Art in Complexity

A manifesto for visual collective experimentation

If (complexity) science requires a hypothesis, art requires a portfolio. Here, we propose to combine both in an immersive and interactive way that brings complexity concepts into the public domain. While static representations of complex phenomena provide foundational understanding, they often fail to capture the emergent, dynamic, and aesthetically pleasing behavior inherent in these systems. This manifesto advocates for embracing the art within complexity, transforming abstract scientific concepts into accessible, playful, and visually appealing experiences.

As a **two-part project**, we propose both the creation of a **living digital archive and an exhibition** to bring people closer to complexity. As part of the digital archive, we have compiled examples illustrating key scientific concepts in an engaging way:

- **Chaos Sampler:** Chaotic systems, characterized by small changes leading to massive, unpredictable outcomes, are everywhere in nature. This interactive demo uses the Lorentz attractor to remix music recordings unpredictably, illustrating the creative potential of chaos.
- **Flocking behavior:** An interactive simulation of flocking behavior demonstrating emergent phenomena.
- **Evolution:** Fitness landscapes, essential in evolutionary biology, help visualize how populations respond to natural selection. Unlike static images, our simulations allow users to interact with parameters like population size and mutation rates, and experiment with dynamic "seascapes" to understand evolution in changing environments and explore the concept of "evolvability."
- **Game of Life:** Conway's Game of Life demonstrates how simple rules can generate complex behaviors on a 2-dimensional grid, where cells live or die based on their neighbors. This demo simulates the game, using sounds and a Novation Launchpad to create a unified physical, auditory, and visual experience, illustrating the emergence of complexity.
- **Physical emergence:** An example of collective painting, how many parts can make a new whole.
- **Gallery:** Beauty often naturally emerges in research on complexity. Created to compile images and media generated by participants of this summer school as a starting point, this gallery aims to continue incorporating everyone's complexity inspirations encountered during our tinkering.

Designed to travel to multiple locations and reach a diverse audience, the exhibition we propose offers an interactive experience, allowing visitors to touch and move physical objects, thereby humanizing complexity. It highlights the aesthetic dimensions and emergent properties of complex systems through networks of interactions, educational modules, and artistic installations. Visitors will be able to immerse themselves in the simplicity of complexity, exploring everything from biological microscopic systems to macroscopic classical physics. The exhibition's design will enable participants to act both as spectators and integral parts of the system, illustrating the concept that the whole is greater than the sum of its parts and that, as with complex systems, interactive art also defies complete predictability.

As accompanying material for the exhibition, the development of educational modules is suggested, using platforms such as Complexity Explorer, to disseminate the concepts presented in the exhibition. These modules will teach participants to transform their favorite complexity concepts into art objects, either physical or digital.

In essence, both the living digital archive and the exhibition aim to be a dynamic and visual collective exploration of complex systems, showing that science and art are not mutually exclusive but rather complementary ways through which we can appreciate the world.

Complex systems science has a lot to gain from interactive simulations, as purely static representations and explanations of complex phenomena often fail to capture the emergent, dynamical, and often aesthetically pleasing behavior. Furthermore, the

Chaos sampler

Chaotic systems are everywhere in nature. These systems are characterized by the way that small changes can snowball into massive changes in behavior, rendering them hard to predict. For example, in our planet's climate the flap of a butterfly wing in the right place and right time can cause a hurricane to form. In this interactive demo we leverage the unpredictability of a simple chaotic system known as the Lorentz attractor to remix music recordings in unpredictable ways. Particularly, we split a recording (or "sample") of music into evenly spaced chunks. A trajectory of the Lorentz attractor is then used to associate each of these pieces of the recording to a point in the system's phase space. The music is then shuffled by continuing to run the trajectory and playing the chunk associated with the nearest written point in phase space at each step. By harnessing this chaos as a creative force we can play with this ubiquitous feature of the world in an accessible way.

Evolution

Fitness landscapes are an important conceptual tool in evolutionary biology that allows researchers to visualize how populations respond to natural selection. Yet, most visualizations of these landscapes are limited to static images where populations are assumed to climb towards high-fitness "peaks". The evolutionary process, however, is more complex than can be summarized in such a simple picture. The fitness landscape simulations allow users to interact with parameters like population size and mutation rates to see if and when populations can find such evolutionary innovations, and also lets users experiment with dynamic "seascapes" to visualize evolution in a changing environment. In addition, they introduce the idea of "evolvability" which has recently been a topic of great discourse in the field.

Flocking behavior

A flock of birds is beautiful as well as complex. Complex emergent behaviors often arise from simple interactions among a large number of units. Boid's Algorithm, with three simple interaction rules, allows us to mimic such emergent behaviors in a flock of birds. In this world, each bird (or Boid) has a finite perception radius, and they (1) align toward their average local velocity, (2) steer toward the local center of mass, and (3) steer away to avoid crowding.

We also imposed an additional rule in this world: the angular velocity of a bird's wing is proportional to its speed. Drawing trails of the wings allows us to create pictures similar to the Ornithography by Xavi Bou.

Other rules, such as avoiding obstacles, can also be imposed. In the visualization, using a webcam and an object detection algorithm, we map the real-time positions of detected humans as obstacles in the 2D world of these birds, which they actively avoid.

Game of life

Conway's game of life is a compact, elegant example of how simple principles can generate complex behaviors. The "game" is played on a 2-dimensional grid, and loosely simulates changes in the population of a species over space and time. Each grid square may either be "alive" or "dead" at each time interval. Only if a grid cell has between 3 and 5 of its 8 neighbors alive will it be alive and happy on the next turn, otherwise it will die of either under- or over-crowding. From this simple rule alone, very complicated behavior can be observed. In this demo we simulate this game of life and play sounds when each of the grid cells is alive. We also mirror our simulation on a Novation Launchpad, an 8 x 8 grid of buttons that can light up with colors. By creating a unified physical, auditory, and visual experience we have an engaging mode to play with this toy example of how complexity can emerge.

Gallery of complexity

Beauty seems to often naturally emerge in research on complexity. On this page we would like to provide a space to compile images and media generated by the participants of this summer school and beyond that we have encountered in the course of our tinkering.

Future plans

Mission:
Certain concepts benefit greatly from interactivity and visuals.
Accessibility in the formats and the design.
Creativity from interactions (persistent interactivity)
Finding art in complexity. Or motivated by complexity.

Future Plans and Vision:
Museum exhibit
Grants
Complexity explorer modules

Things we have done:
Chaos Sampler
Boids
Fitness landscapes
Game of Life Launchpad
Gallery

Overarching umbrella between the projects? Make a coherent class?