Title: Dynamics Of Coupled Nonlinear Systems

Abstract

Since 1990 study of coupled nonlinear systems motivated scientists to model real world physical, chemical, biological and engineering systems. Coupled dynamical systems have been used to model everything from earthquakes to ecosystems, neurons to neutrinos. If we couple two or many nonlinear systems we can not say completely about their collective behaviour. The aim of this thesis is to investigate and analyse the dynamics of coupled nonlinear systems analytically as well as numerically. We have investigated chaos control and chaos synchronisation aspects of coupled chaotic dynamical systems. We discuss applications of hybrid feedback control and tracking control techniques for synchronisation of coupled hyper-chaotic Chen systems. We have applied active control method for synchronisation of two coupled chaotic Nuclear Spin Generator systems, Lorenz systems and Rossler systems. These synchronisation schemes may be useful for secure communication purpose and for understanding dynamics of some electrical circuits. A new scheme for generalised lag synchronization (GLS) between two delay coupled chaotic systems via linear transformation is proposed. Necessary and sufficient conditions for stable GLS of delay coupled identical chaotic systems are derived. We have discussed our scheme taking coupled chaotic Lorenz systems as well as coupled chaotic Lorenz-Stenflo systems. We propose a generalised scheme for designing multistable continuous dynamical systems coupling two identical dynamical systems. Concept of partial synchronization is used to design multistable systems. Our most important observation is that in coupling two m-dimensional dynamical systems multistable nature can be obtained if \( i \) number of variables of the two systems are completely synchronized and \( j \) number of variables keep a constant difference between them, where \( i + j = m \) and \( 1 \leq i, j \leq m - 1 \). This is a generalisation of the existing results of designing multistable systems. We illustrate our scheme taking coupled Lorenz systems. We present the time evolution of state variables, phase diagrams, maximum Lyapunov exponent of the system and bifurcation diagrams to confirm the multistable nature of the coupled systems. We have proposed a technique for designing multistable systems with delay coupling. We have discussed our technique considering two delay coupled Lorenz-Stenflo systems. Efficiency of our technique is shown with numerical simulation results. Delayed coupled multistable system may be useful to understand mechanism for memory storage and temporal pattern recognition in neuronal systems. We have proposed a new scheme for designing multistable systems via linear transformations. We have discussed our scheme taking coupled chaotic Lorenz-like three dimensional systems. Our observation may be very useful for designing multistable biological, physical, chemical and engineering systems. We can conclude that coupled chaotic dynamical systems show wide range of behaviours including fixed point, limit cycles, quasi-periodicity, chaos and multistability depending upon the coupling scheme.

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