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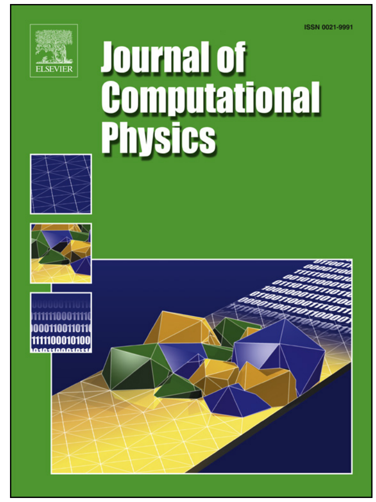


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# Numerical solution of distributed order fractional differential equations by hybrid functions

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**Abstract**

In this paper, a new numerical method for solving the distributed fractional differential equations is presented. The method is based upon hybrid functions approximation. The properties of hybrid functions consisting of block-pulse functions and Bernoulli polynomials are presented. The Riemann-Liouville fractional integral operator for hybrid functions is introduced. This operator is then utilized to reduce the solution of the distributed fractional differential equations to a system of algebraic equations. Illustrative examples are included to demonstrate the validity and applicability of the technique.

**Keywords:** Hybrid functions; Distributed order; Fractional differential equations; Bernoulli polynomials; Caputo derivative; Numerical solution.

## 1 Introduction

Fractional differential equations (FDEs) are generalizations of ordinary differential equations to an arbitrary (noninteger) order. A history of the development of fractional differential operators can be found in [1, 2].

FDEs have attracted considerable interest because of their ability to model complex phenomena such as continuum and statistical mechanics [3], visco-elastic materials [4], and solid mechanics [5]. To the best of our knowledge, two different approaches were performed by using spectral methods for fractional ordinary differential equations (FODEs) and fractional partial differential equations (FPDEs). In the first approach, the classical orthogonal functions have been used as a trail function to find the approximate solution for FODEs and FPDEs, see for example [6–13]. In the second approach, the base

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