A Complex Systems Approach to the Behavioural Sciences

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Inhoudsopgave

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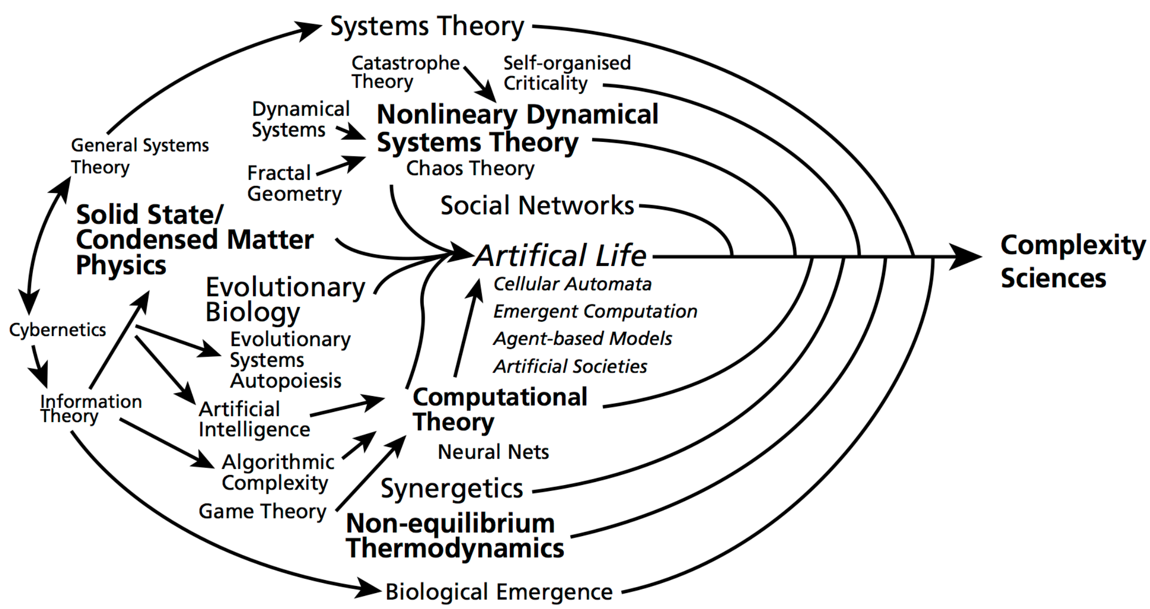

The many foundations of complexity science.

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Preface

Course guide

Complexity research transcends the boundaries between the classical scientific disciplines and is a hot topic in physics, mathematics, biology, economy as well as psychology and the life sciences and is collectively referred to as the Complexity Sciences. This course will discuss techniques that allow for the study of human behaviour from the perspective of the Complexity Sciences, specifically, the study of complex physical systems that are alive and display complex adaptive behaviour such as learning and development. Contrary to what the term "complex" might suggest, complexity research is often about finding simple models / explanations that are able to simulate a wide range of qualitatively different behavioural phenomena. "Complex" generally refers to the object of study: Complex systems are composed of many constituent parts that interact with one another across many different temporal and spatial scales to generate behaviour at the level of the system as a whole that can appear to be periodic, nonlinear, unstable or extremely persistent. The focus of many research designs and analyses is to quantify the degree of periodicity, nonlinearity, context sensitivity or resistance to perturbation by exploiting the fact that "everything is interacting" in complex systems. This requires a mathematical formalism and rules of scientific inference that are very different from the mathematics underlying traditional statistical analyses that assume "everything is NOT interacting" in order to be able to validly infer statistical regularities in a dataset and generalise them to a population. The complex systems approach to behavioural science often overlaps with the idiographical approach of the science of the individual, that is, the goal is not to generalise properties or regularities to universal or statistical laws that hold at the level of infinitely large populations, but to apply general principles and universal laws that govern the adaptive behaviour of all complex systems to study specific facts, about specific systems observed in specific contexts at a specific instant.

The main focus of the course will be hands-on data-analysis and the main analytical tool we will use is R (if you are an expert: It is also possible to use Matlab for most of the assignments, let us know in advance). Practical sessions will follow after a lecture session in which a specific technique will be introduced.

We will cover the following topics:

- Theoretical background of phase transitions (self-organised criticality) and synchronisation (coupling dynamics) in complex dynamical systems and networks.
- Simple models of linear and nonlinear dynamical behaviour (Linear & logistic growth, Predator-Prey dynamics, Lorenz system, the chaos game);
- Analysis of long range dependence in time and trial series (Entropy, Relative roughness, Standardized Dispersion Analysis, Detrended Fluctuation Analysis).
- Quantification of temporal patterns in time and trial series including dyadic interactions (Phase Space Reconstruction, [Cross] Recurrence Quantification Analysis).

- Network analyses (Estimating symptom networks, calculating network based complexity measures)

Teaching formats

Each meeting starts with a lecture addressing the theoretical and methodological backgrounds of the practical applications that will be used in hands-on assignments during the practical sessions. Several meetings include a part where guest lecturers discuss the use of one or more techniques in their recent research.