Research Interests and Goals:

Unstructured Mesh Generation:

- The challenges of mesh generation in the coming decade will be significant increase in speed, handling of considerably larger and more complex non-manifold domains, increased reliability and much better control of mesh refinement to minimize mesh sizes. All of the above goals will enable engineers to quickly iterate through design cycles and increase productivity. To achieve the above goals, I propose to focus on developing
  - automatic parallel meshers running on large networks of medium power workstations to increase speed, and
  - anisotropic meshing and adaptation algorithms to reduce mesh sizes allowing larger problems to be solved.
- Hexahedral mesh generation is a challenging mesh generation problem still requiring significant research. I propose to first research the basic constraints of hexahedral mesh generation and then to research algorithms for automatic parallel generation of all hexahedral mesh for complex geometries.
- The requirements on mesh generators for coupled analyses of fluid and structural domains is yet another area that requires some careful consideration. Some of the meshing needs for such problems are already met by the non-manifold representation of geometric models but it is unclear if this is all that is required of such meshes.
- Finally, mesh adaptation for evolving geometries offers a number of unique challenges. The problems of balancing the cost of remeshing to the loss in accuracy due to mesh distortion, the physical constraints to be respected while adapting the geometry, the actual adaptation of the geometric model and the transfer of solution between meshes, all offer considerable scope for important research.

Computational Geometry and Geometric Modeling

Computational geometry is closely tied to mesh generation. Fast, reliable and robust computational geometric algorithms are required to develop good mesh generation algorithms. Most algorithms developed for computational geometry problems omit consideration of the problems encountered when dealing with finite point tolerances and numerical imprecision. It is my proposal to investigate fast and robust algorithms for computational geometry problems taking into account the above mentioned factors. Since solid modeling requires extensive use of computational geometry, I am interested in investigating challenging problems in that area as well.

Other Research Interests

I am interested, in general, in all computational methods for solving large scale mechanical engineering problems. In particular, I would like to further study and perform active research into various aspects of finite element methods for fluid flow simulations, aeroacoustics and fluid-structure interactions as well as thermo-mechanical analysis of semiconductor devices.

References

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Design Automation Conference at the 1991 ASME Design Technical Conferences, v 32, n pt 2, Miami, FL, 1991.

Technical Reports:

1. Agrawal S.K., Garimella, R. and Desmier G. "Optimal Workspace Designs of Free-floating Planar Manipulators," *NASA Technical Memorandum 103274*, pp. 1653-1658, published by NASA, Washington, DC, Nov 1990.
2. Garimella, R., et. al. "Finite Octree Mesh Generation and Output Options," Technical Report #5-1994, Scientific Computation Research Center, Rensselaer Polytechnic Institute, Troy, NY 12180, Jan 1994.
3. Garimella, R., et. al. "Specification of Mesh Control Functions in Finite Octree," Technical Report #5-1994, Scientific Computation Research Center, Rensselaer Polytechnic Institute, Troy, NY 12180, Jan 1994.
4. Garimella R., "Support of non-manifold modeling with manifold models", Technical Report, Scientific Computation Research Center, Rensselaer Polytechnic Institute, Troy, NY 12180, 1993.
5. Garimella R. and Shephard M.S. "Mesh Generation of ICCA Models Using Finite Octree," Technical Report (submitted to ARPA-ICCA group), Scientific Computation Research Center, Rensselaer Polytechnic Institute, Troy, NY 12180, 1995.
6. "REPAS - Rensselaer Electronic Packaging Analysis Software Users' Manual," Technical Report #17-1994, Scientific Computation Research Center, Rensselaer Polytechnic Institute, Troy, NY 12180, 1994.
7. "REPAS - Rensselaer Electronic Packaging Analysis Software Programmers' Manual," Technical Report #18-1994, Scientific Computation Research Center, Rensselaer Polytechnic Institute, Troy, NY 12180, 1994.

International Electronics Packaging Conference, v4-1, pp. 39-48, Binghamton, NY, Sep 29-Oct 2 1993.

6. Agrawal, S.K. and Garimella, R. "Path planning algorithm for a free-floating closed-chain planar manipulator," in *ASME, Design Engineering Division (Publication) DE, Flexible Mechanisms, Dynamics, and Analysis 22nd Biennial Mechanisms Conference*, v 47, pp. 645-652, Scottsdale, AZ, Sep 13-16 1992.

7. Agrawal, S.K., Garimella, R. "Inverse kinematic solutions of free-floating closed-chain planar manipulators," in *ASME, Design Engineering Division (Publication) DE, Advances in Design Automation 17th Design Automation Conference at the 1991 ASME Design Technical Conferences,* v 32, n pt 2, Miami, FL, 1991.

Conference presentations

1.Garimella, R., Shephard, M.S. and Webster, B.E. "Automatic Mesh Generation Of Complex Configurations Including Viscous Boundary Layers," *10th International Conference on Finite Elements in Fluids*, Tucson, AZ, Jan 98.

2. Frey, P.J., Shephard, M.S., Dey, S., Garimella, R. and Georges, M.K. "Optimization of Tetrahedral Meshes using Local Retriangulation," in *Third U.S. National Congress on Computational Mechanics*, Dallas, TX, Jun 12-14, 1995.

3. Garimella, R., Shephard M.S. "Mesh Generation for Viscous Flow Analysis in Complex Geometric Domains," in *Fourth U.S. National Congress On Computational Mechanics*, San Francisco, CA, Aug 6-8, 1997.

4. Garimella, R. and Shephard, M.S. "Tetrahedral Mesh Generation with Multiple Elements Through The Thickness," *4th International Meshing RoundTable Conference*, Albuquerque, NM, Oct 95.

5. Shephard, M.S., Sham, T.-L., Song, L.-Y. and Garimella, R. "The Use of ABAQUS in the Automated Global/Local Thermomechanical Analysis of Multichip Modules," *Abaqus Users Conference*, Newport, RI, Jun 94.

6. Shephard, M.S., Sham, T.L., Song, L.Y., Wong, V.S., Garimella, R., et.al. "Global/local analyses of multichip modules: automated 3-D model construction and adaptive finite element analysis," *ASME International Electronics Packaging Conference*, Binghamton, NY, Sep 29-Oct 2 1993.

7. Agrawal, S.K. and Garimella, R. "Path planning algorithm for a free-floating closed-chain planar manipulator,"
in ASME, Design Engineering Division (Publication) DE, Flexible Mechanisms, Dynamics, and Analysis 22nd
Biennial Mechanisms Conference, v 47, pp. 645-652, Scottsdale, AZ, Sep 13-16 1992.

8. Agrawal, S.K., Garimella, R. "Inverse kinematic solutions of free-floating closed-chain planar manipulators," in
ASME, Design Engineering Division (Publication) DE, Advances in Design Automation 17th

Lifetime Publications

Journal publications

1.Shephard, M.S., Beall, M.W., Garimella, R. and Wentorf, R. "Automatic construction of 3-D models in multiple scale analysis," *Computational mechanics*, v 17, n 3, pp. 196-207, Dec 1996.

2. Agrawal S.K., Garimella, R. and Desmier, G. "Free-Floating Closed-Chain Planar Robots: Kinematics and Path Planning," in *Nonlinear Dynamics*, v 9, pp. 1-19, Feb 1996.

3. Agrawal, S.K. and Garimella, R."Kinematics, Workspace, and Design of a Dual-Arm Spatial Robot in Zero Gravity," *Journal of mechanical design*, v 116, n 3, pp. 901-907, Sep 1994.

4. Karamete, B.K., Garimella, R. and Shephard M.S. "Recovery of an Arbitrary Edge on an Existing Surface Mesh using Local Mesh Modifications," in preparation for submission to *International Journal of Numerical Methods in Engineering*, 1998.

5. Garimella, R.V. and Shephard M.S. "Unstructured Anisotropic Tetrahedral Mesh Generation for Viscous Flow Simulations in Complex Geometric Domains," in preparation for submission to *International Journal of Numerical Methods in Engineering*, 1998.

6. Garimella R.V. and Shephard M.S. "Anisotropic Tetrahedral Mesh Refinement through the Thickness of Arbitrarily Complex Geometric Domains," in preparation for submission to *International Journal of Numerical Methods in Engineering*, 1998.

7. Garimella R.V. and Shephard M.S. "Construction of Non-Manifold Representations from Appropriately Defined Assemblies in Two-Manifold Geometric Modeling Systems," in preparation for submission to *Engineering with Computers*, 1998.

Conference publications

1.Garimella, R.V. and Shephard, M.S. "Boundary Layer Meshing for Viscous Flows in Complex Domains," accepted for publication in the *Proceedings of the 7th International Meshing Roundtable*, organized by Sandia National Laboratories, Dearborn, MI, Oct 1998.

2. Garimella, R., Shephard, M.S. and Webster, B.E. "Automatic Mesh Generation Of Complex Configurations Including Viscous Boundary Layers," to appear in *Proceedings of the 10th International Conference on Finite Elements in Fluids*, Tucson, AZ, Jan 98.

3. Garimella, R. and Shephard, M.S. "Tetrahedral Mesh Generation with Multiple Elements Through The Thickness," *Proceedings of 4th International Meshing Roundtable Conference*, pp. 321-334, Albuquerque, NM, Oct 95.

4. Shephard, M.S., Sham, T.-L., Song, L.-Y. and Garimella, R. "The Use of ABAQUS in the Automated Global/Local Thermomechanical Analysis of Multichip Modules," in *Proceedings of the Abaqus Users Conference,* Newport, RI*,* pp. 475-490, Jun 94.

5. Shephard, M.S., Sham, T.L., Song, L.Y., Wong, V.S., Garimella, R., et.al. "Global/local analyses of multichip modules: automated 3-D model construction and adaptive finite element analysis," in *ASME, EEP Advances in Electronic Packaging, Proceedings of the 1993 ASME*

Awards and Honors

Letter of Commendation (with copies sent to Dean of Engineering, Rensselaer Polytechnic Institute) from Mr. Andrew Jay, Casting Discipline Chief, Pratt & Whitney, Hartford CT for work on the ICCA project.

Technical Skills

Experience with numerical optimization, computational geometry, geometric modeling, visualization methods, Finite Element Methods, numerical solution of linear and non-linear systems.

Graduate courses in Applied Mathematics, Numerical Methods in Engineering, Optimization, Ordinary/Partial Differential Equations, FEM, Advanced FEM, FE programming, Solid mechanics, Plasticity, Potential flow theory, Heat Transfer, Vibrations, Dynamics and Control.

Software Skills

Programming:	Large scale software development and integration in broad range of computing environments
Languages:	C, C++, FORTRAN
Software Packages:	Parasolid, Shapes, Data Explorer, IMSL, Maple, Matlab, PATRAN, Abaqus, UG, Pro/E.
Operating Systems:	UNIX (Sun OS, Sun Solaris, SGI/IRIX, HP/UX, IBM/AIX, Linux), DOS

Scholarly and Professional Activities

President, American Society of Engineers from India, Athens, OH Chapter. (1991-1992)

Chairman, Co-founder, Association for Development of Science, Mysore, India. (1987-1989)

References

See attached list of references.

Developed and implemented algorithms capable of refining an isotropic mesh through the thickness. The algorithm starts from an isotropic mesh of an arbitrarily complex geometric model and automatically identifies the sections of the model which do not have enough mesh nodes through the thickness necessary to capture a nonlinear solution of a given order. It then anisotropically refines through the thickness introducing multiple nodes through the thickness without refinement in the other directions. These procedures have been used very effectively to generate meshes for casting simulations of airfoils, jet engine diffuser casings, airfoil mounts etc., for soft tissue analysis, for heat transfer analysis of a thin crucible for crystal growth and for thermal analysis in semiconductor devices (Research supported by Advanced Research Projects Aagency's Investment Casting Cooperative Arrangement or ARPA-ICCA project)

- Automated Model Generation:
  Developed algorithms for automatically creating non-manifold models from assemblies (supported by ARPA-ICCA and EDS/Unigraphics) and MultiChip Module (MCM) models from CIF data (supported by Wright-Patterson Air Force Base for the Electronic Packaging Interconnect Initiative project).
- Geometric Modeling and Computational Geometry:
  Developed generic interfaces to commercial modeler kernels (Parasolid and Shapes), modeled industrial parts and implemented spatial search algorithms.
- Finite Element Pre- and Post-processing:
  Developed software for automatically generating input files for soft-tissue analysis using the SCOREC Attribute Manager, SCOREC mesh databases and SCOREC model interfaces. Wrote translators from SCOREC mesh database for commercial FEA input formats (ABAQUS, PATRAN, Spectrum).

Teaching Assistant, Mechanical Engineering, Rensselaer Polytechnic Institute. (Aug. 1992 - May 1993)

Research Assistant, Mechanical Engineering, Ohio University, Athens, OH. (Jan. 1990 - Jul. 1992)

Investigated the kinematics, inverse kinematics and path planning algorithms for a free-floating mechanism (Research supported by National Science Foundation grant).

Teaching Assistant, Mechanical Engineering, Ohio University. (Jan. 1991 - Apr. 1991)

Project Engineer, Aerospace Engineering, Indian Institute of Science, Bangalore, India. (Jan. 1990 - Jun. 1990)

Practical Trainee, Wheel and Axle Plant, Bangalore, India. (Oct. 1985- Nov. 1985)

Publications

See attached list of lifetime publications.

Curriculum Vitae

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Career Objective:

To research, develop and utilize frameworks for numerical solution of challenging engineering problems.

Professional Interests:

Unstructured Mesh Generation, Geometric Modeling, Computational Geometry, Finite Element Methods and Numerical Optimization. (See attached description of research interests).

Education

Ph.D., Mechanical Engineering, Expected September 1998, Rensselaer Polytechnic Institute, Troy, NY.

MS, Mechanical Engineering, 1992, Ohio University, Athens, OH.

BS, Mechanical Engineering, 1989, Sri Jayachamarajendra College of Engineering, Mysore, India.

Experience

Research Assistant, Scientific Computation Research Center (SCOREC),
Rensselaer Polytechnic Institute, Troy, NY. (1993 - current)

Developed and supported research projects for sponsors including Ford, Pratt & Whitney, General Electric, Howmet Corp, PCC Airfoils, Electronic Data Systems (Unigraphics Division), MacNeal-Shwendler Corp, Wright-Patterson Air Force Base, Knolls Atomic Power Labs, Centric Engineering Systems, TMA Inc. and Simmetrix Inc.

Developed algorithms and large scale software for Automatic Mesh Generation. Also developed software for Automatic Model Generation, Geometric Modeling, Computational Geometry, Finite element pre- and post-processing and simple Finite Element Analyses.

- Automatic Boundary Layer Mesh Generation for Viscous Flow Simulations:
  Developed mesh generator capable of generating anisotropic meshes for capturing boundary layers and free shear layers in viscous flow simulations. The mesh generator is capable of generating boundary layer meshes for arbitrarily complex non-manifold geometric models using input directly from geometric modelers. Meshes from this software are being used in the industry to perform simulations on complex automobile exterior models with complete under-the-hood and under-the-body details and in automobile interiors. Meshes from this mesh generator also used for crystal growth simulations, turbulent flow simulations (Reynolds Averaged Navier Stokes Simulation), aeroacoustics analysis and blood flow simulations (Research supported by Simmetrix Inc.)
- Automatic Generation of Tetrahedral Meshes with Multiple Elements through the Thickness: