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Lagrange's operational approach for the approximate solution of two-dimensional hyperbolic telegraph equation subject to Dirichlet boundary conditions

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ABSTRACT

The key purpose of this study is to present two schemes based on Lagrange polynomials to deal with the numerical solution of second order two-dimensional telegraph equation (TDTE) with the Dirichlet boundary conditions. First, we convert the main equation into partial integro-differential equations (PIDEs) with the help of initial and boundary conditions. The operational matrices of differentiation and integration are then used to transform the PIDEs into algebraic generalized Sylvester equation. We compared the results obtained by the proposed schemes with Bernoulli matrix method and B-spline differential quadrature method which shows that the proposed schemes are accurate for small number of basis functions.

1. Introduction

Most of the physical problems can be described in the form of mathematical models and these models are consist of partial differential equations (PDEs). PDEs are observed in many fields of applied sciences and engineering. Among these partial differential equations, hyperbolic PDEs play an important role in several areas of applied sciences. The propagation of signal (digital and analog) through media, the propagation of electromagnetic waves in the earth–ionosphere waveguide [1], mechanical wave [2], an ecological and cosmological phenomena are modeled using hyperbolic PDEs [3]. Recently, many methodologies have been investigated to find the numerical solution of telegraph equation due to their universal applications in the area of applied mathematics. In [4], the phenomena of propagation of electric signal in a cable of transmission is described by one-dimensional telegraph equation which can be derived by using basic principles of electricity.

But Goldstien [5] was the first who derived the one-dimensional telegraph equation with probabilistic argument. He proved that a particle which moves forward and backward direction with speed c satisfies the following hyperbolic one dimensional telegraph equation:

$$\frac{\partial^2 p}{\partial t^2} + 2\lambda \frac{\partial p}{\partial t} = c^2 \frac{\partial^2 p}{\partial x^2} \tag{1}$$

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