Synchronization based on intermittent sampling: PWL multiscroll system

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Abstract. This paper addresses the optimization of resources for the synchronization of chaotic multi-scrolls Piece-Wise Linear (PWL) systems. Considering intermittent coupling, where the system alternates between coupling and free oscillation, the ability of the system to maintain a synchronous state under the premise of data loss is analyzed. The results obtained represent favorable scenarios, in which the system is able to maintain synchrony with unidirectional coupling in the presence of a reduction in available samples of up to 90%.

Introduction

The literature contains work that uses synchronization techniques based on the fact that coupling is not always active in the system. For example, [1] shows that there are regions where a pair of chaotic oscillators should theoretically remain synchronous, but their response is temporarily interrupted, affecting the collective dynamical response. In [2], its consider a digital function that enables and disables coupling between systems. Recently, the study of systems based on the reduction of available information has gained the attention of the scientific community. The goal is to address two important issues: i) to make control techniques more efficient in creating algorithms and implementations that can have inactive states, and ii) to obtain much more robust systems [3], where the loss of information do not reduce the overall performance of the dynamic agent. This paper analyzes the ability of a unidirectional system based on two multi-scroll systems using a Piece Wise Linear (PWL) function as a nonlinearity to maintain complete synchronization, by periodically activating and deactivating the coupling. The synchronization errors between the systems are calculated and the periods of information loss are varied along with the strength of the coupling to find the optimal parameters at which the system converges to the desired state with the least amount of information possible.

Results and Discussion

The onset of complete synchronization in the coupled systems is studied by calculating the synchronization index S, which takes into account the synchronization error and the Pearson correlation between the state variables of the driving and driven systems, as in [4]. Using this method, it is possible to study the effects of creating larger intervals, in which the coupling strategy loses information versus the effects of increasing the coupling force. The obtained results show that there is a pair of parameters (number of samples and coupling force) for which the driven system is able to maintain complete synchronization even when the coupling strategy has lost more than 90% of the capable information. This important result shows that oscillatory systems based on PWL functions do not necessarily need to maintain constant communication between agents to oscillate in unison. Moreover, if this is translated into a communication scheme, the obtained results would allow significant communication loss, or abrupt interruption of the same due to the detection of a possible attack, while maintaining the synchronous state.

References

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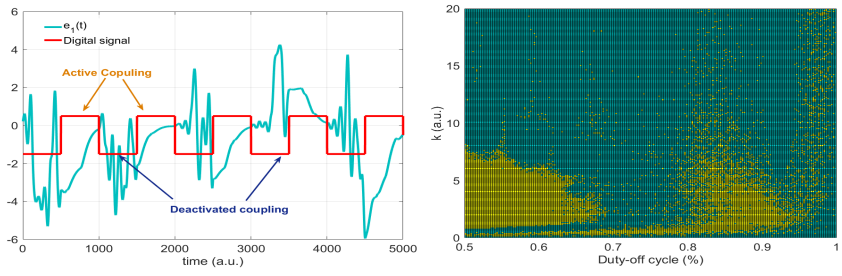

(a) (b)

Figure 1: (a) Temporal behavior of the synchronization error of state x_1 and the activation function for the coupling between the systems. (b) Map of synchronization index obtained for $\alpha = 0.45$, #Samples=600, changing the duty-off cycle of the coupling. Yellow indicates synchronization.