Cellular Automata

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Outline

The Basics

- Spacial Structure

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- Local Interactions

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- Cell State

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- Cell Transitions

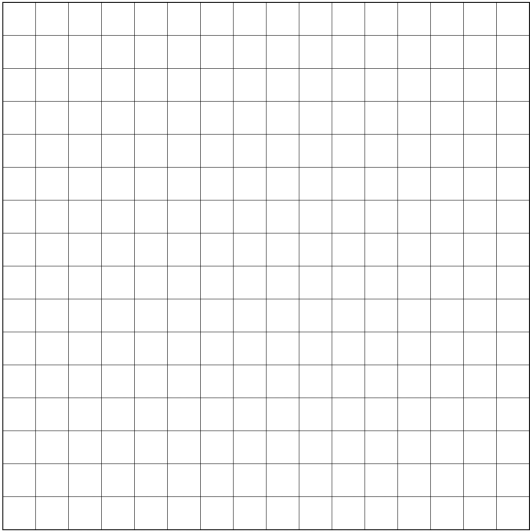
Spacial Structure

- Grid - Like a city

Spacial Structure

- Grid - Like a city
- Agents - Like a home in the city

Spacial Structure



Local Interactions

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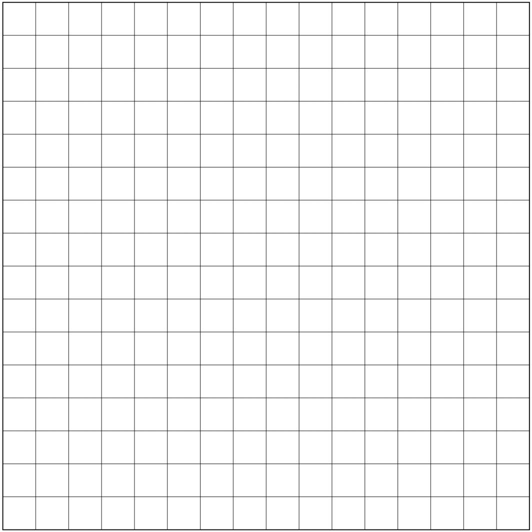
Locality indicates how many agents a single agent interacts with. High locality indicates more interactions (Think of how a rumor spreads).

Local Interactions



Cell State

Cells have a state

- Binary

Cell State

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- Binary
- Any number of states

Cell Transitions

CA have discrete chunks of time called rounds. Each round produces the next "generation" of cells.

Cell Transitions

The next state of a cell is a function of:

- It's current state

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Think of your opinion on a topic changing by being surrounded by people with a different view.

Elementary Cellular Automaton

What is the simplest...

- Grid of cells?

Elementary Cellular Automaton

What is the simplest...

- Grid of cells?
- Useful number of states?

Elementary Cellular Automaton

What is the simplest...

- Grid of cells?
- Useful number of states?
- Neighborhood?

Elementary Cellular Automaton

What is the simplest...

- Grid of cells - an array
- Useful number of states - binary
- Neighborhood - 2 adjacent cells of the agent

Elementary Cellular Automaton

How do we describe the state of cell c_t as a function of the neighbors of c_t at time $t - 1$?

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- There are $2^3 = 8$ neighborhood combinations for any given neighborhood.
- Simply create an assignment for each combination!
- This assignment is called a rule set (how many possible rule sets?)

Example Program

2D CA Example - Conway's Game of Life

Conway's Game of Life

Conway's Game of Life Rules

Conway's Game of Life Entities

Conway's Game of Life is Decidability

The question - "Given a starting pattern and an ending pattern, will the starting pattern ever reach the ending pattern?"

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- Undecidable - halting problem
- "Indeed, since the game of life includes a pattern that is equivalent to a UTM (universal Turing machine), this "deciding" algorithm, if existed, could have been used to solve the halting problem, by taking the initial pattern as the one corresponding to a UTM+input and the later pattern as the one corresponding to a halting state of the machine with an empty tape (as one can modify the Turing machine to always erase the tape before halting). However the halting problem is provably undecidable and so such an algorithm does not exist" (Wikipedia).