Learning Chaos: Visualizing Sensitivity in the Logistic Map

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Fall 2025

Outline

Why Study Chaos?

Key Ideas

- Simple deterministic rules can lead to unpredictable, chaotic behavior.
- Chaos theory explains real-world phenomena: weather, finance, biology.
- The logistic map models population growth, but also period-doubling and chaos.
- It's a simple gateway into understanding how complexity emerges from simplicity.

Model Definition

Logistic Map Formula

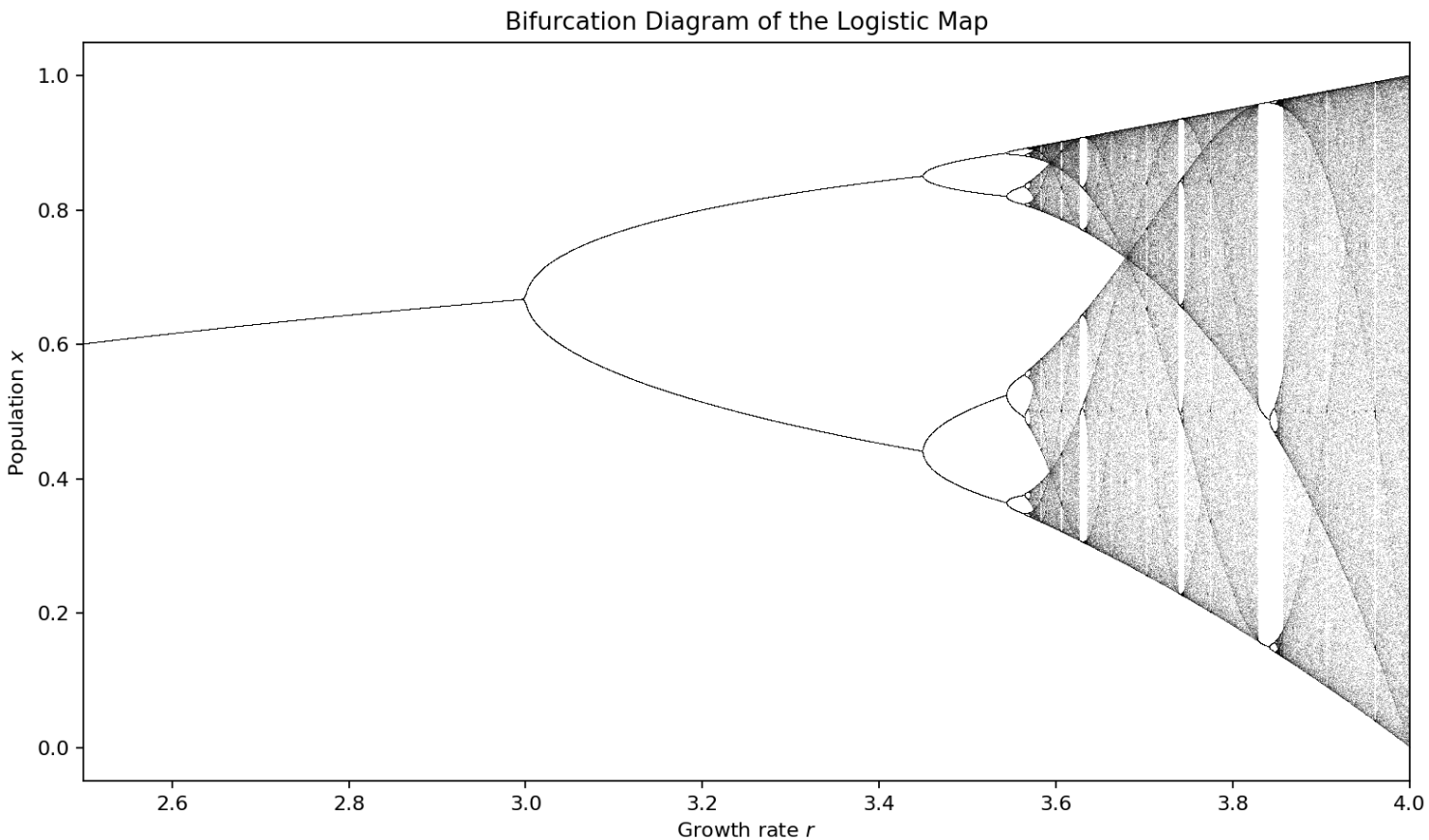
$$x_{n+1} = rx_n(1 - x_n)$$

Terms

- x_n: population at step n
- r: growth rate parameter
- Behavior depends heavily on r

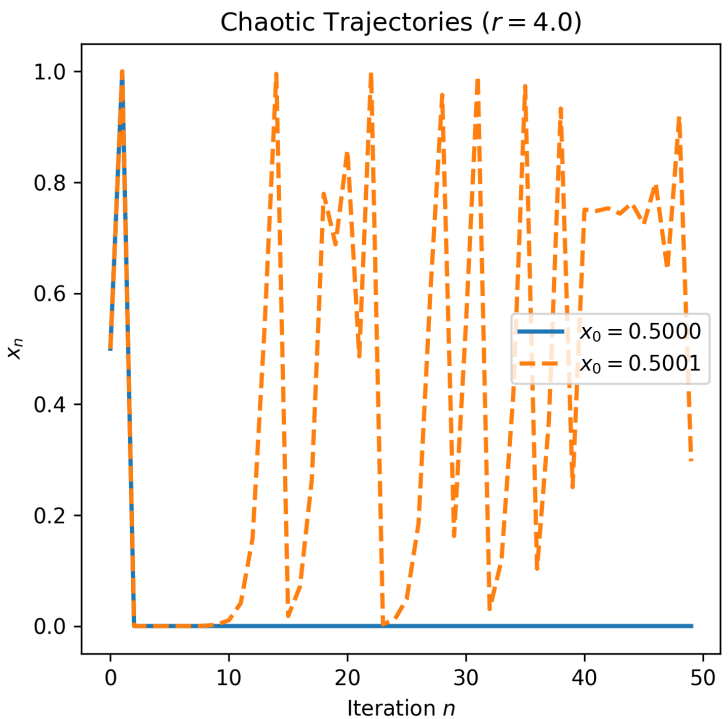
Bifurcation Diagram

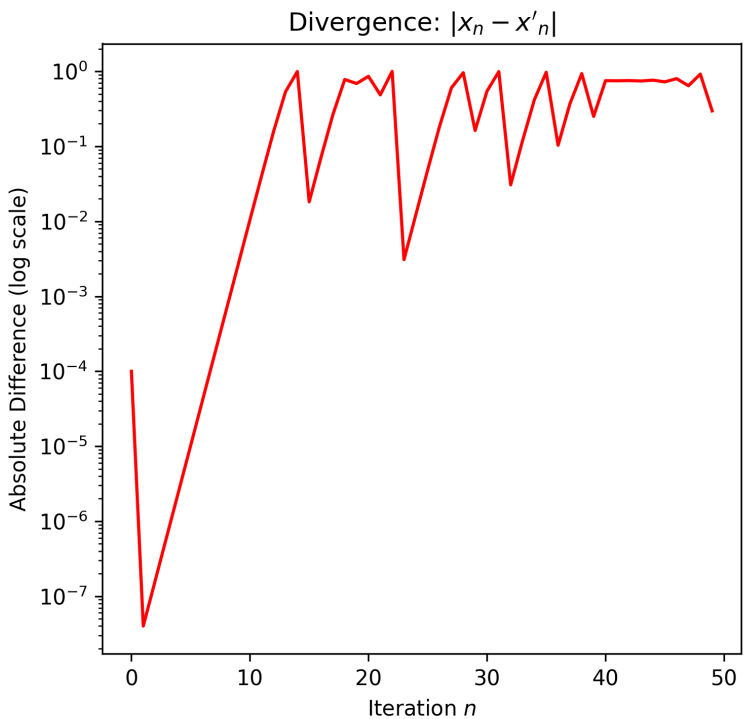
Diagram



Sensitivity to Initial Conditions

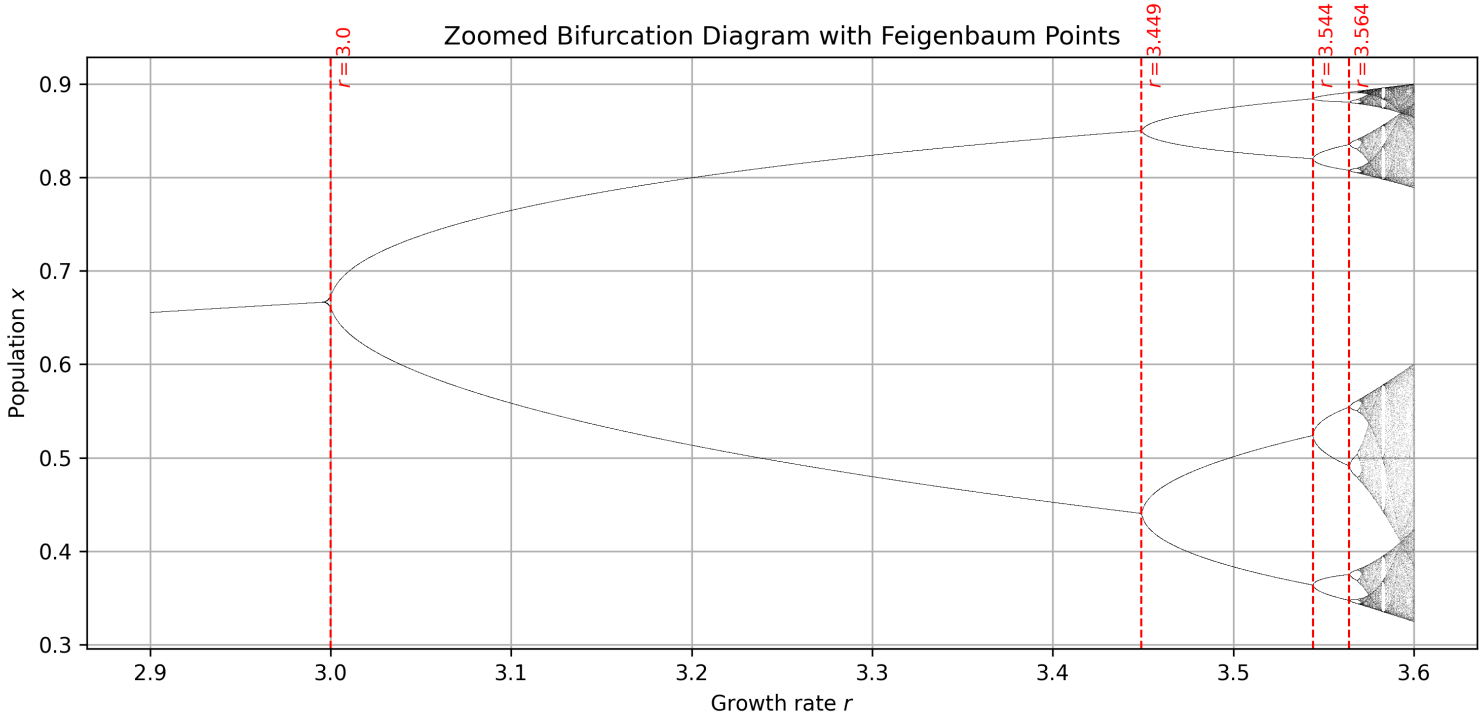
Visualizing Divergence





Feigenbaum Constant Estimation

Zoomed Bifurcation with Annotations



Observation

- Computed $\delta_2 \approx 4.7263$, $\delta_3 \approx 4.7500$
- Close to the theoretical $\delta \approx 4.669$