A Numerical Method for Discrete Fractional–Order Chen System Derived from Nonstandard Numerical Scheme

Mehdi Zeinadini*

Vali-e-Asr University of Rafsanjan

Sadegh Zibaei

Vali–e–Asr University of Rafsanjan

Mehran Namjoo

Vali-e-Asr University of Rafsanjan

Abstract

In this paper, the nonstandard finite difference (NSFD) scheme is implemented to study the dynamic behaviors in the fractional–order Chen chaotic system. The Grünwald–Letnikov method is used to approximate the fractional derivatives. Numerical results show that the NSFD approach is easy to implement and accurate when applied to fractional-order Chen chaotic system.

Keywords: Chaos, Fractional calculus, Fractional–order Chen system, Nonstandard finite difference scheme
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1   Introduction

In the recent years there is increasing interest in fractional calculus which deals with integration/differentiation of arbitrary orders. The list of applications of fractional calculus has been evergrowing and includes control theory, viscoelasticity, diffusion, turbulence, electromagnetism and many other physical processes. An exhaustive treatment of fractional calculus in this respect can be found in references [2]. Recently, most of the dynamical systems based on the integer–order calculus have been modified into the fractional order domain due to the extra degrees of freedom and the flexibility which can be used to precisely fit the experimental data much better than the integer–order modeling. The study of chaotic systems is an important aspect of dynamical systems that finds applications in different areas ranging from engineering to ecology. Although more than three decades have passed since the existence of "chaotic solutions" was demonstrated, still we do not have a theory of chaos from which the existence of chaotic solutions can be predicted. Extensive numerical work has been carried out in order to understand chaos in dynamical systems. Lu and Chen [1] have studied the dynamic of the fractional–order generalization of the well–known Chen system.

This paper is devoted to the construction of a nonstandard discretization scheme given by Mickens to the Grünwald–Letnikov (GL) discretization process for solving the fractional–order Chen chaotic system.

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*Speaker