Journal of Nonlinear Systems and Applications (2010) 87–95

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EXACT AND ASYMPTOTIC SYNCHRONIZATION OF A NEW WEAKLY COUPLED MAPS SYSTEM

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Abstract. The paper deals with the synchronization of a new statistically highly performant function firstly introduced by Lozi. The synchronization is reached via observers which reconstruct all the states of the original system, using only a partial information of it. The map has been rewritten as a piece-wise affine one, which allows to design two types of observers: an exact (dead-beat) observer, and an asymptotic observer. Both observers have been analyzed and compared in the case of white gaussian noise, and temporary (or accidental) switch off. The dead-beat observer guarantees the exact convergence; however, synchronization can not be preserved in any case if the observers are switched off since the map is highly chaotic, and the computer precision is finite. It is shown how to estimate the duration of acceptable synchronization loss from the required error precision. Criteria to define successful synchronization, and maximum synchronization error have also been derived.
Keywords. chaos, synchronization, discrete-time, observer, pseudo-random generators.

1 Introduction

Chaos has recently received a growing interest in various fields of science and engineering, and in particular, in secure communications. Several chaotic cryptographic schemes have been proposed since [1], [2] and can be classified in three main categories : chaotic masking, chaotic modulation and chaotic shift keying.

In the cryptographic application, the chaotic generator must exhibit appropriate features close to those of the pseudo-random generators. These adapted properties have been studied more precisely in [3], [4], [5].

Further researchers have then looked for finding appropriate systems testing different architectures : traditional chaotic maps (for example, the logistic map, the Hénon map, the generalized Hénon map) [6], piece-wise linear map, cascaded map [7] or coupled map lattice. In order to evaluate the features of the system, statistical tests developed for random and pseudo-random number generators (RNG and PRNG) can also be applied to chaotic maps, in order to gather evidence that the map generates "good" chaotic signals, i.e. having a considerable degree of randomness [3] [5].

It appears that most of the maps classically used for chaotic encryption do not pass successfully these tests, and don't exhibit the required features. However, most of the papers dealing with synchronization and observer synthesis consider precisely these kinds of maps, highly inefficient in the context of chaotic encryption. Unlike these models, Lozi introduced in 2008 a new ultra weakly coupled maps system [8] to generate pseudo-random signals which exhibits very good statistical properties.

Synchronization of chaotic systems has received a great interest since the pioneer work of Pecora and Carroll [9] and its application to secure communications attracted lots of works. There are two ways of achieving synchronization: it can be done by the inverse system [10] or by applying observers [11] [12]. Observers allows to reconstruct all the states of a system only with few components of it as shows Figure 1. An overview of observers in the case of secure communications process is avaible in [13]

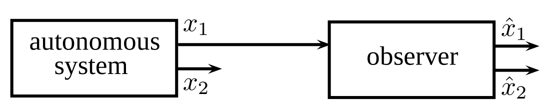

Figure 1: Observer

Our previous works on the new weakly coupled map function introduced by Lozi in 2008 [8] demonstrated its excellent statistical and spectral properties [14]; two kinds of observers have been proposed for the synchronization of the system: an inverse lag, and an exact observer. The latter consisted of 16 sub-observers which had to run in parallel in order to guarantee the exact convergence of one of them.

In comparison with these works, the present paper deepens and completes the previous results on exact observers, in particular by taking into account and exploiting the degrees of freedom in the choice of the observation matrices. The implementation issue related to the finite

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‡Manuscript received October 7, 2009; revised June 5, 2010.