Parallel ODE Solver Based on Convolution in a Transputer/DSP Environment

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Abstract. We consider parallel numerical methods for ordinary differential equations (ODEs) using the potential parallelism of convolution algorithms. These methods are based on approximated Newton iteration and, in fact, are a form of the shifted Picard splitting. The basic idea is to solve the linear ODE on each iteration by computations of the convolution quadrature. After discretization, the convolution quadrature may be computed very efficient by the use of a digital signal processor (DSP) or any parallel convolution algorithm. In this paper we first discuss the advantages of the convolution consideration allowing this additional speedup to be obtained. Besides, there is the opportunity of convolution calculations in the finite fields. On the other hand the convolution permits "automatic using" of the inner parallelism of ODE associated with behaviour of the Jacobian matrix. We also concern with the problems of discretization of the convolution quadrature. The second part of the paper examines the potential performance of the proposed method within a few test problems. All estimates are obtained by numerical experiments on the transputer network.

1 Introduction

In this paper we consider the convolution-based approach to parallel numerical solving the initial-value problem for the nonlinear ordinary differential equation (ODE)

$$\frac{dy}{dt} = f(t, y), \ a \leq t \leq b, \ y(a) = y_0. \tag{1}$$

Most of the numerical methods for solving ODE can be derived by appropriate choice of an interpolation polynomial for the integrand $f(t, y)$ in the equivalent integral equation for (1)

$$y(t) = y_0 + \int_a^t f(\tau, y) \, d\tau, \ a \leq t \leq b. \tag{2}$$

Thus the potential *parallelism across time* [1] of usual recurrence methods (as Runge-Kutta or linear multistep methods) is limited by several simultaneous evaluations of the integrand over one step $[t_0, t_0 + h]$ of a method. Then the parallel step-by-step methods [8], [9] can utilize usually no more than 10 processors (here we do not consider the trivial parallelism across space). For this reason we are looking for new methods allowing large-scale parallelism across time.

Recently a different approach has been proposed [2], [3] than the step-by-step one. These techniques also called *the waveform methods* use an iteration process for solving the integral equation (2) or a similar one over time subinterval $[t_0, t_0 + H]$ of length

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Table of Contents Transputer Research And Applications 6

1. Understanding the eBook Transputer Research And Applications 6
    - The Rise of Digital Reading Transputer Research And Applications 6
    - Advantages of eBooks Over Traditional Books
2. Identifying Transputer Research And Applications 6
    - Exploring Different Genres
    - Considering Fiction vs. Non-Fiction
    - Determining Your Reading Goals
3. Choosing the Right eBook Platform
    - Popular eBook Platforms
    - Features to Look for in an Transputer Research And Applications 6
    - User-Friendly Interface
4. Exploring eBook Recommendations from Transputer Research And Applications 6
    - Personalized Recommendations
    - Transputer Research And Applications 6 User Reviews and Ratings
    - Transputer Research And Applications 6 and Bestseller Lists
5. Accessing Transputer Research And Applications 6 Free and Paid eBooks
    - Transputer Research And Applications 6 Public Domain eBooks
    - Transputer Research And Applications 6 eBook Subscription Services
    - Transputer Research And Applications 6 Budget-Friendly Options
6. Navigating Transputer Research And Applications 6 eBook Formats

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