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A block pulse operational matrix method for solving two-dimensional nonlinear integro-differential equations of fractional order

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Abstract
In this paper, we use two-dimensional block pulse functions (2D-BPFs) and their operational matrix for integration and fractional integration, to reduce two-dimensional fractional integro-differential equations (2D-FIDEs) to a system of nonlinear algebraic equations. The solution is determined by solving this system. Also by two theorems, we prove the convergence of the proposed method. Finally, the numerical solutions guarantee the desired accuracy and efficiency.

Keywords : Two-dimensional fractional integro-differential equations; Two-dimensional block pulse functions; Fractional operational matrix; Nonlinear equations

1 Introduction

Fractional calculus is one of the important branches of mathematics that has numerous applications. Despite the fact that it is a recent concept these applications have led to many studies in last years. For example, fractional calculus is applied to signal processing [1-2], physics [3-4], continuum mechanics [5], viscoelastic materials [6] and many other branches of science.

In this paper, our study focused on the general form of the two-dimensional fractional integro-differential equations (2D-FIDEs)

$$au_{xx}+bu_{tt}+cu_{xt}+u(t,x)+I^{r}u(t,x)=g(t,x)+\Theta(t,x)+\Lambda(t,x)+\rho+\varphi,\ \ (t,x)\in[0,T_1]\times[0,T_2], \tag{1.1}$$

provided that the initial conditions

$$u(t,0)=d_1,\ u(0,x)=d_2,\ u_x(t,0)=d_3,\ u_t(0,x)=d_4,\ u_t(t,0)=d_5, \tag{1.2}$$

where a,b,c are known constant values and d_1,d_2,d_3,d_4,d_5 are known constant or known function. Moreover, we have

$$\Theta(t,x)=\int_0^t\int_0^x k_1(t,s,x,y)u^{p_1}(s,y)dyds,$$

$$\Lambda(t,x)=\frac{1}{\Gamma(r_1)\Gamma(r_2)}\int_0^t\int_0^x(t-s)^{r_1-1}(x-y)^{r_2-1}k_2(t,s,x,y)u^{p_2}(s,y)dyds,$$

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