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Numerical Approach for Solving Incommensurate Higher-Order Fractional Differential Equations

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Abstract: In this research, we present a novel numerical approach to tackle an incommensurate system of fractional differential equations of 2α-order, where $\alpha = (\alpha_1, \alpha_2, \alpha_3, \cdots, \alpha_n)$ with $0 < \alpha_i \leq 1$, $\forall i = 1, 2, 3, \cdots, n$. Our proposed method involves reducing the system to α-fractional differential equations using a newly derived result, followed by the implementation of the Modified Fractional Euler Method (MFEM), a recent numerical technique. We demonstrate the efficacy of our approach through an illustrative example, providing validation for our proposed methodology.

Keywords: *incommensurate system; fractional differential equations; modified fractional Euler method.*

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1 Introduction

In recent years, Fractional Differential Equations (FDEs) have been extensively studied and applied due to their ability to capture the dynamics of systems with long-range interactions, anomalous diffusion, and viscoelasticity. The fractional derivatives allow for the inclusion of memory and hereditary properties, making them suitable for modeling phenomena that exhibit memory retention and relaxation effects. While significant progress has been made in solving FDEs, there remains a challenging class of problems known as incommensurate higher-order FDEs. These equations involve fractional derivatives of different orders that are not rational multiples of each other. As a result, they

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