Dhruv Patel

Curriculum Vitae

University of Southern California, LA, CA
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Research Interests

Scientific machine learning, Bayesian inference, Probabilisitc deep learning, Deep generative modeling, Representation learning, Unsupervised learning, Uncertainty quantification, PDE-constrained optimization, Computational mechanics, Computer vision, Medical imaging.

Education

2016–present **PhD, Computational Mechanics**,
University of Southern California (USC), Los Angeles, USA.
Thesis: Physics-informed data-efficient deep generative modeling for Bayesian inference.
Advisor: Prof. Assad Oberai

2014–2016 : **MTech, Appled Mechanics**,
Indian Institute of Technology - Delhi, New Delhi, India.
Thesis: Modeling of a supercoiled DNA using elastic rod model employing self-contact phenomena.

2009–2013 : **BE, Mechanical Engineering**,
L. D. College of Engineering (LDCE), Ahmedabad, India.

Selected Honours & Awards

2020 Featured articles in Techxplore and USC News on AI-based automatic detection, classification, and localization of semiconductor defects.

2019 Featured articles in 50+ national and international news media outlets including Forbes, Science Daily, Eureka Alert, Medical Xpress, and Oncology Times on deep learning driven elastography for efficient berast cancer diagnosis.

2019 The Honourable Mention of 2019 Karel Urbanek Award for Best Student Paper, SPIE Advanced Lithography, San Jose, CA (2^{nd} place).

2018 Finalist of the best student poster competition, 13^{th} World Congress on Computational Mechanics, New York City, NY.

2018 9^{th} Gene Golub SIAM summer school on inverse problems and uncertainty quantification scholarship, Breckenridge, CO.

2016 Prof. Karunes Memorial Award for ***Best Master's Thesis*** - Applied Mechanics department, IIT Delhi.

2016 Ministry of Human Resource and Deelopment, Government of India fellowship for M.Tech., IIT Delhi.

2009 – 2013 Ministry of Human Resource and Development, Government of India, national merit scholarship, B.E., LDCE.

Publications

Journal Articles

[1] **D. Patel**, R. Tibrewala, A. Vega, L. Dong, N. Hugenberg, A. Oberai "Circumventing the solution of inverse problems in mechanics through deep learning: Application to elasticity imaging", *Journal of Computer Methods in Applied Mechanics and Engineering (CMAME).* [Link]
- Selected media highlights: 1, 2, 3, 4, 5

[2] **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

[3] **D. Patel**, A. Oberai "GAN-based priors for quantifying uncertainty in supervised learning" *SIAM Journal of Uncertainty Quantification* (under review). [Link]

[4] **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 COVID-19 disease severity", *Scientific Reports* (under review). [Link]

[5] **D. Patel**, D. Ray, H. Ramaswamy, A. Oberai, "Solution of Bayesian inverse problems and model order reduction using deep generative modeling", *Journal of Computational Physics* (in preparation)

Peer-reviewed Conference and Workshop Articles

[1] **D. Patel**, R. Bonam, A. Oberai "Engineering neural networks for improved defect detection and classification", *Proc. SPIE 10959, Metrology, Inspection, and Process Control for Microlithography XXXIII, SPIE Advanced Lithography, San Jose, CA*, 2020. [Link]

[2] **D. Patel**, A. Oberai "Generative Adversarial Network priors for Bayesian inference", *Deep inverse workshop,* 33^{rd} *conference on Neural Information Processing System (NeurIPS), Vancouver, BC*, 2019. [Link]

[3] **D. Patel**, C. Hsu, B. Varghese, V. Duddalwar, A. Oberai "Probabilistic recovery of missing phase images in contrast-enhanced CT", *Medical imaging workshop,* 34^{th} *conference on Neural Information Processing System (NeurIPS), virtual, 2020.* [Link]

[4] **D. Patel**, D. Ray, H. Ramaswamy, A. Oberai "Bayesian inference in physics-driven problems with adversarial priors", *Deep inverse workshop,* 34^{th} *conference on Neural Information Processing System (NeurIPS), virtual*, 2020. [Link]

Selected talks

[1] **D. Patel**, A. Oberai "Solution of Bayesian inverse problems and uncertainty quantification in deep learning using deep generative modeling", *Combustion Research Facility, Sandia National Lab, Livermore, CA,* 2020 - virtual **(Invited talk)**.

[2] **D. Patel**, A. Oberai "Solution of Bayesian inverse problems and uncertainty quantification in deep learning using deep generative modeling", *Mechanics of materials department, Sandia National Lab, Livermore, CA,* 2020 - virtual **(Invited talk)**.

[3] **D. Patel**, A. Oberai "Physics-based data-driven deep generative models for efficient Bayesian inference", *Climate Modeling Aliance (CliMA), Caltech, Pasadena, CA*, 2020 **(Invited talk)**.

[4] **D. Patel**, A. Oberai "To know what we don't know: quantifying uncertainty using sample-based priors", *Mechanics seminar series, Department of Aerospace and Mechanical Engineering, USC, Los Angeles, CA*, 2020.

[5] **D. Patel**, E. Gupta, A. Oberai "Bayesian inference using Generative Adversarial Network priors", 15^{th} *U.S. National Congress on Computational Mechanics (USNCCM), Austin, TX*, 2019.

[6] **D. Patel**, R. Bonam, A. Oberai "Engineering neural networks for improved defect detection, classification, and localization", *SPIE Advanced Lithography, San Jose, CA*, 2019.

[7] **D. Patel**, R. Tibrewala, A. Vega, L. Dong, N. Hugenberg, A. Oberai "Circumventing the solution of inverse problems in mechanics through deep learning", 13^{th} *World Congress on Computational Mechanics (WCCM), NYC, NY*, 2018.

[8] **D. Patel**, A. Boquet, C. Bi, H.A. Arguedas "Hessian-free inexact Newton conjugate gradient method for efficient solution of inverse elasticity problems", 9^{th} *Gene Golub SIAM summer school on inverse problems and ucnertainty quantification, Breckenridge, CO*, 2018.

[9] **D. Patel**, R. Tibrewala, A. Vega, L. Dong, N. Hugenberg, A. Oberai "Effectiveness of domain randomization and transfer learning in bio-mechanical imaging", *Computational Science and Engineering seminar series, SCOREC, RPI, Troy, NY*, 2017.

Research Experience

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 computational physics, material science, 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 probabilistic framework in python.

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 GANs.

Probabilistic recovery of missing phase images 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.

August 2016 – May 2018

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

Deep elasticity imaging.

- Developed and implemented a deep learning-based elastography workflow in TensorFlow for breast tumor classification based on mechanical properties of tissue.
- Explored the use of domain randomization and rotational invariant kernels of CNNs for application to 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.

Non-overlapping domain decomposition methods for parallel solution of optimization problems.

Designed and implemented a novel non-overlapping domain decomposition method for parallel solution of large-scale inverse problems using Coupled Adjoint State Equation (CASE) method.

Research Advising

MS candidates

Fall 2019 – present

Chiao-Chih Hsu

Implementing learning-based models to infer missing phase image of renal lesions from partially visible Contrast-Enhanced Computed Tomography (CECT) data.

Fall 2018 – Summer 2019 *Vijay Kothapalli*
Designed and developed deep learning-based models for time series data with application to Contrast-Enhanced Ultrasound (CEUS) imaging.

Undergraduate candidates

Summer 2020 – present *Vikram Kher*
Developing ML-based tools for prediction of clinical prognosis and disease severity in COVID-19 patients – **winner**: Best USC Viterbi summer undergraduate research project.

Summer 2019 *Eeshan Gupta*
Developed software tools for solving physics-driven Bayesian inverse problems using GAN priors.

Summer 2017 *Adriana Vega, Raghav Tibrewala*
Developed deep learning-based elasticity imaging workflow to classify breast tumors based on its mechanical properties.

High-school student

Summer 2018 *Jacqueline Wang*
Developed data processing and visualization pipeline for the tumor classification project.

Teaching Experience

Fall 2020 **AME 599: Machine Learning and Computational Physics**, USC.
- Co-designing and co-teaching the first offering of this graduate level course with my advisor.
- Conducting office hours and grading assignments.

Spring 2017 **ENGR 2050: Introduction to Engineering Design**, RPI.
- Conducted studio sessions and assisted students in conceptual and detailed design of the project for the project-based undergraduate course.

Fall 2016 **ENGR 1200: Engineering graphics and CAD**, RPI.
- Conducted lab sessions as a lead TA for the undergraduate course with 250+ students.
- Conducted office hours, graded assignments, and assisted 50+ students with final CAD project.

Professional membership and service

- Student member, Society of Industrial and Applied Mathematics, Computational Science and Engineering (CSE) group.
- Student member, Society of Industrial and Applied Mathematics, Uncertainty Quantification (UQ) group.
- Reviewer, *Journal of Computer Methods in Applied Mechanics and Engineering (CMAME)*.
- Central team placement coordinator, *IIT Delhi*.

Computer skills

Programming Languages: Python, C, C++, MATLAB, Fortran, Bash scripting

Scientific tools and libraries: TensorFlow, Pytorch, TensorFlow Probability, FEnics, MPI, OpenMP, data analysis packages in python (Scikit-learn, pandas, Scipy), Tenics (developer), Non-Linear Adjoint based Co-efficient Estimator (NLACE) (an adjoint-based optimization library - contributor), ParaView, Ansys, NX, Creo, LaTeX, version control with GitHub