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A POWER SERIES POLYNOMIAL FRAMEWORK FOR THE COMPUTATIONAL SOLUTION OF PARTIAL FRACTIONAL DIFFERENTIAL EQUATIONS WITH MULTI-INDEXED ORDERS

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ABSTRACT

This work presents a power series polynomial framework for the computational solution of partial fractional differential equations involving multi-indexed fractional orders. Such models arise in the description of memory-dependent and spatially non-local phenomena, where fractional derivatives introduce global coupling effects that complicate classical numerical treatments. The proposed method represents the approximate solution as a truncated power series expansion in the spatial variables. Substituting this representation into the governing fractional equation and enforcing the equation at selected collocation points reduces the original problem to a structured algebraic system for the unknown coeffcients. The formulation accommodates multiple fractional orders within a unified computational framework and avoids mesh generation or domain decomposition. The approach is applicable to both linear and nonlinear fractional models while preserving the intrinsic non-local structure of the operators. Convergence behavior is examined through representative test problems involving multi-indexed fractional derivatives. Numerical results indicate that the method provides accurate approximations with moderate computational effort and maintains stability under variations of the fractional parameters. Compared with existing polynomial-based and operational matrix techniques, the proposed framework offers flexibility in handling higher-order and multi-term fractional equations without increasing implementation complexity. The combination of a simple power series basis and collocation strategy makes the method an effcient alternative for the numerical treatment of non-local partial differential equations.

The developed framework contributes to ongoing advances in numerical methods for non-local problems and provides a practical computational tool for fractional models arising in applied mathematics and memory dependent dynamical systems.

***K*eywords** Power Series · Polynomial Fractional Differential Equation · Multi-Indexed Orders

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