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Hybrid function method and convergence analysis for two-dimensional nonlinear integral equations

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Abstract

In the current paper, an efficient numerical method based on two-dimensional hybrid of block-pulse functions and Legendre polynomials is developed to approximate the solutions of two-dimensional nonlinear Fredholm, Volterra and Volterra-Fredholm integral equations of the second kind. The main idea of the presented method is based upon some of the important benefits of the hybrid functions such as high accuracy, wide applicability and adjustability of the orders of block-pulse functions and Legendre polynomials to achieve highly accurate numerical solutions. By using the numerical integration and collocation method, two-dimensional nonlinear integral equations are reduced to a system of nonlinear algebraic equations. The focus of this paper is to obtain an error estimate and to show the convergence analysis for the numerical approach under the L^2-norm. Numerical results are presented and compared with the results from other existing methods to illustrate the efficiency and accuracy of the proposed method.

Keywords: Two-dimensional hybrid of block-pulse functions and Legendre polynomials, Two-dimensional nonlinear integral equations, Collocation method, Convergence analysis.

1. Introduction

In the last decades, numerical methods for solving one-dimensional integral equations of different types have been investigated by several authors [1, 2, 3, 4, 5, 6, 7, 8]. In comparison with the abundant literature concerned with the numerical analysis of one-dimensional integral equations, a few computational approaches have been carried out to approximate the solution of several-dimensional integral equations, specially in the nonlinear case. Many interesting problems in physics, biology and engineering can be transformed to two-dimensional integral equations of the second kind. As it noted in [9], Fredholm integral equations appear in plasma physics [10], electrical engineering [11] and electromagnetic analysis [12]. McKee et al. [13] showed that a class of nonlinear telegraph equations is equivalent to two-dimensional Volterra integral equations. Also, Volterra-Fredholm integral equations arise in a variety of applications in many fields including modeling of the spatio-temporal development of an epidemic, theory of parabolic initial boundary value problems, population dynamics, and Fourier problems [14, 15, 16]. Regarding

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