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A novel high-order algorithm for the numerical estimation of fractional differential equations

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Abstract

This paper uses polynomial interpolation to design a novel high-order algorithm for the numerical estimation of fractional differential equations. The Riemann-Liouville fractional derivative is expressed by using the Hadamard finite-part integral and the piecewise cubic interpolation polynomial is utilized to approximate the integral. The detailed error analysis is presented and it is established that the convergence order of the algorithm is $O(h^{4-\alpha})$. Asymptotic expansion of the error for the presented algorithm is also investigated. Some numerical examples are provided and compared with the exact solution to show that the numerical results are in well agreement with the theoretical ones and also to illustrate the accuracy and efficiency of the proposed algorithm.

Keywords: Fractional differential equation, Caputo fractional derivative, Riemann-Liouville fractional derivative, Error estimates, Hadamard finite-part integral
2010 MSC: 26A33, 65L70, 65L05

1. Introduction

The beginning of the fractional calculus dates back to the end of the 17th century. However, until recently, due to its complexity and the lack of application background it has been investigated mainly from a mathematical point of view [1, 2]. In the 19th century, a complete theory suitable for modern mathematical developments has been

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