The emergence of complex systems (lectures 6-8)

- Networks are potent abstractions of complex systems
  - Agents
  - Interactions

- To understand complex systems, we ask how they have emerged
  - Evolution (a theory for the development of biological systems)
  - Data (fossils/evidence of biological complexity)

Evolution (a theory for the development of biological systems)

- Evolutionary *computation* (algorithms inspired by theory of evolution and realised in computational terms)
- Evolutionary computation simulates the evolution of computational models using *life*-inspired constraints
- Evolutionary algorithms can be used to automatically adapt or optimise agents in accordance with constraints

All evolutionary algorithms involve

- a *population* of individuals
- repeated generations of *genetic modification*, *fitness evaluation* and fitness-proportionate *selection*
- *genetic operators* to perform the genetic modifications (simplified versions of those found in biological systems)

A simple genetic algorithm, genetic programming, the Schema theorem, co-evolution, learning and evolution (including evolving neural networks and the Baldwin effect)

Data (fossils/evidence of biological complexity)

- Data-driven analysis of genomic data (large-scale analysis for "patterns", utilising statistical and machine learning algorithms)
- Enables the development of computational models using static but real observations (snapshots of nature)

Genomic data (gene products, their function and structure)
The cell as a complex system (gene expression, protein trafficking, interaction)
Algorithms for analysing expression data (hierarchical cluster analysis, correlation analysis)
➔ gene expression analysis and inferring gene regulatory networks
Algorithms for classifying data (support vector machine, K-means, probability)
➔ diagnostic gene expression analysis and protein trafficking