Automata Theory (CS1.302)

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Cellular Automata

Cellular automata are systems capable of changing state on their own, based on an initial state and a set of rules.

For example, consider a lattice where each cell can be black or white. Evolution is discrete and depends only on the current state – a white cell turns black if and only if the cell to the left of it is black, and black cells remain black.

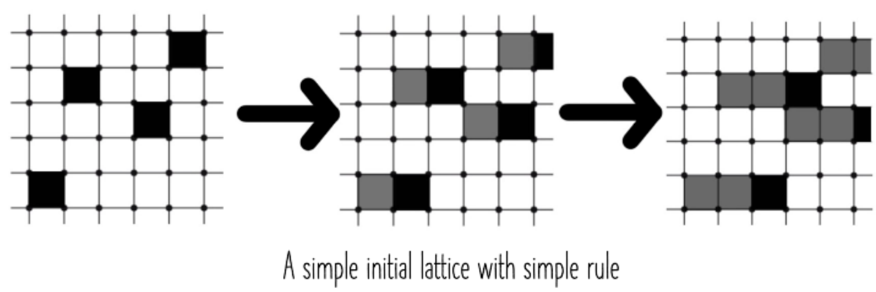

Figure 1: Evolution by a Simple Rule

To limit complexity, the rules for a certain cell are only allowed to involve itself and its neighbours.

Some applications of cellular automata include pseudorandom number generators (by initialising with a seed and assigning a number to each state) and one-way functions (previous states cannot be determined from the current state). They are also used in simulations in the natural sciences.

Conway's Game of Life

Introduction

Conway's Game of Life is a special celullar automaton, with cells that can take two values. Its only input is its initial configuration; rules are applied simultaneously to all cells and each generation is a function of the previous generation.

Rules

The rules of Life are:

- any live cell with < 2 live neighbours dies
- any live cell with 2 or 3 live neighbours stays alive
- any live cell with > 3 live neighbours dies
- any dead cell with exactly 3 live neighbours comes alive.

Evolution

There are various kinds of patterns that arise from these rules: still lifes (do not change from their initial configuration); oscillators (return to the seed after some iterations); spaceships (translate across the grid).

Life is both Turing complete and undecidable.