Fractional Multistep Differential Transformation Method used to analyze a modified form of fractional order Lorenz system

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Dynamics of nonlinear fractional-order Lorenz system is investigated by employing Fractional Multistep Differential Transformation Method (FMDTM). In order to illustrate the new technique, the numerical algorithm is applied in the 3D solution of modified Lorenz system by adding the fourth varied parameter d, considered as a highly simplified model for the weather. Parameter fixed dynamical analysis method and chaos diagram are used. Results show that the fractional order Lorenz system has rich dynamical behavior and it is a potential model for application. Investigation of dynamics is realized by fixing the parameters $a = 40$, $b = 3$, $c = 10$ (system has chaotic behavior) and by changing the added parameter $d \in [5, 38]$, implemented with the aid of Mathematica symbolic package. For $d = 25$, the minimal fractional order, for which the system shows chaotic behavior is $v = 0.8726$, for $d = 0.998$, the minimal value of d, for which system shows chaotic behavior is $d > 12.05219$. The fractional derivatives are described in the Caputo sense. Based on FMDTM, is shown that the system has rich dynamical characteristics, it changes from a non-chaotic system to a chaotic one, using fractional order $v \in (0, 1)$. The method deals with the approximated solutions to integer-order differential equations and is based on polynomial approximations, with good results (based on numerical experiments) for fractional order closed to 1.