

Efe Ali Mert

Theory of Knowledge

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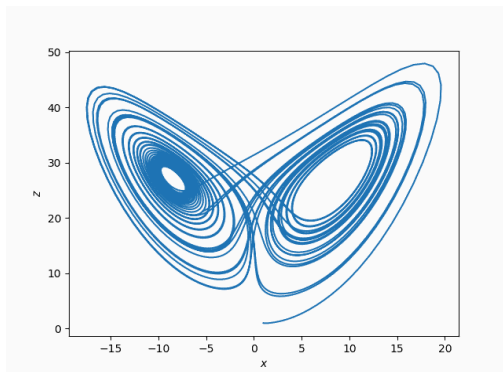
TOK Exhibition Homework Due to 06.10.2025

Select a Knowledge Question

Knowledge question from "TOK Exhibition IA Prompts" selected as Are some types of knowledge more useful than others? The reason is why this question was selected is because the selected object has chaotic properties.

Select and Contextualize a Real-Life Object

Object: Lorenz System's Attractor.

**Fig. 1: Lorenz System's Attractor**

$$\begin{aligned}\frac{dx}{dt} &= \sigma(y - x), \\ \frac{dy}{dt} &= x(\rho - z) - y, \\ \frac{dz}{dt} &= xy - \beta z.\end{aligned}$$

Fig. 2: Lorenz Equation

Lorenz, an academic at MIT. While attempting to model atmospheric convection, Edward N. Lorenz noticed that this system was very sensitive to initial values and became chaotic with subsequent iterations. Moreover published these observations in Lorenz, E. N. (1963). Deterministic nonperiodic flow. *J. Atmos. Sci.*, 20(2):130–141. Furthermore, when he attempted to visualize this system, he realized that it resembled a butterfly. In a lecture, Edward N. Lorenz introduced his system with the same words, "A flap of a seagull's wing can trigger a hurricane halfway around the world." What he actually meant was how sensitive this system was to initial values. Because of its butterfly-like shape, the seagull transformed into a butterfly, giving rise to the concept of the "butterfly effect." Now, the butterfly effect focuses on how small changes can lead to large changes.

Connection Between Object and Knowledge Question

Reason 1: The Usefulness of "Qualitative" vs. "Quantitative" Knowledge

The Lorenz Attractor presents a significant diversity among types of knowledge. The question at hand here is whether we should know the initial values of a system, or whether the output will exhibit only chaotic properties. This question can be interpreted from different perspectives. For example, is it more useful to know that it will rain tomorrow, or that the raindrops will be 5 mm in diameter? This raises a philosophical question. Interpreted from this perspective, knowing the initial values can help us predict future events. However, since each value is linked to the previous value, prediction becomes impossible after a certain point. Knowing that this system will exhibit chaotic properties can change our perspective on the system and remind us that we need to offer a different approach accordingly. For example, while a simple entropy measurement may be useful in this system, it may be more logical to calculate a Lyapunov exponent.

Reason 2: The Pragmatic Usefulness of Understanding Limits

The knowledge provided by the Lorenz Attractor is not entirely comprised of precise information. Paradigms in science prior to chaos theory were generally deterministic, arguing that with sufficient computing power, the future activity of any chaotic system could not be predicted, thus making chaotic systems irrelevant in the eyes of deterministic scientists. The Lorenz attractor and similar nonlinear systems marked a turning point by demonstrating fundamental and simple predictability in nonlinear systems. This knowledge (knowledge of things we cannot know) is crucial and useful. In fields like finance and meteorology, and even more broadly, applied mathematics, it teaches us not to rely on short-term predictions, but rather allows us to make short-term inferences based on knowledge of something in the long term. Rather than seek predictions with unattainable precision, we construct systems that depend on various outcomes. This attractor and chaos theory establish an epistemological limit to the futility and purposelessness of absolute certainty.

Reason 3: The Instrumental Usefulness of a Simple Model for Complex Reality

The utility of the Lorenz Attractor lies in its simplified nature. The real-world atmosphere, of course, cannot encompass its infinite complexity and is merely an abstraction consisting of a three-dimensional differential equation. But the outcome of information is extremely powerful. This attractor has given rise to concepts like the "butterfly effect." This attractor, thanks to its sensitivity to initial values, is used across diverse disciplines, reminding us of the interdisciplinary nature of chaotic systems. For example, this sensitivity to initial values can be applied and is used in many fields, ranging from neuroscience to computer science. It is an inevitable fact that it helps us understand why perfect long-term

predictions are impossible in complex systems. This helps us understand that the most useful information is not factual data, but rather the complexity of the world.

Reflection and Discussion

When we consider the Lorenz attractor, it raises various philosophical questions beyond its status as a chaotic system. This discussion extends from a meteorological question to how knowledge is generated in the modern world. First, we touched upon the importance of quantitative and qualitative information regarding this system. The usefulness of definitive information and its impact on simple systems were discussed. As a result of this information, it became clear that it is more than just an attractor.

Final Reflection

The Lorenz attractor is not only a chaotic system, but also one that opens the door to new philosophical questions. From this system, I learned that quantitative understanding inevitably alters the knowledge we find useful, leading us to ask better questions rather than seek false certainty. I also learned that unpredictable knowledge is more valuable than fragile predictions.

Extra Photos / Websites



Fig. 3: Edward Norton Lorenz

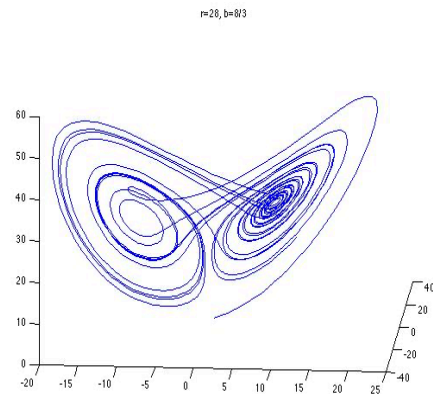


Fig. 4: Lorenz Attractor (2)



Fig. 4: Lorenz Attractor Simulator

Works Cited

Lorenz, E.N. (1963). *Deterministic nonperiodic flow*. *Journal of the Atmospheric Sciences*,
20, 130-141.