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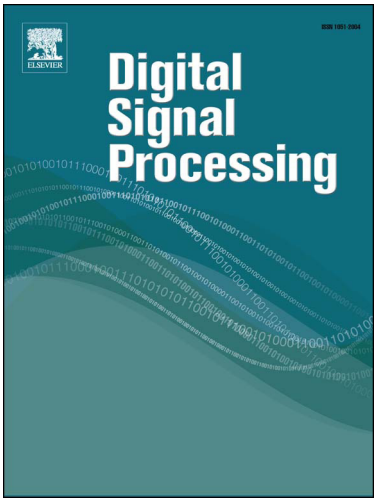

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A Novel Method of Realizing Stochastic Chaotic Secure Communication by Synchrosqueezed Wavelet Transform

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Abstract: Based on synchrosqueezed wavelet transform (SWT) algorithm, a new stochastic chaotic secure communication scheme is proposed in this paper. Information signals are modulated by additive chaos masking in the sending terminal. In order to improve the anti-jamming ability of chaotic systems, the proper controllers are designed to realize mean square asymptotic synchronization for a class of chaotic systems with random perturbation. In the receiving terminal, unlike the traditional extraction methods, a novel SWT algorithm is introduced to recover information signals correctly. Simulation results verify that both the synchronization approach and the security communication scheme are effective. For multi-component sinusoidal signal with adjacent frequency, the accuracy of signals recovered by SWT is higher than that recovered by empirical mode decomposition (EMD) method, even at the high noise level. Finally, the simulation experiment of the orthogonal frequency division multiplexing (OFDM) signal has been carried out, which proves that the proposed scheme based on SWT can reduce the Bit-Error-Rate than other algorithms even under high noise level.

Keywords: Synchrosqueezed wavelet transform, Random perturbation, Mean square synchronization, Secure communication

1. Introduction

Chaos is an important and interesting phenomenon in the nonlinear dynamical system. Studies on the chaos theory show that chaos can exhibit special advantages because of its complexity and unpredictability [1-2]. Therefore, the chaotic theory has been used to solve many engineering problems, especially for the secure communication [3-5].

Chaotic secure communication is generally based on the synchronization of chaotic dynamical systems. Various methods have been proposed in the past few decades, such as the additive chaos masking approach [6], the chaotic shift keying or the chaotic switching approach [7-8], and the chaotic parameter modulation method [9]. However, they do not have good anti-jamming ability especially for stochastic disturbance, which reduces the efficiency of application. Therefore, we try to achieve mean square synchronization of chaotic systems with random perturbation in this paper.

In addition, in the chaotic secure communication system, to effectively separate the chaos and the harmonic signal is an important method of testing the systematic confidential performance [14]. There are two traditional extraction methods of harmonic signal under the chaotic background: one is the phase space reconstruction method and the other is based on the geometric properties of strange attractor [10-12]. However, these methods require more complex conditions and a large quantity of calculations.

With the development of time-frequency theory, some scholars apply time-frequency analysis methods to extract the harmonic signal from chaotic interference in chaotic secure communication. An et al. apply continuous wavelet transform (CWT) denoising method in secure communication [13]. Wang et al. propose a method of extracting the harmonic signal from the chaos interference based on empirical mode decomposition (EMD) [14]. Although EMD achieves a better effect than the wavelet transform in harmonic extraction with chaos interference, it is very sensitive to noise [15-16]. Recently, Daubechies et al. show interesting results on the synchrosqueezed wavelet transform (SWT) to serve as an alternative method of EMD [17]. The SWT can accurately separate the mixed signal disturbed by noise, as it has better robustness than EMD [18]. Wang et al. apply SWT to extract the fixed frequency signal from chaotic interference, in which the communication performance has not been discussed [19]. How to apply the SWT to improve the accuracy of extraction method without reducing the security in secure communication has been an unsolved problem. It motivates us to realize SWT based stochastic chaotic secure communication. It should be noted that, the interest in the secure communication for the OFDM signal lies on its potential application in practical area, such as audio broadcasting, wireless networks, powerline networks, and 4G mobile communications [20-22].

Different from the conventional framework, we propose a novel method of realizing stochastic chaotic secure communication based on SWT. The main contributions of this paper are as follows. 1) The proper controllers are designed to improve anti-jamming ability of chaotic systems. Unlike the traditional LMI method [23], we design simpler controllers to realize mean square synchronization of a class of chaotic system with random perturbation. These controllers are more convenient to the implementation of industry applications. 2) We propose a novel scheme of chaotic secure communication based on SWT, which leads to the trade off between the accuracy of extraction method and the security in communication. Simulation results verify