

Samarth S. Raut

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RESEARCH INTEREST

- Patient-Specific biomedical simulations
- Computational soft-tissue biomechanics
- Image based 3D reconstruction and mesh generation
- Computer vision applications

EDUCATION

Carnegie Mellon University (CMU, Pittsburgh)

Doctor of Philosophy in Mechanical Engg.; GPA: 4.0/4.0

Pittsburgh, PA, USA

Aug.2008-Aug.2012

Indian Institute of Technology Bombay (IIT Bombay)

Master of Technology in Mechanical Engineering; GPA: 9.52/10.0

Mumbai, India

July 2004-July 2006

Walchand College of Engineering (WCE Sangli)

Bachelor of Technology in Mechanical Engineering; Distinction

Sangli, India

Sept.2000-June 2004

ACADEMIC RESEARCH EXPERIENCE

The University of Texas at Austin

Post-doctoral Fellow

Austin TX, USA

Nov.2012-June 2015

Project: Organ scale modeling of the cardiac mechanics

Image based computational model of the cardiac mechanics involving case-specific bi-ventricular geometry, fiber architecture, implementation of constitutive behavior with active contraction using specialized user subroutine for material behavior, and in vivo measured boundary conditions was developed and validated with in vivo measured functional indicators. Project was aimed at i) understanding role of biomechanics in physiological functioning of heart especially in diseased conditions ii) enabling improved medical device design by means of virtual prototyping.

Principle Investigator: Prof. Michael Sacks, Institute for Computational Engineering and Sciences (ICES), UT-Austin. Funding Source — Medtronic Inc. Minneapolis, MN, St. David's Foundation, Austin, TX, Clinical data source — The Gorman cardiovascular research group, University of Pennsylvania, Philadelphia, PA.

- Researched and identified work flow for getting high quality case-specific 3D finite element (FE) meshes for porcine heart from in vivo gated MRI
- Innovated a technique to extract, refine, align, and map fiber directions from Diffusion Tensor MRI data (DTMR) on to biventricular heart FE mesh and to implement spatially varying material anisotropy in Abaqus
- Developed an advanced user subroutine (UMAT) to implement physiologically accurate passive/active nearly incompressible hyperelastic anisotropic cardiac mechanics in Abaqus
- Calibrated simulations with in vivo observed cardiac motion (in-plane displacements, Pressure-Volume loop)

Outcome: Model was developed and calibrated with in vivo measured functional indicators. Framework, cardiac model, fiber architecture, and advanced user material subroutine (UMAT) was shared with industry counterparts. An invited review article on biomechanical models for myocardium is published. This work also contributed to a publication in Science Translational Medicine by a collaborating lab.

Carnegie Mellon University, Pittsburgh

Doctoral student

Pittsburgh, PA, USA

Aug.2008-Aug.2012

Thesis: "Patient-specific 3D Vascular Reconstruction and Computational Assessment of Biomechanics - an Application to Abdominal Aortic Aneurysm" ([link](#))

Overall aim of the project was to develop a framework for image based computational modeling of patient-specific abdominal aortic aneurysm especially with accurate and robust variable wall thickness implementation and multi-domain volume mesh generation in order to explore effect of uncertainty about material parameters, variable wall thickness, and in vivo strain evaluation.

Advisor: Prof. Ender Finol, Vascular Biomechanics and Biofluids Lab, Carnegie Mellon University, Pittsburgh PA

- Developed an in-house framework for 3D vasculature reconstruction and finite element (FE) mesh generation using segmented medical image data (CT and MR imaging modalities) as an input. Implemented this framework for numerous patient-specific multi-domain aneurysmatic aorta models with bifurcation. Special FE mesh generation capabilities:

* Modeling thin walled geometries with node-to-node control over variation in vessel wall thickness

- * Generating multi-domain FE mesh that offers tetrahedral and hexahedral (or wedge) elements
- * Modeling a priori unknown number of intra-luminal-thrombus lumps and a lumen of arbitrary shape
- * Ensuring node-to-node contact at interface, for FSI simulations
- * Achieving coordinate frame and image grid independence to robustly handle arbitrary geometries with unpredictable number/pattern of bifurcations
- o Developed framework for velocity extraction from phase-contrast (PC) MR images that was used to derive transient velocity for computational simulations of patient-specific abdominal aortic aneurysm
- o Quantified relative importance of material model and geometry on AAA biomechanics
- o Characterized and verified mesh generation framework by performing sensitivity study
- o Quantified the effect of spatially varying wall thickness on vascular wall biomechanics
- o Conceived and demonstrated in vivo strain and material parameter extraction strategy using ECG gated medical image data
- o Performed mesh convergence study exploring various mesh refinement approaches

Outcome: This research resulted in 6 articles published in reputed peer reviewed scientific journals, an invited chapter in a peer reviewed book, software tool for image based multi-domain vasculature FE mesh creation. One of the publications was appreciated with Editors Choice Paper award (2013).

Indian Institute of Technology, Bombay

Masters student

Mumbai, India

July 2004-July 2006

Thesis: "Study of pull-in instabilities in electrostatically actuated Micro-Electro-Mechanical-Systems devices"

Advisors: Prof. D. N. Pawaskar and Prof. P. S. Gandhi

Masters thesis research in Suman Mashruwala Advanced Microengineering Lab, Department of Mechanical Engineering, IIT Bombay. 'Pull-in' instabilities in Micro-Electro-Mechanical-Systems (MEMS) were analyzed experimentally, analytically, and computationally.

- o Designed specimen and corresponding masks for lithography to fabricate micro-cantilevers with varying geometries
- o Identified a flaw in the chemical etching process as the root cause behind unrealistically high actuation voltages by detecting and correlating change in direction of an accidental microscopic crack propagation path in one of the specimen; devised remedy by altering etchant concentration, temperature and circulation
- o Characterized response of cantilevers to electrostatic actuation using interference based measurements
- o Derived analytical solution for parallel plate model with non-linear stiffness
- o Rayleigh-Ritz method was used to analyze multi-physics problem and to simulate deflection of micro-cantilevers and capture their non-linear behavior
- o Performed verification using multi-physics simulations capabilities in ANSYS

INDUSTRIAL EXPERIENCE

Samsung R&D Institute India

Senior Chief Engineer

Bangalore, India

June 2015 - Mar.2019

- o **R&D project manager:** Design and development of a presentation attack detection system for secure biometric authentication using fingerprint
 - * Developed fingerprint spoofing techniques which could hack into commercially available mobile devices
 - * Established wet-lab set-up that resulted in an in-house database fingerprints images (65K) using varied methods and sensors.
 - * Designed and implemented machine learning based image classification package to detect fake fingerprint attack
- o **Innovation management:** lead by example to inculcate innovation in team
 - * Resulted in 6 patents and a funded project
 - * One of the top-10 creative project proposal ideas out of 200 submissions; C-Lab finalist innovation award; patent pending
- o **Program manager:** Iris biometric authentication and Aadhaar RD service integration
 - * Coordinated technical development (HW, RD service, iris extraction engine) and QA (more than 5500 test subjects)
 - * Task scheduling and progress tracking to meet deadlines in VUCA environment with limited manpower & skillset
 - * Compliance and communication with certifying agency (STQC, Govt. of India)

Applied Materials

Design Engineer

Bangalore, India

July 2006-July 2008

Participated in all component design stages - conceptualization, initial sketch, material and manufacturing process selection, cost estimation, engineering drawings, manufacturing, integration in final assembly, and review

- o Applied computer aided engineering (CAE) for collaborative product design and development (DFx)
- o GD&T practices for large mechanical assembly CAD models consisting of few thousand components — 3D models and corresponding 2D engineering drawings
- o FEA/CFD simulations for wafer deformation and air circulation

TEACHING EXPERIENCE

- Teaching Assistant, Computational Fluid Mechanics, graduate level course (Spring 2011)
- Teaching Assistant, Fluid Mechanics, undergraduate course (Spring 2010)
- Advised four senior undergraduate students for their research (Fall'10, Spring'11, Summer'13, Spring'14)

HONORS

- Samsung R&D India innovation competition - C-Lab Top 10 finalist idea (2017)
- 2013 Editor's choice paper, Journal of Biomechanical Engineering (2014)
- John & Clair Bertucci Fellowship, Carnegie Mellon University, Pittsburgh (2010-2011)
- Dean's Fellowship, Department of Mechanical Engineering, Carnegie Mellon University (2008-2009)
- Graduate conference funding award, Graduate Programs Office, Carnegie Mellon University (2009, 2011, 2012)
- Best C++ programming project among 12 teams (Tank game); Contribution - Artificial intelligence for enemy tank path planning using A-star algorithm implementation (2009)
- All India Rank 13 (among approx. 24,500 candidates, percentile 99.95) in GATE (Graduate Aptitude Test in Engineering - entrance test for post-graduate programs in IITs and IISc) exam (2004)
- Prestigious NTS (National Talent Search) scholarship by Govt. of India (1999)

PUBLICATIONS

Journal Publications

- Avazmohammadi R., Soares J., Li D.S., **Raut S.S.**, Gorman R.C., Sacks M.S., "A contemporary look at biomechanical models of myocardium", Annual Reviews in Biomedical Engineering, 2019, 21, 417-442 ([link](#))
- Jesus U., Roy A., **Raut S.S.**, Anton R., Muluk S.M., Finol E.A., "Geometric surrogates of abdominal aortic aneurysm wall mechanics", Medical Engineering and Physics, 2018, 59(1): 43-49 ([link](#))
- Park J., Choi S., Janardhan A.H., Lee S.Y., **Raut S.S.**, Soares J., Shin K., Yang S., Lee C., Kang K.W., Cho H.R., Kim S.J., Seo P., Hyun W., Jung S., Lee H.J., Lee N., Choi S.H., Sacks M., Lu N., Josephson M.E., Hyeon T., Kim D.H., Hwang H.J., "Electromechanical cardioplasty using a wrapped elasto-conductive epicardial mesh", Science Translational Medicine, 2016, 8(344): 344ra86-344ra86 ([link](#))
- **Raut S.S.**, Liu P., Finol E.A., "An approach for patient-specific multi-domain vascular mesh generation featuring spatially varying wall thickness modeling", 2015, 48(10), 1972-1981 ([link](#))
- **Raut S.S.**, Jana A., et al, "The Importance of Patient-Specific Regionally Varying Wall Thickness in Abdominal Aortic Aneurysm Biomechanics," J Biomech Eng., 2013, 135(8), 081010-10 ([link](#))
- **Raut S.S.**, Chandra S., et al, "The Role of Geometric and Biomechanical Factors in Abdominal Aortic Aneurysm Rupture Risk Assessment", Ann Biomed Eng., 2013, 41(7), 1459-1477 ([link](#))
- Chandra S., **Raut S.S.**, et al, "Fluid-Structure Interaction Modeling of Abdominal Aortic Aneurysms: the impact of patient-specific inflow conditions and fluid/solid coupling", J Biomech Eng., 2013, 135(8), 081001-14 ([link](#))
- **Raut S.S.**, Chandra S., Shum J., Washington C., Muluk S. C., Finol E.A., Rodriguez J., "Biological, geometric and biomechanical factors influencing abdominal aortic aneurysm rupture risk: a comprehensive review", Recent Patents In Medical Imaging, 2013, 3(1): 44-59 ([link](#))

Invited Chapters in Edited Book Series

- **Raut S.S.** et al, "The effect of Uncertainty in Vascular Wall Material Properties on Abdominal Aortic Aneurysm Wall Mechanics", Computational Biomechanics in Medicine, pg. 69-86, Springer Publications, New York, 2014 ([link](#))

PATENTS

- **Raut S.S.**, "Method and system for friction ridge vibration based biometric authentication and gesture recognition", India Patent application 201841015522, Date filed Apr. 24, 2018, Patent Pending
- **Raut S.S.**, Deotale G.P, "System providing biometric spoof attack susceptibility assessment in an electronic device and a system thereof", India Patent application 201741028210, Date filed Aug. 8, 2017, Patent Pending
- Deotale G.P, **Raut S.S.**, Shah J.S., "Method for enabling interaction using fingerprint on display and electronic device thereof", US Patent application US20190095079A1, Date filed Sept. 14, 2018, Patent Pending ([link](#))
- De A.A., Mathur S., Deotale G.P, **Raut S.S.**, Shaik K., Vijay A., Das S., Malla A.H., "Method and electronic device for providing multi-level security", US Patent application US20180173867A1, Date filed Nov. 13, 2017, Patent Pending ([link](#))
- (Two additional patents filings are in progress)

PROFESSIONAL ACTIVITIES

Reviewer for:

- IEEE Journal of Biomedical and Health Informatics
- IEEE Transactions on Biomedical Engineering
- International J. Numerical Modeling in Biomedical Engineering
- ASME Journal of Biomechanical Engineering
- Tissue Engineering
- ASME Journal of Medical Devices
- Computer Methods in Biomechanics and Biomedical Engineering
- Advances in Engineering Software
- International J. Computer Assisted Radiology and Surgery
- ASME Summer Biomechanics, Bioengineering, Biotransport (SB3C) Conferences