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Two-dimensional wavelets collocation method for electromagnetic waves in dielectric media

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ABSTRACT

In this article, we deal with a numerical wavelet collocation method (NWCM) using a technique based on two-dimensional wavelets (TDWs) approximation proposed for the fractional partial differential equations (FPDEs) for electromagnetic waves in dielectric media (EWDM). By implementing the Riemann–Liouville fractional derivative, TDWs approximation and its operational matrix along with collocation method are utilized to reduce FPDEs firstly into weakly singular fractional partial integro-differential equations (FPIDEs) and then reduced weakly singular FPIDEs into system of algebraic equation. Using Legendre wavelet approximation (LWA) and Chebyshev wavelet approximation (CWA), we investigated the convergence analysis and error analysis of the proposed problem. Finally, some examples are included for demonstrating the efficiency of the proposed method via LWA and CWA respectively.

1. Introduction

Wavelets are powerful tool which have been used in numerical techniques. Nowadays, wavelets theory is mostly used in the field of applied science and engineering. Also, this allow the accurate representation of a variety of functions and operators. Recently, wavelets have been found their location in many applications (see for instant [1–3]). Particularly, wavelets are very successfully used in signal analysis [4]. It is proved that wavelets are powerful tool to explore new direction in solving partial differential equations. Wavelets are localized functions [5], which are the basis for energy-bounded functions [6] and in particular for $L^2(R)$. So, we implement orthogonal wavelet function in our proposed method. The most frequently used orthogonal function are Legendre function [7], Chebyshev [8], Laguerre polynomials [9], etc. The main notion of using an orthogonal basis is that the problem under consideration reduces to a system of linear or nonlinear algebraic equations. This can be done by truncated series of orthogonal basis function for the solution of the problem using the operational matrices (see for instant [10–12]). It is noted that wavelets operational matrix method not only simplifies the problem but also speedup the computation. Therefore, in the last two decades different families of wavelets have been widely used for solving FPDEs.

FPDEs have been one of the essential tools for various areas of applied Mathematics (see for instant [1–3]). FPDEs occur naturally in many fields of science and engineering. In recent years fractional derivatives have found numerous applications

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