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CSCI 101
Connecting with Computer Science
Lecture 4: Applications of CS II

Jetic Gū

2020 Fall Semester (S3)

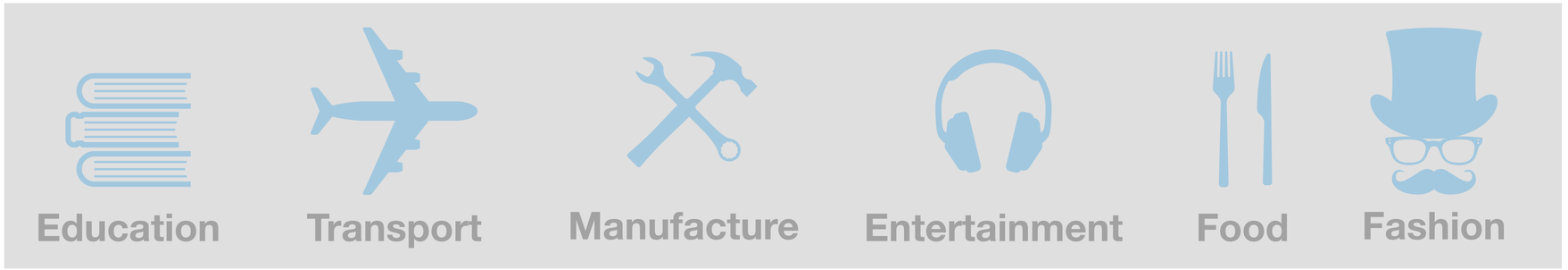
Overview

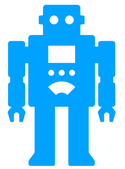
- Focus: Computing Science in Production
- Architecture: von Neumann
- Readings: 6, 7
- Core Ideas:

    1. CS in Research

P0
Review

The Digital Revolution



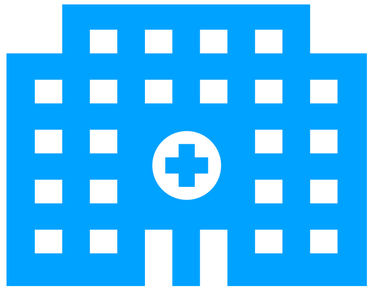


Review

P0
Review

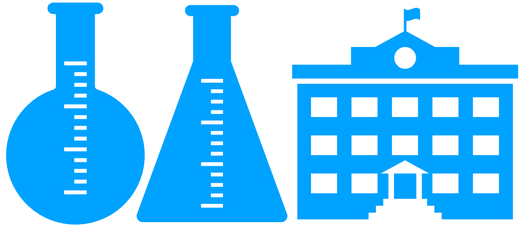
Bioinformatics

Medicine



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

Review

CS in Research

How CS is changing the way research is done

Summary

What is unique to CS Methods?

Research

- Analyse large quantities of data in short periods of time
- Discover correlations between parameters and output
- Automate experimental procedures
- Physical simulations of Models

Concept

P1
CS in Research

Science: Computer-assisted proofs

- 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

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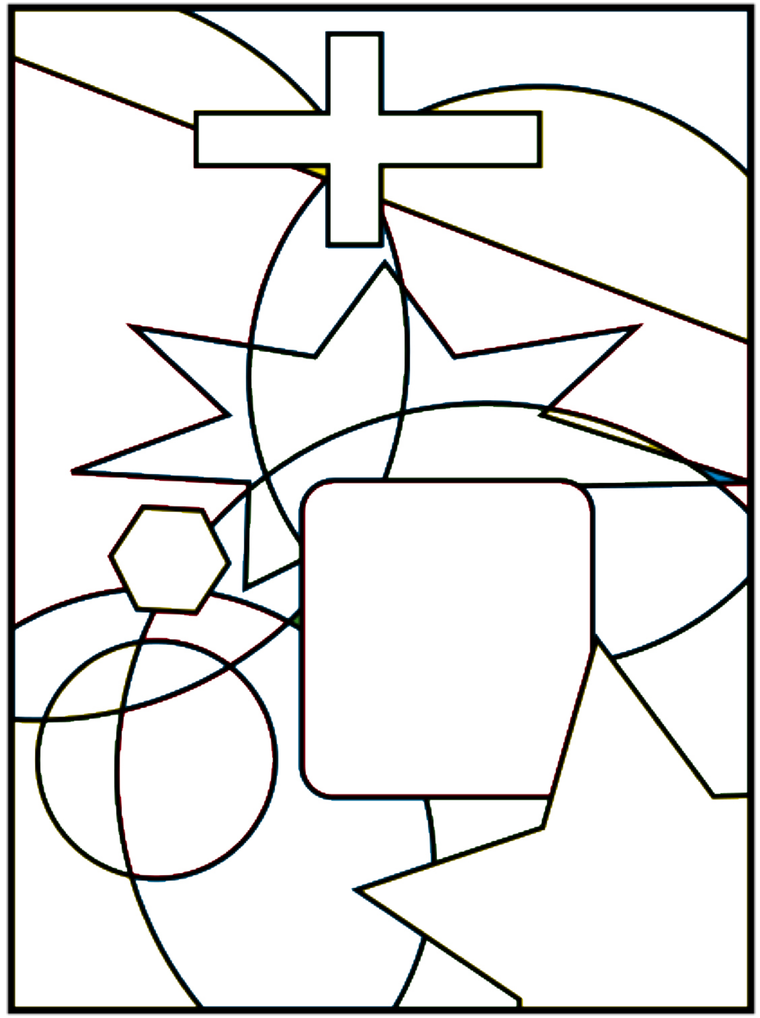
Science: Computer-assisted proofs

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



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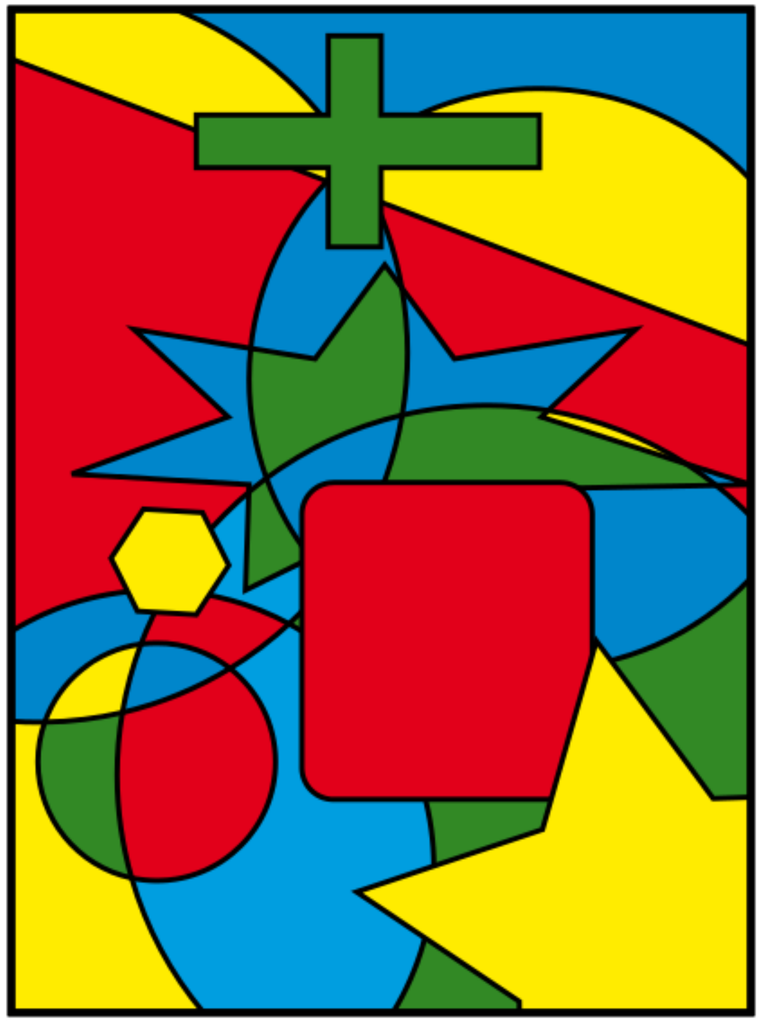
Science: Computer-assisted proofs

- 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



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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!

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

P1
CS in Research

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

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P1
CS in Research

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?

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1. https://geoffboeing.com/2015/03/chaos-theory-logistic-map/

P1
CS in Research

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

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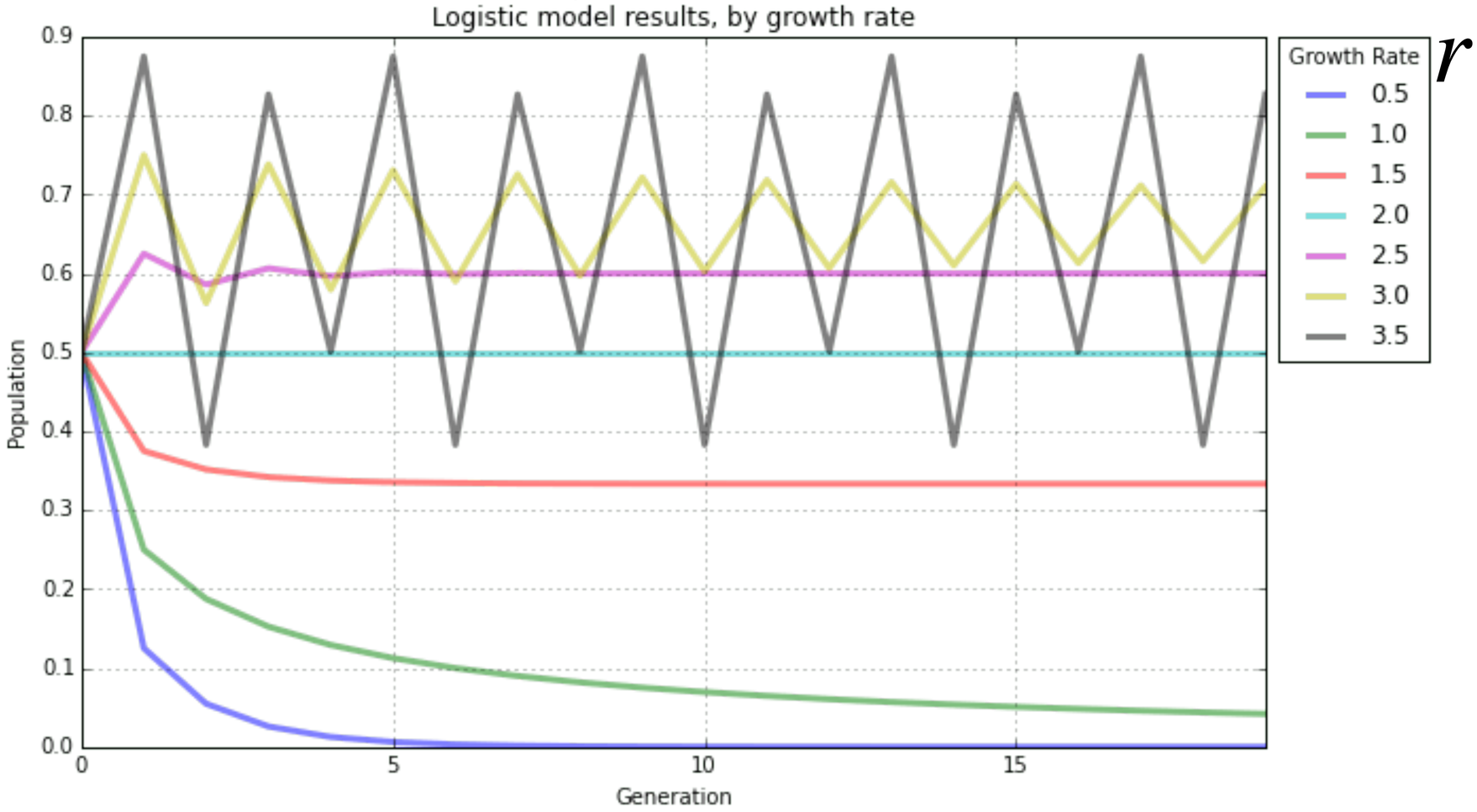
Social Science: Chaos Theory

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



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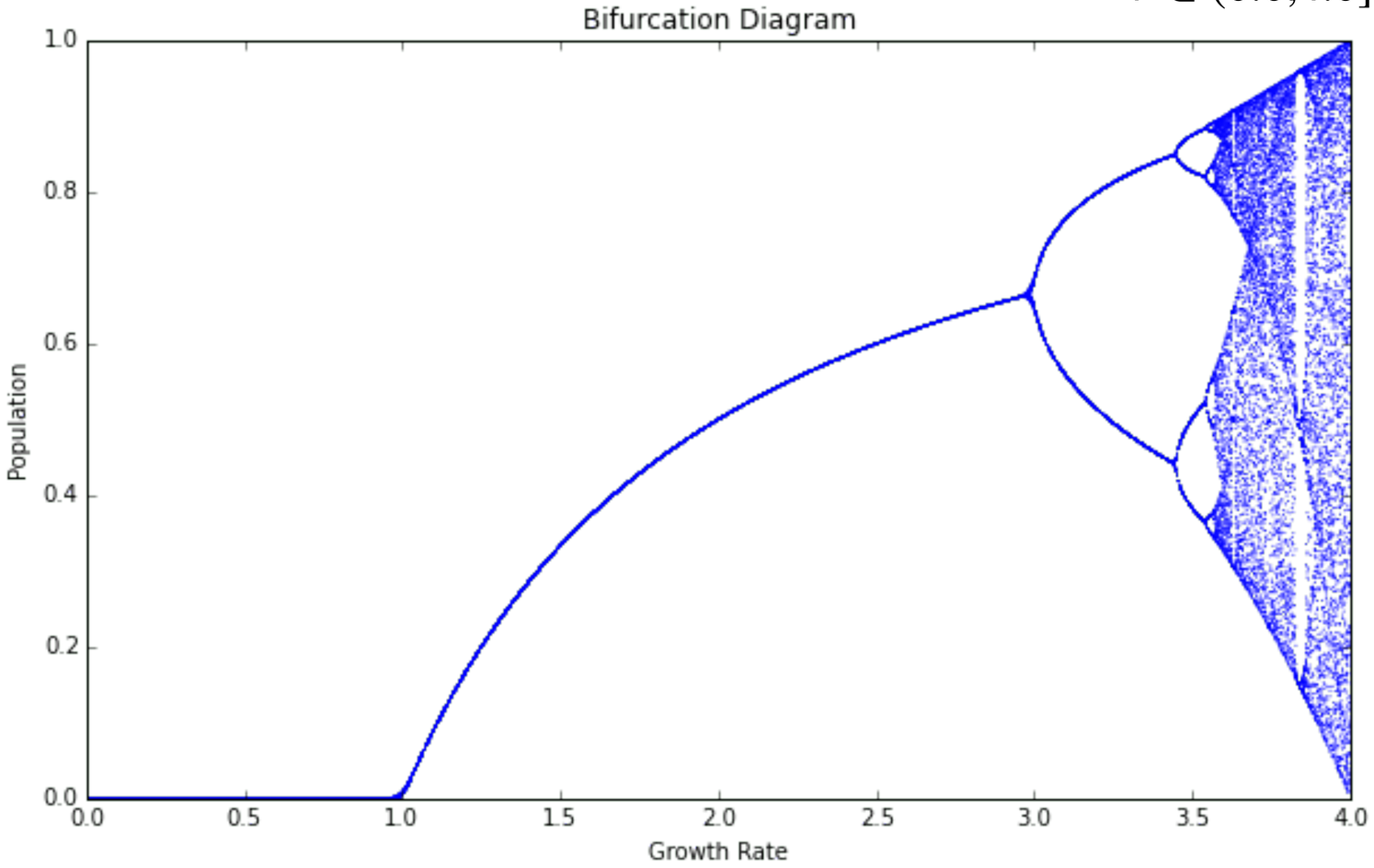
Social Science: Chaos Theory

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

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



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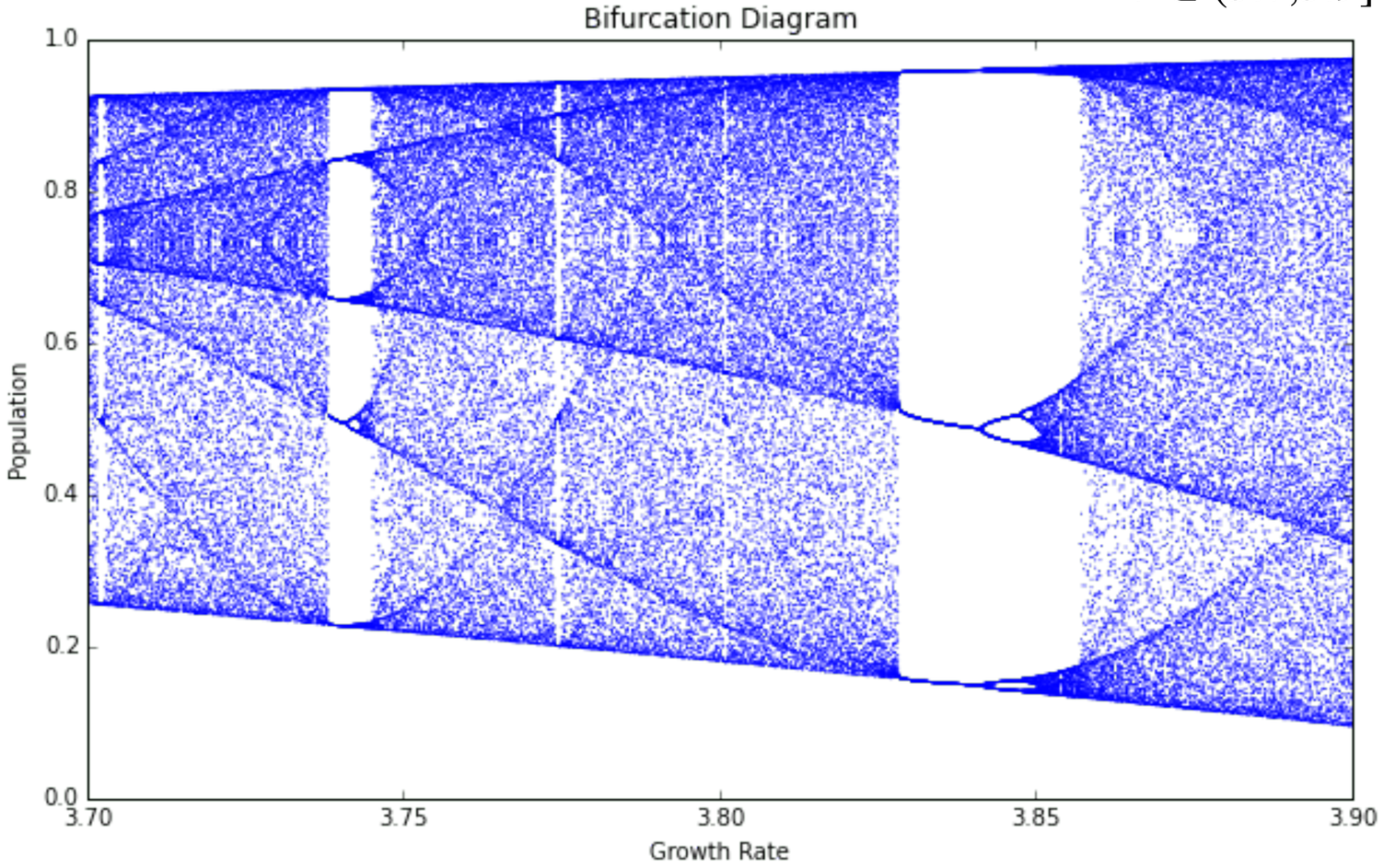
Social Science: Chaos Theory

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

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



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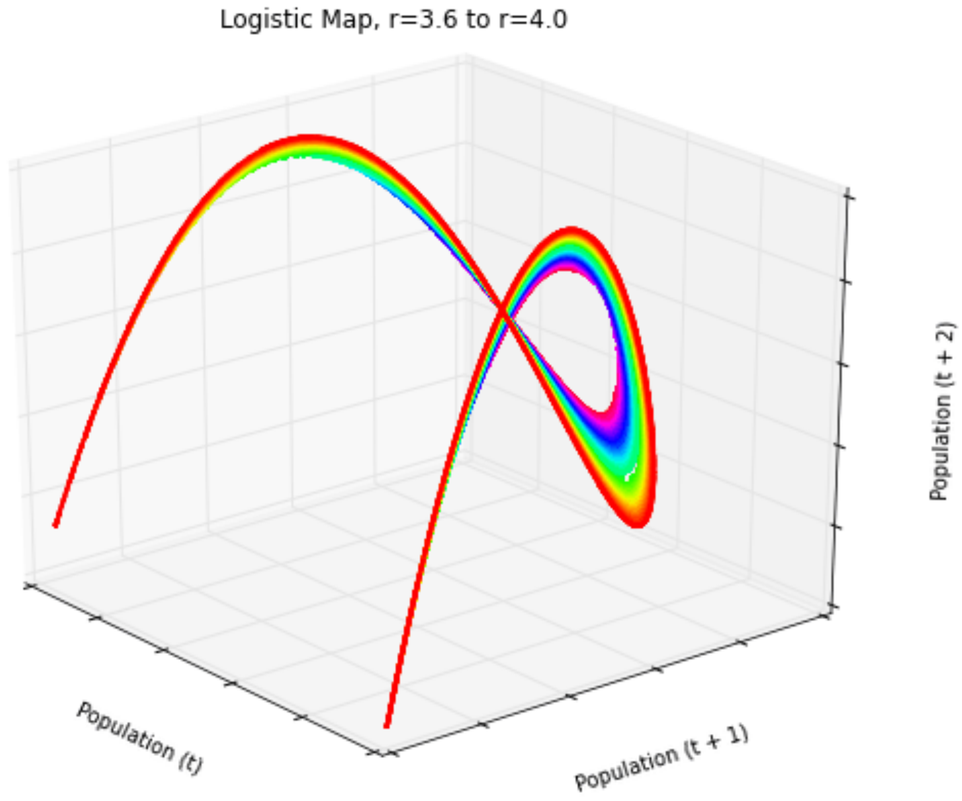
Social Science: Chaos Theory

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

3 dimensional projection



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P1
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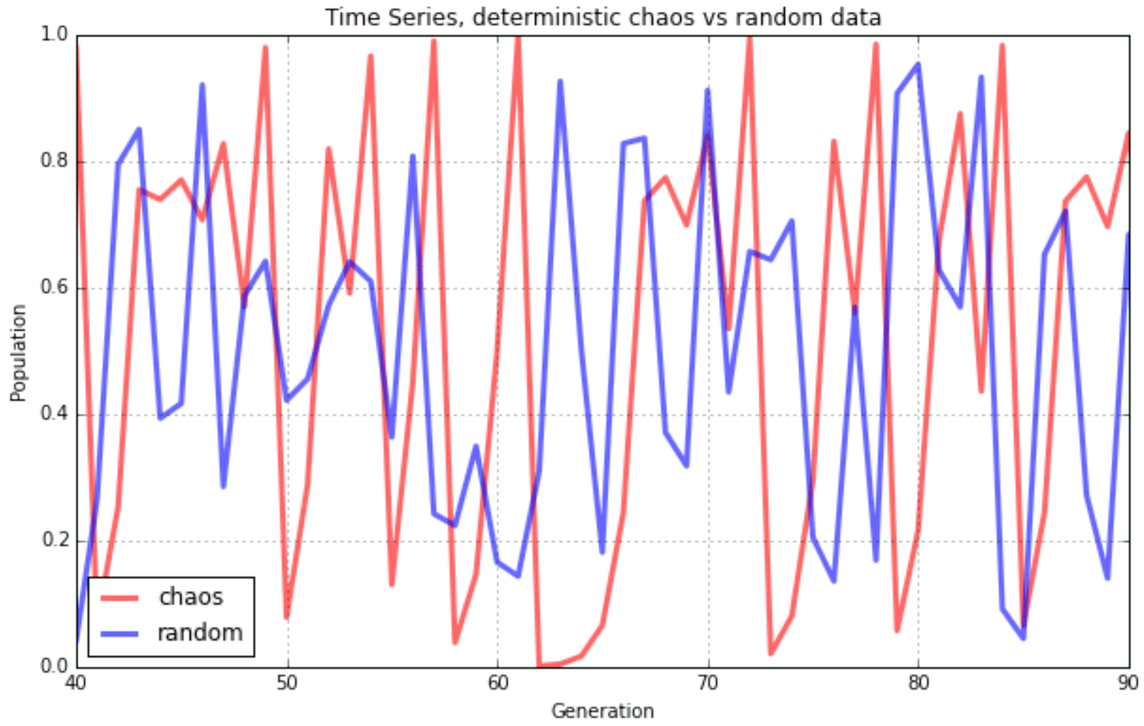
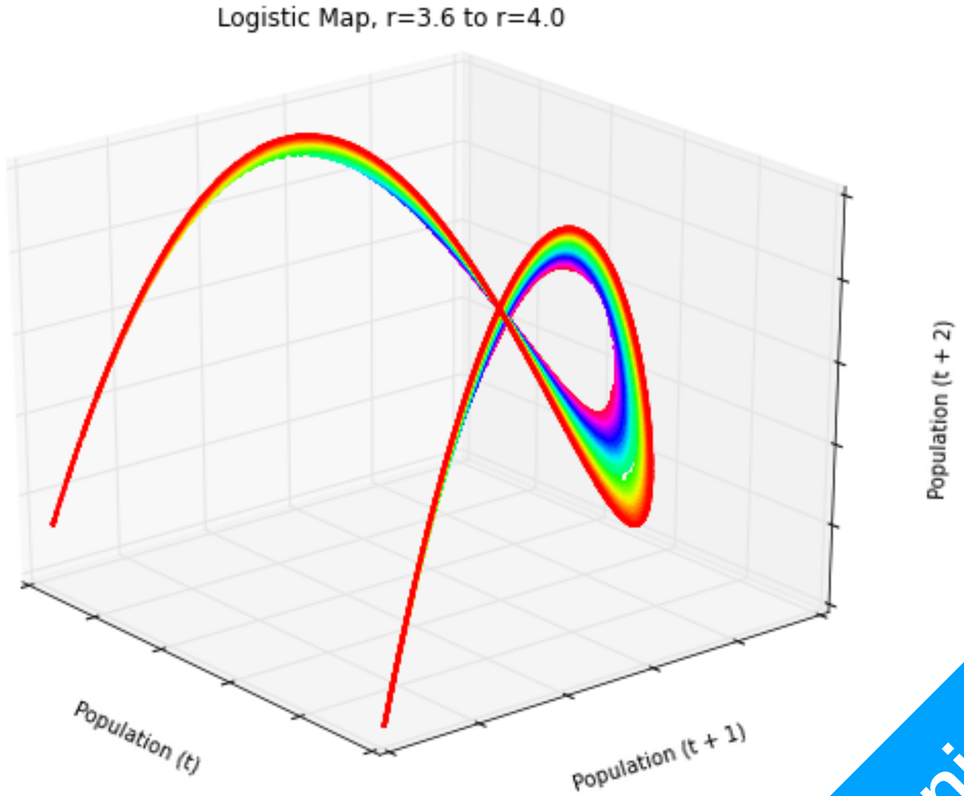
Social Science: Chaos Theory

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

3 dimensional projection





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

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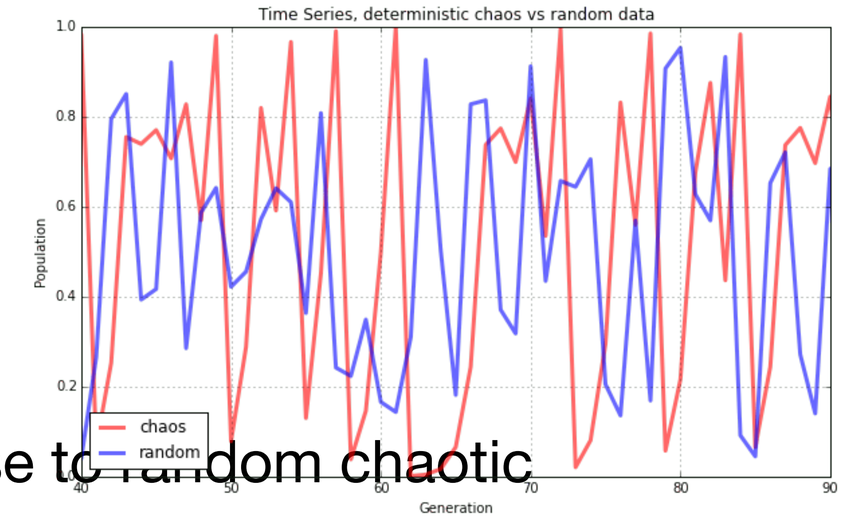
Social Science: Chaos Theory



- 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

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CS in Research

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

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P1
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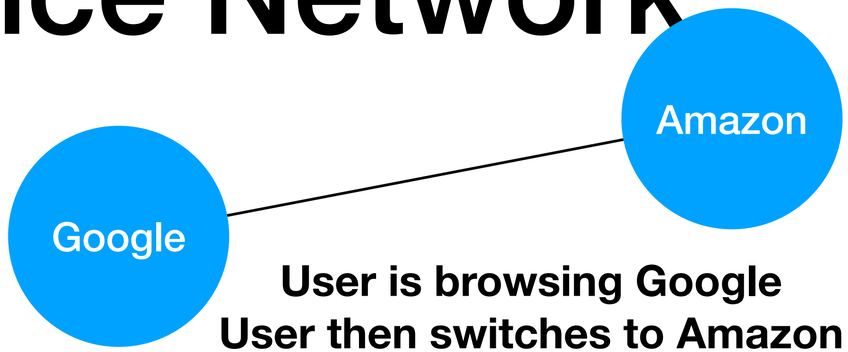
Social Science:
Social Influence Network



- 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?

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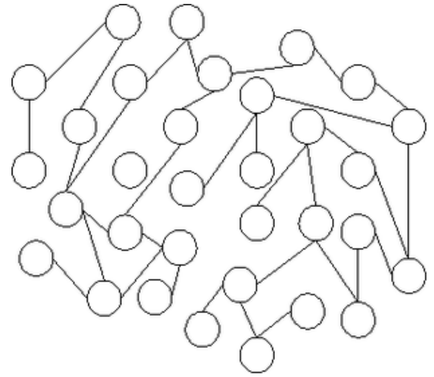
Social Science:
Social Influence Network

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



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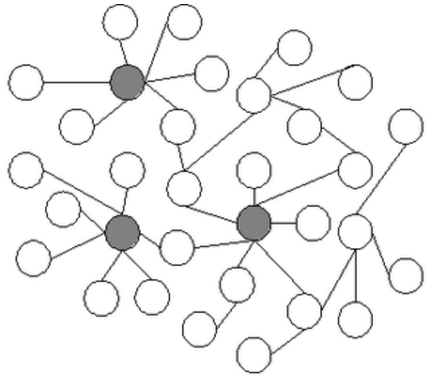
Social Science: Social Influence Network

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



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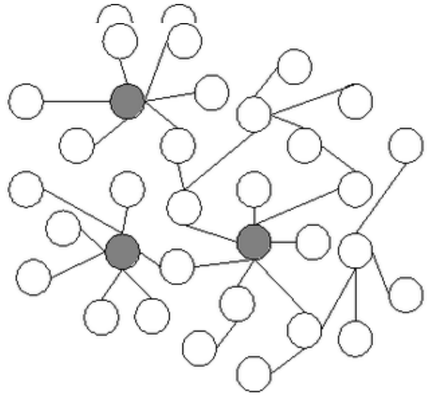
1. Delre et al., 2010. Will It Spread or Not? The Effects of Social Influences and Network Topology on Innovation Diffusion. JPIM

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



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