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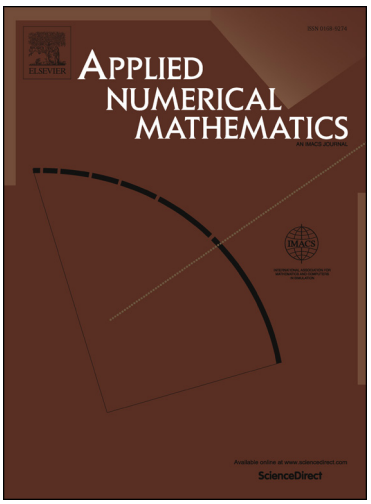

Numerical analysis of an operational Jacobi Tau method for fractional weakly singular integro-differential equations

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Numerical analysis of an operational Jacobi Tau method for fractional weakly singular integro-differential equations

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Abstract The main concern of this paper is to develop and analyze an operational Tau method for obtaining the numerical solution of fractional weakly singular integro-differential equations when the Jacobi polynomials are used as natural basis functions. This strategy is an application of the matrix-vector-product approach in Tau formulation of the problem. We first study the regularity of the exact solution and show that some derivatives of the exact solution have a singularity at origin dependence on both order of fractional derivative and weakly singular kernel function which makes poor convergence results for the Tau discretization of the problem. In order to recover high-order of convergence, we propose a new variable transformation to regularize the given functions and then to approximate the solution via a satisfactory order of convergence using an operational Tau method. Convergence analysis of this novel method is presented and the expected spectral rate of convergence for the proposed method is established. Numerical results are given which confirm both the theoretical predictions obtained and efficiency of the proposed method.

Keywords Fractional weakly singular integro-differential equations · Operational Tau method · Regularity · Convergence analysis · Jacobi polynomials

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1 Introduction

In recent years, it has been developed that derivatives and integrals of fractional orders are very suitable for the description of properties of various real materials like physics, chemistry and engineering. It has been shown that new fractional order models are more adequate than previously used integer-order models and theirs advantages become apparent in modeling and description of real phenomena[26].

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