Scientific Computing at UMass Dartmouth

January 2014

My work: numerical solution of hyperbolic PDEs

- The governing equations for many fluid flows are hyperbolic PDEs. The flows feature sharp gradients and shocks that require careful and sophisticated algorithms for numerical simulation.
- Two components are needed: a spatial discretization and a time discretization, but the two need to work together to preserve important properties of the flow under consideration.
- Weighted essentially non-oscillatory (WENO) methods are designed to prevent numerical oscillations in shock wave calculations. My goal is to develop more efficient WENO methods that better suppress the oscillations.
- Strong stability preserving (SSP) methods guarantee that the desirable properties of the spatial discretization are preserved for high order time-stepping. My goal is to develop **high order** SSP time discretizations with the largest possible allowable step-size. This work has been funded by the AFOSR since 2006.

Center for Scientific Computing and Visualization Research

Who are we?

The CSCVR is made up of faculty whose research interests lie in the modeling, simulation, and visualization of complex physical processes.

Our Research interests . . .

The mathematical development of efficient and accurate numerical methods as well as simulations of applied problems in oceanography, astrophysics, civil and mechanical engineering, chemistry, biology, and bioinformatics.

Significance

This group is unique to our knowledge: we have a well-integrated group of scientists that communicate regularly on scientific and computational issues, hold joint seminars and workshops, co-advise graduate and undergraduate students, and collaborate.

Scientific Advisory Board

Our scientific advisory board is made up of scientists of the highest caliber who support our mission and believe in our potential. Their willingness to take from their precious time to serve as our board is a recognition of our excellence and potential.

1. Marsha Berger, NYU
2. Paul Fischer, Argonne
3. Ian Foster, Argonne
4. Antony Jameson, Stanford
5. Kirk Jordan, IBM
6. Randy LeVeque, UWash
7. Robert Panoff, Shodor Foundation
8. Richard Price, UTexas
9. Stanley Osher, UCLA
10. Chi-Wang Shu, Brown
11. Jack Dongarra, U. of Tennessee/ORNL
12. Alex Pothen, Purdue University

Computing Resources

1. Grants from the AFOSR and the NSF totaling \$400,000 and startup funds allowed the purchase of our HPC cluster. The cluster has now grown to some 86 nodes (688 CPU cores), with 64 Nvidia Tesla GPU cards, networked with QDR Infiniband, and providing over 50 TB of NAS storage.
   At last count, the computational facility supports 17 faculty investigators and 28 postdoctoral, graduate student, and undergraduate student users, and has produced numerous scientific publications. Additionally, it has been utilized in several undergraduate and graduate courses in the Mechanical Engineering, Mathematics, and Physics departments.

Computing Resources

1. We are also part of the MGHPCC: UmassD invested close to $100,000, which about 256 cores (about 16 servers with 256GB RAM per server), 3 of our servers have GPUs, the only GPUs in the system.
2. The Air Force Research Lab (AFRL) at Rome, NY granted CSCVR four full racks (176 units) of Sony PlayStation 3s for research computing. UMass Dartmouth pioneered the use of PS3s for astrophysics research back in 2007 when Prof. Khanna (Physics) created a compute cluster of 16 PS3s and ran his black hole research simulations at supercomputer-level performance.

Recent research highlights and grants

1. Gaurav Khanna (PHY) and his team used high performance computing simulations to explain why and how it is that a rapidly spinning black hole simply avoids capturing a test particle that could potentially overspin it (NSF $245,000).
2. Cheng Wang (MTH) is developing and analyzing algorithms for numerical simulations of Thin film growth mechanisms that are critical to the semi-conductor industry; Tumor growth using the Cahn-Hilliard-Hele-Shawmodel (NSF $104,283).
3. Akil Narayan and Alfa Heryudono (MTH) are working on computation of crowded geodesics on the universal Teichmuller space for planar shape matching in computer vision (NSF $325,698)
4. Mehdi Raessi is working on analysis and design of textured super-hydrophobic surfaces capable of preventing ice formation on wind turbine blades. (NSF $214,583)

Recent research highlights and grants

1. Mehdi Raessi (MNE), Mazdak Tootkaboni (CEN), and Geoff Cowles (SMAST) are developing an advanced computational tool foranalysis and optimization of ocean wave energy converters (NSF $368,221).
2. Mazdak Tootkaboni (CEN) is applying computational uncertainty quantification techniques and model validation for the design of thin-walled structures. His work develops a probabilistic paradigm for advancing analysis-based design (NSF $215,255).
3. Robert Fisher (PHY) and collaborators from the University of Chicago and the Weizmann Institute have used numerical simulations to conclusively demonstrate a connection between white dwarf stars that fail to completely detonate and a class of oddly dim supernovas.

Recent research highlights and grants

1. Yanlai Chen (MTH) is extending model reduction methods to allow efficient simulations of a wide variety of problems including such application areas as: fine-tuning of the shape and material for stealth technology important to national security, design of solar cells for renewable energy, non-destructive sensing (NSF $161,113.)
2. Mehdi Raessi (MNE), Mazdak Tootkaboni (CEN), and Youssef Marzouk (MIT) are working on simulations of underwater buoyant oil leaks.