Accepted Manuscript

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PII: S0377-0427(17)30196-6
DOI: http://dx.doi.org/10.1016/j.cam.2017.04.026
Reference: CAM 11105

To appear in: *Journal of Computational and Applied Mathematics*

Received date: 15 April 2016
Revised date: 22 February 2017

Please cite this article as: M.S. Asl, M. Javidi, An improved PC scheme for nonlinear fractional differential equations: Error and stability analysis, *Journal of Computational and Applied Mathematics* (2017), http://dx.doi.org/10.1016/j.cam.2017.04.026

An improved PC scheme for nonlinear fractional differential equations: error and stability analysis

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Abstract

A novel computationally effective fractional predictor–corrector (PC) scheme is proposed to solve fractional differential equations involving Caputo derivative. The properties of the Caputo derivative are used to reduce the fractional differential equation into a Volterra integral equation. To design high order numerical solution of FDEs, the Simpson's 3/8 rule is applied to the Volterra type integral equation. The scheme is capable of handling both linear and nonlinear fractional differential equations. A detailed error analysis and stability analysis of the numerical scheme are rigorously established. The proposed scheme is compared with the PC schemes of literature for illustrating the effectiveness of the algorithm.

Keywords: Predictor–corrector scheme, Fractional differential equation, Caputo derivative, Volterra integral equation

2010 MSC: 26A33, 65D05, 65D25, 65D30

1. Introduction

The concept of differentiation to an arbitrary order was started in the 17-th century by the ideas of Leibniz and Hospital. At the end of the 19-th century, Liouville and Riemann introduced the first definition of the fractional derivative [1]. However, the idea of fractional calculus did not attract much attention for a long time, this idea started to be interesting for engineers only in the late 1960s, especially when it was observed that the fractional derivatives allow us to describe and model many systems in the real

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