

CITS7211 Modelling Complex Systems

Lecture 3: Cellular Automata

Overview

This lecture introduces the fundamentals of cellular automata. Building on the foundations of finite automata and Turing Machines we explore the origins and theory of interacting (cellular) automata. We examine two classical cellular automata: Conway's Game of Life, and the one dimensional cellular automata corresponding to the Wolfram numbers..

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Topics:

1. Review of finite state automata: states; inputs; outputs; transition functions. Finite state machines model simple behaviours
2. Brief overview of Turing machines. Turing machines model computations.
3. Origins of cellular automata from computation to inter-stellar travel.
4. Formal Definition: A CA is give by the tuple (L, S, N, f) , where
 - a. L is a d dimensional lattice (or grid).
 - b. S is the finite set of possible cell states.
 - c. N is a neighbourhood schema, mapping each cell to the other cells it can see.
 - d. f is the update function, mapping each cells neighbourhood to its new state, $f: S^N \rightarrow S$.
5. Generalizations: Neighbourhood functions, Network automata, interacting automata, and turtles.
6. Conway's Game of Life: self-replication, Turing completeness, and simple organisms
7. Wolfram numbers: a new kind of science?

Reading:

1. Franco Bagnoli, 2008, *Cellular Automata*, to appear in *Dynamical Modelling in Biotechnologies*, pages 1-27 (some parts are quite technical)
2. Cosma Shalizi, <http://www.cscs.umich.edu/~crshalizi/notebooks/cellular-automata.html>, a more relaxed, but nonetheless interesting overview of cellular automata.
3. Nino Boccara, *Modeling Complex Systems*, Springer 2004, Sections 6.1 - 6.3

Tim French, 2009.