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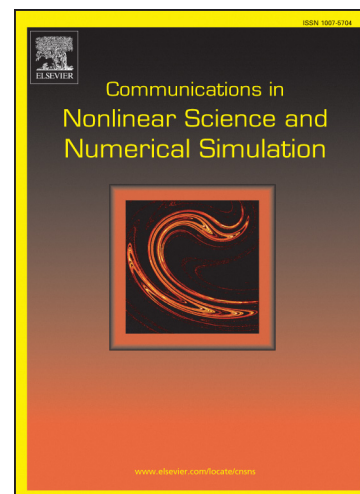
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# Global exponential stability for stochastic networks of coupled oscillators with variable delay

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## Abstract

A general model of stochastic networks of coupled oscillators with variable delay is considered. Together the methods of graph theory and Lyapunov function, some sufficient conditions which ensure the  $p$ -th moment exponential stability and the almost surely exponential stability are presented. Finally, the results are applied to an example and the numerical simulations are given to verify and also visualize the theoretical results.

**Keywords:** Stochastic network; Coupled oscillators; Variable delay; Exponential stability

## 1. Introduction

Networks of coupled oscillators (NCOs) have become an active research area, which lead to its widely applications in mechanical, electrical engineering, and biological systems [1, 2, 3, 4, 5, 6, 7, 8, 9, 10]. In particular, self-excited systems and synchronization in NCOs are of great significance in the past years. Since there naturally exists a consequence of finite information transmission and processing speeds among the units in many large-scale networks, time-delays are always taken into account in the realistic modeling, such as the time-delayed coupling in biological neural networks, gene regulatory networks, epidemiological models, communication networks and electrical power grids [11, 12, 13] etc. On the other hand, various types of environmental noises exist in nature, and the realistic NCOs are often perturbed by noises [14, 15, 16, 17]. So it is also necessary to introduce stochastic arguments into NCOs. Especially, the stability of these systems is important in applications.

In this paper, we consider the stability of a general stochastic NCOs with variable delay as follows:

$$\begin{aligned} \ddot{x}_k(t) + \varphi_k(x_k(t))\dot{x}_k(t) + x_k(t) + \sum_{h=1}^l \bar{H}_{kh}(x_k(t - \tau(t)), x_h(t - \tau(t)), t) \\ = \left[ h_k(x_k(t)) + \sum_{h=1}^l \bar{N}_{kh}(x_k(t - \tau(t)), x_h(t - \tau(t)), t) \right] \dot{W}(t), \quad t \geq 0, \quad k = 1, 2, \dots, l, \end{aligned} \quad (1)$$

in which  $x_k(t) \in \mathbb{R}$  is the state variable of the  $k$ -th dynamical node at time  $t$ ,  $\varphi_k$  is a continuously function, coupling delay function  $\tau(t) \in [0, \tau]$  is differentiable and its derivative is bounded by constant  $\bar{\tau} \in [0, 1)$ ,  $h_k$

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