A Coupled Oscillator Model of Creative Cognition Process for Emergent Systems

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Introduction

Psychologists (e.g., Wallas 1926; Guilford 1959; Finke et al. 1992) have clarified the existence of a process controlled by imagination that precedes what is called design, which are deductive logic operations, for the act of creation, in which things that had hitherto not existed are created; a creative act absent this process in mental space is not possible. In other words, a process that could be perceived as what is called insight or idea generation before deductive logic operations substantially controls the creative process. However, research proposing mathematical models for such as the creative cognition process for direct linkage to creativity has seldom been conducted.

When, analyzing the musical work's structures of Brahms, Wagner, for example, a melody is present here, although the melody and harmony are inseparable; there is absolutely no way to first have the melody and then harmonization with it. Moreover, the melody and harmony are allocated to individual instruments for respective sounds and with harmonic progression are changed to be extremely effective as melody; if melody and harmony do not exist simultaneously and if changes in both harmonic progression and timbre in the process of creation do not exist simultaneously in the brain of the composer as a sound image, then creation of a work like this would be close to impossible. That is, harmony, melody, and timbre are in a mode where they are blended into one another and creation must be interpreted to progress with simultaneous processing of these in parallel in the brain of the composer. However, the music theory proposed until now is only static system theory (e.g., Lerdahl & Jackendoff 1983; Forte 1973) and dynamical system theory is not proposed yet.

A Device for Emergent Systems

Two continuous-time autonomous dynamical systems $\mathbf{X_a}$ and $\mathbf{X_b}$ are considered in n-dimensional Euclidean space $\mathbf{R}^n$.

$$\dot{\mathbf{X}}_\mathbf{a} = \mathbf{F}(\mathbf{X}_\mathbf{a}), \quad \dot{\mathbf{X}}_\mathbf{b} = \mathbf{F}(\mathbf{X}_\mathbf{b}) \quad \cdots(1)$$

Here, $\mathbf{F}$ is considered to be the Lorenz system for both with n=3, when considering the $\mathbf{X_a}$ and $\mathbf{X_b}$ in bi-directionally coupled by $0<c_{1,2,3}<1$ are temporal coupling coefficients and $0<d_{1,2,3}<1$ are spatial coupling coefficients, where individual vector components are

$$\mathbf{X}_\mathbf{a} = [x_1, x_2, x_3], \quad \mathbf{X}_\mathbf{b} = [x_4, x_5, x_6] \quad \cdots(2)$$

$$\begin{pmatrix} \dot{x}_{1,4} \\ \dot{x}_{2,5} \\ \dot{x}_{3,6} \end{pmatrix} = \begin{pmatrix} \sigma(x_{2,5} - x_{1,4}) \\ x_{1,4}(r - x_{3,6}) - x_{2,5} \\ x_{1,4}\, x_{2,5} - b\, x_{3,6} \end{pmatrix} + \mathbf{D} \begin{pmatrix} x_4 - x_1 \\ x_5 - x_2 \\ x_6 - x_3 \end{pmatrix} \quad \cdots(3)$$

$$\mathbf{D} = \begin{pmatrix} c_1 & d_2 & d_3 \\ d_1 & c_2 & d_3 \\ d_1 & d_2 & c_3 \end{pmatrix} \quad \text{: excitatory connection}$$

$$\tilde{\mathbf{D}} = \begin{pmatrix} c_1 & d_2 & 1-d_3 \\ 1-d_1 & c_2 & d_3 \\ d_1 & 1-d_2 & c_3 \end{pmatrix} \quad \text{: inhibitory connection}$$

Discussion

The presented Lorenz model having two parameters c and d is a device that has coupled three one-dimensional information codes of $\{x_1$-x_4, x_2-x_5, x_3-$x_6\}$. This device can be used as an emergent device for three channels through control of on-off intermittent chaos as observed in this model with the c and d as parameters. The c and d control on-off intermittent chaos, although they have no direct effect on individual vectors and work as independent parameters without providing internal disturbance. The wandering on the three one-dimensional information coded space in the burst phase with seeking and gathering of valuable information from this, synchronized stabilization on a point in the laminar phase can be modeled as a process that intermittently and irregularly repeats and the phase transition between laminar phase and burst phase simultaneously occur in three dimensions. Figure 1 shows the phase transition from chaos→limit cycles→intermittent chaos → laminar phase with increase of the value of d=d_1=d_2=d_3 in case as constant of c=c_1=c_2=c_3. The figure is plotted in t=0~100000, d=0~1. The d is changing linearly with t, where d=0.00001t.

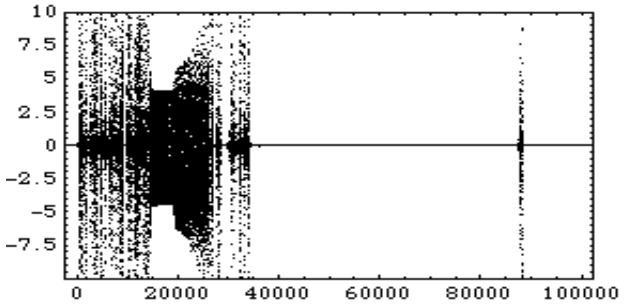

Figure 1. x_1-x_4 versus d (indicated by 10^5), where, σ=10, b=8/3, r=28, c=0.4, inhibitory connection.