

Langton's Ant

Author: Michael Colebrook

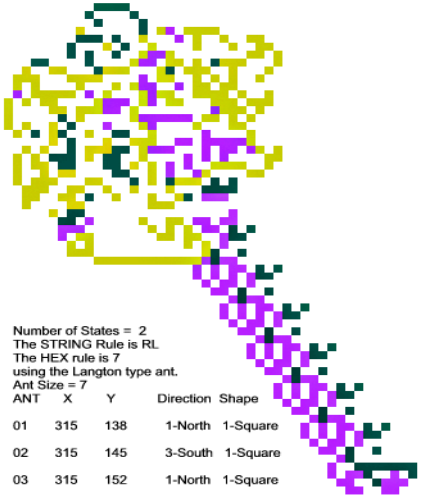
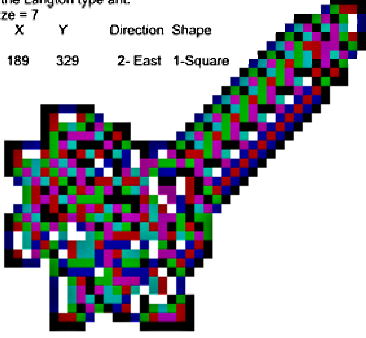
A good example of how a simple and totally determined system can produce both chaos and order is provided by an algorithm devised by Christopher Langton which has become generally known as Langton's Ant. This is one of the simplest forms of a class of dynamical systems known as cellular automata. Basically these consist of a grid of squares which either do or do not change colour according to a set of rules.

<p>Imagine an ant walking on a large grid of squares. Initially all the squares are white. Whenever the ant walks onto a white square it turns green and the ant turns left. Whenever the ant walks onto a green square it turns white and the ant turns right.</p>	
<p>The ant walks and walks and for about 10,000 moves it meanders around and creates this apparently chaotic pattern.</p>	
<p>Then the ant starts walking in a complex closed loop of 104 moves. Each loop creates a step along this 'highway'.</p>	

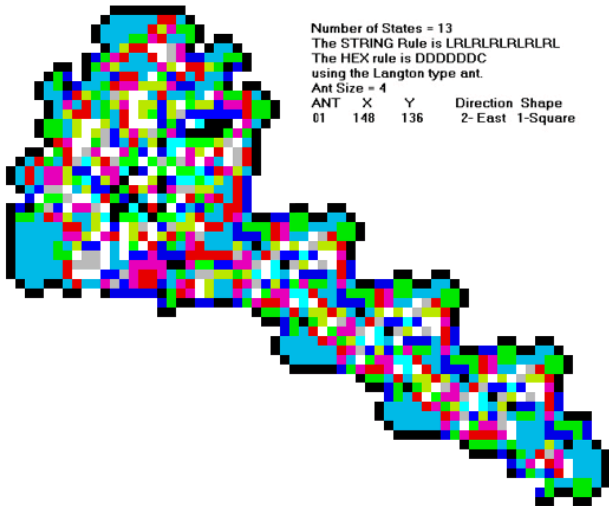
If you want to see the ant do its stuff you can run a Java programme available at [UBC](#). You may have to be patient, on my computer it takes over 20 minutes for the ant to start building the 'highway'.

Alternatively you can download a windows programme available as: [Langton.zip](#). This programme allows you to play more complex games with the ant using more colours and different sequences of lefts and rights. It is also possible to have more than one ant walking at the same time.

The data included in each of the following examples are the initial state files produced by the above programme.

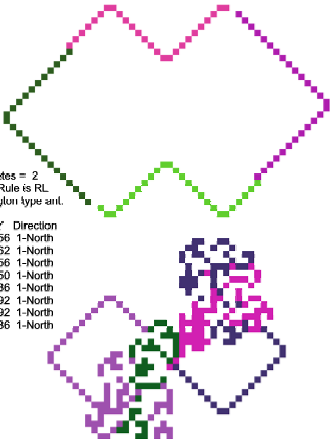
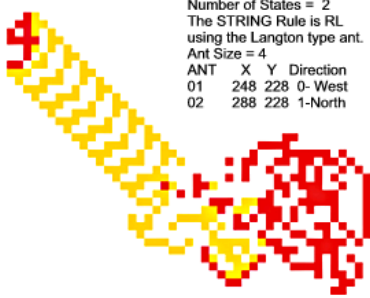
<p>The initial state involves three ants walking the simple right/left pattern and starting from adjacent squares. The highway is produced by the co-operative efforts of two of the ants.</p>	<p>In this run the ant follows a more complex sequence of lefts and rights and creates a more complex highway</p>																														
 <p>Number of States = 2 The STRING Rule is RL The HEX rule is 7 using the Langton type ant. Ant Size = 7</p> <table border="1"> <thead> <tr> <th>ANT</th> <th>X</th> <th>Y</th> <th>Direction</th> <th>Shape</th> </tr> </thead> <tbody> <tr> <td>01</td> <td>315</td> <td>138</td> <td>1-North</td> <td>1-Square</td> </tr> <tr> <td>02</td> <td>315</td> <td>145</td> <td>3-South</td> <td>1-Square</td> </tr> <tr> <td>03</td> <td>315</td> <td>152</td> <td>1-North</td> <td>1-Square</td> </tr> </tbody> </table>	ANT	X	Y	Direction	Shape	01	315	138	1-North	1-Square	02	315	145	3-South	1-Square	03	315	152	1-North	1-Square	 <p>Number of States = 7 The STRING Rule is LLLRRRL The HEX rule is FD5C using the Langton type ant. Ant Size = 7</p> <table border="1"> <thead> <tr> <th>ANT</th> <th>X</th> <th>Y</th> <th>Direction</th> <th>Shape</th> </tr> </thead> <tbody> <tr> <td>01</td> <td>189</td> <td>329</td> <td>2-East</td> <td>1-Square</td> </tr> </tbody> </table>	ANT	X	Y	Direction	Shape	01	189	329	2-East	1-Square
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This run involves a single ant walking a complex right/left sequence. The ant walks a chaotic path for about 4500 moves. It then creates a complex highway looking rather like a stair. Each step of the stair requires over 800 moves. This is the most complex highway I have found so far.



Number of States = 13
The STRING Rule is LRLRLRLRLRL
The HEX rule is DDDDDC
using the Langton type ant.
Ant Size = 4

ANT	X	Y	Direction	Shape
01	148	136	2-East	1-Square

<p>These runs differ only in that one of the elements is displaced by a single grid square.</p>	<p>This run performs an endless loop of 7200 steps, including the building and destruction of a highway.</p>
 <pre> Number of States = 2 The STRING Rule is RL using the Langton type ant. Ant Size = 6 ANT X Y Direction 01 222 156 1-North 02 222 162 1-North 03 330 156 1-North 04 330 150 1-North 05 222 386 1-North 06 222 392 1-North 07 330 392 1-North 08 330 386 1-North </pre>	 <pre> Number of States = 2 The STRING Rule is RL using the Langton type ant. Ant Size = 4 ANT X Y Direction 01 248 228 0-West 02 288 228 1-North </pre>

It is quite impossible to convey the richness of the almost endless possibilities inherent in the rules governing Langton's Ant. It is possible to play for hours and still be surprised. The significance of Langton's Ant is that it is a completely determined system, with relatively simple rules, but also with an almost infinite number of possible outcomes. Most of these are chaotic, some are ordered, and some contain elements of both order and chaos, as in the above examples.

There is no general analytical method of predicting the position of the ant after any given number of moves. The only way of finding out how any ant or combination of ants behaves and that is to let the ant or ants run. In spite of being constrained by relatively simple rules, Langton's Ant exhibits a measure of autonomy. Its behaviour cannot be reduced to the rules that govern it.

Ian Stewart and Jack Cohen (*Figments of Reality*, CUP, 1997) use Langton's Ant as an analogue representing an essential stage in the evolution of complex systems such as life: a stage in which the existence of chaotic behaviour contains the potential for the spontaneous emergence of unpredictable forms of order. The chaotic state provides the basis for the exploration of almost endless possibilities and is thus a significant feature in creative freedom.

A good web site for finding out more about Langton's Ant is:

<http://www.math.sunysb.edu/~scott/ants/>