Journal of Zhejiang University-SCIENCE A (Applied Physics & Engineering)

Synchronization stability between initial-dependent oscillators with periodical and chaotic oscillation

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Cite this as: Wu, F., Ma, J. & Ren, G, 2018. Synchronization stability between initial-dependent oscillators with periodical and chaotic oscillation. *Journal of Zhejiang University-SCIENCE A (Applied Physics & Engineering)*, 19(12):889-903. https://doi.org/10.1631/jzus.A1800334

Initial-dependent dynamical system

$$\begin{cases} \dfrac{\mathrm{d}x}{\mathrm{d}t} = -y - z, \\ \dfrac{\mathrm{d}y}{\mathrm{d}t} = x + ay - kz^2 y, \\ \dfrac{\mathrm{d}z}{\mathrm{d}t} = b + z(x - c), \end{cases} \quad (1)$$

Mechanism and characteristics: Slight difference in setting initial value for variable z can induce distinct difference in dynamics, oscillation transition between periodic and chaotic states. Any changes in initial value for variable z can generate distinct parameter modulation in the nonlinear term z^2y and the nonlinear modulation is enhanced.

Synchronization stability and approach

$$\begin{cases} \dfrac{\mathrm{d}x_i}{\mathrm{d}t} = -y_i - z_i, \\ \dfrac{\mathrm{d}y_i}{\mathrm{d}t} = x_i + a y_i - k_i z_i^{\,2} y_i + g_y (y_{i+1} + y_{i-1} - 2y_i), \\ \dfrac{\mathrm{d}z_i}{\mathrm{d}t} = b + z_i (x_i - c), \end{cases} \quad (2)$$

Synchronization factor *R*

$$R = \frac{< F^2 > - < F >^2}{\dfrac{1}{N}\sum_{i=1}^{N} < x_i^2 > - < x_i >^2}, \quad F = \frac{1}{N}\sum_{i=1}^{N} x_i, \quad (3)$$

Where *i* is the subscript for oscillator in the network, g_y is the coupling intensity, R is the factor of synchronization. Perfect synchronization is stabilized at *R*~1, while non-perfect synchronization is reached at lower factor *R*~0.

Conclusions

- The synchronization approach is dependent on the initial setting for variable *z*.
- Two different oscillators are activated when different initials are applied for the variable *z*.
- Two periodical oscillators can be coupled to reach chaotic synchronization.
- Chaotic oscillator can be suppressed when it is coupled with another periodical oscillator.
- Diversity and difference in the initial setting for variable *z* of oscillators can generate heterogeneity in the network, and the synchronization approach becomes difficult.
- This network model can be further used for pattern selection and image encryption.