Bluenose Numerical Analysis Day 2009, Acadia University

Final Report – October 26, 2009

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The tenth annual Bluenose Numerical Analysis Day was held July 10, 2009 at Acadia University in Wolfville NS. This anniversary meeting went quite well and we are appreciative to AARMS for their continued support.

Included in this document is a brief summary of the event. Claims for expenses incurred for the meeting have been made and I understand processed by the AARMS office. Many thanks!

There were approximately 30 people in attendance during the day including faculty and students from Acadia, Dalhousie, Saint Mary's, UNB, and CBU. A complete schedule and list of speakers with abstracts is included below. The day ended with a great bbq social, held at the Acadia Faculty club, with food provided by funding from the Dr. Tom Herman's office – the VP Academic at Acadia. Refreshments during the day were provided with monies from the Department of Mathematics and Statistics at Acadia and Dr. Rob Raeside's office – the Dean of Science at Acadia.

Final Schedule July 10, 2009 (See titles and abstracts below)

9:30 Opening Remarks, Dr. Rob Raeside, Dean of Science, Acadia U.
9:40 Plenary Speaker, Dr. Bruce Simpson, University of Waterloo
10:25 Coffee
10:40 Rebecca White, Dalhousie University
11:15 Dr. David Greenberg, Bedford Institute of Oceanography
12:00 Lunch in Wolfville
1:30 Adam Alcolado, Dalhousie University
2:00 Dr. Brian Lowry, University of NewBrunswick
2:45 Coffee
3:00 Dr. Paul Muir, Ling Lin, Tom Arsenault, Saint Mary's University
3:45 Tim Dunbar, Martec
4:30 BBQ and Social

Titles and Abstracts

Bruce Simpson, Professor Emeritus, School of Computer Science, University of Waterloo.

A look at unstructured meshing for piecewise linear approximation

A large class of 2-D meshing applications can be abstracted in the following terms: "Given a function, f(x,y), defined in a region D, produce a good piecewise linear approximation to f in D." There are two (at least) independent meshing requirements posed by this task. One is for the mesh to conform to D. The other is for the mesh to support computing the approximation to f with satisfactory accuracy and efficiency. This talk will review the basis of current methods for addressing these two requirements and comment on their interaction.

Brian Lowry, Department Chemical Engineering, University of New Brunswick.

Tim Dunbar, Martec Limited, Halifax, NS

Simulation of Structural ReSPONSE from Underwater Explosions

A numerical method for performing two-way coupled fluid-structure interaction simulations has been developed to model a wide class of problems in which structural response significantly influences subsequent fluid flow, through motion-induced cavitation, structural failure or both. We demonstrate the suitability of the approach to simulate such events by applying our method to the early-time response of plates exposed to contact and near-contact underwater explosions in three dimensions. The FSI approach, originally developed for structural shell elements, is also extended to solid structural elements for problems where through the-thickness stress and strain variations are important. The plates exhibit a variety of behaviors including petalling failure with venting of explosive products through the resulting holed plates. The deformation and failure patterns of the plates are compared with experimental data from trials performed by Defense Research Development Canada at Suffield.

David Greenberg, Bedford Institute of Oceanography

Resolution issues in ocean models

The baroclinic and barotropic properties of ocean processes vary on many scales. These scales are determined by various factors such as coastline, bottom topography, meteorological forcing, latitudinal dependence of the Coriolis force, and the Rossby radius of deformation among others. An attempt is made to qualify and quantify scales of these processes, with particular attention to the horizontal resolution necessary to accurately reproduce physical processes in numerical ocean models.

Rebecca White, Dalhousie University

Adam Alcolado, Dalhousie University

Paul Muir,Saint Mary's University

Error Control Software for Time-Dependent 1D Partial Differential Equations

In this talk we review two recently developed "production level" or "library level" software packages for the numerical solution of a general class of second order parabolic PDEs in one spatial dimension. The packages, called BACOL and BACOLR, employs high order adaptive methods in time and space within a method-of-lines approach. The DAEs resulting from the spatial discretization (collocation with a B-spline basis) are handled in BACOL by a modified version of the well-known DAE solver, DASSL, and in BACOLR, by the well-known Runge-Kutta DAE solver, RADAU5. Both DAE solvers adaptively control an estimate of the temporal error. An unusual feature of the BAOCL/BACOLR codes is that they adaptively control a high order estimate of the spatial error. In this talk we will briefly review the algorithms employed by these packages and present numerical results to show that the new software is more efficient, reliable and robust than other comparable packages, especially for problems with solutions exhibiting narrow spikes or boundary layers. This is joint work with Pat Keast, Dalhousie University, and Rong Wang, Wuhan University.

Ling Lin, Saint Mary's University

High Order Collocation Software for the Numerical Solution of Fourth Order PDEs

BACOL is an effcient software package for solving systems of second or- der parabolic PDEs in one space dimension; a significant feature of the package is that it employs adaptive error control in both time and space. In a second order PDE, spatial derivatives up to second order will appear. However, many applications lead to mathematical models which involve fourth order PDEs - such equations include spatial derivatives up to fourth order. The goal of our research has been to extend BACOL so that it can handle fourth order PDEs. We have explored an approach that involves converting the fourth order PDE to a coupled system which contains one second order PDE and one second order ODE (in space). Two different treatments are discussed: epsilon-BACOL and BACOL42. For epsilon-BACOL, we apply the original BACOL package to solve an approximate form of the converted system. For BACOL42, we have modified the original BACOL package to allow it handle the coupled PDE/ODE system. We will describe the two approaches and provide numerical results to demonstrate the effectiveness of the two approaches. This is joint work with Pat Keast, Dalhousie University, and Paul Muir, Saint Mary's University.

Tom Arsenault Saint Mary's University

Efficient Error Estimation for 1D Time-Dependent PDE Solvers based on Superconvergent Interpolants

BACOL and BACOLR, two recently developed software packages for the numerical solution of systems of 1D time-dependent parabolic PDEs, have been shown to be more efficient, reliable and robust than other comparable packages, especially for problems with solutions exhibiting narrow spikes or boundary layers. The two packages generate a spatial error estimate based on the computation of two global solutions to the PDEs, one based on B-splines of order p and the other based on B-splines of order $p+1$ (where p is a user chosen parameter). The difference between these two solutions gives a high order estimate of the spatial error and this estimate is required to satisfy the user tolerance after every time step. The computation of the second global solution is obviously a significant computational expense and thus our recent work has focused on the development of a more efficient error estimation algorithm based on the use of low cost superconvergent interpolants which can replace the expensive higher order global solution. Numerical results will be presented to demonstrate the efficacy of this new approach. This is joint work with Pat Keast, Dalhousie University, and Paul Muir and Tristan Smith, Saint Mary's University.

Budget

AARMS funding was used to provide for the following travel expenses:

Patrick Keast:	$181.73
David Greenberg:	$189.36
Tim Dunbar:	$196.95