

An Ode: Exploring Aesthetic Theory Through the Visual Representation
of Ordinary Differential Equations

TEP325

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1. Introduction

The artwork in this project visualizes the behavior of solutions to linear ordinary differential equations (ODEs) through dynamic simulations and phase plane plots. These images are generated using computational tools like Python and Pygame, with specified matrix initializations driving the evolution of particle systems under defined ODEs. By changing these matrix properties, the system's dynamics—from convergent spirals to saddle points—are revealed as aesthetic patterns shown in Fig. 1. The project's essence extends beyond its technical framework, inviting discourse on aesthetic theory through the lens of mimesis, avant-garde and kitsch, quantum art, and the cosmic web.

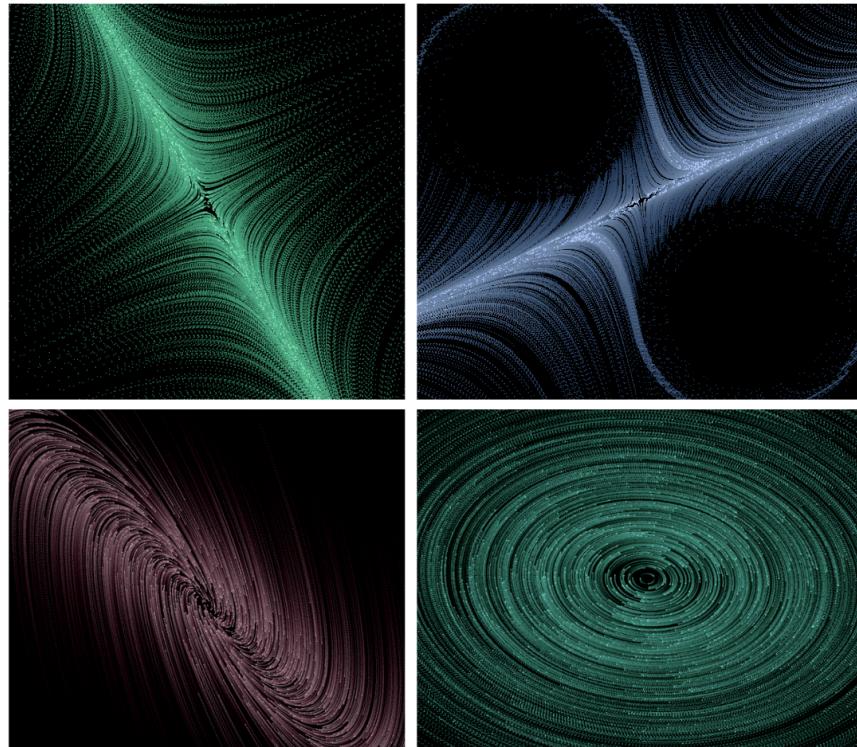


Figure 1. Sample ODE Artwork of different systems

2. Inspiration and Engineering and Science

ODEs are the foundation of every dynamic system such as circuits, population dynamics, harmonic oscillators, etc [1]. This project took inspiration from drawings of Leonardo da Vinci, where science served as the main story of the piece. Pieces such as the Vitruvian man or Da Vinci's engineering sketch works aim to convey the story of science and leave less interpretation of the engineering principle to the audience, and instead visibly manifest in the artwork [2]. One should not “connect this work to engineering and science” because it simply is engineering and science in existence. Similarly, the scientific aspects of this piece are intentional and evident,

however, the systems they describe are different. In other words, it is not up to the audience to decipher whether this piece is an ODE - it simply is - but understanding what system this piece represents is up to interpretation. For instance, the ODE in Eq.1 can represent a resistor-capacitor (RC) circuit and the equation for thermal cooling, depending on variable interpretation. Therefore, even if the artwork is intended to represent an RC circuit, it is not an inaccurate interpretation to think otherwise.

$$\frac{dx}{dt} + ax = b \quad \text{Eq.1}$$

Additionally, obstacles were introduced to the equations, leading to altered trajectories of solutions (Fig. 2). The nature of these obstacles was only mathematical when they were created, but the audience can interpret them as physical obstacles or force fields. Furthermore, engineering notes regarding these systems were also annotated on the artwork, similar to notes in da Vinci's paintings (Fig. 3).

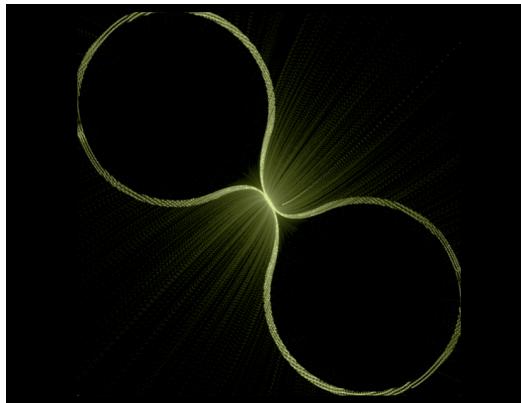


Fig 2. ODE solution with two obstacles

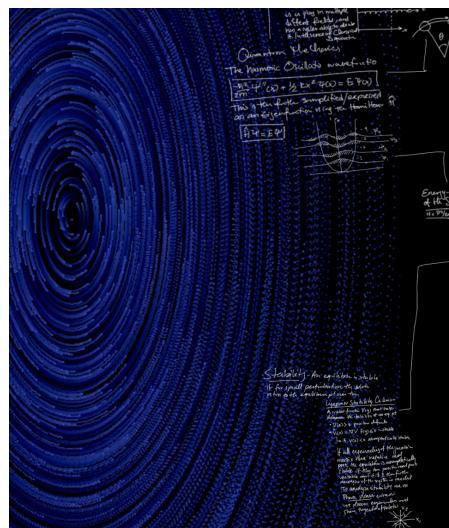


Fig 3. [Left] Da Vinci's notes [3], [Right] Inspiration in artwork

3. Connections to Aesthetic Theory

3.1 Plato and Aristotle: Mimesis as Representation and Truth

Plato's philosophy positions art as a form of mimesis—a representation of ideal forms beyond the physical realm [4]. In this context, the phase plots and ODE solutions represent an esoteric, mathematical reality. The solutions and eigenvalues are not just visualizations, rather they are manifestations of the underlying laws of physics and mathematics that govern the dynamic systems. From a platonic viewpoint, these artworks mimic the "truth" of the universe, as ODEs capture the essence of dynamic systems in their purest form. In other words, the relationship of the ODE with the physical system is the relationship of the esoteric with the exoteric manifestation. However, a caveat of this artwork, when viewed through the lens of Plato, is that if its beauty is appreciated solely on a sensory level, without an understanding of the underlying dynamics and equations, it risks activating the irrational part of the soul, diverting attention from the pursuit of higher truths. Whereas looking at it with awareness is the engagement of the rational soul which is viewed positively by Plato.

Aristotle's interpretation of mimesis, however, emphasizes its role in catharsis and emotional engagement [5]. The artistic value of these ODE drawings lies in their capacity to engage the viewer to contemplate the harmony and chaos of the system. Depending on what the system represents, the thought process would also differ in depth. For instance, a system of population dynamics, with values suggesting a decrease in the population of the prey, may evoke a sense of sadness due to the fact that the spirals will converge to the center (origin) of the page, suggesting extinction. The spiraling patterns of eigenvector alignment, the convergence to equilibrium, and the aesthetic appeal of these geometries showcase the coming together of form and function. For Aristotle, this project aligns science with art by creating visuals that resonate emotionally while remaining intellectually rigorous.

3.2 Susan Sontag: Against Interpretation

Susan Sontag's critique of the over-interpretation of art emphasizes the immediacy of sensory experience [6]. These ODE visuals are designed to be intuitively understood rather than overanalyzed. The interplay of colors, symmetry, and dynamic behavior when simulated invites the viewer to "feel" the behavior of the system without needing an engineering background to dissect its mechanics.

Sontag's philosophy therefore allows the artwork to display mathematics as pure visual poetry. The phase planes become canvases, their beauty independent of their mathematical rigor. This interpretation allows the artwork to be universal as it decouples the worth of the artwork from the audience's background knowledge.

3.3 Greenberg: Avant-Garde and Kitsch

The debate between avant-garde and kitsch is particularly relevant to this project. Clement Greenberg's characterization of avant-garde art as experimental and intellectually challenging contrasts with kitsch, which he sees as easily reproducible and accessible [7]. These artworks live in a space between these two concepts.

On one hand, the project is avant-garde due to its conceptual depth. By blending computational methods with aesthetic presentation, it challenges traditional boundaries of art and science and invites intellectual engagement. On the other hand, the reproducibility of these works through code could place them in the realm of kitsch. This duality highlights the evolving definition of art in the digital age, where the "hand of the artist" is replaced by algorithms.

3.4 Quantum Art and the Cosmic Web

The project also draws inspiration from quantum art and its emphasis on the interconnectedness of systems. Quantum art explores phenomena at the smallest scales, where probabilities and uncertainties govern outcomes. Beyond differential equations being the foundation of quantum mechanics, the random generation of the matrices, RGB values, and initial conditions, reflects the probabilistic aspect of the field as well.

These artworks relate to the cosmic web—the vast network of galaxies connected by filaments. Hayles suggests that everything in the universe is interconnected, meaning that nothing is truly independent [8]. This artwork both agrees and disagrees with this statement. On one hand, the dependence of solutions on their derivatives suggests the interconnectedness of all variables. However, the solutions to ODEs given different initial conditions are unique, meaning that they will never intersect due to the existence and uniqueness theorem. This can be interpreted as opposing Hayle's cosmic web theory, depending on the initial assumption the viewer makes.

4. Conclusion

This project serves as a convergence point for engineering, science, and aesthetic theory. It begins with the mathematical precision of ODEs and transforms these abstract concepts into visual forms that invite philosophical contemplation. The aesthetic theories of Plato, Aristotle, Sontag, Greenberg, and the cosmic web analogy collectively shape how this artwork is conceptualized, represented, and ultimately interpreted.

4. References

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