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ABSTRACT

Over the last decades there has been a great interest to harness the very peculiar chaotic behavior in deterministic systems. A chaotic system is a nonlinear deterministic system that displays complex and unpredictable behavior. The sensitive dependence on the initial conditions is a prominent characteristic of chaotic behavior. Over the past two decades, many chaotic systems have been found, such as the Lorenz system, the Lur'e system, the Duffing-Holmes system, the Genesio system, the Rössler system, Chua's circuit, and so on. Chaos has gradually moved from simply being a scientific curiosity to a promising subject with practical significance and applications in different fields such as communication, biological systems, economics and other fields.

Chaotic behavior could be beneficial feature in some cases (e.g., fluid mixing), but can be undesirable in some engineering, biological and other physical applications (e.g., chaos in the brain, cardiac chaos) ; and therefore it is often desired that chaos should be controlled, so as to improve the system performance. Thus, it is of considerable interest and potential utility, to devise control techniques capable of forcing a system to maintain a desired dynamical behavior even when intrinsically chaotic. The control of chaos and bifurcation is concerned with using some designed control input(s) to modify the characteristics of a parameterized nonlinear system. There might be needed for different components of a chaotic system to follow different trajectories when controlled, therefore, there is the need for mixed tracking or control. A number of methods such as OGY closed-loop

feedback method, active control, active backstepping and recursive active control exist for the control of chaos in systems. Chaos control is considered as a special case of chaos synchronization.

Chaos synchronization, on the other hand, involves the coupling of two chaotic systems so that both systems achieve identical dynamics asymptotically with time. There are two forms of coupling: mutual (bidirectional) coupling and the drive-response (unidirectional) coupling. In mutual coupling, the two systems influence or alter each other's dynamics until both systems achieve identical dynamics. In the unidirectional coupling, control functions are designed to force the dynamics of one system referred to as the response system to track the unaltered dynamics of the other system referred to as the drive system.

Chaos synchronization is directly related to the observer problem in control theory. The problem may be treated as the design of control laws for full chaotic observer (response system) using the known information of the plant (drive system) so as to ensure that the controlled receiver (response system) synchronizes with the transmitter (i.e., the plant or drive system). Hence, the response chaotic system tracks the dynamics of the drive system in the course of time. Projective synchronization based on the drive-response configuration has direct application in secure communication. Complete synchronization, which is a especial case of projective synchronization, of two chaotic systems was first demonstrated by Pecora and Carroll in 1990. Other types of synchronization identified thereafter include sequential, phase, anticipated, measure, generalized, lag projective synchronization, and reduced-order synchronization.

It is noted that most of the researches mainly focused on the previous master-slave synchronization scheme within one master and one response system. Only a few research papers have been published on combination synchronization where three or four chaotic systems were taken into account. Combination synchronization scheme is more flexible and applicable to the real world systems. In addition, the combination synchronization also gives better insight into the complex synchronization and several pattern formations that take place in real world systems since synchronization in real world systems are complex.