PREFACE

This thesis consists of seven chapters beginning with introductory chapter (**Chapter 1**) which deals with the basic of dynamical systems, delay differential equations, chaos theory, synchronization, fractional calculus and latest methods which have used as tools in this thesis. Each of these topics plays an important role throughout the thesis and the inclusion of this chapter makes the thesis self-contained.

Chapter 2 deals with the anti-synchronization between two identical chaotic fractional-order Qi systems and Genesio–Tesi systems, and also between two different fractional-order Genesio–Tesi and Qi systems using active control method. The chaotic attractors of the systems are found for fractional-order time derivatives described in Caputo sense. Numerical simulation results which are carried out using Adams–Boshforth–Moulton method show that the method is reliable and effective for anti-synchronization of nonlinear dynamical evolutionary systems.

The **chapter 3** is related to the fractional order SIR model with an information variable and divided into two sections that represent two different kinds of SIR model in the context of fractional order SIR. The **first section** presents the synchronization between a pair of identical SIR epidemic chaotic systems with fractional order time derivative using Active control method. The fractional derivative is described in Caputo sense. Numerical simulation results show that the method is effective and reliable for synchronizing the fractional order chaotic systems while it also allows the system to remain in chaotic state. The striking features of this section are successful presentation of the stability of the equilibrium state and the revelation that time for synchronization varies with the variation in fractional order derivatives close to the standard one for different specified values of the parameters of the system. The **second section** is concerned with the stability analysis of a controlled fractional Water-Borne disease model, which is an extension of existing fractional order SIR model with a new information variable. The striking feature of this chapter is the successful graphical presentation of the numerical results of different considered variables, which vary from the fractional order to the standard order of time derivative for different specified values of the parameters in the model.

The **chapter 4** aims to study the projective synchronization between two identical and non-identical time-delayed chaotic systems with fully unknown parameters. Here the asymptotical and global synchronization are achieved by means of adaptive control approach based on Lyapunov–Krasovskii functional theory. The proposed technique is successfully applied to investigate the projective synchronization for the pairs of time-delayed chaotic systems amongst advanced Lorenz system as drive system with multiple delay Rössler system and time-delayed Chua's oscillator as response system. An adaptive controller and parameter update laws for unknown parameters are designed so that the drive system is controlled to be the response system. Numerical simulation results, depicted graphically, are carried out using Runge–Kutta Method for delay-differential equations, showing that the design of controller and the adaptive parameter laws are very effective and reliable and can be applied for synchronization of time-delayed chaotic systems.

In the **chapter 5**, a new modified adaptive function projective synchronization method is proposed for the synchronization of time-delayed chaotic systems. The adaptive function projective synchronization controller and identification parameter laws are developed based on Lyapunov-Krasovskii functional approach to stabilize the error system which makes the state vector of two chaotic systems asymptotically synchronized. The proposed method is successfully applied to investigate the function projective synchronization for the pair of multiple time-delayed Rössler System for three different cases. Graphical plots of numerical simulation results, which are carried out by means of Runge-Kutta Method for delay differential equations, clearly exhibit that the proposed modified method will be convenient for receiving faster function projective synchronization of time-delay chaotic systems. In this chapter the research article of Sudheer K. S. and Sabir M (Physics Letter A. 375 1176 (2011)) is carefully revisited and it is claimed that the new proposed method is much more effective and reliable as compared to the said existing method for synchronizing time-delayed chaotic systems.

In the **chapter 6**, the chaos control and the function projective synchronization between fractional order identical T-system, and non-identical T-system and Lorenz chaotic system using tracking control scheme are studied. According to the stability theory, the conditions for local stability of nonlinear three-dimensional commensurate and incommensurate fractional order systems are discussed. Feedback control method is used to control the chaos in the considered fractional order T-system. Using the fractional calculus theory and computer simulation techniques, it is found that the chaotic behaviour exists in the fractional-order T system for the lowest order of the system 2.85. **N**umerical simulations are carried out using Adams-Bashforth-Moulton method and the results are depicted through graphs.

Chapter 7 deals with in-phase and anti-phase synchronizations between different fractional order Genesio-Tesi and Qi systems with parametric uncertainties and external disturbances using active control method. In the presence of model uncertainties and external disturbances, an appropriate feedback control scheme is applied to stabilize a pair of fractional-order chaotic systems. The numerical simulation results show that the method is effective and convenient for synchronization and anti-synchronization of fractional order chaotic systems. The key feature of this chapter is the comparison of time of synchronization and anti-synchronization through graphical presentations for different particular cases.