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A new numerical method for solving high-order fractional eigenvalue problems

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Abstract

The paper presents a new numerical method for solving eigenvalue problems for fractional high-order differential equations with variable coefficients. It combines two techniques: the method of external excitation (MEE) and the backward substitution method (BSM). The first one is a mathematical model of physical measurements when a mechanical, electrical or acoustic system is excited by some source, and resonant frequencies can be determined by using the growth of the amplitude of oscillations near these frequencies. The BSM consists of replacing the original equation by an approximate equation which has an exact analytic solution with a set of free parameters. These free parameters are determined by the use of the collocation procedure. Some examples are given to demonstrate the validity and applicability of the new method, and a comparison is made with the existing results. In particular, fractional problems of the fourth, sixth and eighth orders are considered. The numerical results show that the proposed method is of a high accuracy and is efficient for solving a wide class of eigenvalue problems

Key words: Fractional eigenvalue problems; High-order; Caputo derivative; Numerical method; Method of external excitation; Backward substitution method.

1 Introduction

In this paper we present a novel method for solving fractional high-order eigenvalue problems with variable coefficients. We consider the governing equations of the form

$$L\left[u\right]+\lambda p\left(x\right)u(x)\equiv\alpha_{n}\left(x\right)D^{(\nu)}u(x)+\sum_{k=1}^{K}\alpha_{k}\left(x\right)D^{(\nu_{k})}u(x)+\lambda p\left(x\right)u(x)=0,\ 0\leq x\leq 1,\ (1)$$

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