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Author: Sara Davaeifar Jalil Rashidinia

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Solution of a system of delay differential equations of multi pantograph type

Sara Davaeifar, Jalil Rashidinia[1]

Department of Mathematics, Central Tehran Branch, Islamic Azad University, Tehran, Iran.

Abstract

A collocation method is proposed to obtain an approximate solution of a system of multi pantograph type delay differential equations with variable coefficients subject to the initial conditions. The general approach is that, first of all the solution of the system has been expanded according to First Boubaker polynomials (FBPs) basis. Then, by employing the matrix operations and collocation nodes, the original problem and the associated initial conditions are reduced to a nonlinear system. By solving such system, the unknown coefficients of the approximate solution can be determined. Convergence analysis of the proposed method has been proved. The presented method has been tested of three different examples. The computed results confirm the high accuracy of collocation method based on FBPs.

Keywords: System of delay differential equations; First Boubaker polynomials; Approximate solution; Collocation method; Matrix equation

AMS subject Classification: 34k06; 34k28; 41A10; 65L05

1. Introduction

In 1851, it was the first time that a device named pantograph was used in the construction of the electric locomotive which this name was originated from that time. Pantograph was modeled mathematically in 1971 [1]. Pantograph equations are one of the most prominent kinds of functional differential equations with proportional delay and often appear in many scientific models such as number theory, nonlinear dynamical systems, electrodynamics, quantum mechanics, population studies and etc.

We consider the system of delay differential equations of multi pantograph type in the following general form:

$$\begin{aligned}\sum_{i_2=1}^{M} J_{i_1,i_2}(x)\, y_{i_2}^{(1)}(x) &= \sum_{i_2=1}^{M} R^{*}_{i_1,i_2}(x)\, y_{i_2}(x) + \\ &\sum_{i_3=1}^{\wp}\sum_{i_2=1}^{M} P^{i_3}_{i_1,i_2}(x)\, y_{i_2}(\mu_{i_3}x) + \sum_{q=2}^{\gamma}\sum_{i_4=1}^{\varpi}\sum_{i_2=1}^{M} P^{*\,i_4}_{i_1,i_2}(x)\left(y_{i_2}(\sigma_{i_4}x)\right)^{q} + f_{i_1}(x), \\ &M \geq 1,\ \ i_1 = 1\,(1)\,M,\ \ \wp,\ \varpi \in \mathbb{N},\ \ \gamma \in \mathbb{N}-\{1\},\ \ x \in I = [0,\ 1],\end{aligned} \tag{1}$$

[1]Corresponding author. E-mail addresses: Rashidinia@iust.ac.ir(Jalil Rashidinia), sara.davaei@yahoo.com(Sara Davaeifar)