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IDENTIFYING CODES IN THE DIRECT PRODUCT OF A PATH AND A COMPLETE GRAPH

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Abstract

Let G be a simple, undirected graph with vertex set V. For any vertex $v \in V$, the set $N[v]$ is the vertex v and all its neighbors. A subset $D \subseteq V(G)$ is a dominating set of G if for every $v \in V(G)$, $N[v] \cap D \neq \emptyset$. And a subset $F \subseteq V(G)$ is a separating set of G if for every distinct pair $u, v \in V(G)$, $N[u] \cap F \neq N[v] \cap F$. An identifying code of G is a subset $C \subseteq V(G)$ that is dominating as well as separating. The minimum cardinality of an identifying code in a graph G is denoted by $\gamma^{ID}(G)$. The identifying codes of the direct product $G_1 \times G_2$, where G_1 is a complete graph and G_2 is a complete/ regular/ complete bipartite graph, are known in the literature. In this paper, we find $\gamma^{ID}(P_n \times K_m)$ for $n \geq 3$, and $m \geq 3$ where P_n is a path of length n, and K_m is a complete graph on m vertices.

Keywords: identifying code, direct product, path, complete graph.

2010 Mathematics Subject Classification: 05C69, 05C76, 68R99.

A new family of methods for solving delay differential equations

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Abstract

In the present paper, we introduce a new family of $\theta-$methods for solving delay differential equations. New methods are developed using a combination of decomposition technique viz. new iterative method proposed by Daftardar Gejji and Jafari and existing implicit numerical methods. Using Butcher tableau, we observed that new methods are non Runge-Kutta methods. Further, convergence of new methods is investigated along with its stability analysis. Applications to variety of problems indicates that the proposed family of methods is more efficient than existing methods.
Keywords: New iterative method (NIM), Delay differential equation, numerical methods, convergence analysis.
MSC Classification: 65L05, 65L06,65L20, 65L99. :

1 Introduction

A delay differential equation (DDE) is a differential equation in which state function is given in terms of value of the function at some previous times. Introduction of delay term in modelling allows better representation of real life phenomenon and enriches its dynamics. Due to presence of delay terms in the model, Delay differential equations (DDEs) are infinite dimentional and hence are difficult to analyse. Hence now a days, solving delay differential equations is an important area of research. Every DDE cannot be integrated analytically and hence there is a need to be dependant on numerical methods to solve DDEs. To develop efficient, stable and accurate numerical algorithms is primarily important task of research.

DDEs are receiving increasing importance in many areas of science and engineering like biological processes, population growth and decay models, epidemiology, physiology, neural networks etc [20], [6], [3]. The classical numerical methods such as Eulers method, trapezoidal method, Runge-Kutta methods are discussed in [8]. Enright and Hu [14] have developed a tool to solve DDEs with vanishing delay with iteration and interpolation technique. Karoui and Vaillancourt [19] presneted a SYSDEL code to solve DDEs using Runge kutta methods of desired convergence order. In [21], a new MATLAB program dde23 has been developed to solve wide range of DDEs with constant delays. A new Adomian decomposition method is given in [15] to solve DDEs. Further in [17], two point predictor-corrector block method for solving DDEs is described. Recently New iterative method (NIM) developed by Daftardar-Gejji and Jafari is used to develop many efficient numerical methods to solve fractional differential equations [12], partial differential equations [9], boundary value problems [10]. In [2], a solution of DDE is acheived by using Aboodh transformation method. Recently in [13] , a new numerical technique for solving fractional generalised pantograph-delay differential equations by using fractional order hybrid Bessel functions is developed.

In the present article, we use the powerful technique of NIM to generate new efficient numerical tools to solve DDEs which are reducible to solve ODEs.

The paper is organized as follows. In section 2, important preliminaries like Delay differential equations (DDEs), New iterative method (NIM) etc. are reviewed. In next section 3, we developed a new family of numerical methods to solve DDEs and system of DDEs. In section 4, error analysis of newly proposed