IN-61-CR
84772
P. 10

Semi-Annual Status Report for NASA Grant NAG2-513
The analysis of control trajectories using symbolic and database computing

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March, 1991

(NASA-CR-190234) THE ANALYSIS OF CONTROL TRAJECTORIES USING SYMBOLIC AND DATABASE COMPUTING Semiannual Status Report, 1 Jul. - 31 Dec. 1991 (Chicago Univ.) 10 p

N92-25636

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Contents

1 Introduction

This is the semi-annual status report for NASA grant NAG2-513, "The analysis of control trajectories using symbolic and database computing." This report covers the period July 1, 1991 through December 31, 1991. The research supported by this grant is broadly concerned with the symbolic computation, mixed numeric-symbolic computation, and database computation of trajectories of dynamical systems, especially control systems. The NASA Technical Officer for this grant is Dr. George Meyer, NASA Ames Research Center, Mail Stop 210-3, Moffet Field, California, 94035. In Section 2, we review the progress during the past six months. Section 3 contains bibliographic references for the articles related to this grant that were completed during this period.

2 Review of Work During Report Period

The work in this grant involves three areas:

- analytic computing
- database computing
- hybrid systems

During the report period, we have made the following progress.

Analytic computing

- Trees can be used to compute symbolically series which approximate solutions to differential equations. We derive several formulas useful in this area in [4].

- State spaces of nonlinear systems often satisfy geometric constraints: in general, numerical algorithms do not preserve these constraints. We are continuing our study of a general approach to generate numerical algorithms with the property that by construction they preserve certain geometic structures. See [3].

  During the report period, a number of third order algorithms of this type were tested. The results look promising: on the nonlinear systems studied, our intrinsic third order algorithm performed as well as a fifth order IMSL Runge-Kutta algorithm. The intrinsic algorithm preserved the geometric structure (in the tested case the constraint $r^2 = 3$) to machine accuracy. The complexity of the tested intrinsic algorithm is approximately the same as a Runge-Kutta algorithm. This work is described in [2].

Database computing

- We have been investigating means to increase the efficiency of scientific computations using databases. During the past year, a simple prototype has been developed and applied to the analysis of particle collisions in the CDF experiment at Fermi Lab. The prototype database completed the sample analysis of collider collisions in 12 minutes. Standard software used at Fermi Lab requires 1 hour and 24 minutes for the same analysis. A similar prototype to analyse trajectories of nonlinear control systems is being tested. This work is described in [1].

Hybrid systems

- We have succeeded in developing a formulation of systems, general enough to include both nonlinear control systems and automata. Products of two systems of this type is also a system of this type. For this reason, it makes sense to view a system of this type as a hybrid system, since such a system can include both continuous and discrete subsystems. This work is described in [5].

3 Articles Written During the Report Period

In this section we include the title pages of the articles resulting from the research supported by this grant during the reporting period.

The symbolic computation of series solutions to ordinary differential equations using trees (extended abstract)

Robert Grossman
University of Illinois at Chicago

November, 1991

Abstract

In this note, we give formulas which can be used for the efficient symbolic computation of series expansions to solutions of nonlinear systems of ordinary differential equations. As a by product of this analysis, we derive formulas relating trees to the coefficients of the series expansions, similar to the work by Leroux and Viennot.

Acknowledgments

This research is supported in part by NASA grant NAG2-513, NSF grant DMS-9101089, and the Laboratory for Advanced Computing.

Status

Submitted for publication.

A third order Runge-Kutta algorithm on a manifold

P. E. Crouch, R. Grossman and Y. Yan

Center for Systems Science and Engineering
Arizona State University

Laboratory for Advanced Computing
University of Illinois at Chicago

December 1991

Abstract

We describe a third order Runge-Kutta type algorithm with the property that it preserves certain geometric structures. In particular, if the algorithm is initialized on a Lie group, then the resulting iterates remain on the Lie group.

Acknowledgments

Robert Grossman's research was supported in part by NASA grant NAG2-513, NSF grant DMS-9101089, and the Laboratory for Advanced Computing.

Status

Submitted for publication.

A simple example of modeling hybrid systems using bialgebras

R. L. Grossman and R. G. Larson
University of Illinois at Chicago

December, 1991

Abstract

By a hybrid system, we mean a network of consisting of continuous, nonlinear control system connected to discrete, finite state automata. Our point of view is that the automata switches between the control systems, and that this switching is a function of the discrete input symbols or letters that it receives. We review how a nonlinear control system may be viewed as a pair consisting of a bialgebra of operators coding the dynamics, and an algebra of observations coding the state space. We also review a similar representation for finite automata. From this point of view, a hybrid system is modeled by taking suitable products of the bialgebras coding the dynamics and the observation algebras coding the state spaces.

Acknowledgments

Robert Grossman's research was supported in part by NASA grant NAG2-513, NSF grant DMS-9101089, and the Laboratory for Advanced Computing.

Status

Submitted for publication.

Analyzing High Energy Physics Data Using Database Computing: Preliminary Report

Andrew Baden, Chris Day,
Robert Grossman, Dave Lifka, Ewing Lusk,
Edward May, and Larry Price

December, 1991

Abstract

We describe a proof of concept system for analyzing high energy physics (HEP) data using database computing. The system is designed to scale up to the size required for high energy physics experiments at the Superconducting SuperCollider (SSC) laboratory. These experiments will require collecting and analyzing approximately 10 to 100 million "events" per year during proton colliding beam collisions. Each "event" consists of a set of vectors with a total length of approximately one megabyte. This represents an increase of approximately 2-3 orders of magnitude in the amount of data accumulated by present large HEP experiments. The system is called the HEPDPC System (High Energy Physics Database Computing System). At present, the Mark 0 HEPDBC System is completed, and can produce analysis of HEP experimental data approximately an order of magnitude faster than current production software on data sets of approximately 1 GB. The Mark 1 HEPDBC System is currently undergoing testing and is designed to analyze data sets 10 to 100 times larger.

Acknowledgments

This project is supported in part by the Office of Energy Research, U.S. Department of Energy. In addition, the work of Robert Grossman was supported in part by NASA Grant NAG 2-513, and the Laboratory for Advanced Computing, University of Illinois at Chicago. Ewing Lusk's work was supported by the Applied Mathematical Sciences subprogram of the Office of Energy Research, U.S. Department of Energy, under contract W-31-109-Eng-38.

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[2] P. E. Crouch and R. Grossman "A third order Runge-Kutta algorithm on manifolds," *Laboratory for Advanced Computing Technical Report LAC91-R10,* 1991.

[3] P. Crouch, R. Grossman and R. Larson, "Trees, bialgebras and intrinsic numerical algorithms," *Laboratory for Advanced Computing Technical Report LAC90-R23*, 1990.

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