



CSCI 101

Connecting with Computer Science

Lecture 4: Applications of CS II



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2023 Fall Semester (S3)

Overview

- Focus: Computing Science in Production
- Architecture: von Neumann
- Readings: 6, 7
- Core Ideas:
 1. CS in Research

The Digital Revolution



Education



Transport



Manufacture



Entertainment



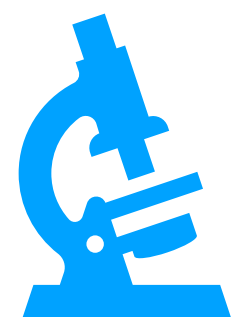
Food



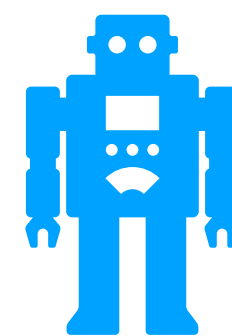
Fashion



Medicine

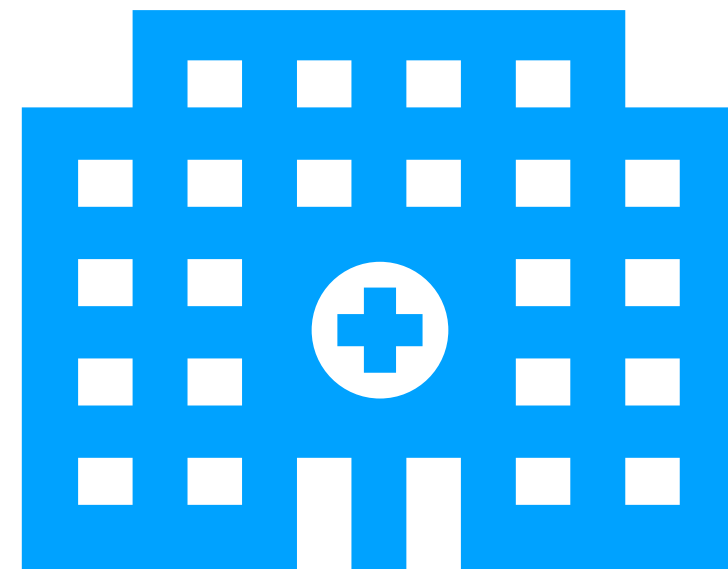


Research

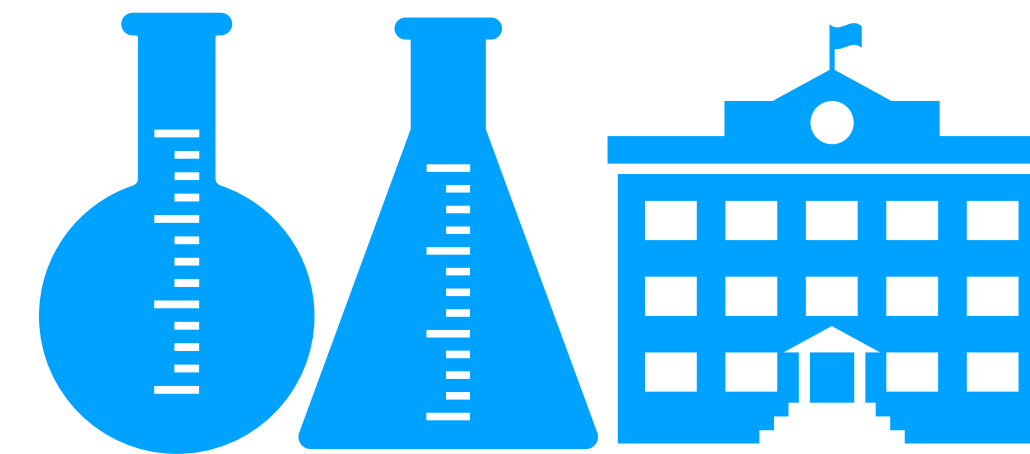


Robotics

Bioinformatics



Hospitals
Patient Oriented



Universities and Labs
Knowledge Oriented

- Digitisation of Patient Records
database optimisation
- Computer analysis of Individual
Examination Reports
- Quantitative Analysis
including HGP
- Study biology, develop new
treatments

CS in Research

How CS is changing the way research is done

What is unique to CS Methods?



- Analyse large quantities of data in short periods of time
 - Discover correlations between parameters and output
- Computer Assisted Proofs
- Physical simulations of Models
- Other theories related to Computers

Science: Computer-assisted proofs

P1

CS in Research

- The Technology of using computer software to prove mathematical statements: mostly using proofs-by-exhaustion
- Proofs-by-exhaustion: also proof by cases, enumerate all possible cases, and perform verification one-by-one
- e.g. Prove that there are 168 prime numbers in $[1, 1000]$
The computer would enumerate all numbers from 1 to 1000, and test each one's primeness

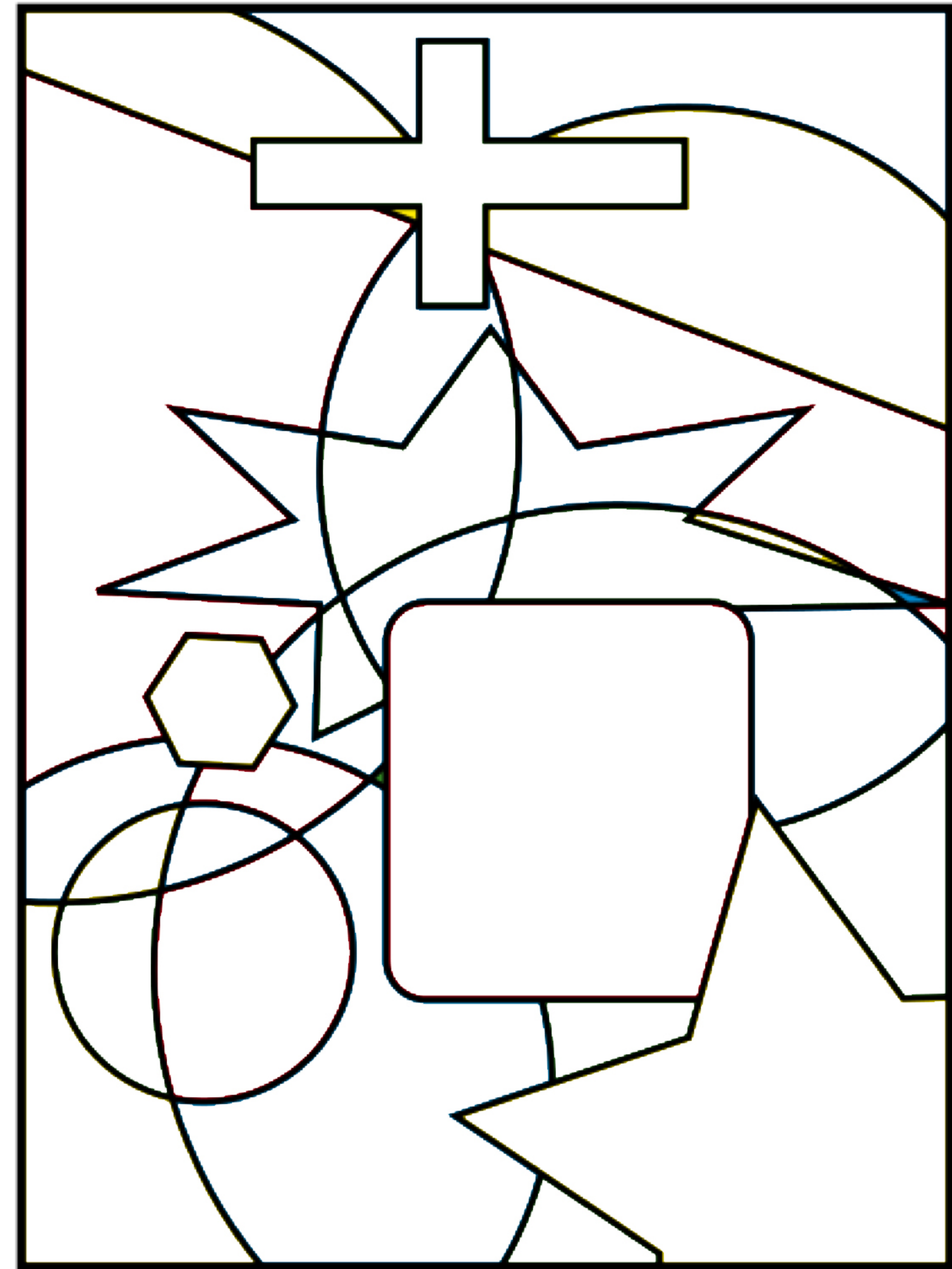
Technical

Science: Computer-assisted proofs

P1

CS in Research

- Consider this a map for countries, you want to colour it so that adjacent countries have different colours



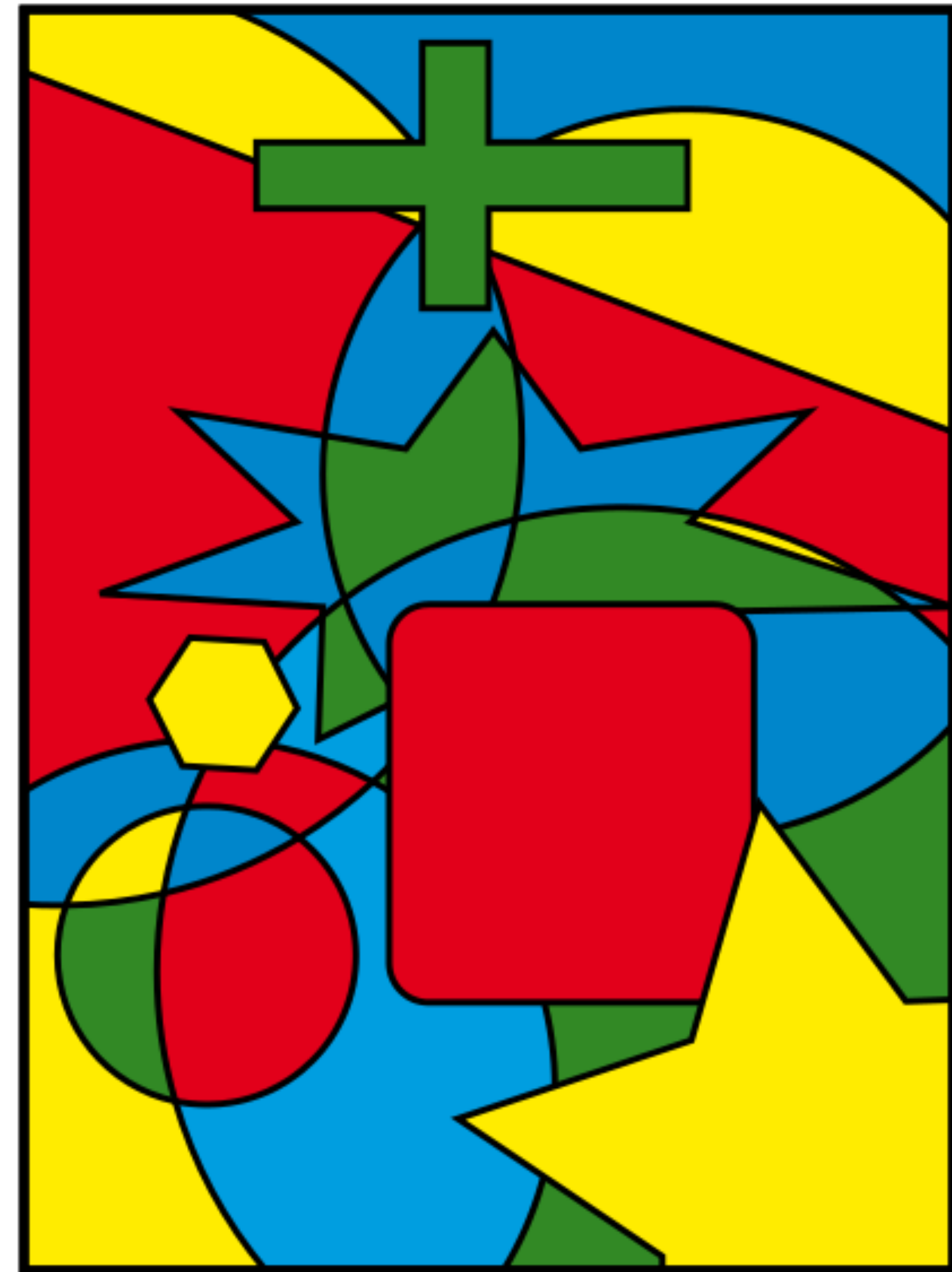
Technical

Science: Computer-assisted proofs

P1

CS in Research

- Four colour theorem
 - given any separation of a plane into contiguous regions, **no more than four colours** are required to colour the regions so that **no two adjacent regions have the same colour.**
- In 1970s, mathematicians proved this using computer-assisted proofs



Technical

Applied Science: Physical Simulations

- 1976: DYNA3D, a programme for simulating car crash
 - Used by the US car manufacturers and regulators to design and test cars
 - Nowadays all car designs are simulated before even a prototype is built!

1. https://www.youtube.com/watch?v=zssG3n19_yE

Social Science: Quantitative Analysis

- There's a lot of theories discovered using computers, we are going to discuss 2 interesting ones
 - Chaos Theory
 - Social Hubs

Social Science: Chaos Theory

- A Chaos system
 - Dynamic system highly sensitive to small differences in their initial conditions and also to rounding errors in numerical computation.
 - E.g. 1972 Edward Lorenz: "Predictability: Does the Flap of a Butterfly's Wings in Brazil Set a Tornado in Texas?"
 - How difficult is it to discover the simple truth in life?

Technical

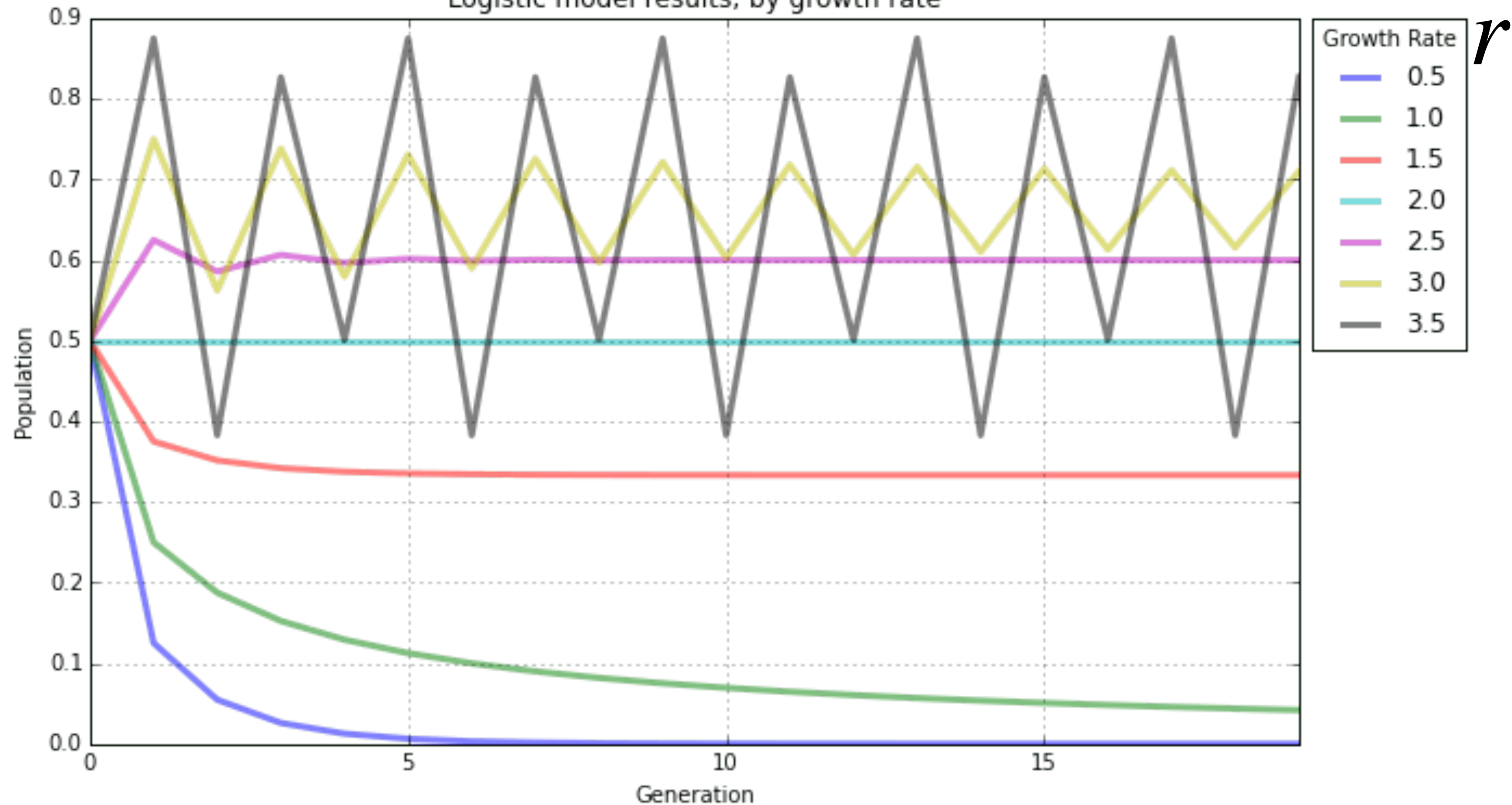
Social Science: Chaos Theory

- Chaos Logistic Map
 - $x_{t+1} = rx_t(1 - x_t)$
 - Initial condition: $x_0 = 0.5$
 - r here is called the growth rate

Social Science: Chaos Theory

$$x_{t+1} = rx_t(1 - x_t)$$

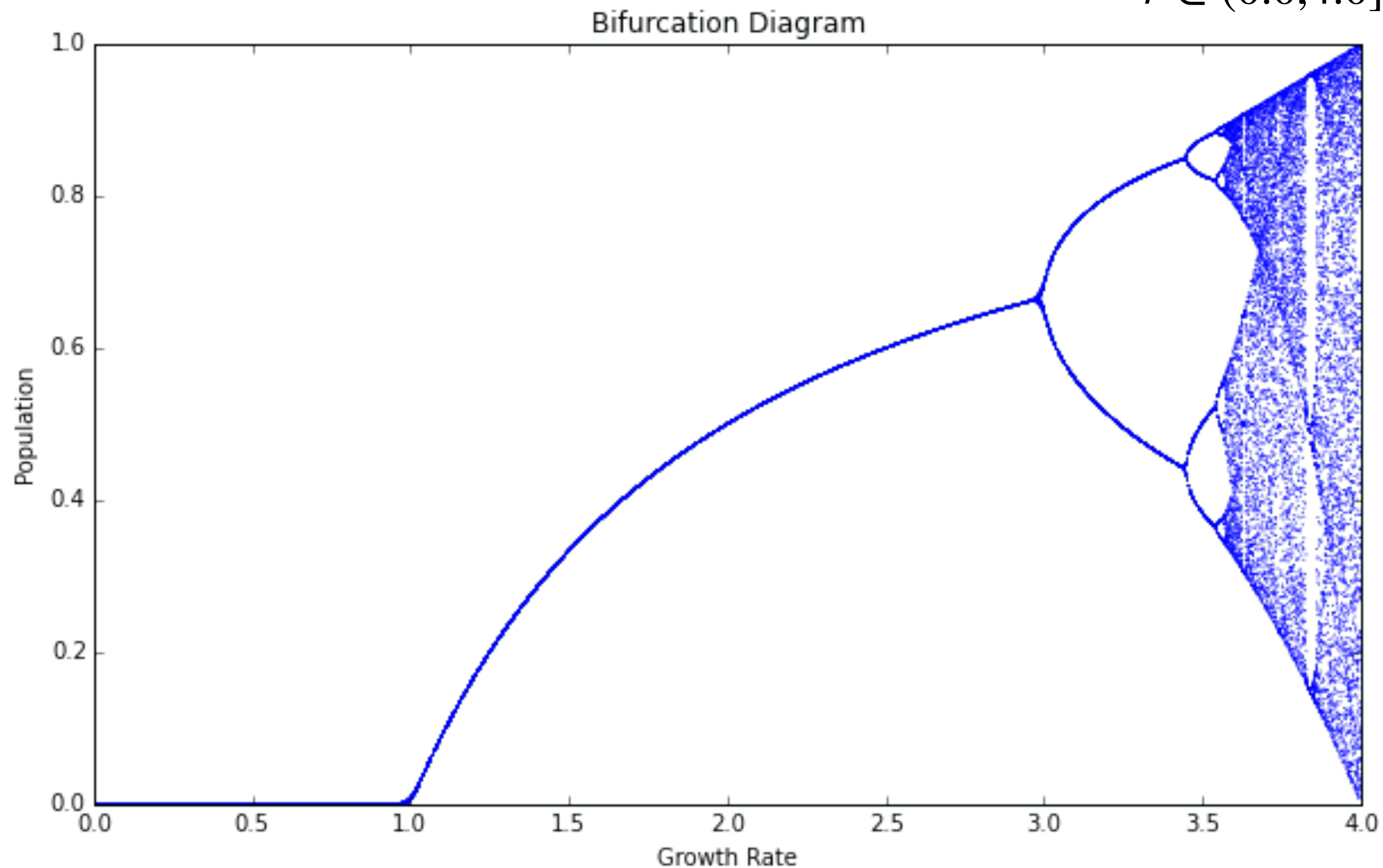
Logistic model results, by growth rate



Social Science: Chaos Theory

$$x_{t+1} = rx_t(1 - x_t)$$

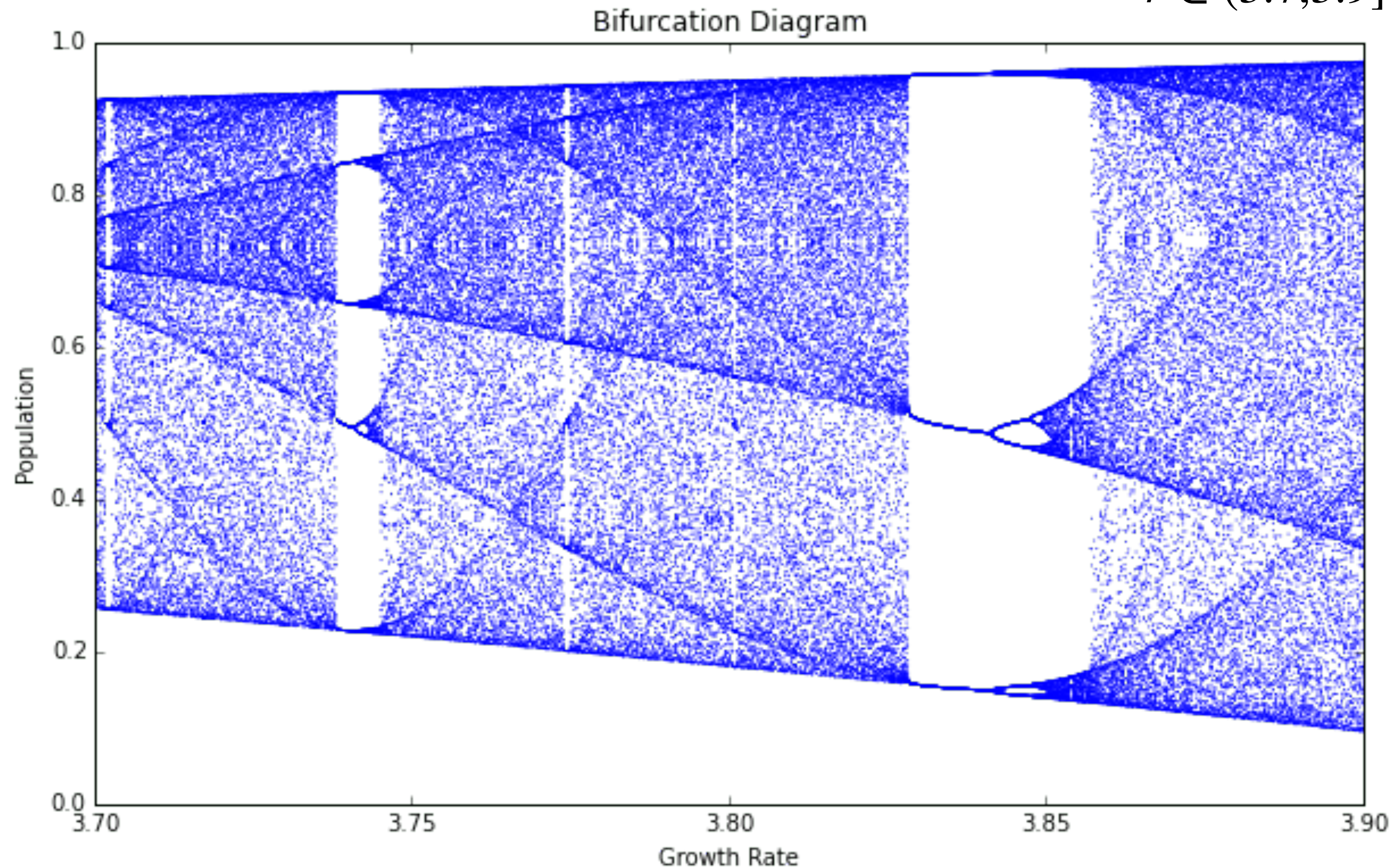
200 Generations, 100 values for
 $r \in (0.0, 4.0]$



Social Science: Chaos Theory

$$x_{t+1} = rx_t(1 - x_t)$$

200 Generations, 100 values for
 $r \in (3.7, 3.9]$

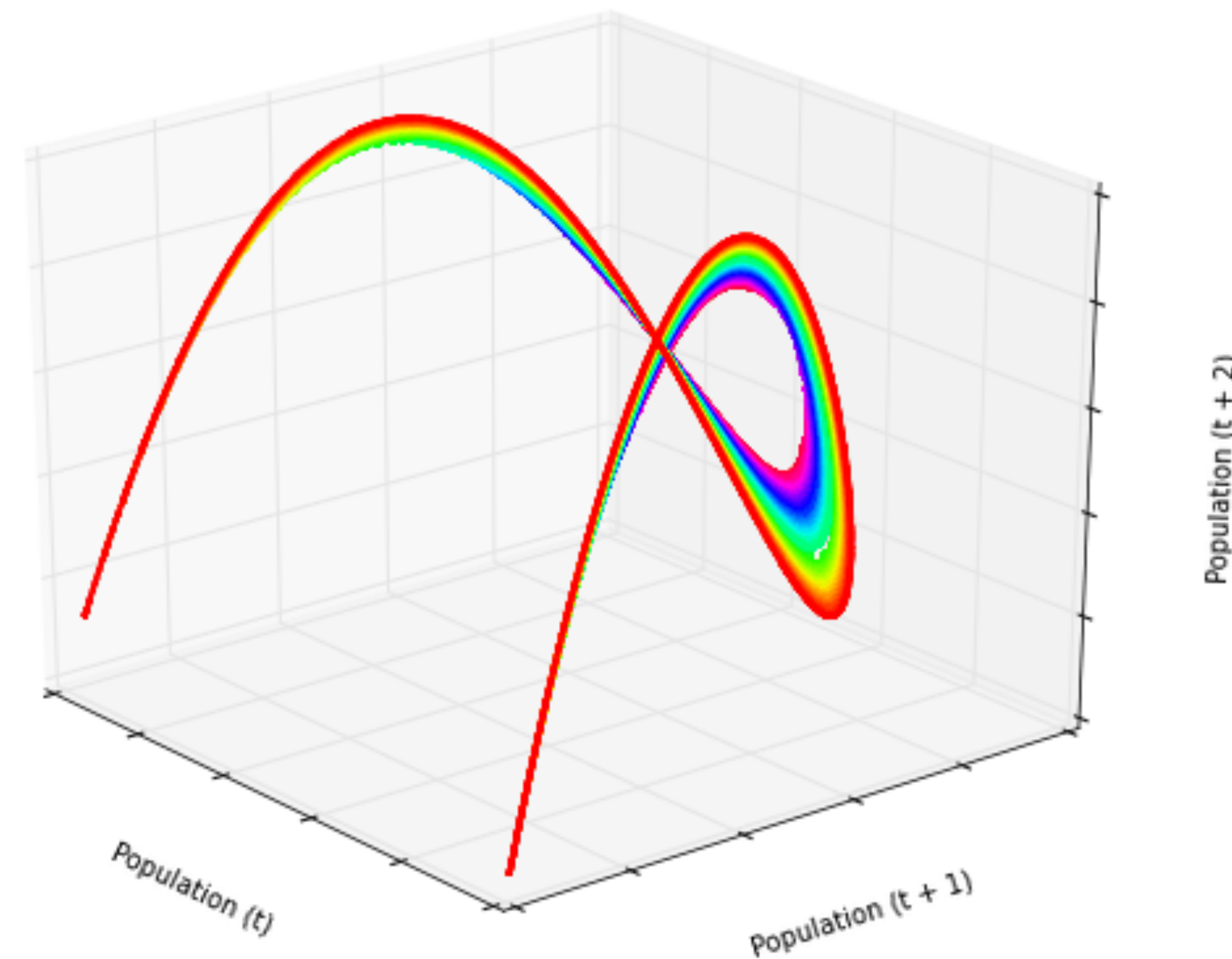


Social Science: Chaos Theory

$$x_{t+1} = rx_t(1 - x_t)$$

3 dimensional projection

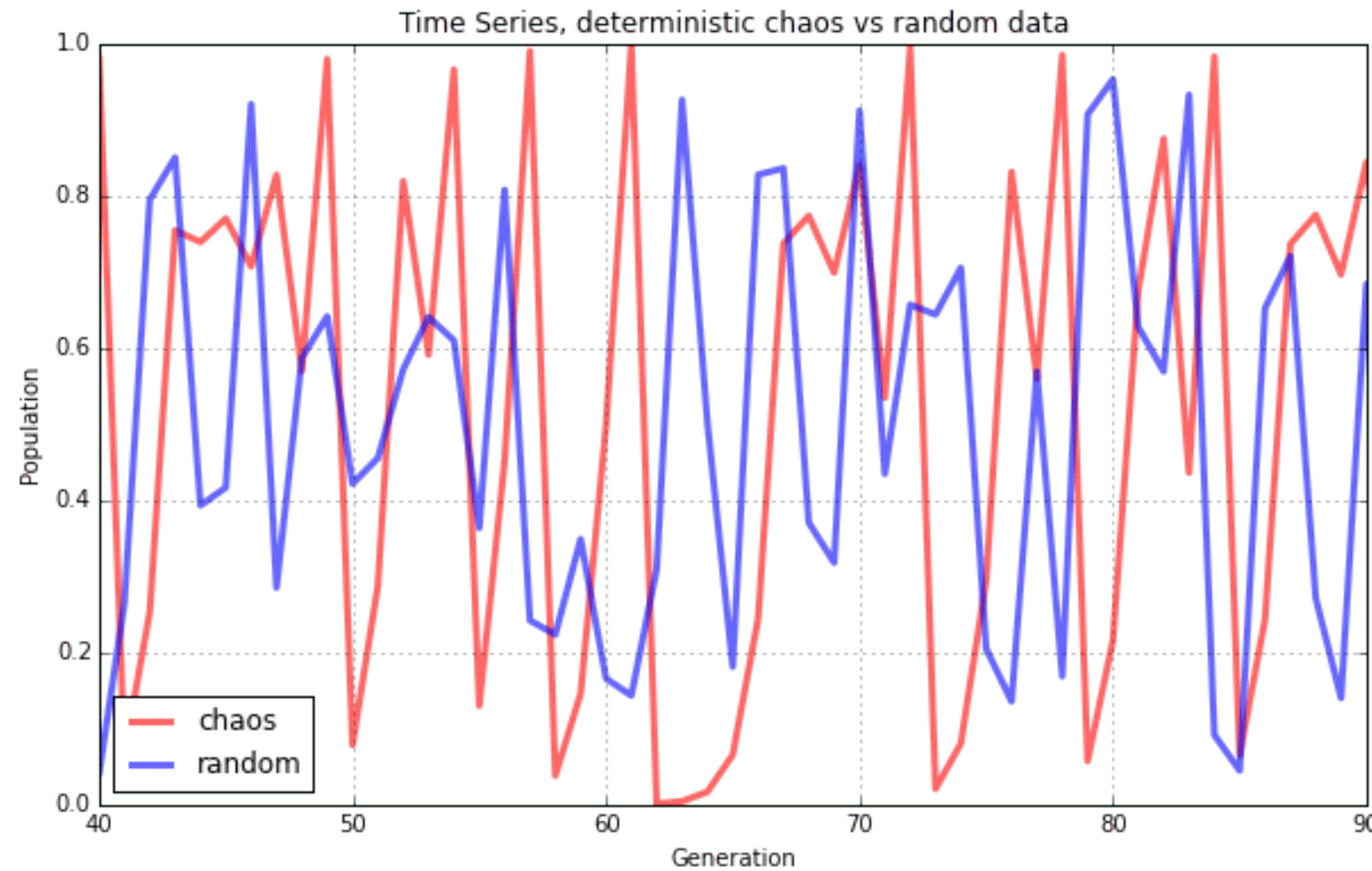
Logistic Map, $r=3.6$ to $r=4.0$



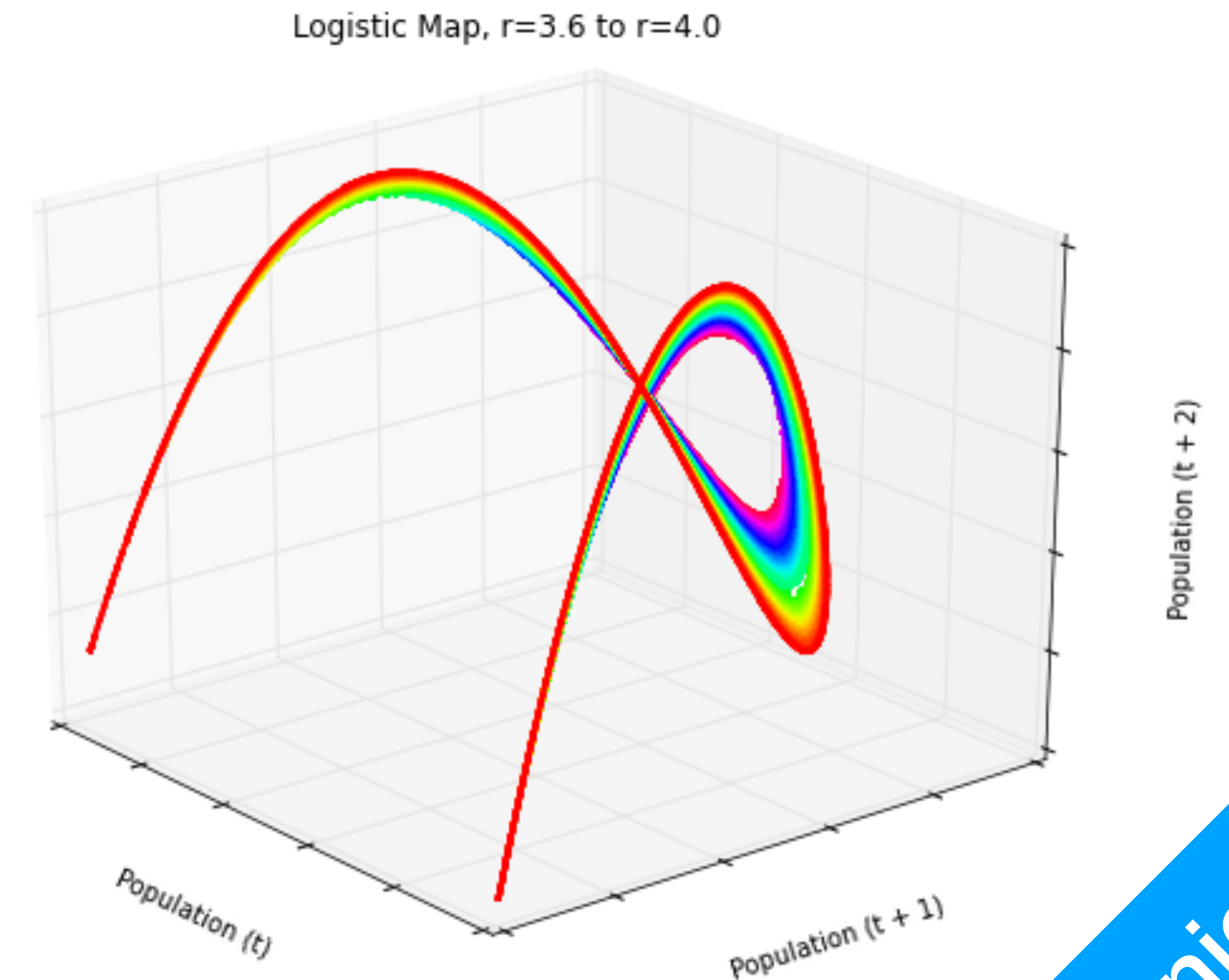
Social Science: Chaos Theory

$$x_{t+1} = rx_t(1 - x_t)$$

3 dimensional projection

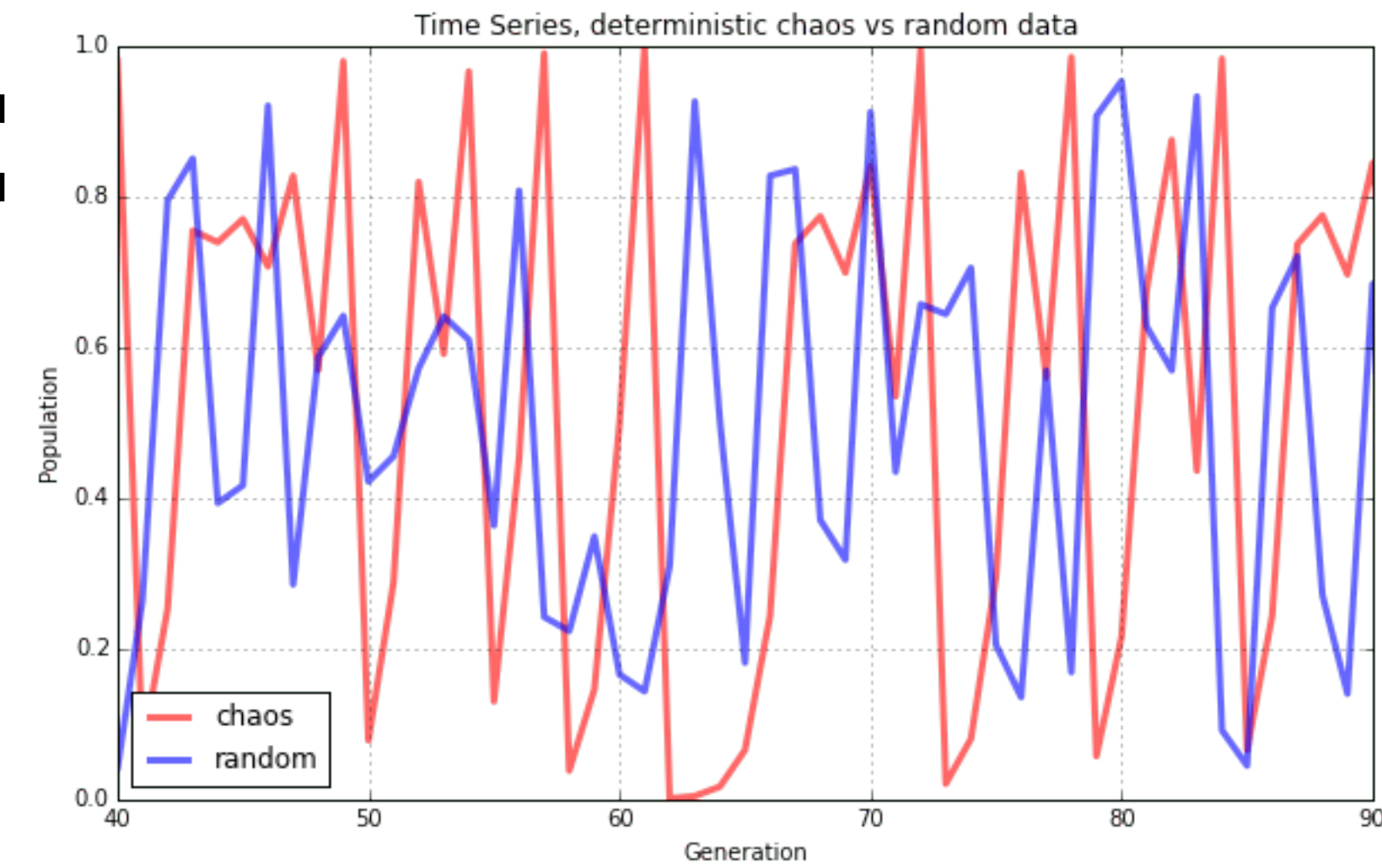


Here the red line is growth rate $r = 3.99$





Technical

Social Science: Chaos Theory



- Chaos Theory
$$x_{t+1} = 3.99x_t(1 - x_t)$$
- Even a seemingly simple equation can generate close to random chaotic outcome
- Social science: even seemingly insignificant events can cause massive effects,
- Another example: climate change and weather forecast, there is NO reliable real world model for such predictions

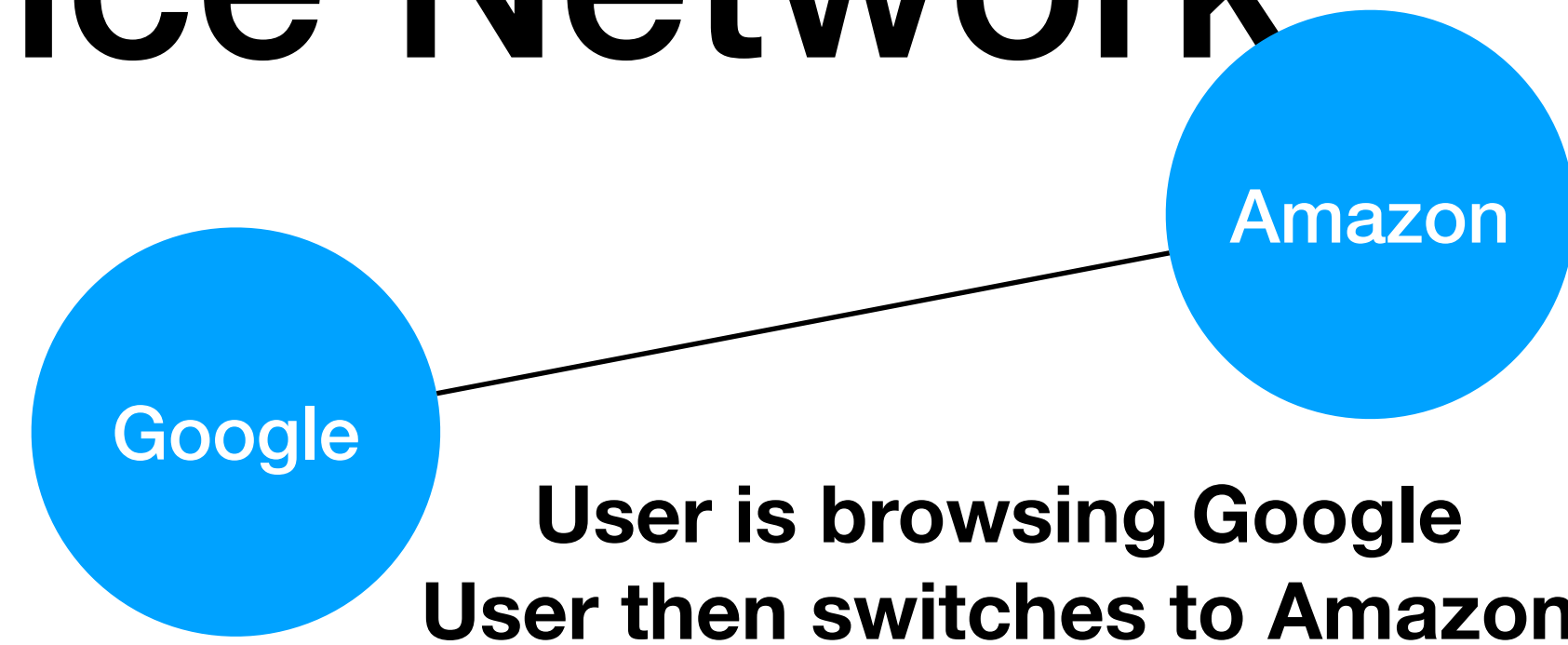
Social Science: Chaos Theory

- Applications?
- **Pseudo-Randomisation** (Computers cannot do actual random numbers)
seed as x_0 , then some function to generate a series of numbers x_i 
- **Cryptography**
modern Public-key encryption method is based on Chaos theory 

Social Science: Quantitative Analysis

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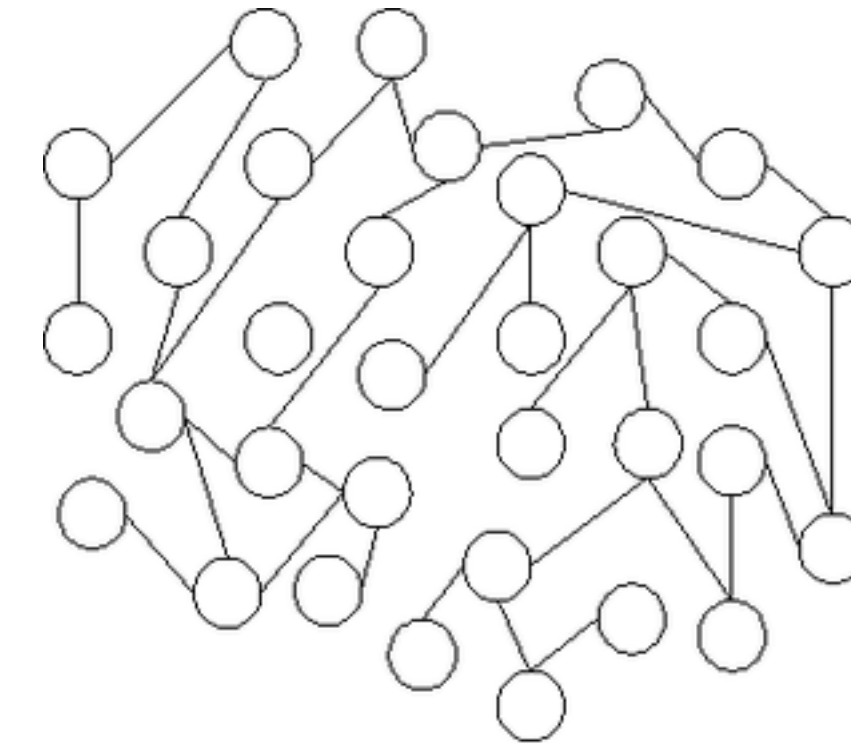
Social Science: Social Influence Network



- Social Network Structure
- Imagine the internet, each website is a node
- A user accessing one website, then switch to another website, will create a link between the two nodes
- What will the network look like?

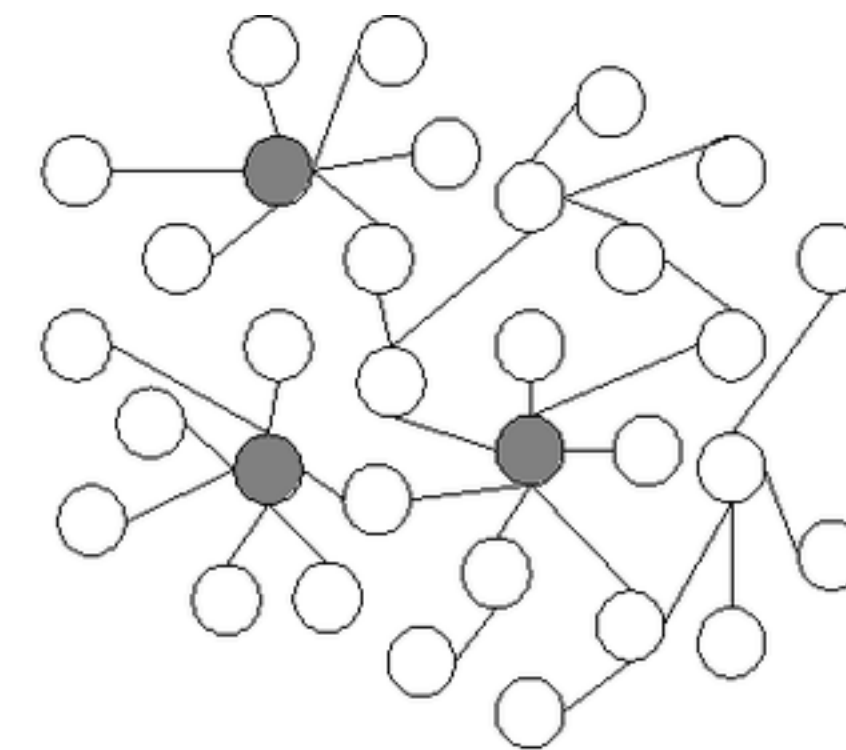
Social Science: Social Influence Network

- Random Network
 - Nodes inside the network have random connections with each other
 - Each node will have statistically similar number of connections



Social Science: Social Influence Network

- Scale-Free Network
 - Hubs: nodes with substantially more connections than others
 - Social Hubs emerges naturally, in fact, it dominates any network



Social Science: Social Influence Network

- Social Hubs
 - The myth: 2% of the population control 98% of the world's wealth
- Internet
 - Netflix + Youtube: 26% of all internet traffic globally, that's almost half of the entire video traffic on the internet

