The purpose of this paper is to present a numerical method to solve linear integro-differential equations. This method is based on a new investigation of ultraspherical integration matrix to approximate the highest order derivative in the equations and generating approximations to the lower order derivatives through integration of the highest-order derivative. The produced equations are then leads to algebraic system and solved as mathematical programming. Numerical examples are given to demonstrate the proposed idea and method.

We introduce a new spectral method based on Ultraspherical polynomials for solving systems of initial value differential algebraic equations. Moreover, the suggested method is applicable for a wide range of differential equations. The method is based on a new investigation of the ultraspherical spectral differentiation matrix to approximate the differential expressions in equations. The produced equations lead to algebraic systems and are converted to nonlinear programming. Numerical examples illustrate the robustness, accuracy, and efficiency of the proposed method.

In this paper a computational method based on ultraspherical approximation matrices method is presented to solve the quadratic optimal control problems. The method approximates each of the state and control variables by finite ultraspherical polynomials of unknown parameters. The method converts the optimal control problem into a constraint optimization problem which can be solved more easily than the original. This paper gives explicit results that simplify the implementation of the method. To show the numerical behavior of the proposed method, the numerical results of some examples are presented.
Spectral/Spline Collocation Methods for the Solutions of Some Partial Differential Equations (PDEs)

In this thesis we present a mixed spectral/spline approach to solve the generalized Burger’s equation and the Korteweg de Vries equation. The method is based on an ultraspherical spectral approximation in combination with 4-point spline collocation methods.

Ultraspherical Approximations and Their Applications for Solving Optimal Control Problems

The main goal of this thesis, which consists of six chapters, is to introduce a new procedure for solving optimal control problems governed by some differential problems. This procedure depends on a new spectral approximations for any continuous function and its finite integral and derivatives.