Preface

Time delays are omnipresent in nature. Delays arise in various natural and man-made systems due to the finite speed of signal propagation, finite response time, and switching speed. The presence of time delay in a dynamical system makes it infinite dimensional and if the system is nonlinear it may give rise to many interesting phenomena, like bifurcation, chaos, and multistability. Many of the natural phenomena, such as blood production in patients with leukemia (the well known Mackey–Glass model), optical systems (e.g., the Ikeda system), El Niño or southern oscillation (ENSO), population dynamics, and neural networks have been successfully modeled by considering time delay in their dynamics. Although a large number of time-delayed systems are reported in the literature where delay differential equations are used for mathematical modeling, only a few practical implementations of those systems are reported. A systematic *wishful* design of chaotic time-delayed system is important from the fundamental interest—these systems can contribute to improve our understanding of the intricate and subtle dynamical behaviors of isolated time-delayed systems, subsequently, it also offers an excellent opportunity for the researchers to explore the collective behaviors of coupled time-delayed systems under natural experimental setups. Also, from the application point of view, these studies can be extended to exploit chaotic time-delayed system in several engineering applications.

Motivated by the above-mentioned reasons, in this book, we describe a systematic design principle of chaotic time-delayed dynamical systems and discuss their collective behaviors, such as synchronization and oscillation suppression. We describe how a proper choice of nonlinearity leads to chaos and hyperchaos even in a first-order time-delayed system. The occurrence of chaos and the efficacy of the considered design techniques are supported by rigorous theoretical studies, numerical characterization, and experimental demonstrations with electronic circuits. To extend our knowledge of nonlinear time-delayed system, we study the coupled dynamics of these systems and report some novel collective phenomena related to synchronization and oscillation suppression. This book actually provides a *bridge* between two broad topics, namely the design technique of chaotic time-delayed systems and the collective phenomena shown by these systems when coupled with each other through a proper physical coupling scheme.

Apart from rigorous theory and experiments, for an entry level researcher, we also provide two brief, yet effective, tutorials on the numerical package XPPAUT and the experimental technique of data acquisition through LabVIEW.

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