Dhruv Patel

PhD. candidate, Department of Aerospace and Mechanical Engineering,
University of Southern California
Website: dhruvpatel108.github.io | GitHub: dhruvpatel108 | E-mail: dhruvvpa@usc.edu

Education

- **University of Southern California** *Los Angeles, CA*
  PhD. in Mechanical Engineering *2016-present*
  - Thesis topic: "Physics-guided data-driven modeling for efficient inference"
  - GPA: 3.9/4.0
- **Indian Institute of Technology, Delhi** *New Delhi, India*
  M.Tech. in Applied Mechanics *June 2016*
  - Thesis title: "Modeling of a supercoiled DNA using elastic rod model employing self-contact phenomena"
  - GPA: 8.9/10.0
- **L.D. College of Engineering** *Ahmedabad, India*
  B.Tech. Mechanical Engineering *June 2013*
  - Thesis title: "Optimal design and stress analysis of power screw"
  - GPA: 8.5/10.0

Research Interests

Scientific machine learning, Deep learning, Inverse problems, Bayesian inference, Computational mechanics, Deep generative modeling, Uncertainty quantification, Active learning, Computer vision, Medical imaging.

Selected Honors and Awards

- The Honorable Mention of *2019 Karel Urbanek Best Student Paper Award*, SPIE Advanced Lithography, San Jose, CA [Feb. 2019] (2nd place).
- Finalist of the best student poster competition, 13th World Congress on Computational Mechanics, New York City, NY [July 2018].
- *9th Gene Golub SIAM summer school on inverse problems and uncertainty quantification* scholarship, Breckenridge, CO [June 2018].
- *Prof. Karunes Memorial Award for* ***Best Master's Thesis*** - Applied Mechanics Department, IIT Delhi [June 2016].
- Ministry of Human Resource and Development (Government of India) fellowship for M.Tech., IIT Delhi [2014 – 2016].
- National merit scholarship by Ministry of Human Resource and Development (Government of India), bachelor's degree, LDCE [2009 – 2013].

Research Experience

- **Graduate Research Assistant** *June 2018 – Present*

  Computational and Data-driven Discovery (CD^3) group, USC *Los Angeles, CA*

  - **Efficient Bayesian inference using deep generative modeling**:
    - Proposed a novel algorithm and developed a framework for efficient Bayesian inference using Generative Adversarial Network (GAN) priors.
    - Demonstrated the effectiveness of proposed algorithm in diverse uncertainty quantification and optimal experimental design/active learning tasks arising in physics, computer vision, and medical imaging.
    - Developed a new software tool (*Tenics* = TensorFlow + FEnics) for solving hybrid probabilistic problems involving PDEs and deep learning-based models by coupling adjoint-based gradients of PDEs with automatic differentiation of neural networks in a unified Bayesian framework.
  - **Probabilistic recovery of missing phase in contrast-enhanced CT**:

    (in collaboration with Keck school of medicine - USC, LA, CA)

    Mentoring and collaborating with a Master's student for developing a learning-based model for recovery of missing phases in contrast-enhanced CT imaging using GAN-based priors.
  - **Improved defect detection, classification, and localization using deep learning**:

    (in collaboration with IBM AI Research Center, Albany, NY)
    - Developed and implemented a deep learning-based unified workflow to automatically detect, classify, and locate defects in manufactured semi-conductor chips in a *weakly supervised* fashion.
    - Developed an *unsupervised* model for defect detection and classification using GAN.

- **Graduate Research Assistant** *August 2016 – May 2018*

  Scientific Computation Research Center (SCOREC), RPI *Troy, NY*

  - **Non-overlapping domain decomposition methods for parallel solution of large-scale optimization problems**: Designed and implemented a novel non-overlapping domain decomposition method for parallel solution of large-scale PDE-constrained optimization problems using Coupled Adjoint State Equation (CASE) method.
  - ***Mechanical classification* of breast tumors using deep learning**:
    - Developed and implemented a deep learning-based elasticity imaging model in TensorFlow for breast tumor classification based on mechanical properties of tissue.
    - First demonstration of domain randomization in bio-mechanical imaging.
  - **Adjoint-based solution of PDE-constrained optimization problems**: Derived and implemented novel adjoint-based algorithm for inference of visco-elastic properties of tissue from interior time-harmonic displacement data, by posing the inverse problem as a constrained optimization problem.

Journal publications

- **D. Patel**, R. Tibrewala, A. Vega, N. Hugenberg, L. Dong, A. Oberai "Circumventing the solution of inverse problems in mechanics through deep learning: an application to elasticity imaging", *Computer Methods in Applied Mechanics and Engineering.* [Link]
    - Selected media highlights**:** 1 , 2 , 3 , 4 , 5
- **D. Patel**, R. Bonam, A. Oberai "Deep learning-based detection, classification, and localization of defects in semiconductor processes", *Journal of Micro-nanolithography, MEMS and MOEMS*. [Link]
    - Selected media highlights: 1 , 2
- **D. Patel**, A. Oberai "GAN-based priors for quantifying uncertainty in supervised learning", *SIAM Journal of Uncertainty Quantification* (under review). [Link]
- **D. Patel**, V. Kher, B. Desai, L. Xiaomeng, S. Cen, N. Nanda, A. Gholamrezanezhad, V. Duddalwar, B. Varghese, A. Oberai "Machine learning-based predictors for ICU care in the COVID-19 era" – *Journal of Emerging Infectious Diseases* (under review). [available upon request]
- **D. Patel,** H. Ramaswamy, D. Ray, A. Oberai, "Solution of Bayesian inverse problems in computational physics using deep generative modeling" – Journal TBD (in preparation).

Peer-reviewed conference and workshop publications

- **D. Patel**, A. Oberai "Generative Adversarial Network Priors for Bayesian Inference", *Deep-inverse workshop, 33rd conference on Neural Information Processing System (NeurIPS)*, 2019, Vancouver, BC. [Link]
- **D. Patel**, R. Bonam, A. Oberai "Engineering neural networks for improved defect detection, classification, and localization", *Metrology, Inspection, and Process Control for Microlithography XXXIII* 2019, San Jose, CA. [Link]

Selected talks

- **D. Patel,** A. Oberai "Physics-based data-driven modeling for efficient inference", *Climate Modeling Aliance (CLiMA), Caltech*, Los Angeles, CA [2020] **(Invited talk)**.
- **D. Patel**, A. Oberai "Adversarial regularization in inverse problems", *Mechanics Seminar series*, Department of Aerospace and Mechanical Engineering, USC, Los Angeles, CA [2020].
- **D. Patel,** E. Gupta, A. Oberai "Bayesian Inference using Generative Adversarial Network Priors (BI-GANP)", *15th U.S. National Congress on Computational Mechanics (USNCCM)*, Austin, TX [2019].
- **D. Patel**, R. Bonam, A. Oberai "Engineering neural networks for improved defect detection, classification, and localization", *SPIE Advanced Lithography*, San Jose, CA [2019].

- **D. Patel**, R. Tibrewala, A. Vega, N. Hugenberg, L. Dong, A. Oberai "Circumventing the solution of inverse problems in mechanics through deep learning", *13th World Congress on Computational Mechanics (WCCM)*, NYC, NY [2018].
- **D. Patel**, A. Boquet, C. Bi, H.A. Arguedas "Efficient solution of inverse elasticity imaging problem using Hessian-free inexact Newton conjugate gradient method", *9th Gene Golub SIAM summer school on inverse problems and uncertainty quantification*, Breckenridge, CO [2018].
- **D. Patel**, R. Tibrewala, A. Vega, L. Dong, N. Hugenberg, A. Oberai "Effectiveness of domain randomization and transfer learning in bio-mechanical imaging", *Graduate Research Symposium*, RPI, Troy, NY [2017].
- **D. Patel**, R. Tibrewala, A. Vega, L. Dong, N. Hugenberg, A. Oberai "Mechanical classification of tumors using deep learning", *Computational Science & Engineering seminar series*, SCOREC, RPI, Troy, NY [2017].
- **D. Patel**, P. Dube, A. Ghosh, "Finite element analysis of toroidal shell under uniform pressure", Applied *Mechanics Seminar series*, IIT Delhi, New Delhi [2016].
- **D. Patel**, A. Kumar, "Modeling the twist and buckling in a supercoiled DNA using elastic rod model" *Applied Mechanics Seminar series*, IIT Delhi, New Delhi [2016].
- **D. Patel**, M. Kotecha, T. Mehta, H. Patel, S. Pathan, "Vibration control and dynamic analysis of a car hood using finite element method", *Mechanics seminar*, L. D. College of Engineering, Ahmedabad [2013].

Teaching Experience

- *Machine Learning and Computational Physics (AME 599)* *Fall 2020*
  - Assisting my advisor preparing course material and programming assignments for the first offering of the graduate level course; *Conducting office hours and grading assignments.*
- *Introduction to Engineering Design (ENGR 2050):* *Spring 2017*
  - Conducted studio sessions and assisted students in conceptual and detail design of the project for the project-based undergraduate course.
- *Engineering graphics and CAD (ENGR 1200):* *Fall 2016*
  - Conducted lab sessions as a lead TA for the undergraduate course with more than 250 students.
  - Conducted office hours, graded assignments, and assisted 50+ students with final CAD project.
- *Advanced Solid Mechanics (IITD):* *Spring 2016*
  - Conducted office hours and graded assignments.

Research Advising

- **MS candidates, USC** *(Chiao-Chih Hsu, Vijay Kothapalli)* *August 2018 – Present*
  - Developing learning-based models to infer and classify renal lesions from partially visible Contrast-Enhanced Computed Tomography (CECT) data.

- **Undergraduate candidates**

  Vikram Kher *Summer 2020 - Present*

  - Developing ML-based tools for prediction of clinical prognosis and disease severity in COVID-19 patients – **Winner**: Best USC Viterbi summer undergraduate research project.

  Eeshan Gupta *Summer 2019*

  - Developed software tools for solving physics-driven Bayesian inverse problems using GAN priors.

  Raghav Tibrewala and Adriana Vega *Summer 2017*

  - Developed deep learning-based elasticity imaging workflow to classify breast tumors based on its mechanical properties while circumventing the need of solving expensive inverse problems.

- **High-school student** *(Jacqueline Wang)* *Summer 2018*
  - Developed data processing and visualization pipelines for tumor classification project.

Relevant coursework

- Mechanics: Continuum Mechanics, Applied Elasticity, Advanced Solid Mechanics, Applied Fluid Mechanics, Theory of Plates and Shells, Fracture Mechanics, Mechanics of Composite Materials.
- Computational science and Applied mathematics: Applied Computational Methods, Numerical Optimization, Computational Linear Algebra, Learning from Data, Machine Learning, Deep Learning, Parallel programming and Visualization, Programming system design, Finite Element Analysis, Advanced Finite Element methods, Uncertainty Quantification**.**

Professional membership and service

Student Member:

- Society of Industrial and Applied Mathematics (SIAM) – Computational Science and Engineering (CSE) activity group, Uncertainty quantification (UQ) activity group.
- Society of Photo-Optical Instrumentation Engineers (SPIE) – Medical Imaging

Reviewer: CMAME

Computer Skills

- **Programming languages**:
  - Python, C, C++, MATLAB, bash scripting, version control with git.
- **Scientific tools and libraries**:
  - TensorFlow, TensorFlow Probability, PyTorch, scikit-learn, pandas, OpenMPI, FEnics, Non-Linear Adjoint based Coefficient Estimator (NLACE) (an adjoint-based optimization library-contributor), Tenics (developer), ParaView, Ansys, NX, Creo, LaTeX.

Reference

- **Dr. Assad Oberai** (email: aoberai@usc.edu; phone +1 213-740-1882)
  Professor of Aerospace and Mechanical Engineering, USC
- **Dr. Roger Ghanem** (email: ghanem@usc.edu; phone +1 213-740-9528)
  Professor of Civil and Environmental Engineering and Aerospace and Mechanical Engineering, USC