Turmites

Project in Algorithms, Logic and Complexity (TÖL203F spring 2014)

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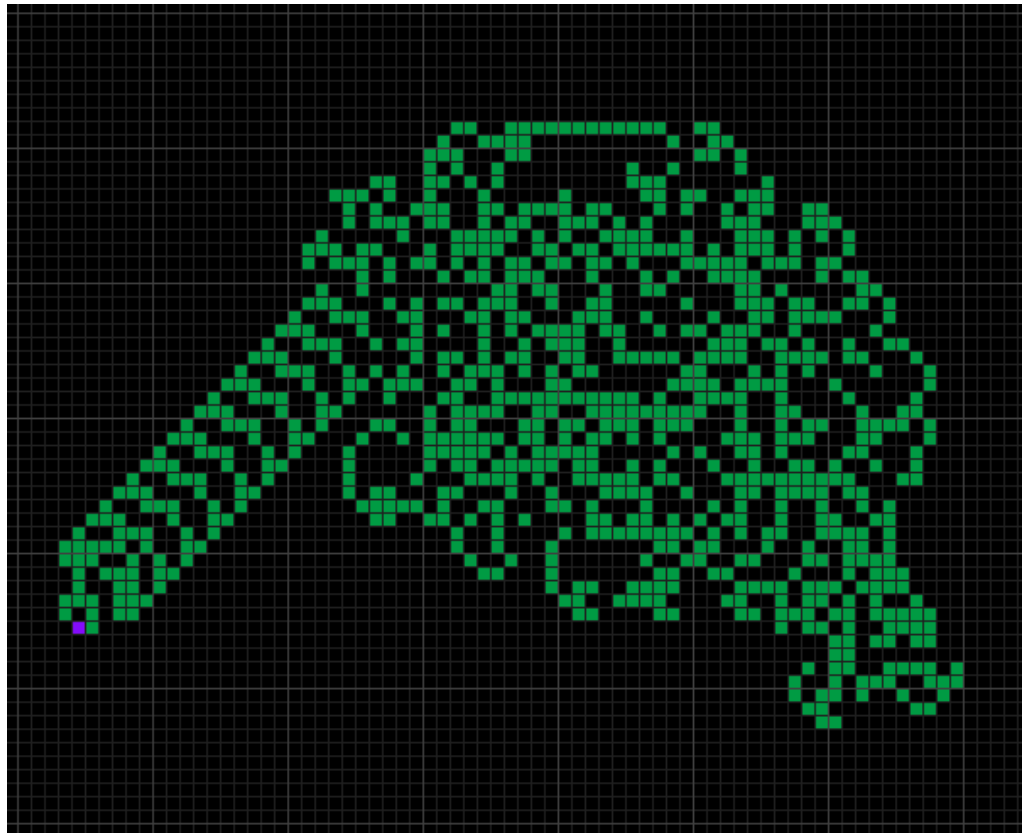
Introduction



Turmites

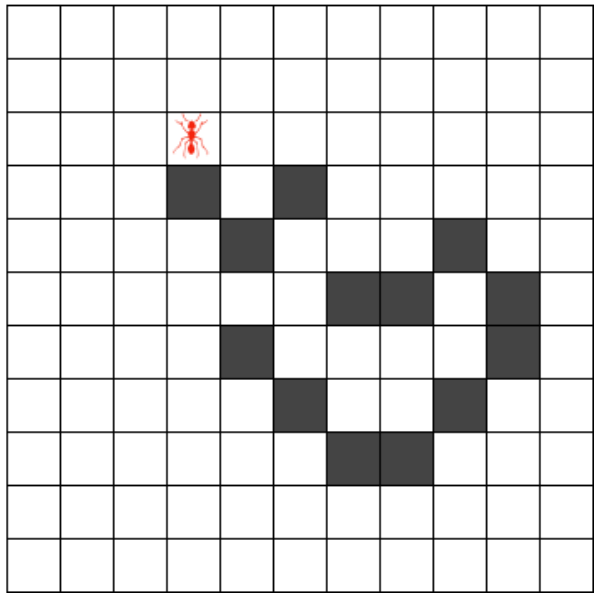
- Two-dimensional grid of cells, i.e. Turing machines in 2D.
- Most well-known type of turmites are Langton's ant (see fig. above).
- Shown to be equivalent to Turing machines.

Turmites

Two categories:

- Relative
  - Also known as 'Turning Machines'.
  - All moves are relative to current orientation.
  - Moves: Forward, left, right and U-turn.
  - Example: Langton's ant.
  - Usually have chaotic, spiral and/or highway patterns.
- Absolute
  - Also known as 'Two-dimensional Turing machines'.
  - Use directions in absolute terms.
  - Moves: North, South, West and East.
  - Not as widely used as relative turmites.

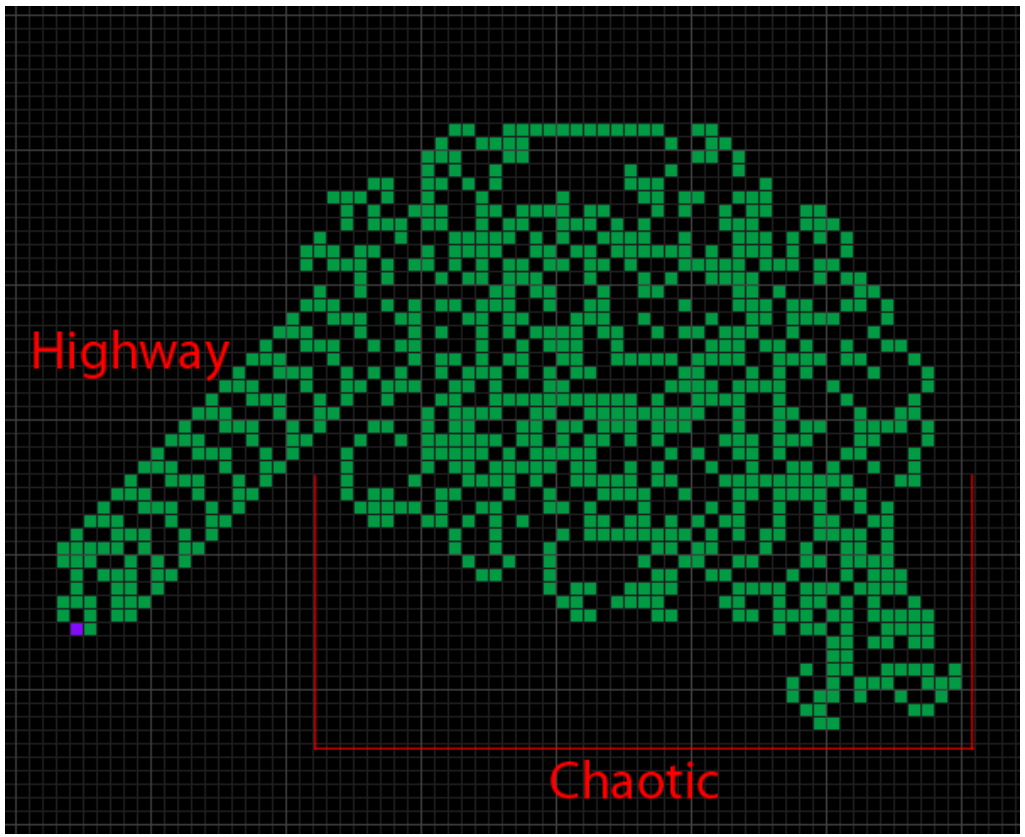
Relative turmites: Langton's ant



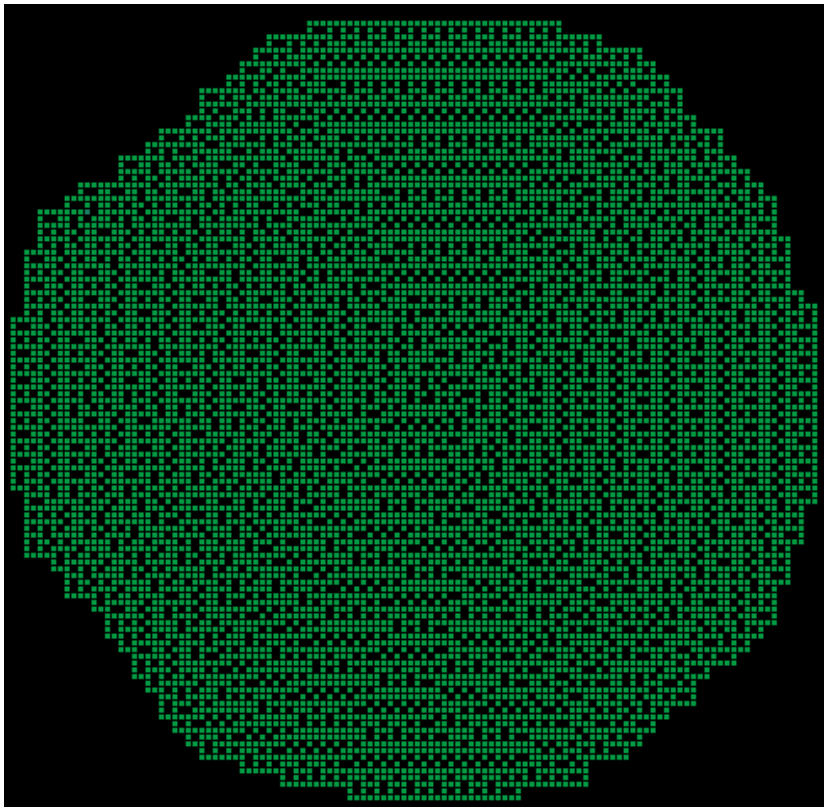
- Invented by Chris Langton in 1986.
- Has only one state and starts in an empty configuration.
- Rules:
  - At a white (empty) square, write black and move right.
  - At a black square, write white and move left.
- The universality of Langton's ant was proven in 2000.
- Animation: `http://upload.wikimedia.org/wikipedia/commons/0/09/LangtonsAntAnimated.gif`

Relative turmites: Langton's ant

- Will never actually halt.
- Becomes predictable after 9,977 steps.
- Has two stages called:
  - Chaotic (not predictable)
  - Highway (predictable)

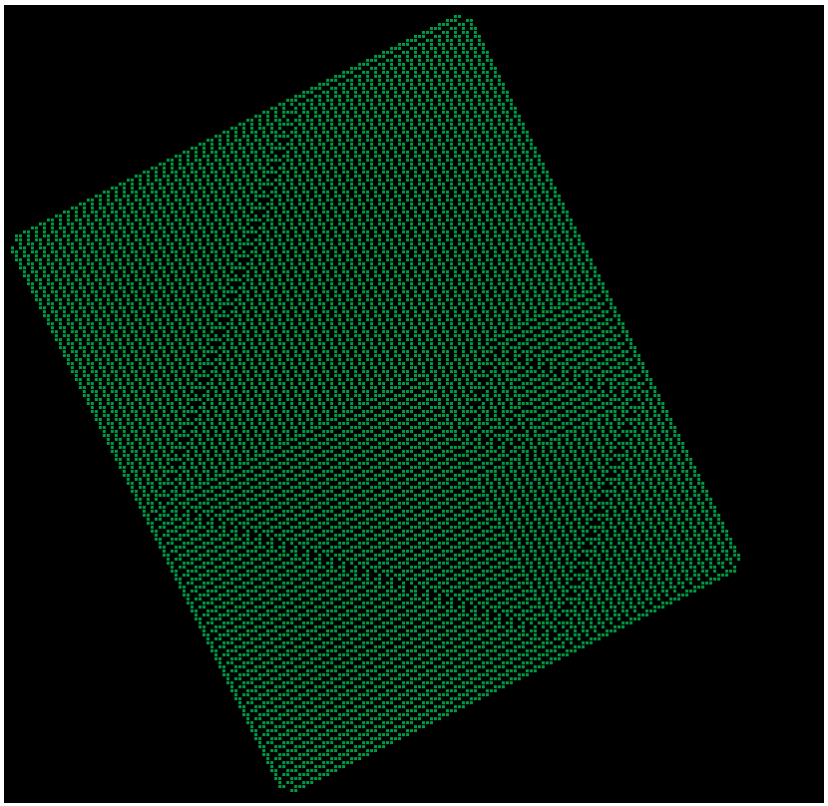


Relative turmites: Spiral



- State 0:
  - At an empty square, write a stroke, move forward and go to state 1.
  - At a stroked square, keep the stroke, move left and go to state 0.
- State 1:
  - At an empty square, write a stroke, move right and go to state 1.
  - At a stroked square, remove the stroke, move forward and go to state 0.

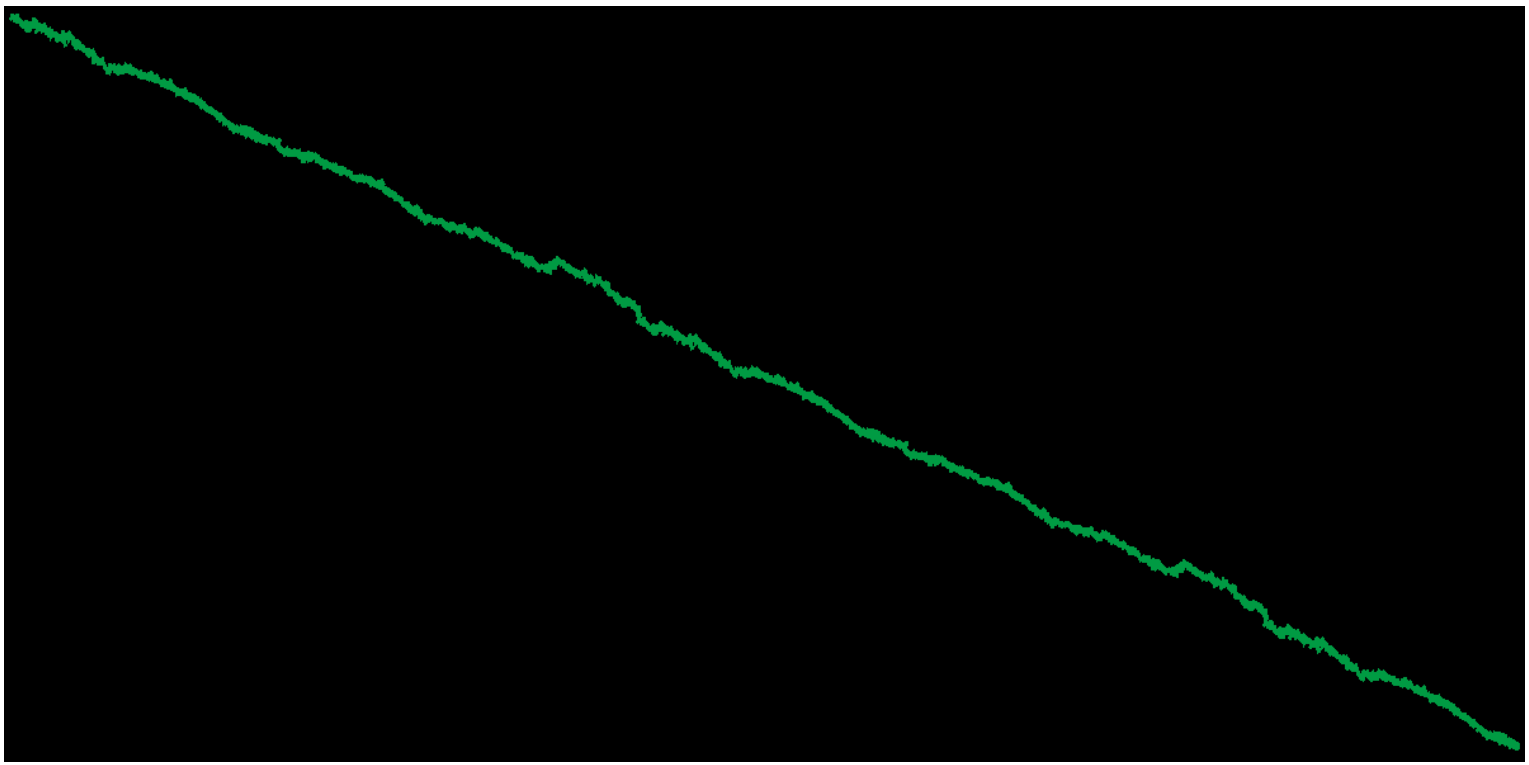
Relative turmites: Fibonacci spiral (golden ratio squares)



- State 0:
  - At an empty square, write a stroke, move left and go to state 1.
  - At a stroked square, keep the stroke, move left and go to state 1.
- State 1:
  - At an empty square, write a stroke, move right and go to state 1.
  - At a stroked square, remove the stroke, move forward and go to state 0.

Absolute turmites

- A machine that always knows which direction is North, South, West and East.
- Usually not as interesting as relative turmites.
  - We can create a more simple but equivalent Turing machine.
- An example: Stephen Wolfram's 4-state absolute turmite (shown after 5 million steps).
  - Has a period of roughly 2 million steps.



'The Busy Beaver' game for turmites

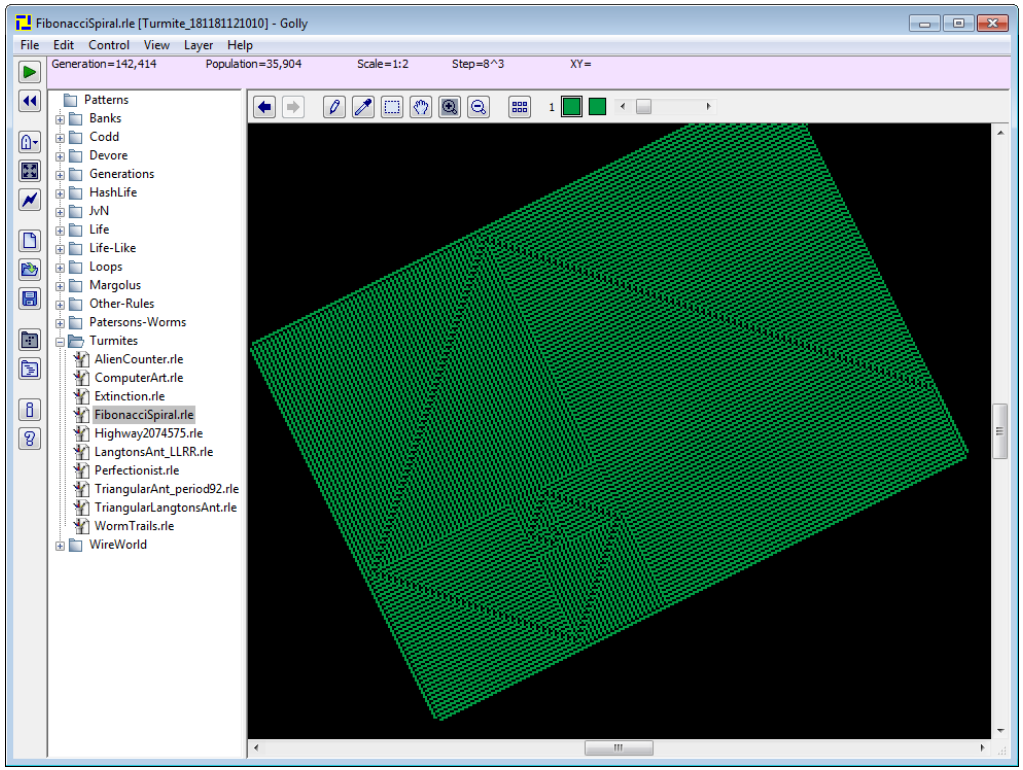
- Trying to find which turmite runs longest before it becomes predictable.
- The table below shows the maximum number of steps found using n-state and m-color.

	2-color	3-color	4-color	5-color
1-state	9,977	67,620,060	6.65×10^9	2.17×10^{11}
2-state	9.53×10^{12}	1.9×10^{61}	???	???

- The only proved machine to be the best is the 1-state, 2-color machine (which is Langtom's ant).

Golly

- Golly (`http://golly.sourceforge.net/`) is an open source application I used to simulate turmites.
- Can also be used for Conway's Game of Life and other simulations on a grid of cells.
- Requires Python.



Golly

Some instructions if you want to try simulating turmites in Golly:

1. In Golly go to: **File** $\rightarrow$ **Run Script...** $\rightarrow$ **Scripts** **Python** **Rule-Generators**
2. Choose `Turmite-gen.py` for relative turmite and `AbsoluteTurmite-gen.py` for absolute turmites.
3. Enter a machine encoded to the form: $\{\{\{a, b, c\}, ...\}, ...\}$ where a is the new colour, b is the movement (1=forward, 2=right, 4=u-turn and 8=left) and c is the new state.

Example of machines:

- Langtom's ant (relative): $\{\{\{1, 2, 0\}, \{0, 8, 0\}\}\}$
- Fibonacci's spiral (relative): $\{\{\{1, 8, 1\}, \{1, 8, 1\}\}, \{\{1, 2, 1\}, \{0, 1, 0\}\}\}$
- Stephen Wolfram's 4-state 2-color (absolute): $\{\{\{1, \text{'N'}, 1\}, \{0, \text{'S'}, 1\}\}, \{\{1, \text{'S'}, 3\}, \{0, \text{'N'}, 2\}\}, \{\{1, \text{'W'}, 0\}, \{1, \text{'N'}, 1\}\}, \{\{1, \text{'S'}, 2\}, \{0, \text{'E'}, 1\}\}\}$

Further read

- 'Turmite' on the English Wikipedia:
  `http://en.wikipedia.org/wiki/Turmite`
- 'Turmite' on WolframMathworld:
  `http://mathworld.wolfram.com/Turmite.html`
- Busy Beaver Turmite Challenge
  `https://code.google.com/p/ruletablerepository/wiki/EdPeggsBusyBeaverTurmiteChallenge`