Harish Narayanan

Department of Scientific Computing
Simula Research Laboratory
Martin Linges v 17, 1364 Fornebu
Norway

Phone: +47-4003-4801
Fax: +47-6782-8201

E-mail: harish@simula.no
Website: http://home.simula.no/~harish/

Born: October 12, 1980—Madras, India
Nationality: Indian

Areas of specialisation

Classical and modern field theories of mechanics • Modelling multi-physics phenomena

Mathematics of growth and remodelling of biological tissues

Analysis of numerical methods • Error-controlled finite element methods

Appointments held

2008 – Postdoctoral fellow, *Simula Research Laboratory, Norway* (Current position)

2002 – 2008 Research assistant, *University of Michigan, Ann Arbor*

Education

2007 Ph.D. in Mechanical Engineering and Scientific Computing, *University of Michigan, Ann Arbor*
Dissertation: *"A continuum theory of multiphase mixtures for modelling biological growth"*
Advisor: *Prof. Krishna Garikipati*

2006 M.S. in Mathematics, *University of Michigan, Ann Arbor*

2003 M.S.E. in Mechanical Engineering, *University of Michigan, Ann Arbor*

2002 B.E. in Mechanical Engineering, *University of Madras, India* (First class with distinction)

Academic honours

2001 – 2002 Received the *Sir C.P. Ramaswamy Aiyar Endowment Scholarship* from the University of Madras for excellent academic performance at the undergraduate level.

1998 Received a *Certificate of Merit* for outstanding academic work throughout 12^{th} grade, including securing the first rank in physics, AISSCE (CBSE 12^{th}).

Publications & communications

PhD dissertation

H. Narayanan, "A continuum theory of multiphase mixtures for modelling biological growth," *University of Michigan,* 2007. [DOI] [PDF]

Peer-reviewed journal articles

H. Narayanan, S.N. Verner, K.L. Mills, R. Kemkemer and K. Garikipati, "*In silico* estimates of the free energy changes in growing, avascular, tumor spheroids," *Journal of Physics: Condensed Matter*, Submitted in 2009.

H. Narayanan, E. Arruda, K. Grosh and K. Garikipati, "The micromechanics of fluid-solid interactions during growth in porous soft biological tissue," *Biomechanics and Modeling in Mechanobiology*, vol. 8(3), pp. 167–181, 2009. [DOI] [PDF]

K. Garikipati, M. Falk, M. Bouville, B. Puchala and **H. Narayanan**, "The continuum elastic and atomistic viewpoints on the formation volume and strain energy of a point defect," *Journal of the Mechanics and Physics of Solids*, vol. 54(9), pp. 1929–1951, 2006. [DOI] [PDF]

K. Garikipati, J. Olberding, **H. Narayanan**, E. Arruda, K. Grosh and S. Calve, "Biological remodelling: Stationary energy, configurational change, internal variables and dissipation," *Journal of the Mechanics and Physics of Solids*, vol. 54(7), pp. 1493–1515, 2006. [DOI] [PDF]

K. Garikipati, E. Arruda, K. Grosh, **H. Narayanan** and S. Calve, "A continuum treatment of growth in biological tissue: The coupling of mass transport and mechanics," *Journal of the Mechanics and Physics of Solids*, vol. 52(7), pp. 1595–1625, 2004. [DOI] [PDF]

Chapters in books

E. Arruda, S. Calve, K. Garikipati, K. Grosh and **H. Narayanan**, "Characterization and modeling of growth and remodeling in tendon and soft tissue constructs," *Mechanics of Biological Tissue,* chap. 5, pp. 63–75, 2006. [DOI] [PDF]

K. Garikipati, **H. Narayanan,** E. Arruda, K. Grosh and S. Calve, "Material forces in the context of biotissue remodelling," *Mechanics of Material Forces,* chap. 8, pp. 77–84, 2005. [DOI] [PDF]

Conference proceedings

H. Narayanan, K. Garikipati and A. Logg, "Collaborative computational frameworks and the growth problem," *The mathematics of growth and remodelling of soft biological tissues,* Mathematisches Forschungsinstitut Oberwolfach Reports, no. 39, pp. 29–31, 2008. [PDF]

Unpublished works

H. Narayanan, "Variational level sets in shape reconstruction from unorganised data sets," *University of Michigan,* 2005. [PDF]

Selected talks

"A goal-oriented error-controlled solver for biomedical flows," *Fifth M.I.T. Conference on Computational Fluid and Solid Mechanics,* Cambridge, MA, June 2009. [slides]

"Collaborative computational frameworks and the growth problem," *Workshop on the Mathematics of Growth and Remodelling of Soft Biological Tissues,* Mathematisches Forschungsinstitut Oberwolfach, Germany, September 2008. [slides]

"Reshaping tumour growth," *University of Michigan Engineering Graduate Student Symposium,* Ann Arbor, MI, November 2007. [slides]

"The numerical implications of multiphasic mechanics assumptions underlying growth models," *Ninth U.S. National Congress on Computational Mechanics,* San Fransisco, CA, July 2007. [slides]

"Finite Element Methods in General Relativity," *University of Michigan Engineering Graduate Student Symposium*, Ann Arbor, MI, November 2006. [slides]

"Viscoelastic and Growth Mechanics in Engineered and Native Tendons," *43rd Annual Technical Meeting of the Society of Engineering Science,* University Park, PA, August 2006. [slides]

"The numerical implications of fluid incompressibility in multiphasic modelling of soft tissue growth," *Seventh World Congress on Computational Mechanics,* Los Angeles, CA, July 2006. [slides]

"Tendon Growth and Healing: The Roles of Reaction, Transport and Mechanics," *15th U.S. National Congress on Theoretical and Applied Mechanics,* Boulder, CO, June 2006. [slides]

"Computational Modelling of Mechanics and Transport in Growing Tissue," *Eighth U.S. National Congress on Computational Mechanics,* Austin, TX, July 2005. [slides]

"Simulations of coupled mechanics and transport in growing soft tissue," *Third M.I.T. Conference on Computational Fluid and Solid Mechanics,* Cambridge, MA, June 2005. [slides]

"A Continuum Treatment of Coupled Mass Transport and Mechanics in Growing Soft Tissue," *Materials Research Society Fall Meeting,* Boston, MA, November 2004. [slides]

"Multi-Scale Simulations of the Mechanics of Transport and Growth in Soft Tissue," *41st Annual Technical Meeting of the Society of Engineering Science,* Lincoln, NE, October 2004. [slides]

"Material forces in the context of biological tissue remodelling," *Seventh U.S. National Congress on Computational Mechanics,* Albuquerque, NM, July 2003. [slides]

"A continuum treatment of growth in tissue: Mass transport coupled with mechanics," *Second M.I.T. Conference on Computational Fluid and Solid Mechanics,* Cambridge, MA, June 2003. [slides]

Teaching experience

2008 – Ph.D. Co-advisor, *Simula Research Laboratory*
Guide Kristoffer Selim, a Ph.D. student at the University of Oslo and Simula Research Laboratory with his research on robust numerical methods for fluid-structure interaction problems.

2006 Graduate Student Instructor, *University of Michigan*
Assisted Prof. Ellen Arruda and Prof. J. Wayne Jones in teaching Mechanical Behaviour of Materials (ME 382) to junior undergraduate students at the Department of Mechanical Engineering.

Professional development & service

2009 Participated and successfully completed the requirements of the course *Communicating Scientific Research* offered by Prof. Michael Alley, Pennsylvania State University.

2008 Attended a short course on *Nonlinear Finite Element Analysis* taught by Prof. Thomas J.R. Hughes and Prof. Ted Belytschko in Paris, France.

2007 – 2008 Served as a reviewer for articles on biological tissue growth for the *ASME Journal of Biomechanical Engineering* and *Philosophical Transactions of the Royal Society*.

2005 Recognised as an *Engineering Academic Scholar* by the office of the Associate Dean for Graduate Education, University of Michigan, after successfully completing the *Academic Careers in Engineering and Sciences* program.

2003 – 2008 Served as system administrator and webmaster for the *Computational Physics Group*, University of Michigan.

Programming & IT skills

Programming languages: C++, Python, FORTRAN

Numerical programming environments: COMSOL, MATLAB

Research finite element method codes: FEniCS, FEAP

Symbolic computation: Mathematica, GiNaC, Maple

Scripting languages: Shell script (Bash), AppleScript

Web programming: PHP, SQL, XHTML, CSS, XML, JavaScript

Typesetting: LaTeX

Graphics and illustration: Photoshop, Inkscape, Gnuplot

Operating environments: Mac OS X, Linux, Windows

References

Krishna Garikipati

Associate Professor
Department of Mechanical Engineering &
Michigan Center for Theoretical Physics
University of Michigan

3003B EECS
Ann Arbor, MI 48109–2122
U.S.A.

E-mail: krishna@umich.edu
Phone: +1-734-936-0414
Fax: +1-734-647-3170

Anders Logg

Research Scientist
Department of Scientific Computing &
Center for Biomedical Computing
Simula Research Laboratory

Martin Linges v 17, 1364 Fornebu
P.O. Box 134, 1325 Lysaker
Norway

E-mail: logg@simula.no
Phone: +47-6782-8288
Fax: +47-6782-8201

Ellen Arruda

Professor
Departments of Mechanical Engineering &
Macromolecular Science and Engineering
University of Michigan

3126 GGB
Ann Arbor, MI 48109–2125
U.S.A.

E-mail: arruda@umich.edu
Phone: +1-734-763-5328
Fax: +1-734-615-6647

Karl Grosh

Professor
Departments of Mechanical Engineering &
Biomedical Engineering
University of Michigan

2026 GGB
Ann Arbor, MI 48109–2125
U.S.A.

E-mail: grosh@umich.edu
Phone: +1-734-763-9414
Fax: +1-734-647-3170

Garth Wells

Hibbitt Lecturer in Solid Mechanics
Department of Engineering
University of Cambridge

Trumpington Street
Cambridge CB2 1PZ
U.K.

E-mail: gnw20@cam.ac.uk
Phone: +44-1223-332743
Fax: +44-1223-332662