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A highly accurate numerical method for solving nonlinear time-fractional differential difference equation. (English) Zbl 07387596

Summary: This work is based on the implementation of an iterative perturbation method to attain the series solutions of nonlinear fractional differential difference equation (NFD\(\Delta\)E). Perturbation-iteration algorithm (PIA) assigns a perturbation parameter \(\varepsilon\) to all nonlinear terms and converts it into a simple fractional differential difference equation (FD\(\Delta\)E). By simply solving this FD\(\Delta\)E, series solutions can be obtained. To show the efficacy and accuracy of this method, three famous NFD\(\Delta\)E, i.e. fractional Lotka-Volterra equation, fractional discrete KdV equation and discretized fractional mKdV lattice equation, will be solved numerically via PIA. Also, comparison of numerical results for \(\alpha = 1\) will be done with exact solutions, and their absolute error will also be provided. Graphical illustrations for different values of \(\alpha\) will be given to establish the certainty of results. Also, to prove the proficiency among other methods, comparison with different numerical methods is given. Advantage of PIA is that nonlinear terms get vanished during the calculations of Taylor series expansion; therefore, less calculation effort can obtain comprehensive accurate solutions.

MSC:

33E30 Other functions coming from differential, difference and integral equations
26A33 Fractional derivatives and integrals
41A58 Series expansions (e.g., Taylor, Lidstone series, but not Fourier series)
34Kxx Functional-differential equations (including equations with delayed, advanced or state-dependent argument)
47A55 Perturbation theory of linear operators
34A34 Nonlinear ordinary differential equations and systems

Keywords:
fractional calculus; nonlinear differential difference equation; perturbation expansion; series solution; Taylor series

Full Text: DOI