Complexity, Complexities and Complex Knowledges
Discussion of Pr. Batty: "Complexity in Urban Systems"

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More or Less Complex Urban Systems ?

Source: Geoportail, Google maps

Some Types of Complexity

Various approaches to complexity, corresponding definitions, characterizations and measures. We consider:

- Complex Systems as systems exhibiting Weak Emergence [Bedau, 2002]
- Computational Complexity: $\mathbf{P} \neq \mathbf{NP}$, Algorithmic Complexity (see [Moore and Mertens, 2011])
- Informational Complexity: information theory, Complexity profile [Allen et al., 2017]

$\rightarrow$ *What are the links between these different types of complexities ?*

Computational Complexity of Complex Adaptive Systems

Complex Systems require a minimal level of computational complexity

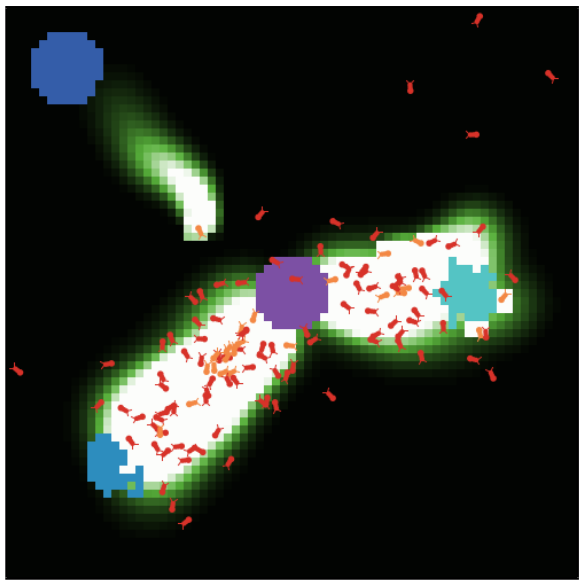
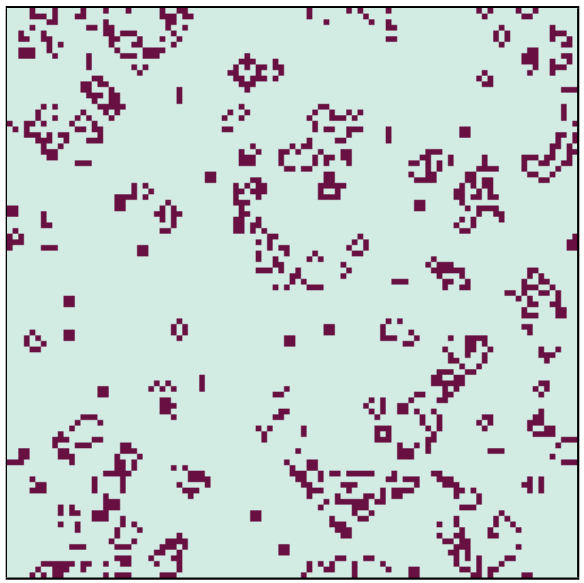
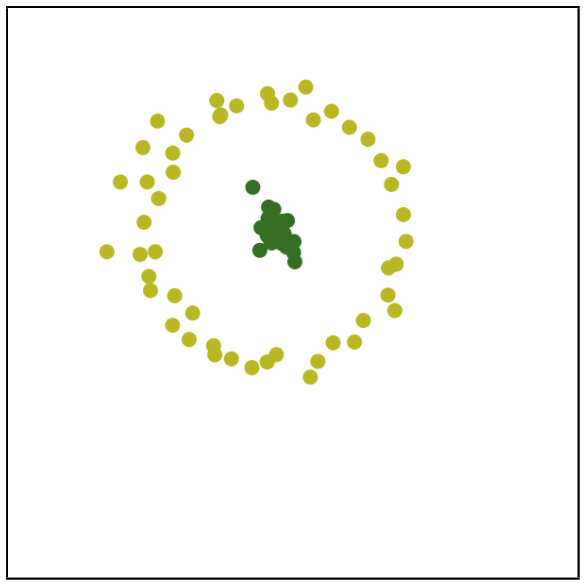
$\rightarrow$ [Bolotin, 2014] shows that solving the Schrodinger equation with an arbitrary Hamiltonian is NP-complete

$\rightarrow$ [Tošić and Ordonez, 2017] gives a lower bound for computational complexity of very simple ABMs when adding interactions with the environment

Computation by Complex Adaptive Systems

Computation is achieved by diverse Complex Systems

→ Ant algorithm solves generalized TSP [Pintea et al., 2017]

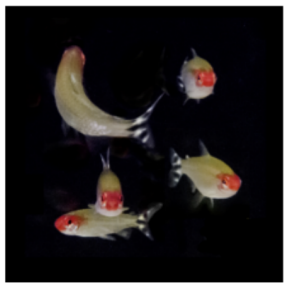




Sources. Ants, Game of Life: NetLogo Library; Swarm chemistry: implementation of [Sayama, 2007]

Information and Complex Systems

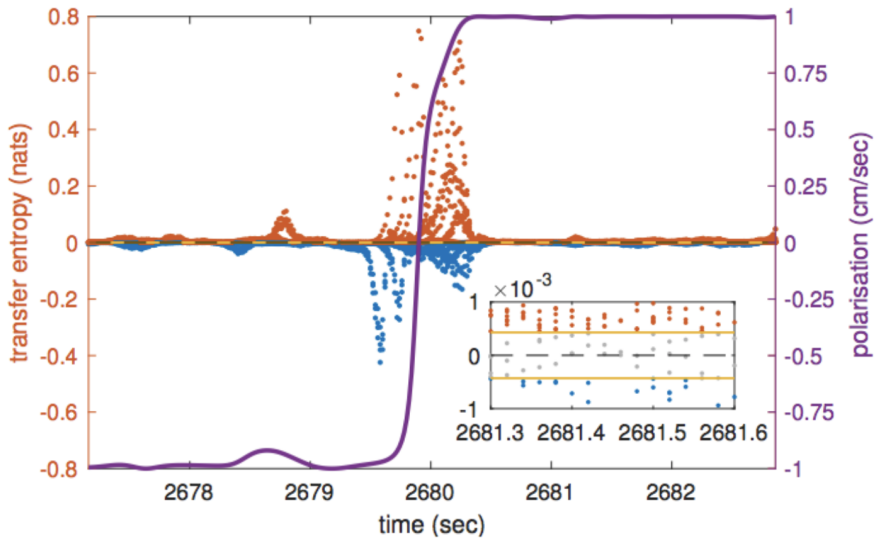
Central role of information in Complex Systems

→ Chua's local activity principle [Mainzer and Chua, 2013] drives local entropy for some reaction-diffusion systems
→ Central role of Signals and their processing in Holland's approach to CAS [Holland, 2012]



(a)

(b)



(c)

Role of transfer entropy in collective behavior in a school of fishes, from [Crosato et al., 2017]

Knowledge of the Complex

Given that:

1. *Processes of knowledge production on Complex Systems necessite high level of complexity for each aspect.*
2. *They must translate the different type of complexities, and the relations between these.*

Postulate : Knowledge of the Complex has an inevitable reflexive nature, in the sense of recursive theories (knowledge on producer of the knowledge is part of the knowledge)

$\rightarrow$ *Knowledge of the Complex* is thus Complex Knowledge (cf law of requisite complexity [Gershenson, 2015]). Link with an "Evolutive Rationality", Complex Knowledge being both the product and the support of its evolution ?

Conclusion

$\rightarrow$ Non-reflexive approaches will never fully grasp Urban Complexity (or *Social Sciences are necessary*)

$\rightarrow$ Extension to other types of complexity such as Pumain's "disciplinary complexity" [Pumain, 2005] ? *Integrative approaches may be necessary*

$\rightarrow$ Link with Knowledge Domains [Raimbault, 2017]

Reserve Slides

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