Dual combination synchronization of the fractional order complex chaotic systems

Ajit K. Singh, Vijay K. Yadav, and S. Das *

The authors have proposed a novel scheme for the dual combination synchronization amongst four master systems and two slave systems for the fractional order complex chaotic systems. Dual synchronization is a special circumstance in synchronization in which two different pairs of chaotic systems, i.e., two master systems and two slave systems are synchronized. The dual synchronization in integer order systems was first proposed by Liu and Davis [1] in 2000, where a pair of master systems was synchronized with another pair of slave systems. In 2013, Xiao et al. [2] have constructed a theory frame about dual synchronization and the theory was successfully used to design a synchronization controller to achieve synchronization of fractional order chaotic systems. In the combination synchronization, three chaotic systems, i.e., two master systems and one slave system are synchronized. The importance of combination synchronization in secure communication has already been established by Runzi et al. [3], in the year 2011 by splitting the transmitted signals into several parts, each part loaded in different master systems or by means of splitting time into intervals so that the signals in different intervals are loaded in different master systems in order to ensure that the transmitted signals have stronger anti-attack and anti-translated capability. In 2015, Jiang et al. [4] proposed a generalized combination complex synchronization taking two fractional order complex chaotic systems as master systems and one fractional order complex system as slave system. For the three different pairs, i.e., four master systems and two slave systems, the dual combination synchronization was recently studied by Sun et al. [5] for the integer order real chaotic systems.

Motivated by the above discussion, the authors have investigated the dual combination synchronization for the six fractional order complex chaotic systems which has not yet been explored. Since in the present scenario, the numbers of variables are increased in the complex space, it will be more secure and interesting to transmit and receive signals in application of communication. As the fractional order complex systems are in complex variables, it provides a best instrument to describe a variety of physical phenomena such as amplitudes of electromagnetic field, thermal convection of liquid flow, detuned laser system etc.

Based on the Lyapunov stability theory, six complex chaotic systems are considered and corresponding controllers are designed to achieve synchronization. The special cases, such as combination synchronization, projective synchronization, complete synchronization and many more can be derived from the proposed scheme. The corresponding theoretical analysis and numerical simulations are shown to verify the feasibility and effectiveness of the proposed dual combination synchronization scheme.

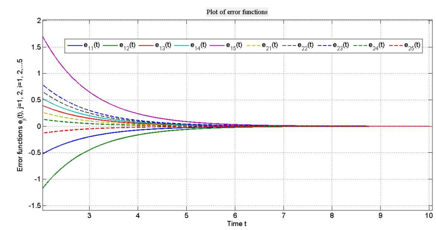

Figure 1: The evolution of error functions at fractional order 0.95

Full paper published in A. K. Singh, V. K. Yadav and S. Das, Dual combination synchronization of the fractional order complex chaotic systems, *ASME J. Comput. Nonlinear Dyn.*, **12(1)**, 2017, p. 011017, doi: 10.1115/1.4034433.

References

[1] Y. Liu and P. Davis. Dual synchronization of chaos. *Phys. Rev. E*, 61:2176–2184, 2000.

[2] J. Xiao, Z. Z. Ma, and Y. H. Yang. Dual synchronization of fractional order chaotic systems via linear controller. *Sci. World J.*, 2013:159194, 2013.

[3] L. Runzi, W. Yinglan, and D. Shucheng. Combination synchronization of three classical chaotic systems using active backstepping design. *Chaos*, 21(4):043114, 2011.

[4] C. Jiang, S. Liu, and D. Wang. Generalised combination complex synchronization for fractional order chaotic complex systems. *Entropy*, 17(8):5199–5217, 2015.

[5] J. Sun, S. Jiang, G. Cui, and Y. Wang. Dual combination synchronization of six chaotic systems. *ASME J. Comput. Nonlinear Dyn.*, 11(3):034501, 2016.

*Ajit Kumar Singh, Vijay Kumar Yadav and Subir Das are with the Department of Mathematical Sciences, Indian Institute of Technology (B.H.U.), Varanasi-221 005, India, email: ajit.brs@gmail.com