Hindawi
International Journal of Differential Equations
Volume 2017, Article ID 2097317, 10 pages
https://doi.org/10.1155/2017/2097317

Research Article

Collocation Method Based on Genocchi Operational Matrix for Solving Generalized Fractional Pantograph Equations

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Received 2 January 2017; Revised 16 March 2017; Accepted 16 May 2017; Published 13 June 2017

Academic Editor: Patricia J. Y. Wong

An effective collocation method based on Genocchi operational matrix for solving generalized fractional pantograph equations with initial and boundary conditions is presented. Using the properties of Genocchi polynomials, we derive a new Genocchi delay operational matrix which we used together with the Genocchi operational matrix of fractional derivative to approach the problems. The error upper bound for the Genocchi operational matrix of fractional derivative is also shown. Collocation method based on these operational matrices is applied to reduce the generalized fractional pantograph equations to a system of algebraic equations. The comparison of the numerical results with some existing methods shows that the present method is an excellent mathematical tool for finding the numerical solutions of generalized fractional pantograph equations.

1. Introduction

Fractional calculus, the calculus of derivative and integral of any order, is used as a powerful tool in science and engineering to study the behaviors of real world phenomena especially the ones that cannot be fully described by the classical methods and techniques [1]. Differential equations with proportional delays are usually referred to as pantograph equations or generalized pantograph equations. The name pantograph was originated from the study work of Ockendon and Tayler [2]. Many researchers have studied different applications of these equations in applied sciences such as biology, physics, economics, and electrodynamics [3–5]. Solutions of pantograph equations were also studied by many authors numerically and analytically. Bhrawy et al. proposed a new generalized Laguerre-Gauss collocation method for numerical solution of generalized fractional pantograph equations [1]. Tohidi et al. in [6] proposed a new collocation scheme based on Bernoulli operational matrix for numerical solution of generalized pantograph equation. Yusufoglu [7] proposed an efficient algorithm for solving generalized pantograph equations with linear functional argument. In [8], Yang and Huang presented a spectral-collocation method for fractional pantograph delay integrodifferential equations and in [9] Yüzbasi and Sezer presented an exponential approximation for solutions of generalized pantograph delay differential equations. Chebyshev and Bessel polynomials are, respectively, used in [10, 11] to obtain the solutions of generalized pantograph equations. Operational matrices of fractional derivatives and integration have become very important tool in the field of numerical solution of fractional differential equations. In this paper, a member of Appell polynomials called Genocchi polynomials is used; although this polynomial is not based on orthogonal functions, it possesses operational matrices of derivatives with high accuracy. It is very important to note that this polynomial shares some great advantages with Bernoulli and Euler polynomials for approximating an arbitrary function over some classical orthogonal polynomials; we refer the reader to [6] for these advantages. On top of that, we