1-20

Synchronization Phenomena in a Ring of Cubic Maps Containing Delay Coupling

Yuki FUJISAWA[1] **Yoko UWATE**[1] **Yoshifumi NISHIO**[1]
([1] Tokushima University)

1. Introduction

Generally, complex dynamical phenomena can be observed in networks formed by many elements with nonlinearity. Coupled Map Lattice (CML) has been proposed by Kaneko [1]-[4], to represent the complex high-dimensional dynamics. We investigate the relation between average length of laminar part and combination of the delay. And we consider coupling cubic map with four periodic solution easily to become to the synchronization states by delay.

2. Coupled Cubic Maps

A cubic map is expressed as following equation:

$$f(x) = ax^3 + x(1 + a),$$

where a represents a bifurcation parameter. We consider coupled maps with delays. The coupling method is expressed as following equation:

$$\begin{aligned} x_{n+1}(i) &= (1 - g)f(x_n(i)) \\ &+ (g/2)(f(x_{n-\tau}(j)) + f(x_{n-\tau}(k))), \end{aligned}$$

where g represents the coupling strength, τ represents the delay between the maps and n represents the iteration time. Figure 1 shows the bifurcation diagram of cubic map. This figure shows periodic windows (near a = -3.69, -3.83). We focus on the boundary of periodic windows in the bifurcation diagram of cubic map. Figure 2 shows the time series of coupled cubic map with intermittency chaos (a = 3.82842712). This figure shows intermittency chaos is switching between laminar and burst. Furthermore, in the case of a = 3.82842712, intermittency chaos including four periodic laminars are observed.

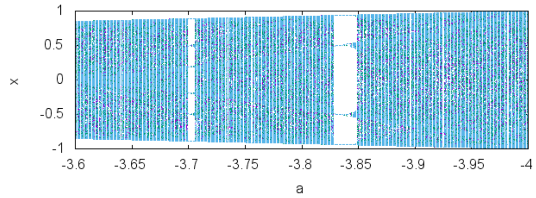


Figure 1: The bifurcation diagram of cubic map.

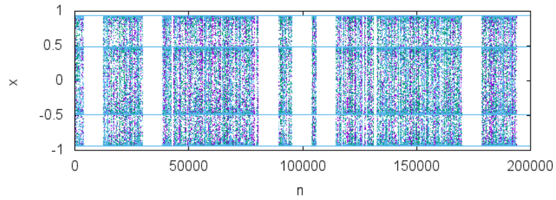
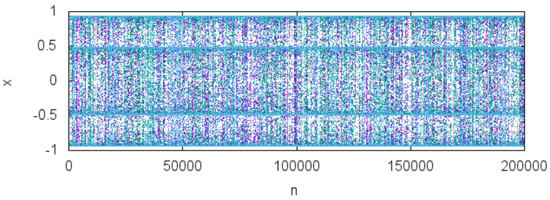
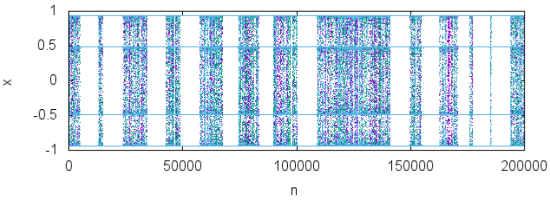


Figure 2: Time series of coupled cubic maps ($\tau_1 = 0$, $\tau_2 = 0$, $\tau_3 = 0$).



(a) $\tau_1 = 1$, $\tau_2 = 1$, $\tau_3 = 2$.



(b) $\tau_1 = 2$, $\tau_2 = 4$, $\tau_3 = 2$.

Figure 3: Time series of cubic maps containing delay.

3. Simulation results

In this study, the initial conditions and the parameters of cubic maps are fixed with a = 3.82842712, x_1 = 0.1, x_2 = 0.2, x_3 = 0.3, g = 0.000001. The iteration time is fixed with n = 200000. And range of the delay is τ_m = 0, 1, 2, 3, 4(m = 1, 2, 3). Figure 3 shows the difference by combination of delay. When τ_m is set to 0 or 2 or 4, coupling cubic map with four periodic solution easily to become to the synchronization states by delay. Furthermore, the synchronization pattern is changed by combination of delay.

4. Conclusions

In this study, we have investigated the influence of the delay in coupled cubic maps with intermittency chaos. First, we could consider maps with four periodic solution easily to become to the synchronization states when τ_m is set to 0 or 2 or 4. Next, synchronization pattern is changed when τ_m is set to 0 or 2 or 4.

Reference

[1] K. Kaneko, "Spatiotemporal Intermittency in Coupled Map Lattice," Prog. Theor. Phys., vol.75, no.5, pp.1033-1044, 1985.
[2] K. Kaneko, "Pattern Dynamics in Spatiotemporal Chaos," Physica D, vol.34, pp.1-41, 1989.
[3] K. Kaneko, "Spatiotemporal Chaos in One- and Two-Dimensional Coupled Map Lattice," Physica D,vol.37, pp.60-82, 1989.
[4] C. G. Langton, "Computation at the Edge of Chaos: Phase Transitions and Emergent Computation," Physica D, vol.42, pp.12-37, 1990.