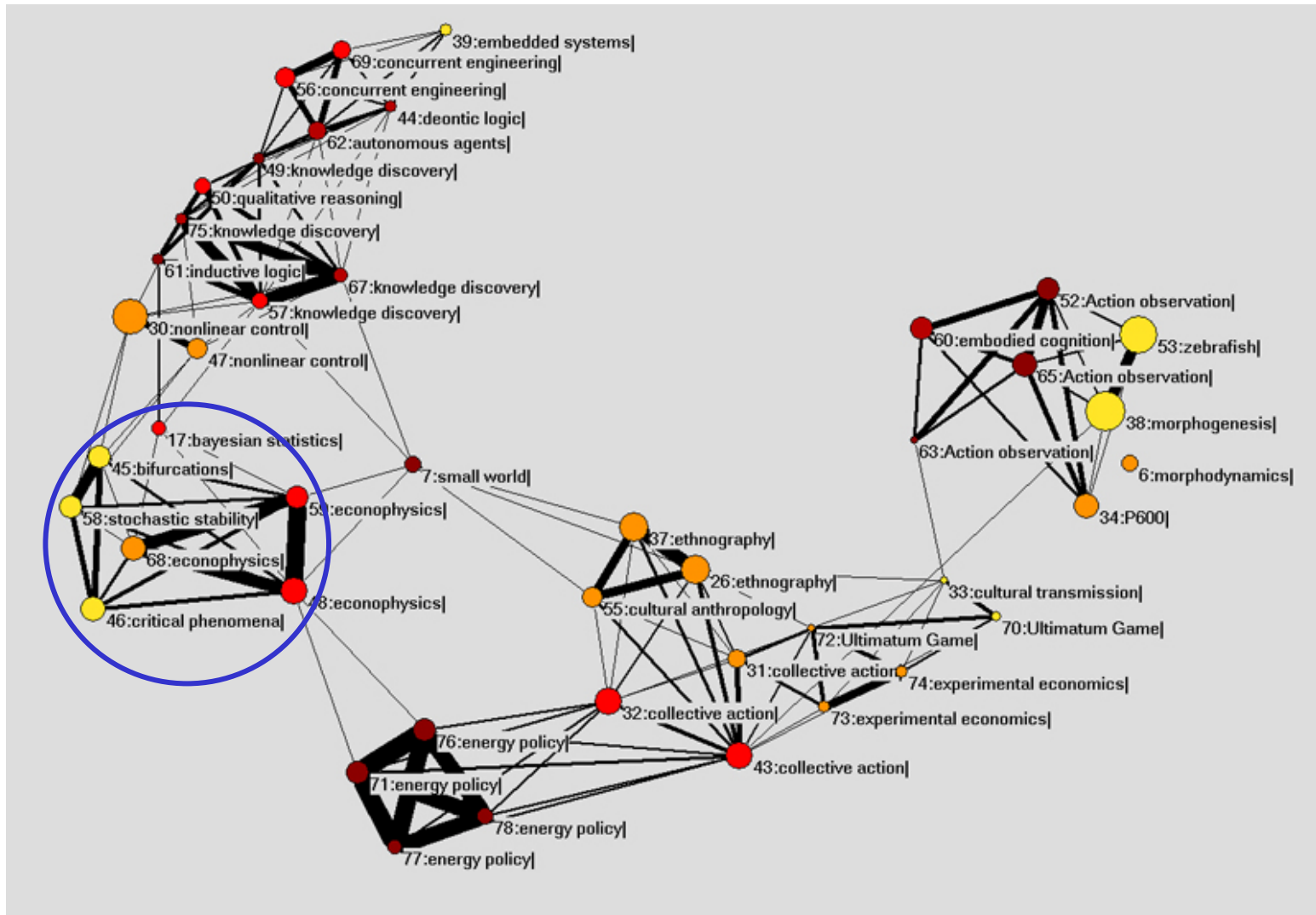
What are complex systems methods?

- Up to now no general agreed canon
- Self-organisation paradigma: Nonlinear dynamics (chaos), statistical physics (spin glasses), non-equilibrium thermodynamics (pattern formation)
- Biological and social systems: Networks, complex adaptive systems
- General (Computer Science, Mathematics): Information theory, Dynamical Systems, (computational) complexity theory
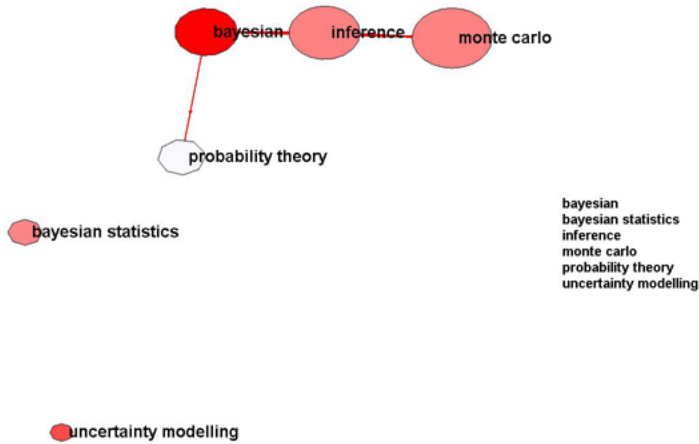
Complexity Science
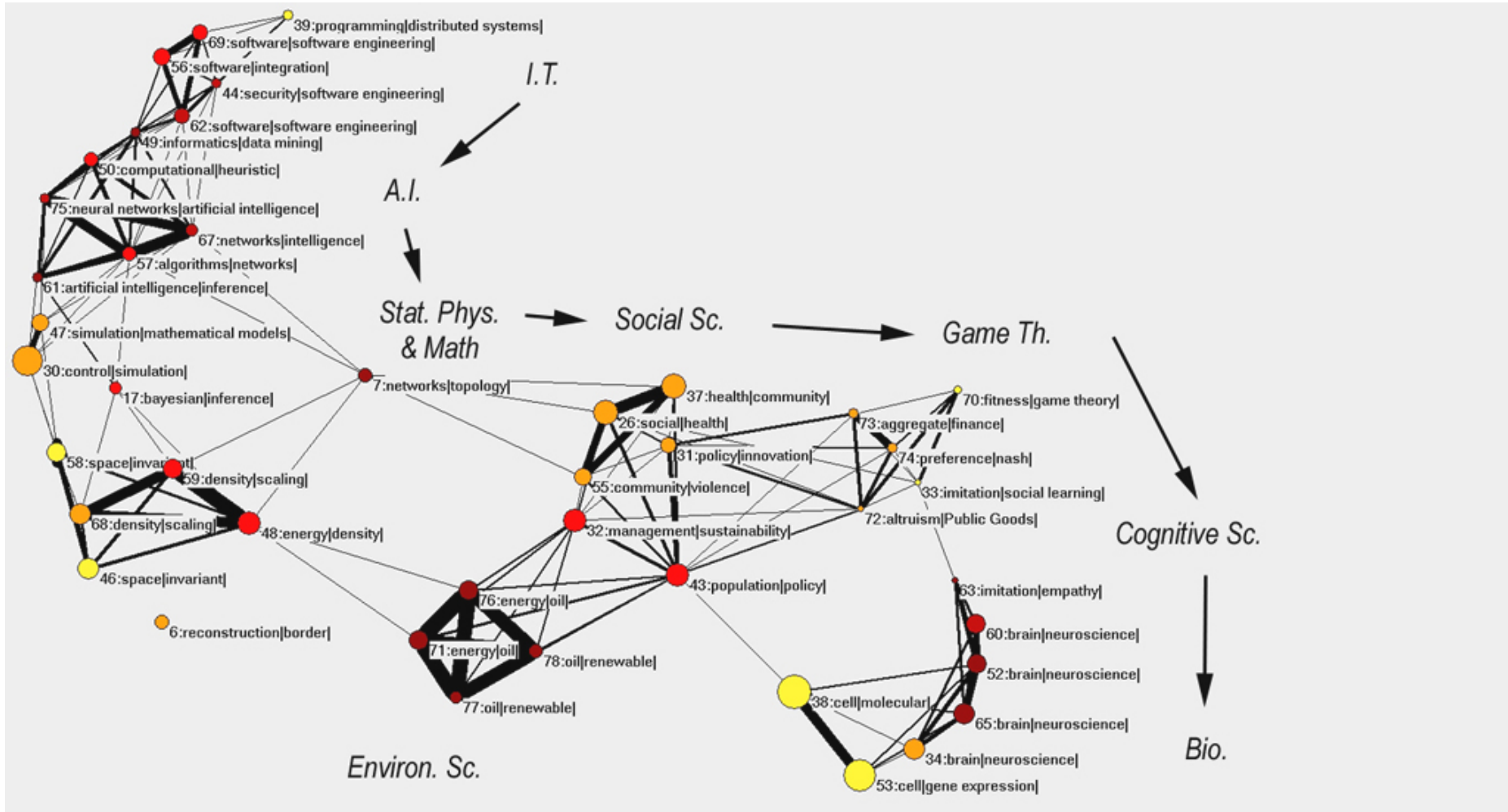
Complexity Science Map from David Chavalarias and Jean-Philippe Cointet
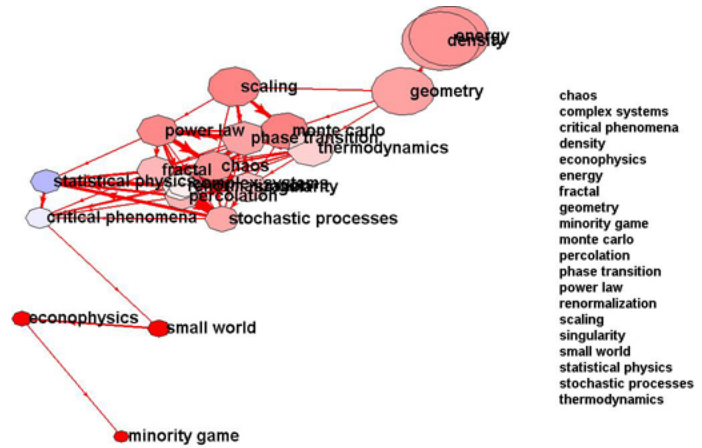http://cssociety.org/tiki-index.php?page=CSM

Complexity Science

Critical phenomena

bayesian
bayesian statistics
inference
monte carlo
probability theory
uncertainty modelling

chaos
complex systems
critical phenomena
density
econophysics
energy
fractal
geometry
minority game
monte carlo
percolation
phase transition
power law
renormalization
scaling
singularity
small world
statistical physics
stochastic processes
thermodynamics

Fields number: 17

Fields number: 48

This Lecture

- Complexity measures from Information theory

- Exkurs: Graphical Models and Bayesian Inference

- Critical Phenomena – self organized criticality (SOC)

- „Computation at the edge of chaos"

Literature

- Thomas M. Cover and Joy A. Thomas, Elements of Information Theory, Wiley, 2nd edition 2006

- Didier Sornette, Critical Phenomena in Natural Sciences, Springer, 2nd edition 2006

What's probably not in this lecture

Might be partially included

- Dynamical systems, nonlinear dynamics
- Networks (random, scale free, small world)
- ...

Not planned to include

- Pattern formation
- Models of Evolution - Evolutionary game theory
- ...