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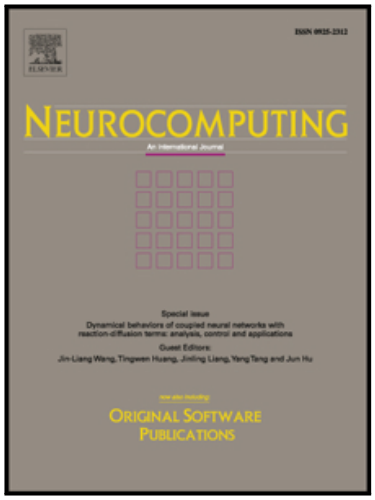

The existence and exponential stability of periodic solution for coupled systems on networks without strong connectedness

Pengfei Wang, Guangshuai Wang, Huan Su

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The existence and exponential stability of periodic solution for coupled systems on networks without strong connectedness

Pengfei Wang, Guangshuai Wang, Huan Su*

[a]*Department of Mathematics, Harbin Institute of Technology (Weihai), Weihai, 264209, PR China*

Abstract

This paper focuses on the problem of the existence and global exponential stability of periodic solution for coupled systems with delays on networks without strong connectedness (NWSC), which extends previous results of strongly connected networks. An innovative hierarchical method is proposed to characterize a large NWSC. Then each layer consists of several independent strongly connected subnets. By using the existing results of strongly connected networks and constructing auxiliary systems, we investigate the existence of periodic solution for original coupled systems on NWSC layer by layer. Moreover, the uniqueness and global exponential stability of periodic solution are considered as well. Then the theoretical results are applied to coupled oscillators on NWSC. Finally, a numerical example is also provided to illustrate the effectiveness of the theoretical results.

Keywords: Periodic solution, Global exponential stability, Graph theory, Lyapunov method, Networks without strong connectedness

1. Introduction

Coupled systems on networks (CSNs) are usually systems presenting a very high number of components which interact with each other. In such way, some global phenomena that cannot be deduced from the knowledge of the dynamics of each unit emerge appear. So studying global properties in such coupled structure is a really challenging task and is very meaningful for their omnipresence in the fields such as epidemiology [1, 2], biology [3], neural networks [4, 5, 6, 7, 8], population dynamic [9, 10], physics [11, 12] and so on. An effective method of capturing the global properties is to model these systems on a digraph, in which each vertex stands for an individual system called vertex system and the directed arcs represent the interconnections and interactions among vertex systems. Recently, Li et al. [13, 14] used the graph theory to explore the global stability for coupled systems on strongly connected networks. From then on, various forms of CSNs have been developed and investigated, such as stochastic CSNs [15, 16, 17, 18, 19], discrete-time CSNs [20, 21], fractional-order CSNs [22], complex-valued CSNs [23, 24, 25] and impulsive CSNs [26].

Among emergent dynamical phenomena of CSNs, another widely observed phenomenon in concrete life is periodicity, such as the periodicity of celestial bodies motion, the wave vibration, climate changes and so on. In recent decades, many scholars have devoted themselves to studying the existence of periodic solutions and until now, many methods such as fixed point theorem [27, 28], coincidence degree theory [29], Lyapunov method

*Corresponding author. Tel.: +86 0631 5687035; fax: +86 0631 5687572.
Email address: suhuan1981@163.com (Huan Su)