

Application of Differential Transform Method to Integral and Integro-Differential Equations

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ABSTRACT--- *In this paper, Differential Transform Method (DTM) has been used to solve some systems of linear and nonlinear Integro-differential equations. The approximate solution in the form of a series are calculated with easily computable terms. The solution obtained using this method is compared with the solution obtained using existing methods.*

Keywords--- Initial conditions, Integro-differential equations, Volterra equations, Linear and nonlinear system, Differential Transform Method, Analytic solution

1. INTRODUCTION

The Differential Transform Method (DTM) is a method for solving a wide range of problems whose mathematical models yield equations or systems of equations involving algebraic, differential, integral and integro-differential equations. The concept of the differential transform was first proposed by Zhou (1986) where in both linear and non-linear initial value problems in electric circuit analysis [1] were solved. This method constructs an analytical solution in the form of polynomials. It is different from the high-order Taylor series method, which requires symbolic computation of the necessary derivatives of the data functions. The Taylor series method is computationally expensive for large orders. The differential transform is an iterative procedure for obtaining analytic Taylor series solutions of differential equations. In recent years the application of differential transform theory has been appeared in many researches.

The theory and application of integro-differential equation is an important subject with in applied mathematics. A large class of scientific and engineering problems modelled by partial differential equations can be expressed in various forms of differential or integro-differential equations in abstract spaces. Integro-differential equations include many physical phenomena such as heat flow in materials with memory, viscoelasticity, heat conduction and wave propagation. Quasilinear integro-differential equation is also a factor which describes the study of nonlinear behavior of elastic strings and nonlinear conservative law with memory. One of the most important fields of modern research is the distributed control systems which is exercised through the boundary in a different way[2].

These are motivations to solve these kind of equations. Using the DTM several examples of linear and nonlinear integro-differential equations are tested and the results reveal that the DTM is very effective and simple.

In this paper, two linear and two nonlinear integro-differential equations are solved. In Section 2, some properties of DTM are given. In Section 3 DTM has been applied to solve linear and nonlinear integro-differential equations.

2. DIFFERENTIAL TRANSFORM METHOD

In this section, some basic properties of differential transform method are given. The differential transform of a function $f(y)$ is defined as follows.

$$F(k) = \frac{1}{k!} \left[\frac{d^k f(y)}{dy^k} \right], \quad (2.1)$$

where $f(y)$ is the original function and $F(k)$ is the differential transform of $f(y)$.

The differential inverse transforms of $F(k)$ is defined as

$$f(y) = \sum_{k=0}^{\infty} F(k) (y - y_0)^k. \quad (2.2)$$

From (2.1) and (2.2) we get

$$f(y) = \sum_{k=0}^{\infty} \frac{(y - y_0)^k}{k!} \frac{d^k f(y)}{dy^k}. \quad (2.3)$$

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