STATISTICS, PROBABILITY AND CHAOS

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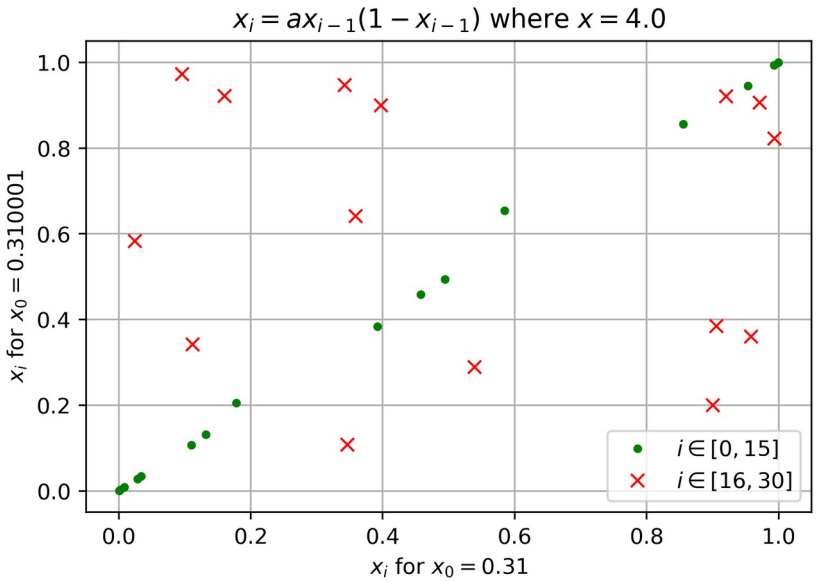
WHAT IS CHAOS?

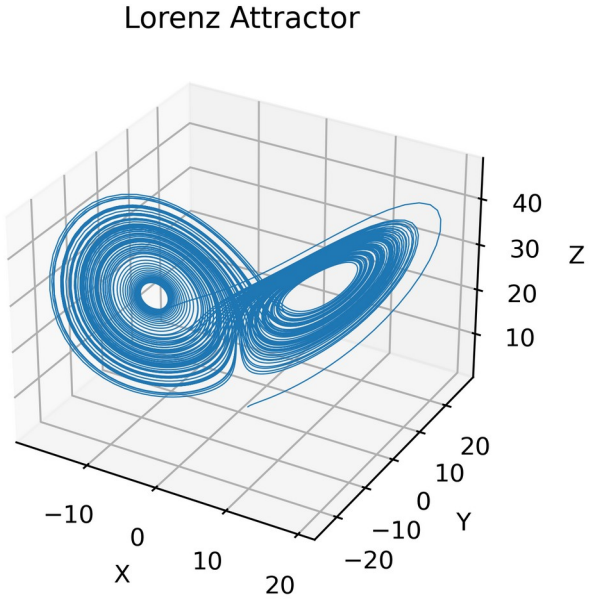
- Chaotic systems are systems where small **differences in initial conditions**, such as those due to errors in measurements or due to rounding errors in numerical computation, can yield widely diverging outcomes.
- Lorenz defined Chaos as: When the present determines the future, but the approximate present does not approximately determine the future.
- A metaphor for this behavior is that a **butterfly** flapping its wings in Brazil can cause a tornado in Texas (butterfly effect).
- Why is chaos theory important for statistics?

EXAMPLES OF CHAOTIC SYSTEMS

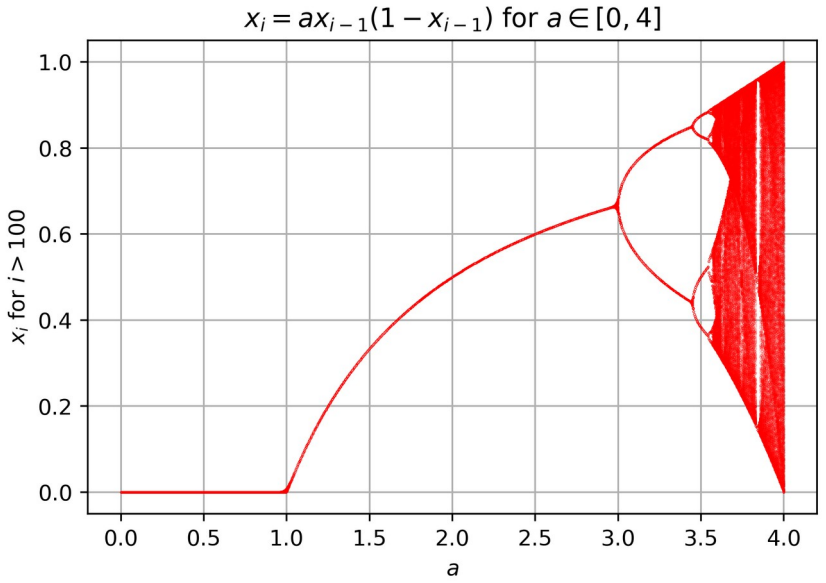
LOGISTIC MAP

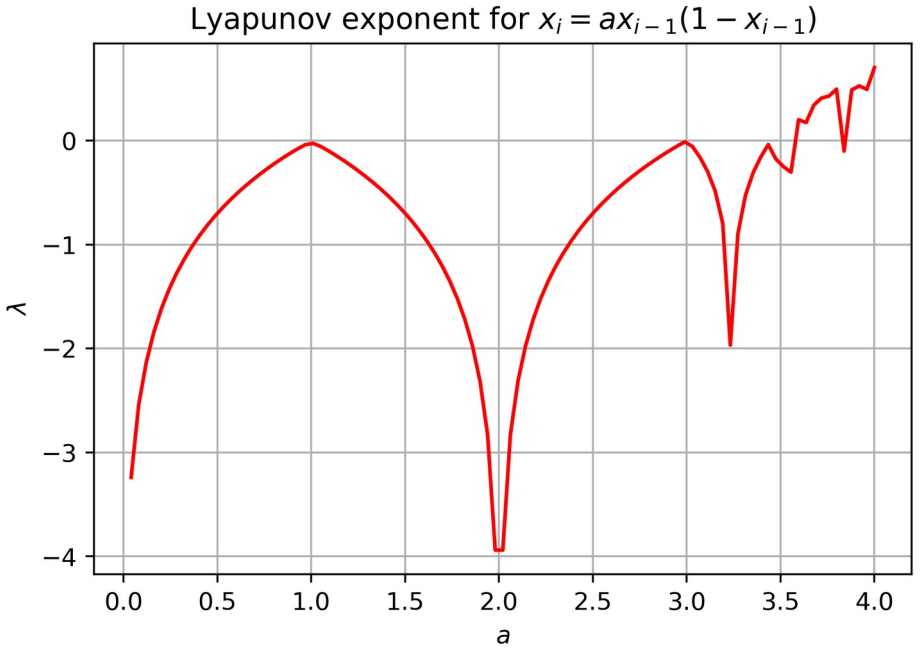


LORENZ ATTRACTOR

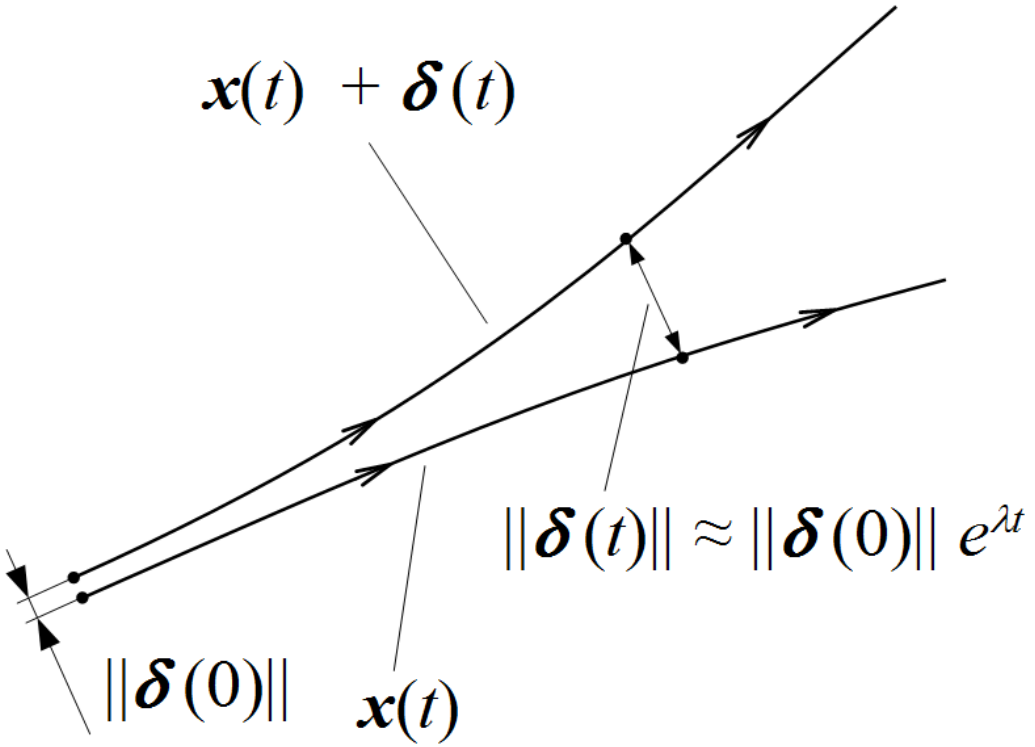


LOGISTIC MAP

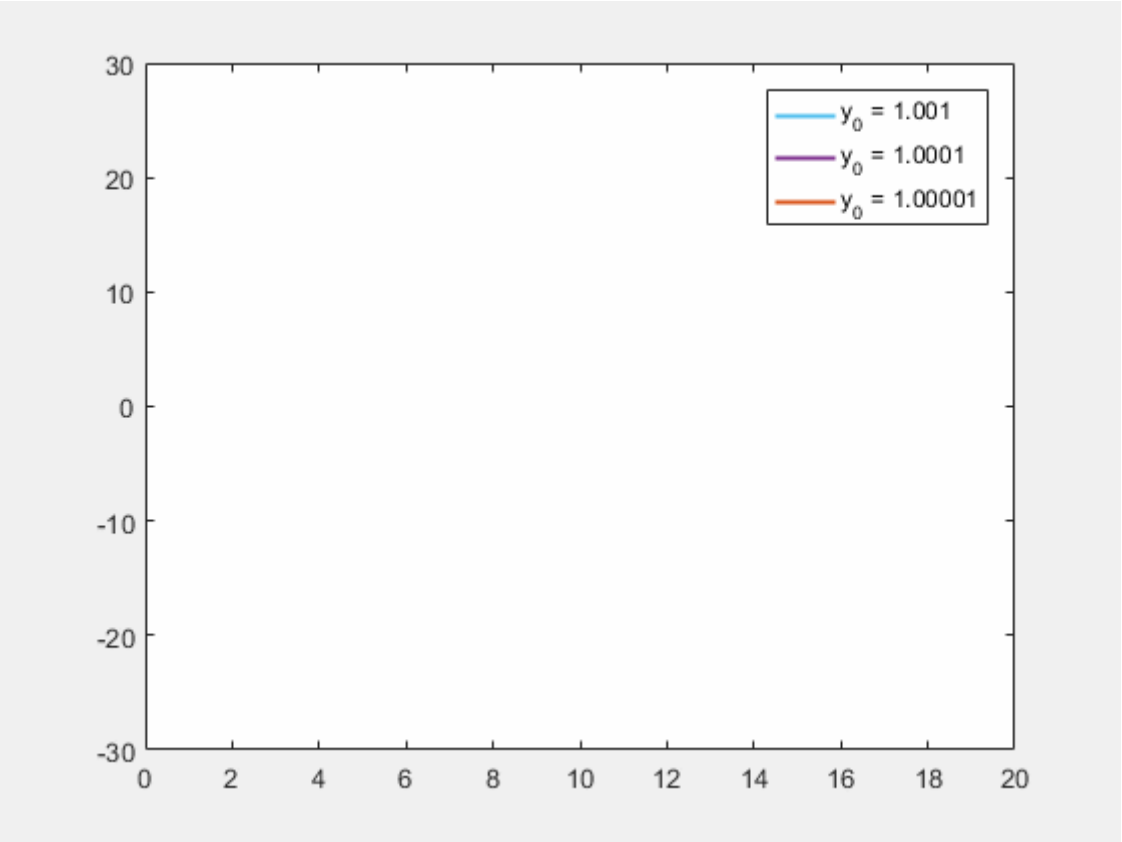




LYAPUNOV EXPONENT

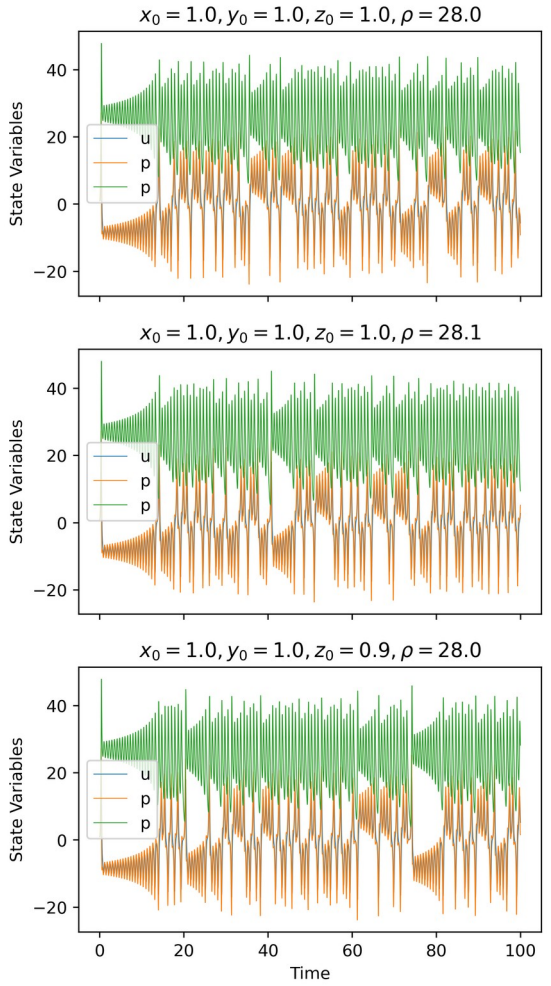


LORENZ SYSTEM



LORENZ SYSTEM

The Lorenz system/attractor not only shows high sensitivity to initial conditions, but also to the pre-defined parameters



HOW CAN WE ANALYZE CHAOTIC SYSTEMS?

- **Phase space analysis**: This involves plotting the behavior of the system in a multi-dimensional space, where each dimension represents a different variable or parameter.
- **Lyapunov exponents**: These are mathematical quantities that measure the sensitivity of a chaotic system to small perturbations in initial conditions.
- **Bifurcation diagrams**: These are graphical representations of how a chaotic system changes as a parameter is varied.
- **Time series analysis**: Time series analysis techniques can be used to identify and analyze trends, patterns, and correlations in the data over time.
- **Probability distributions**: Statistical techniques can be used to analyze the probability distribution of the system's behavior.
- **Monte Carlo simulations (MCMC)**, **Machine Learning**

QUESTIONS?