

“ChaoSwitch”

Toward Experiential and Reflective Learning of Complex Phenomena in 3D Virtual World

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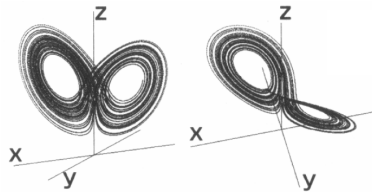
1. Introduction

In this presentation, we propose a new experimental tool for learning complex phenomena of “chaos”, which it is difficult to understand intuitively because of their complex behaviors. In our method, the students learn the complex phenomena not only by listening teacher’s lecture, but also by simulating the models in 3D virtual world.

2. Lorenz Attractor

We introduce an experimental tool for generating three-dimensional patterns of “Lorenz attractor”, which is discovered by E. Lorenz (1963) as a simplified model of convection rolls in the atmosphere. It is one of the famous “strange attractor”, which is based on the simple rules as follows, but acts so complex.

$$\begin{aligned}\frac{dx}{dt} &= -10x + 10y \\ \frac{dy}{dt} &= 28x - y - xz \\ \frac{dz}{dt} &= xy - \frac{8z}{3}\end{aligned}$$



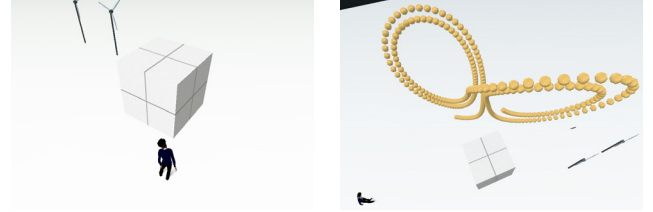
Though this system arises under a deterministic rule and the behavior seems periodic, the trajectory never gets fixed point or periodic orbit. It means that the values generated by the function are different each other forever. It is difficult to understand the shape of the attractor, because the attractor is usually described by mapping the three-dimensional structure into two-dimensional figure as follows.

3. “ChaoSwitch”

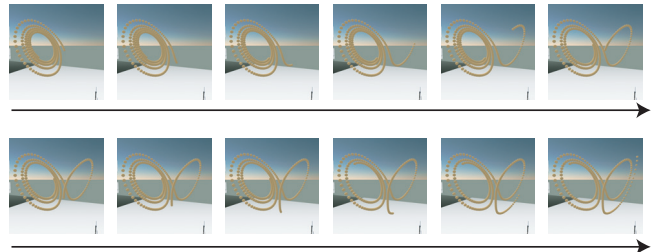
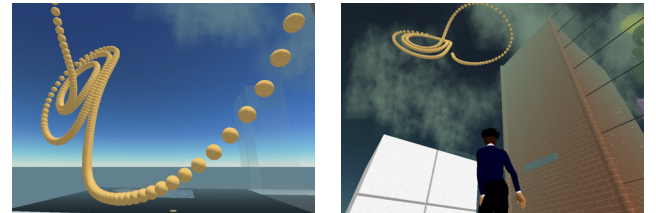
We create a virtual tool “ChaoSwitch” which generates the three-dimensional patterns of Lorenz attractor in the metaverse of “Second Life”. The “Second Life” is a 3D virtual world provided by Linden Lab. When you touch the box of “ChaoSwitch”, the box generates the Lorenz attractor above the box. The box of “ChaoSwitch” generates Lorenz attractor in the three-dimensional space and we can observe the trajectory from every point of view where you want.

As results of the experiment, we can see the complex trajectory of nonlinear dynamics more visually and the ChaoSwitch gives us a new experience in understanding Lorenz Attractor.

The following figures show the trajectory of Lorenz Attractor generated by “ChaoSwitch” in Second Life. In Second Life, we can move everywhere (even fly in the sky) and also take a view point from anywhere. This enables us to observe the complex orbit more visually. As shown in figure, we can observe the trajectory moving complicated



and it reveals that orbit never cross itself or gets stable fixed point. Taking these various view points proposes a new experience in understanding complicated trajectory of nonlinear dynamics. Comparing with the visualization in two-dimensional, it is more the 3D virtual world obvious difference could be observed in visuals. We found that the method describing those complicated trajectories in 3-dimensional virtual-world has a potential for new understandings about mathematical notion.



4. Experiential and Reflective Cognition

We design “ChaoSwitch” for supporting to learn the complex phenomena with both of experiential cognition and reflective cognition. D.A. Norman suggests that there are two mode of human cognition: experiential cognition and reflective cognition (Norman 1993). The experiential cognition is the cognition to react the change of environment subconsciously, and it grabs the attention and generates excited emotion. On the contrary, the reflective cognition is the cognition to examine and think over the matter. Our tool supports both of experiential cognition and reflective cognition by providing the interesting phenomena in 3D virtual world.

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