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SYNCHRONIZATION BETWEEN INTEGER AND FRACTIONAL ORDER DELAY NEURAL NETWORKS SYSTEM

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Abstract

The purpose is to present a method for synchronizing a recurrent neural networks system between integer and fractional-order order delay by active sliding mode control [1-3]. The Active Sliding Mode Control (ASMC) scheme is used to deal with the problem of synchronization among the integer order delayed neural network system (IoDRNNASMC) and the fractional order recurrent neural networks system (FoDRNNASMC) relying on the Lyapunov direct fractional method (LDFM) [4]. To explore the behavior of the IoDRNNASMC systems and the FoDRNNASMC systems, we performed the technique of numerical simulations using MATLAB software to prove the feasibility and strength of the archived outcomes. This concept can also be enhanced with the implementation of double encryption using RSA encryption to secure communication [5]. Because we expected in the future that this enhanced concept will strengthen and increase the network security capabilities that will provide powerful protection in secure communications.

Research Highlights

- Synchronizing the fractional-order with integer-order with the framework of neural networks of the.
- The systems are synchronized using ASMC and LDFM.
- Systems are synchronised in the form of delayed systems.
- The implementation of the master-slave system in the secure communication system.

Graphical Abstract

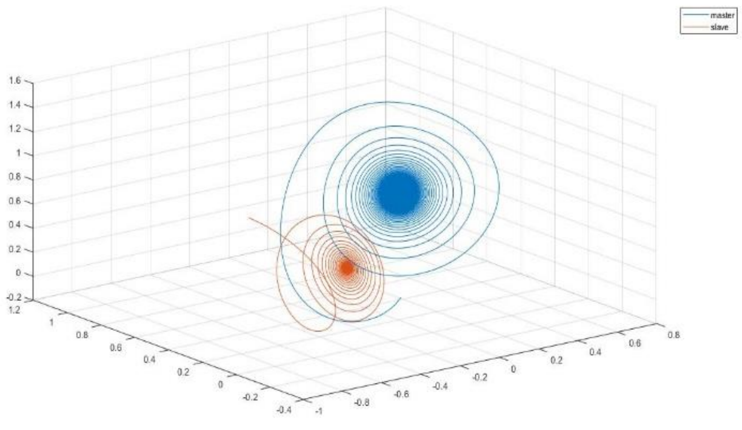

Fig. 1: Synchronization of chaotic attractor of IoDRNNASMC system and FoDRNNASMC system

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Research Objectives

- A new fractional-order integral inequality is obtained for dealing with time delay properties
- To overcome the activation function problem, a class of novel Lyapunov fractional functions is established to indicate that the synchronization error asymptotically converges to zero..
- To proposed that the neural networks of fractional order and integer order are synchronized globally with time delays relying on a novel Lyapunov fractional function and delayed active sliding mode controller (DASMC).
- To construct DASMC that will ensure the synchronization between FoDRNNASMC and IoDRNNASMC systems.
- To suggested an ideas that are more effective and secure compared with the previous literary results.

Methodology

This part summarizes the methodology for synchronization process and RSA encryption process used for in this paper. The research guidelines are given in *Fig. 2* and *Fig. 3*.

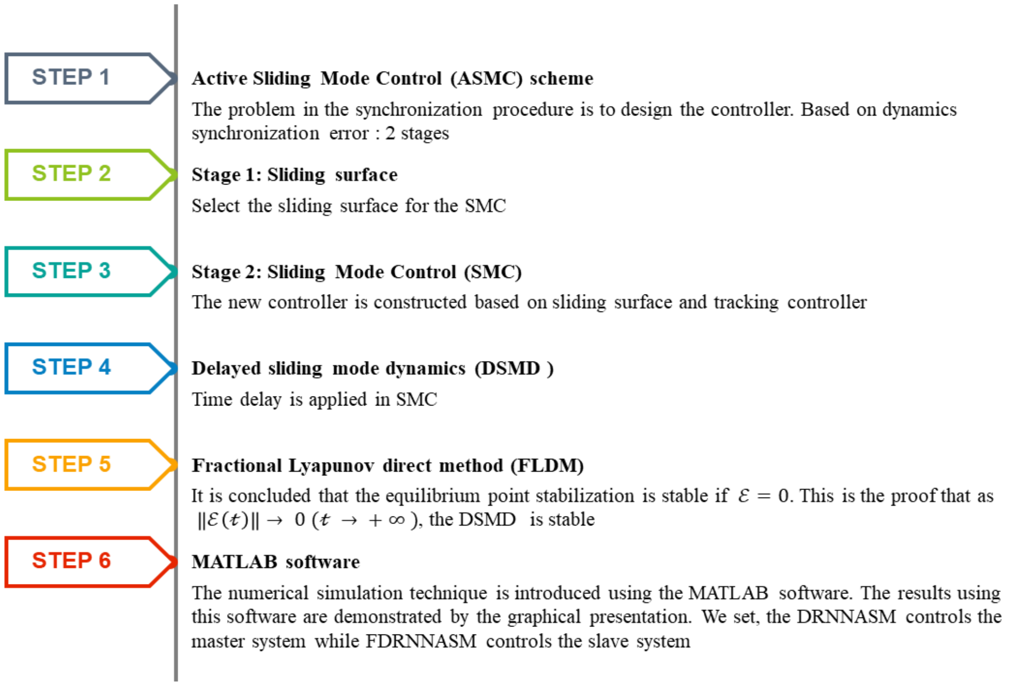

Fig. 2: Methodology

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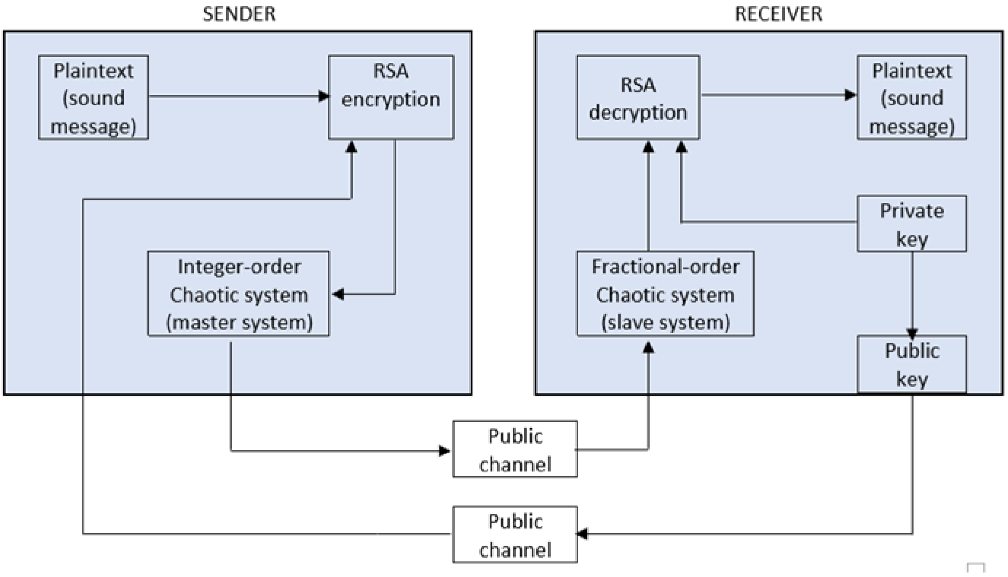

Fig. 3: RSA encryption IoDRNNASMC and FoDRNNASMC system.

Results

This part, the suggested idea with numerical examples is revealed to to check the viability and efficiency of results obtained. As we know that the master schemes are in the form of an integer number, so the order value is 1. Assume the master IoDRNNASMC systems and the slave FoDRNNASMC systems with the proposed results are as follows.

$$D^1\varkappa(t) = -q\varkappa(t) + uf(\varkappa(t)) + vf(\varkappa(t-\tau)) + \Gamma$$

$$D^{\beta}\mho(t) = -e\mho(t) + bg\big(\mho(t)\big) + tg\big(\mho(t-\tau)\big) + \beth + D^1\varkappa(t) - f(\varkappa(t)) + \mathfrak{H}(\mho(t),\varkappa(t))$$

$$\mathfrak{H}\big(\mho(t),\varkappa(t)\big) := \sqcup_1\,\varkappa(t) + \sqcup_2\,\varkappa(t-\tau),$$

Where $\beta = 0.99$, $\tau = 0.5$, $f(\varkappa(t)) = tanh(\varkappa(t))$, $g(\mho(t)) = tanh(\mho(t))$, $\sqcup_1 = (0,1,0)$, $\sqcup_2 = (0,1,0)$, $\Gamma = (0,0,0)^T$, $\beth = (0,0,0)^T$,

$$q = \begin{bmatrix} -9.5 & 0 & 0 \\ 0 & -10.5 & 0 \\ 0 & 0 & -3.7 \end{bmatrix},\ u = \begin{bmatrix} 2 & 0.5 & 5.5 \\ 0.5 & 0.5 & 5.1 \\ 0.5 & 1 & -5.5 \end{bmatrix},\quad v = \begin{bmatrix} 7 & 7 & 4.1 \\ 1 & 1 & 2.5 \\ 0.1 & -10.1 & 4.5 \end{bmatrix}$$

$$e = \begin{bmatrix} -1 & 0 & 0 \\ 0 & -3 & 0 \\ 0 & 0 & -7.7 \end{bmatrix},\quad b = \begin{bmatrix} 0.01 & 0.3 & 7.5 \\ 0.01 & 0.5 & 7.5 \\ 0.01 & 3 & -5.5 \end{bmatrix},\quad t = \begin{bmatrix} 0.3 & 5.5 & 5.5 \\ 0.5 & 2.5 & 5.5 \\ 0.1 & -1.5 & 1.5 \end{bmatrix}$$

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Using MATLAB tools the numerical simulation technique is implemented here. The findings are illustrated via the graphical visualization using this program. For this, IoDRNNASMC acts as a master system while FoDRNNASMC acts as a slave system.. The results are presented with the master system's initial conditions as $(\varkappa_1(0), \varkappa_2(0), \varkappa_3(0)) = (0.1\,, 0.3\,, -0.1\,)$ whereas the initial condition of the slave system is $(\mho_1(0), \mho_2(0), \mho_3(0)) = (0.1\,, 1.2\,, 0.1)$.

The effects of IoDRNNASMC and FoDRNNASMC synchronization with controller activation are shown in *Fig.* ***4*** shows that the synchronization error does converge to zero in the fixed time. This showed that the synchronization process is succeed.

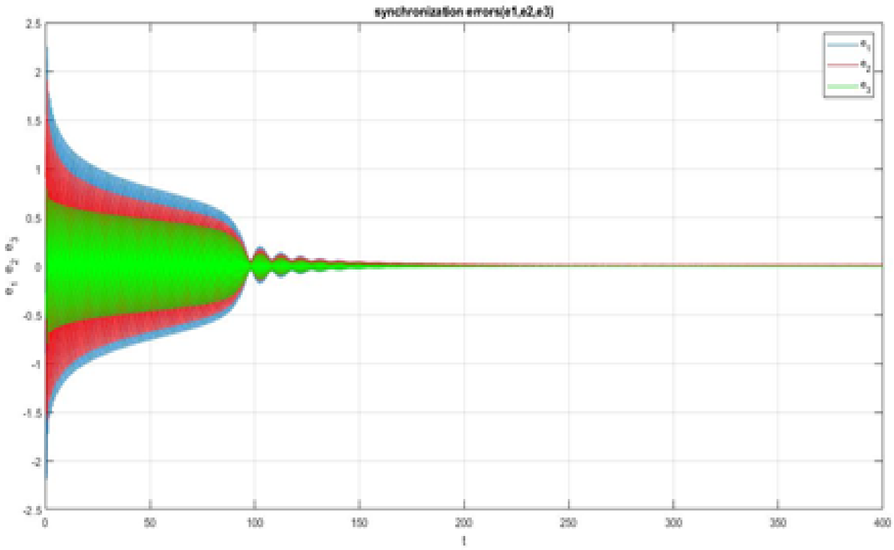

Fig. 4: The error trajectories of IoDRNNASMC system and FoDRNNASMC system with control input

Findings

We studied the synchronisation of IoDRNNASMC systems and FoDRNNASMC systems in this paper. Depending on the DASMC, the DAMC theory, the LDFM is implemented to illustrate the effectiveness of synchronisation. We have shown that IoDRNNASMC systems and FoDRNNASMC systems can be synchronized when the proposed controller is enabled and the result showed that the state error translated to zero. In future, we will be aiming to synchronize the FoDRNNASMC with non-identical order.

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Author's Biography

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