Iterative Solution of Very Large Systems of Linear Equations 1990-2000

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Students and postdocs working on this project during the period 1990-2000

- Mirela Popa (graduate), PhD in progress
- G. Scott Lett (graduate), PhD 1990
- Ellen Applebaum (graduate)
- Petr Vanek (postdoc)
- Sugata Ghosal (postdoc)
- Marian Brezina (graduate), PhD 1997
- Radek Tezaur (graduate), PhD 1998
- Temesgen Aziz (undergraduate)

Objective

- Develop new technologies for fast solution of very large systems of equations from engineering models of computational mechanics on high performace computers

Major New Technologies Developed

- Guiding numerical computations by artificial intelligence
- Iterative methods for high order approximation methods for elasticity
- Iterative substructuring methods for massively parallel computers: Balancing Domain Decomposition for elasticity, FETI (Finite Element Tearing and Interconnecting) extension to plates and shells
- Algebraic multigrid for elasticity
- Iterative substructuring by FETI for coupled fluid-solid acoustics

Funding

2000–2001 *Acquisition of a High-Performance Parallel Computer for Mathematical Sciences and Applications.* NSF DMS 0079719 Co-PI (Andrew Knyazev, PI), $100,000.

2000-2003 *Scalable Submesh Computing.* NSF DMS 0074278, $155,000, PI.

1997–2001 *High Performance simulation of Multiphysics Problems*, Subcontract PI (C. Felippa, UCB, PI); NSF ECS-9725504. $312,00

1995–2001 *Sensitivity Analysis Of Coupled Acoustic Problems to Structural Boundary Conditions and Efficient Numerical Solution Algorithms*, Co-PI (C. Farhat, UCB, PI), ONR N-00014-95-1-0663, $481,000.

1995-1996 *Mathematical Sciences Computing Research Environments*, NSF DMS-9508328, Co-PI (T. Russell, PI), $50,000

1994-1996 *Artificial Intelligence in Numerical Computing – CISE Postdoctoral Research Associateship for S. Ghosal*, Co-PI with H. Greenberg, NSF ASC-9404734, $42,000.

1994 *Advanced Iterative Solvers for High Order Finite Elements*, NSF SBIR DMI-9360015, PI, $64,857.

1993-1996 *Parallel Methods for Large-Scale Computations*, NSF Grant ASC-9121431, PI, $240,595.

1992-1997 *GAFD Turbulence and Coupled Fields*, NSF ASC-9217394 (Grand Challenge, C. Felippa, UCB, PI), subcontract PI, $312,500.

1991 *Fast Iterative Solvers for MSC/EMAS*, MacNeal-Schwendler Corporation, PI, $50,000

Impact

- **Iterative solver for p-version Finite Element Method**
  - first method to solve systems of millions of equations from high order approximation of structural stress calculations
  - used by Aeronautic Research Institute of Sweden for structural analysis of JAS 39 Gripen fighter jet (1994), to date in use by Saab Scania
- **Balancing Domain Decomposition**
  - Implemented by INRIA (France) as part MODULEF software package
  - Implemented at University of Bergen for European PARASOL project
  - Implemented at University of Tokyo to solve systems of 100 million equations on 1000 processor Hitachi supercomputer
  - Implemented in oil reservoir codes at Rice University, to date part of codes at UT Austin and used in U.S. oil industry
- **Algebraic Multigrid**
  - Implemented as part of ANSYS (a major commercial engineering package)