CSCI 154 - Project Presentations

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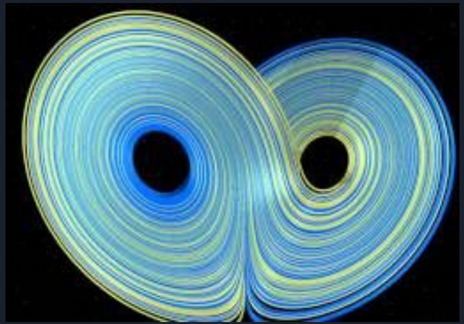
Overview

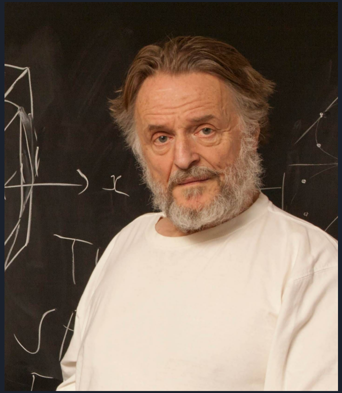
- Project 1: Conway's Game of Life
- Project 2: Blackjack
- Project 3: CHAOS Movie



Project 1 - Conway’s Game of Life

Introduction

- Conway’s Game of Life is a cellular automaton created by John Horton Conway.
- Cellular automaton is a collection of cells that can be arranged in a grid where each cell changes their state according to a set of rules given by the neighboring cells.
- Original concept created in 1940s by John von Neumann.



Motivation

- Help to define unpredictability in cellular automatons.
- Therefore, the Game of Life is intended to create a universal set of cellular automaton.
- Produce complexity pattern and behaviors from a set of simple rule.
- Design efficient algorithms for evolution of each cell in a large grid.
- Exploring different kind of pattern from static to dynamic.

Problem Statement

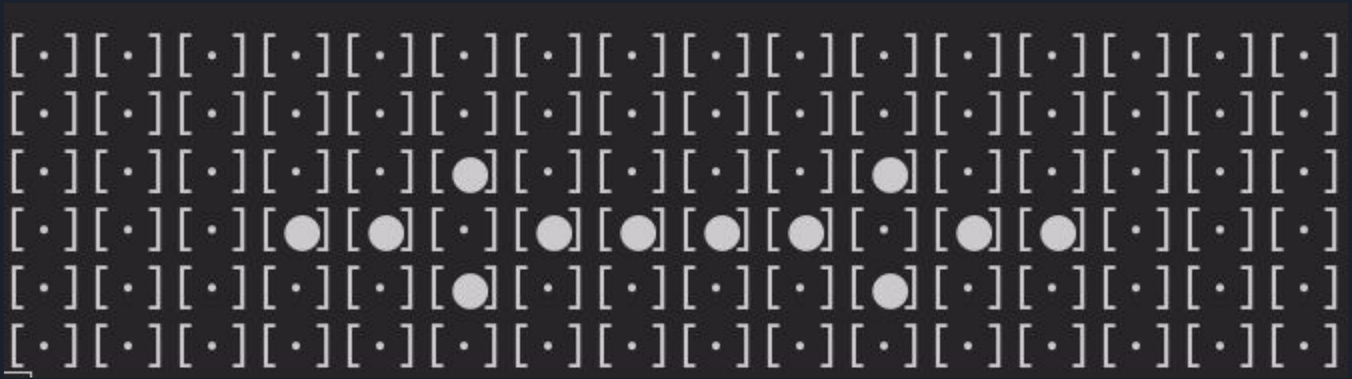
- What types of rules that need to be followed?
- Are there any interesting properties?
- Any interesting objects found in the game?
- How does object evolve overtime?
- How does various pattern interact with each other?

Rules

1. Underpopulation or exposure is when live cells containing less than two live neighbors die.
2. Overpopulation or overcrowding is when live cells containing more than three live neighbors die.
3. Any live cells that contain two or three live neighbors will move on to the next generation of cells.
4. Any dead cell that has exactly three live neighbors will become alive.

Approach

- Used Python and used Pygame and Numpy libraries.
- Numpy generates random grid and cells in the grid are either 0 (dead) or 1 (alive).
- They are based on the 0.7 and 0.3 probability distribution.
- Randomly assigns 0 or 1 to each cell in the grid with a probability of 0.7 for 0 (dead) and 0.3 for 1 (alive).
- The grid is then updated to check the status of the neighbors and determine the new state of the cells.
- This would then draw the grid out with the current alive cells.

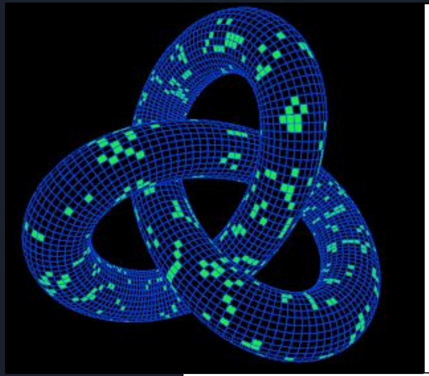


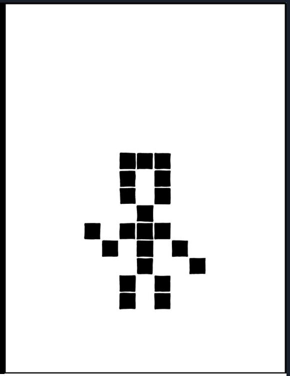
Interesting Properties

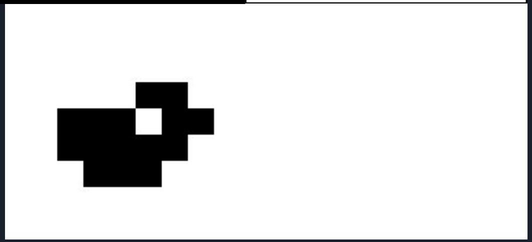
- It is a Turing complete game
- Zero-player game (meaning that it evolves as determined by the initial state without the need of further human involvement)
- Self replication
- Interaction of different pattern
- Randomness outcomes

Interesting Patterns/Objects

1. Still Life
2. Oscillator
3. R-Pentomino
4. Glider
5. Glider Gun
6. Lightweight Spaceship
7. Beehive
8. Ship

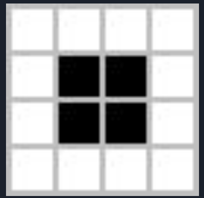




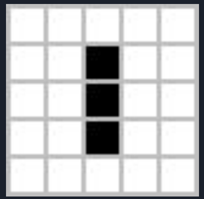


Still Life & Oscillator

- Stays in one spot.
- Known as a static pattern.
- Does not change overtime.

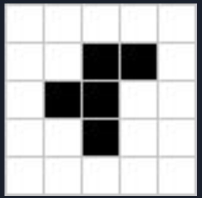


- Pattern that changes but repeats itself.
- Looks like a spinning fan.
- Maintains its position.

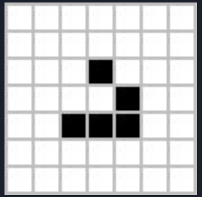


R-Pentomino & Glider

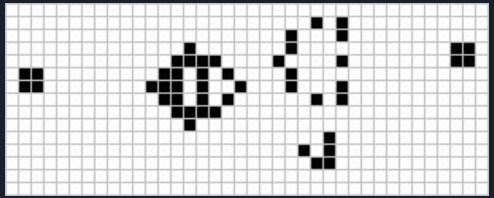
- Pattern containing five connected cells along its edges.
- It is unstable.
- First pattern that is not finite.
- Dies out or becomes stable after ten generations.



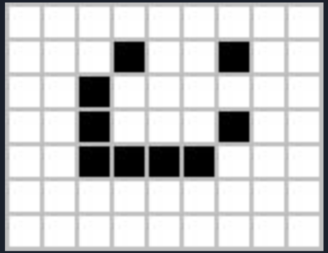
- This pattern moves continuously along the grid.
- Movement is like gliding on the screen.
- Shifts position in a cyclical motion.



Glider Gun & LWSS

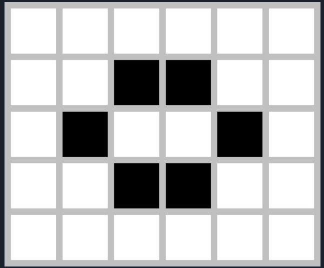


- Similar to the glider, this pattern would grow and result in a continuous stream of gliders.
- Bigger version of a glider.
- Grows independently.
- Consists of a group of cells that periodically emit gliders.

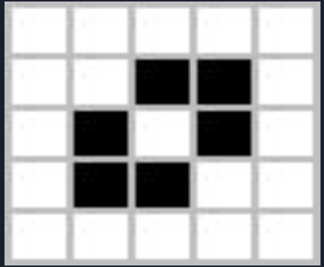


- Known as a lightweight spaceship.
- Smallest known orthogonally spaceship.
- Possess a tail spark or emit glider to disrupt other objects.

Beehive & Ship



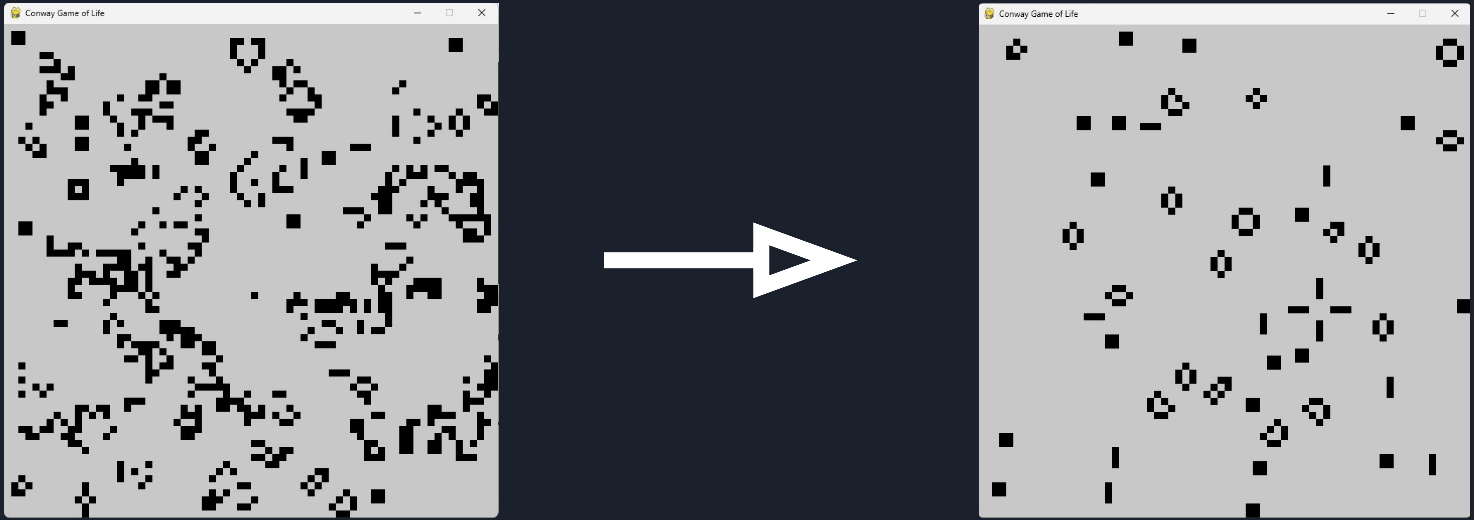
- Consists of 6 cells.
- Second most common still life.
- It’s static and does not evolve overtime.
- It’s stable unless disturbed by neighboring pattern.



- Moves in straight line.
- Maintaining its shape through the grid.
- Adding one cell to the corner to forms a fleet.
- Removing one cell from the corner forms a boat.
- Removing both cells forms a tub.

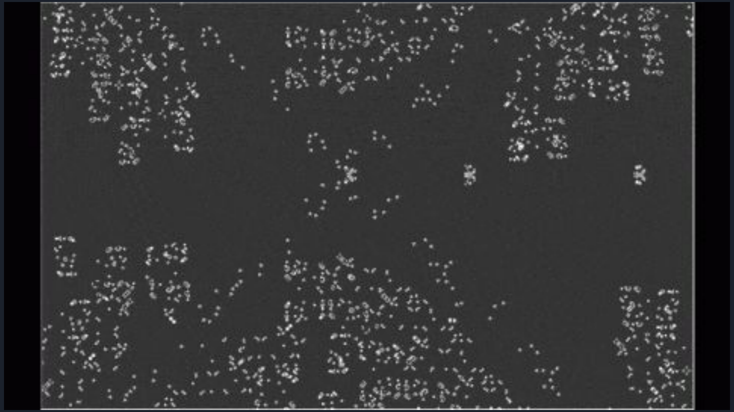
Results

- Created the Game of Life and was able to see the various patterns and movement of the game.
- Alive cells displayed in black and dead cells displayed in gray
- Transition from observing the start towards the end of the game.
- The cells change their state based on the rule.
- Not many cells are alive by the end.



Conclusion and Contributions

- Notice the cell distribution within the game where a lot of cells were alive and towards the end, many had died.
- The Game of Life shows the evolution of cells and how they disappear over a period of time.
- Used in real world phenomenons from traffic patterns to the spreading of diseases.



Project 2 - Blackjack

Motivation

- To apply Monte Carlo simulations to real world problems.
- To develop a better understanding of the game.
- To be able to analyze the winning percentage with different policies.
- To improve the chance of winning.

Problem Statement

- To determine the best strategy for playing the game in order to maximize the player's chances of winning.
- Analyzing the winning percentages of different strategies.

Related Work and Background Material

At the start of the game, each player receives two cards, and one of the dealer's cards is hidden until the end of the round.

Face cards (Jack, Queen, King) are worth 10 points, and Aces can be worth either 1 or 11 points, depending on the player's choice.

During the game, players have three options: hit, stick, or burst.

- Hit means drawing another card from the deck to increase the player's hand value.
- Stick means holding the current hand value and ending the player's turn.
- Burst happens when the player's hand value exceeds 21, resulting in an automatic loss, regardless of the dealer's hand value.

If a player's initial hand consists of an Ace and a card with a value of 10 points (10, Jack, Queen, or King), they have Blackjack and win the round.

Approach

There were 5 different policies chosen in this simulation:

1. Stick >= Soft 17: This strategy involves sticking (not taking another card) when the player's hand value is 17 or greater, including when an Ace is being used as an 11 (soft hand).
2. Stick >= Hard 17: This is similar to the previous strategy but applies only to hard hands (without an Ace).
3. Always stick: This strategy involves always sticking regardless of the hand value, which is a conservative approach that avoids the risk of going bust.
4. Stick >= 17, if dealer < 7 and player > 11, stick. Else hit.
5. Stick >= 17, if dealer < 7 and player > 14, stick. Else hit.

HAND TOTALS	DEALER UPCARD									
	2	3	4	5	6	7	8	9	10	A
17	S	S	S	S	S	S	S	S	S	S
16	S	S	S	S	S	H	H	H	H	H
15	S	S	S	S	S	H	H	H	H	H
14	S	S	S	S	S	H	H	H	H	H
13	S	S	S	S	S	H	H	H	H	H
12	S	S	S	S	S	H	H	H	H	H
11	H	H	H	H	H	H	H	H	H	H
10	H	H	H	H	H	H	H	H	H	H
9	H	H	H	H	H	H	H	H	H	H
8	H	H	H	H	H	H	H	H	H	H

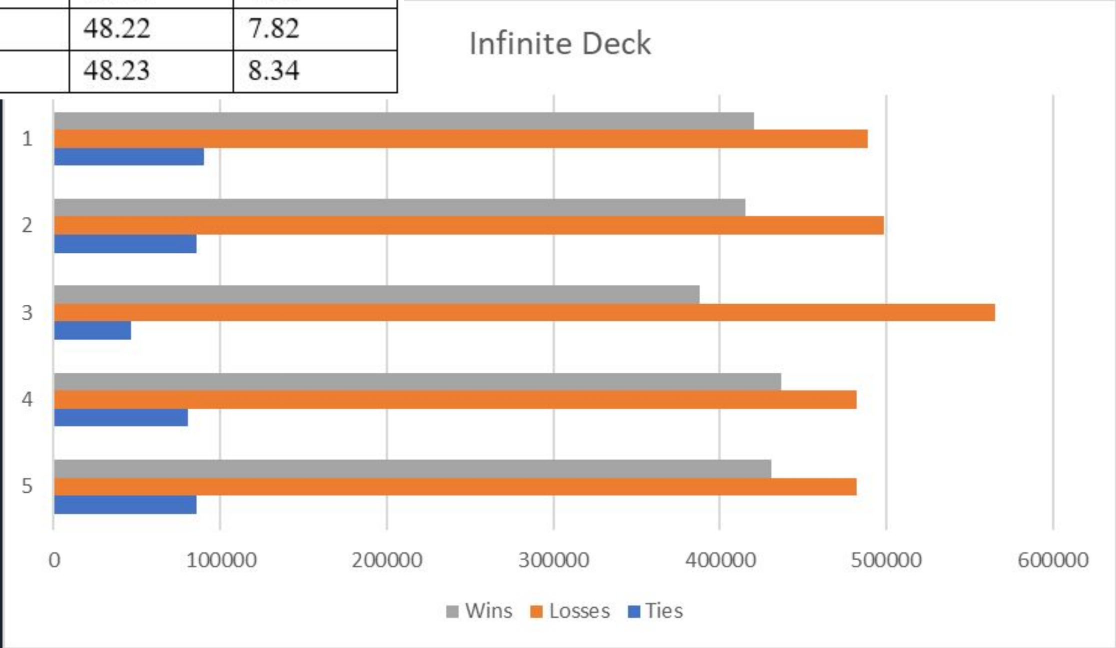
Experiment set-up

1. The player is asked to select a policy to play the game.
2. The player is asked to choose between a single deck or infinite deck to use during the game.
3. The player is asked to specify the number of rounds they want to play. Basically asking for number of iterations which is 1,000,000 in this experiment.
4. At the end of the experiment, the program displays several statistics, including the number of wins, losses, and ties recorded during the game, as well as the winning percentage of the chosen strategy. The program also shows the total amount of time taken to run the experiment.

Results

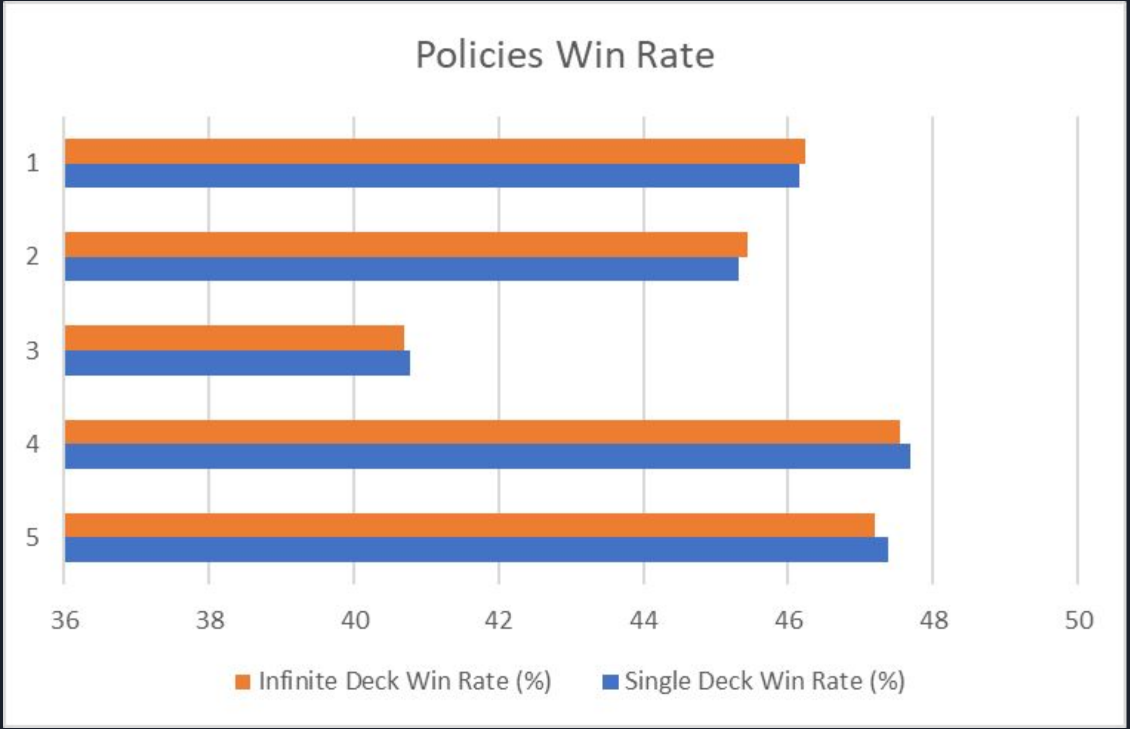
Policies	Infinite Deck			Single Deck		
	Wins (%)	Losses (%)	Ties (%)	Wins (%)	Losses (%)	Ties (%)
1	42.07	48.93	9.00	42.14	49.16	8.70
2	41.53	49.86	8.61	41.56	50.16	8.28
3	38.81	56.54	4.64	38.99	56.64	4.37
4	43.73	48.23	8.05	43.96	48.22	7.82
5	43.14	48.26	8.60	43.43	48.23	8.34

Single Deck version shares a similar trend as Infinite Deck version.



Results

Policies	Infinite Deck Win Rate (%)	Single Deck Win Rate (%)
1	46.23	46.16
2	45.44	45.32
3	40.70	40.78
4	47.55	47.69
5	47.20	47.38



Results

- The Single Deck policy and the Infinite Deck policy have a very minimal difference (about ±0.12%) in their average win percentage.
- Policies 4 and 5 performed better than policies 1, 2, and 3, regardless of deck type.
- Policy 3, which is to always stick regardless of the hand value, had the lowest average win percentage for both deck types.
- Policy 4 have slightly higher average win percentage than Policy 5, as it resembles a similar outcome table to strategy chart found online.
- The ties percentage is around 8~9% for all policies except policy 3.
- The overall performance of a policy was not greatly impacted by ties because they were fewer than wins and losses.

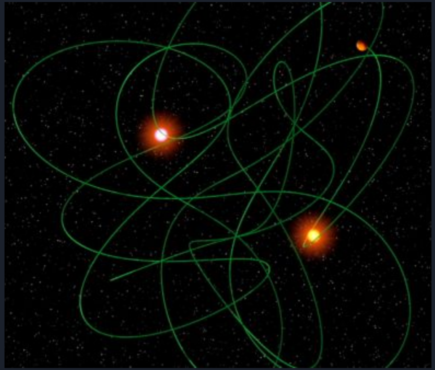
Conclusion and Contributions

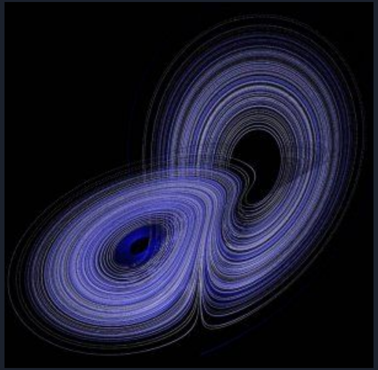
- The player has a slightly higher chance of losing than winning in the game of blackjack.
- With the use of certain strategies, policy 4 and 5 or other better strategies, the player can reduce their chances of losing.
- Implementing strategies such as card counting may further increase the player’s win rate.

Project 3 - CHAOS Movie

Introduction

- It is a 9-part movie created by Jos Leys, Etienne Ghys, and Aurelien Alvarez.
- We will discuss the main concepts of the 9 chapters.
- The movie talks about topics from dynamical systems, the butterfly effects, and chaos theory.





Motivation

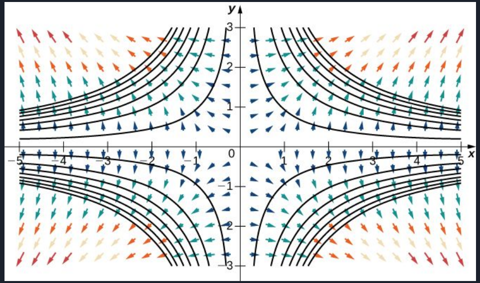
- Understanding how complex system works
- Have a better understanding of natural phenomena
- Study the boundaries of predictability
- Exploring origins of complex systems

CHAOS 1 - Motion & Determinism

- The philosophy of Chaos was developed by Heraclitus.
- In Mathematics, everything is in motion.
- Idea of determinism.
- Determinism is a claim that the order of something happening happens due to causality.
- Different from fatalism which describes it to be that all events are destined to happen a certain way.
- The study of planets have limited the use of determinism.
- First part of the movie suggests that we can have a different view of determinism such as predicting the averages or statistics.

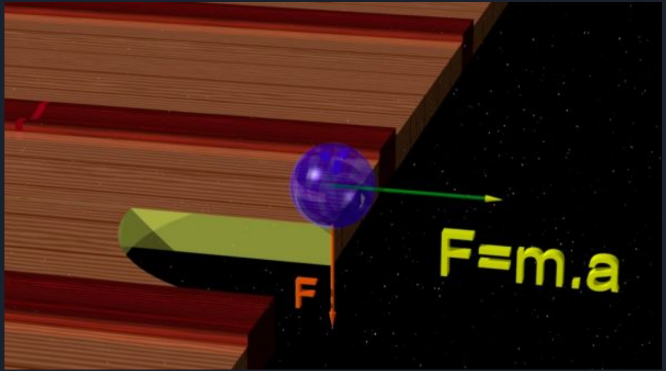
CHAOS 2 - Vector Fields

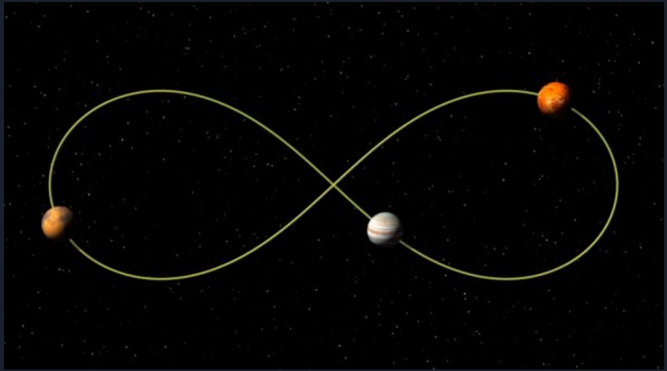
- 17th century, Gottfried Wilhelm Leibniz and Isaac Newton created infinitesimal calculus.
- Through the form of differential equations, ability to predict the future.
- Calculating derivative is the goal of differential calculus.
- Integral calculus is the opposite, it calculates the trajectories of the vector field.
- Cauchy-Lipschitz theorem: Claims starting points determine future trajectories and there is a tangent everywhere to their velocity vectors.
- James Clerk Maxwell mentioned there is a limit to determinism with implied importance of initial conditions for physical phenomenons.



CHAOS 3 - Mechanics

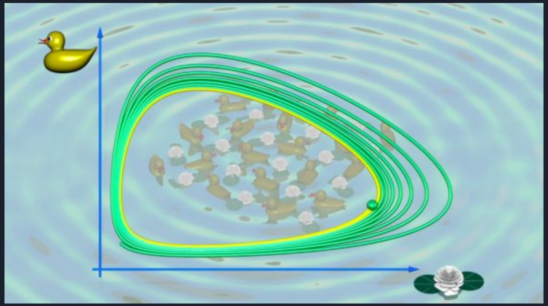
- In the 17th century, Galileo Galilei studied falling objects, but it was Isaac Newton who formulated the universal law of gravitation.
- All objects, like apples or the Moon, are attracted by the Earth. It is gravity affecting everything around us.
- Newton's formula is one of the most simple, but also most fundamental in physics: **F=m.a** . Here **F** is the force, **m** is the mass and **a** is the acceleration.
- We can construct a planetary choreography using Newton’s formulas.





CHAOS 4 - Oscillations

- A pendulum can be described by two numbers which is its position and speed.
- To sustain a pendulum's motion, we push it at the right time despite friction. The resulting phase portrait on a graph is a closed curve called a limit cycle, as coined by Henri Poincaré.
- Poincaré-Bendixson theorem in dynamical systems theory, late 19th century, states that vector fields in a plane stabilize over time, either by stopping or periodic oscillation. No recurrence is possible, except for periodic trajectories.



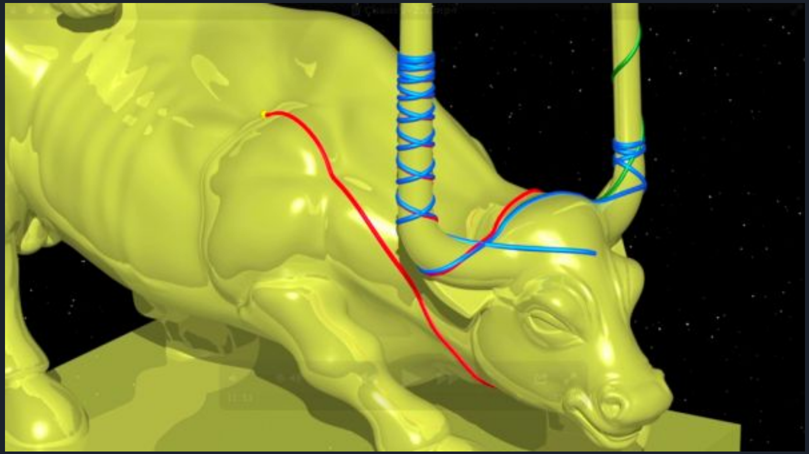
CHAOS 5 - Duhem’s Bull

- The geodesic curves are defined as the path that would follow on a surface with no external forces affecting it.

- An example of a billiard ball moving on a frictionless surface, where the path of the ball depends on the initial position and velocity is shown.

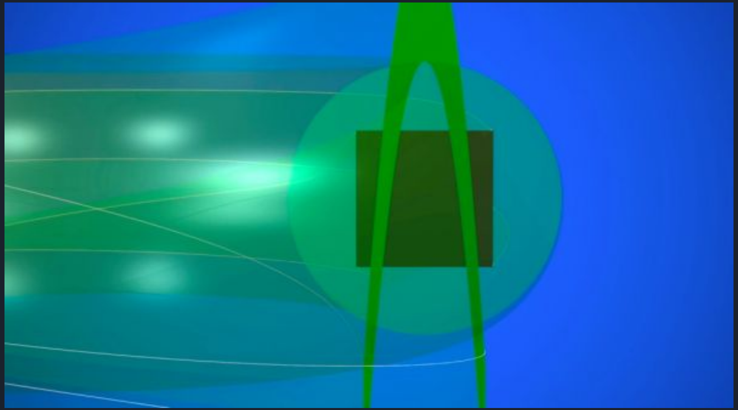
- The surfaces can have periodic or non-periodic trajectories under certain conditions. A small change in initial conditions can greatly impact the trajectory.

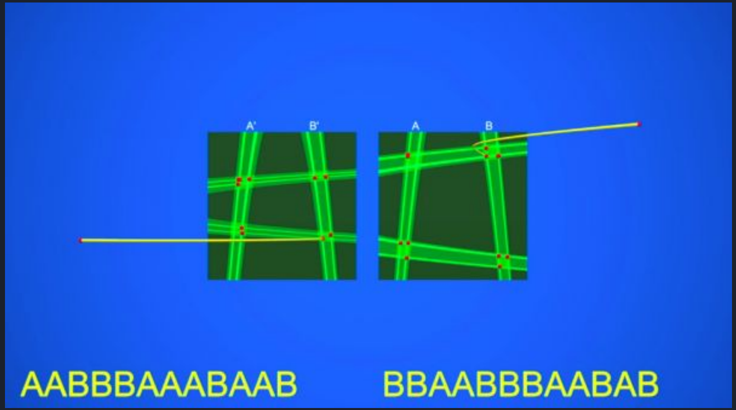
- The behavior of a point on a surface can be incredibly complex and depends on initial conditions, which makes it difficult to predict the movement of celestial objects.



CHAOS 6 - Chaos & The Horseshoe

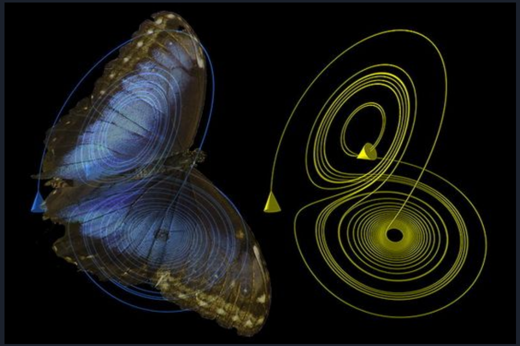
- The horseshoe is a concept where a transformation of a square using a combination of scaling, contraction, and folding forms a horseshoe shape.
- Even though the horseshoe has structural stability, the trajectories in the horseshoe are very sensitive to the initial conditions. It is almost impossible to predict the trajectories.





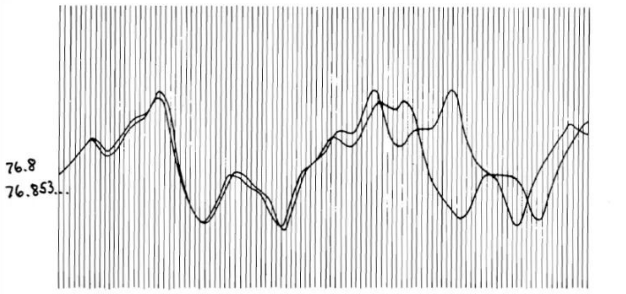
CHAOS 7 - Strange Attractors (The Butterfly Effect)

- Strange attractors are complex patterns that arise in certain nonlinear systems, which can exhibit chaotic behavior.
- The Butterfly Effect is a popular concept in Chaos theory, which describes the idea that a small change in the initial conditions of a system can have a large and unpredictable effect on its future behavior.



CHAOS 8 - Statistics (Lorenz' Mill)

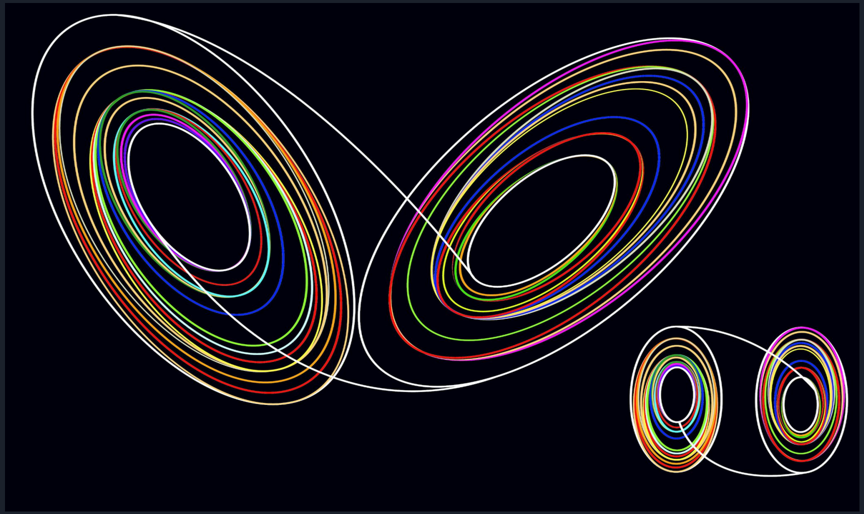
- In statistics, chaos theory is relevant in the analysis of time series data, which is a set of measurements taken over time.
- Lorenz's Mill is a combination of non linear ordinary differential equations that shows chaotic behavior.
- $dx/dt = \sigma(y - x)$
- $dy/dt = x(\rho - z) - y$
- $dz/dt = xy - \beta z$



HOW TWO WEATHER PATTERNS DIVERGE. From nearly the same starting point, Edward Lorenz saw his computer weather produce patterns that grew farther and farther apart until all resemblance disappeared. (From Lorenz's 1961 printouts.)

CHAOS 9 - Research Today

- Applications in biology
- Complex networks
- Control of chaotic system



Thank you