Investigating Chaos in Schelling's Model

Alex Ledger

Reed College

aledger@reed.edu

April 23, 2015

Overview

Goal

- Big question: Is society "chaotic"?
- Methodology: Investigate a system that simplifies social relations.
- See if "chaos" arises in this simpler model.

What is chaos?

Three major ways to think about chaos:

1. Sensitivity to initial conditions
   - 1.1 Aka the "butterfly effect"
   - 1.2 If the initial conditions are changed by a marginal amount, how much does that change the output?
   - 1.3 e.g. Game of Life: changing one cell in Game of Life can dramatically change the output; hence GoL is chaotic.
   - 1.4 e.g. Weather: a slight difference in pressure can lead to dramatically different weather patterns.
2. Boundedness
   - 2.1 i.e. agents move off into infinitude
   - 2.2 Aaron's presentation of Game of Life gave some example.
   - 2.3 Essentially, the settings to game of life were such that it was easy to birth cells and hard to kill cells, so more and more cells became alive. Cells quickly went off into infinitude.
3. Unpredictability
   - 3.1 More similar to weak emergence than chaos, but still applicable.
   - 3.2 Applicable because unpredictability implies that there is no

Does society exhibit chaos?

1. Sensitivity to initial conditions
   - 1.1 Depends on what condition you change.
   - 1.2 Example 1:
     - 1.2.1 If in one world a baby dies and another the same baby lives, how different are the world?
     - 1.2.2 No idea. Classic argument: what is that baby is Einstein?
     - 1.2.3 However, most likely no major effect.
2. Boundedness
   - 2.1 Seems like the answer depends on your scope.
   - 2.2 Example 1: A big society - The World.
     - 2.2.1 Our population is growing exponentially
     - 2.2.2 We are using more and more resources. Likely to eventually go to Space.
   - 2.3 Example 2: A smaller society - Reed College
     - 2.3.1 Reed College is a local ecosystem of social relations.
     - 2.3.2 And it hasn't outgrown its bounds yet.
     - 2.3.3 I would say the Reed college ecosystem is bounded.
   - 2.4 Worthwhile to ask: what are the key differences between Reed College and all of Mankind that explain the differences in boundedness?

When, why and how does society exhibit Chaos?

When, why and how does society exhibit Chaos?

The Model

1. I thought the best model to use to address the chaos question is Schelling's model.
2. Schelling's Model and my implementation:
   - 2.1 Two types of people located on an *ntimesn* board (think chessboard).
   - 2.2 Each type of person has a preference for who they like to live by.
   - 2.3 If a person's preferences are not met, then they are unhappy.
   - 2.4 During each iteration of the model, one unhappy person is randomly selected.
   - 2.5 Then that person moves to a random, empty space such that they are happy.

Justification for Using Schelling's Model

1. Schelling's model is a simplification of many social relations.
2. Schelling's model obvious misses a lot of important aspects of social relations, but for the most part those are beside the point.
3. If Schelling's model under realistic parameters does *not* exhibit chaotic behavior, then
   - 3.1 Society is not chaotic
   - 3.2 Society is chaotic
     - 3.2.1 since Schelling's model is a simplification of reality, reality may also be chaotic in the same way.
   - 3.3 Schelling's Model does not sufficiently model society and we can make no claim about whether society is chaotic.
4. Conversely, if Schelling's model under realistic parameters does exhibit chaotic behavior, then there are three possibilities
   - 4.1 Society is chaotic, but the chaos stems from phenomena that Schelling's model is not capturing.
   - 4.2 Society is not chaotic
   - 4.3 Schelling's Model does not sufficiently model society and we can make no claim about whether society is chaotic.

Overview of the Tests

1. Sensitivity to inital conditions
   - 1.1 Computed Lyapunov's Exponent
2. Boundedness
   - 2.1 Idea: initialize to a 20×20 board but only place people in the middle 8×8 square. Do the people move outward to the edge of the 20×20 board?
     - 2.1.1 Given the model that I gave earlier, of course they do!
     - 2.1.2 The people move the random empty spaces.
   - 2.2 Change model such that people only move within their "vision"
   - 2.3 I.e. people have a radius that use to calculate the composotion of their neighbors, and they have a radius that if they are unhappy, they move a random empty square inside of that radius
   - 2.4 Actually makes the model more realistic, because it's unlikely that people move long, random distances when unhappy; they would be more likely to stay as close as possible while still being happy.
   - 2.5
3. Predictability
   - 3.1 Can a machine learning algorithm predict the behavior of the