

CONTACT INFORMATION	University of Southern California 3650 McClintock Avenue Bldg. #145, Los Angeles CA 90089	Email: deepray@usc.edu Website: deepray.github.io
RESEARCH INTERESTS	Scientific machine learning • Numerical methods for conservation laws • Uncertainty quantification • Bayesian inference.	
EMPLOYMENT HISTORY	<p>Postdoctoral Research Associate July 2020 - present <i>Aerospace and Mechanical Engineering, University of Southern California (USC), Los Angeles</i> Developing machine learning tools for uncertainty quantification; investigating strategies to embed physical constraints in prediction models.</p> <p>Postdoctoral Research Associate July 2019 – June 2020 <i>Computational and Applied Mathematics, Rice University, Houston</i> Developed high-resolution numerical methods to simulate multiphase flows through real rock structures at the pore scale.</p> <p>Postdoctoral Researcher July 2017 – June 2019 <i>Computational Mathematics and Simulation Science, EPFL, Switzerland</i> Developed deep learning strategies to resolve computational bottlenecks in numerical methods for PDEs.</p>	
EDUCATION	<p>Ph.D., Mathematics May 2017 <i>Tata Institute of Fundamental Research (TIFR-CAM), Bangalore, India</i> Dissertation: Entropy-stable finite difference and finite volume schemes for compressible flows Advisors: Praveen Chandrashekar (TIFR-CAM) and Siddhartha Mishra (ETH Zürich). Awarded the Harish Chandra Memorial Award for the best Ph.D. thesis.</p> <p>M.Phil., Mathematics September 2013 <i>Tata Institute of Fundamental Research (TIFR-CAM), Bangalore, India</i> Advisor: Praveen Chandrashekar</p> <p>M.Sc. in Mathematics May 2012 <i>Tata Institute of Fundamental Research (TIFR-CAM), Bangalore, India</i></p> <p>B.Sc (Honours) in Mathematics June 2010 Hindu College, University of Delhi, India</p>	
PUBLICATIONS	<p>Journals:</p> <ol style="list-style-type: none"> 18. Solution of Physics-based Bayesian Inverse Problems with Deep Generative Priors. D. Patel, D. Ray, A. A. Oberai. <i>Computer Methods in Applied Mechanics and Engineering</i>, Vol. 400, 2022. 17. Probabilistic Medical Image Imputation via Deep Adversarial Learning. R. Raad, D. Patel, C.-C. Hsu, V. Kothapalli, D. Ray, B. Varghese, D. Hwang, I. Gill, V. Duddalwar, A. A. Oberai. <i>Engineering with Computers</i>, 2022 16. On the approximation of rough functions with deep neural networks. T. De Ryck, S. Mishra, D. Ray. <i>SeMA Journal</i>, 2022. 	

15. A pressure-correction and bound-preserving discretization of the phase-field method for variable density two-phase flows.
C. Liu, D. Ray, C. Thiele, L. Lin, B. Riviere. *Journal of Computational Physics*, Vol. 449, 2022.
14. A discontinuous Galerkin method for a diffuse-interface model of immiscible two-phase flows with soluble surfactant.
D. Ray, C. Liu, B. Riviere. *Computational Geosciences*, 2021.
13. Controlling oscillations in spectral methods by local artificial viscosity governed by neural networks.
L. Schwander, D. Ray, J.S. Hesthaven. *Journal of Computational Physics*, Vol. 431, 2021.
12. Multi-level Monte Carlo finite difference methods for fractional conservation laws with random data.
U. Koley, D. Ray, T. Sarkar. *SIAM/ASA Journal on Uncertainty Quantification*, Vol. 9(1), 2021.
11. Iterative Surrogate Model Optimization (ISMO): An active learning algorithm for PDE constrained optimization with deep neural networks.
K. O. Lye, S. Mishra, D. Ray, P. Chandrashekar. *Computer Methods in Applied Mechanics and Engineering*, Vol. 374, 2021.
10. Deep learning observables in computational fluid dynamics.
K. O. Lye, S. Mishra, D. Ray. *Journal of Computational Physics*, Vol. 410, 2020.
9. Constraint-Aware Neural Networks for Riemann Problems.
J. Magiera, D. Ray, J. S. Hesthaven, C. Rohde. *Journal of Computational Physics*, Vol. 409, 2020.
8. Controlling oscillations in high-order Discontinuous Galerkin schemes using artificial viscosity tuned by neural networks.
N. Discacciati, J. S. Hesthaven, D. Ray. *Journal of Computational Physics*, Vol. 409, 2020.
7. Detecting troubled-cells on two-dimensional unstructured grids using a neural network.
D. Ray, J. S. Hesthaven. *Journal of Computational Physics*, Vol. 384, 2019.
6. Non-intrusive reduced order modelling of unsteady flows using artificial neural networks with application to a combustion problem.
Q. Wang, J. S. Hesthaven, D. Ray. *Journal of Computational Physics*, Vol. 384, 2019.
5. An artificial neural network as a troubled-cell indicator.
D. Ray, J. S. Hesthaven. *Journal of Computational Physics*, Vol. 367(15), 2018.
4. An entropy stable finite volume scheme for the two dimensional Navier-Stokes equations on triangular grids.
D. Ray, P. Chandrashekar. *Applied Mathematics and Computation*, Vol. 314, 2017.
3. Convergence of fully discrete schemes for diffusive-dispersive conservation laws with discontinuous flux.
U. Koley, R. Dutta, D. Ray. *ESAIM: Mathematical Modelling and Numerical Analysis*, Vol. 50(5), 2016.
2. Entropy stable schemes on two-dimensional unstructured grids for Euler equations.
D. Ray, P. Chandrashekar, U. S. Fjordholm, S. Mishra. *Communications in Computational Physics*, Vol. 19(5), 2016.
1. A sign preserving WENO reconstruction method.
U. S. Fjordholm, D. Ray. *Journal of Scientific Computing*, Vol. 68(1), 2015.

Conference Proceedings:

4. Bayesian Inference in Physics-Driven Problems with Adversarial Priors.
D. Patel, D. Ray, H. Ramaswamy, A. A. Oberai. *NeurIPS Workshop on Deep Learning and Inverse Problems*, 2020.
3. A Third-Order Entropy Stable Scheme for the Compressible Euler Equations.
D. Ray. *Theory, Numerics and Applications of Hyperbolic Problems II. HYP 2016. Springer Proceedings in Mathematics and Statistics, Vol. 237*, 2018.
2. Entropy stable schemes for compressible Euler equations.
D. Ray, P. Chandrashekar. *Int. J. Numer. Anal. Model. Ser. B, no. 4*, 2013.
1. Kinetic energy preserving and entropy stable finite volume schemes for compressible Euler and Navier-Stokes equations.
D. Ray, P. Chandrashekar. *14th Annual CFD Symposium - Aeronautical Society of India, IISc, Bangalore, 10-11 August, 2012*.

Under Review

2. Probabilistic Brain Extraction in MR Images via Conditional Generative Adversarial Networks. (*submitted, 2022*)
S. Moazami, D. Ray, D. Pelletier, A. A. Oberai.
1. The efficacy and generalizability of conditional GANs for posterior inference in physics-based inverse problems. (*submitted, 2022*)
D. Ray, H. Ramaswamy, D. Patel, A. A. Oberai.

TEACHING
EXPERIENCE**Instructor/co-instructor:**

- AME-508: Course on Machine Learning and Computational Physics, at USC (August - December, 2022)
- AME-508: Course on Machine Learning and Computational Physics, at USC (August - December, 2021)
- MATH-459: Graduate course on Numerical Methods for Conservation Laws, at EPFL (September - December, 2020)
- Mini-course on the Application and Implementation of Deep Learning, at TIFR-CAM (January, 2019).
- Workshop on Inverse Problems and Related Topics, at ICTS Bangalore (October 2021).

Course development:

- AME-599 (special topics): Course on Machine Learning and Computational Physics, at USC (August - December, 2020)

Teaching assistant:

- MATH-459: Graduate course on Numerical Methods for Conservation Laws, at EPFL (September - December, 2018)
- MATH-459: Graduate course on Numerical Methods for Conservation Laws, at EPFL (September - December, 2017)
- Graduate course on Computational Partial Differential Equations, at TIFR-CAM (January - May, 2015)
- Graduate course on Numerical Analysis, at TIFR-CAM (August - December, 2013)
- Graduate course on Numerical Analysis, at TIFR-CAM (August - December, 2012)

MENTORING EXPERIENCE	Master thesis co-supervision:		
	Niccolò Discacciati	EPFL/Politecnico di Milano	2018
	Andrea Romani	EPFL/Politecnico di Milano	2019
	Lukas Schwander	ETH	2019
	Tim De Ryck	ETH	2019
	Bachelors thesis co-supervision:		
	Moritz Reinders	ETH	2019
	Undergraduate project co-supervision:		
	<ul style="list-style-type: none"> • Data-driven predictions for COVID-19 severity. USC, 2021. • Data-driven predictions for bladder cancer recurrence. USC, 2021. • Senior mentor for the Center for Undergraduate Research in Viterbi Engineering (CURVE) program. USC, 2021. 		
PROFESSIONAL SERVICE & OUTREACH	<ul style="list-style-type: none"> • Served as external expert for the oral exam of a Master's project at EPFL (July 2021). • Session chair and organizer for the minisymposium <i>Advances in data-enhanced predictive modeling in simulation science</i> at SIAM-CSE, 2021. • Judged at the Science and Engineering Fair of Houston (February 2021). • Judged at the Science and Engineering Fair of Houston (February 2020). • Led an interactive session on applied mathematics for high-school students visiting Rice University (July 2019). • Led an initiative to systematically overhaul the waste management and recycling system at TIFR-CAM (2013-14). • Organised numerical sessions for optimal control at the IFCAM Summer School on Numerics and Control of PDEs-2013, at the Indian Institute of Science, Bangalore. • Organiser of the Students Seminar Series at TIFR-CAM (2012-13). The purpose of this committee was to organise and oversee talks by motivated students, on mathematical or other science oriented topics. • General Secretary of the mathematics society ALPHA at Hindu College (2008-09). • Founding member of <i>Science Forum</i> at Hindu College (2008-10). • Founding member of the model UN society <i>Caucus</i> at Hindu College (2009-10). 		
TALKS AND POSTERS	<ul style="list-style-type: none"> • Conditional GANs and their generalizability in physics-based inverse problems (18th August, 2022) USACM Thematic Conference UQ-MLIP, Arlington, Virginia. • Deep learning-based posterior inference for inverse problems (28th April, 2022) Conference on PDE and numerical analysis, TIFR-CAM, Bangalore. • A data-driven approach to predict artificial viscosity in high-order solvers (27th March, 2022) AMS Spring Central Sectional Meeting. • Deep learning-based posterior inference for inverse problems (26th March, 2022) Annual Math Symposium, IISER Bhopal. • Deep learning-based enhancements in computational physics (10th Dec, 2021) Seminar talk, Department of Artificial Intelligence, IIT Hyderabad. • Bayesian inference using generative adversarial networks (7th Dec, 2021) 87th Annual Conference of the Indian Mathematical Society, Aurangabad, India. 		

- Deep learning-based enhancements in computational physics (29th Nov, 2021)
Seminar talk, Department of Mathematics and Statistics, Auburn University.
- Solving physics-based inverse problems using generative adversarial networks (8th Oct, 2021)
Seminar talk, Department of Mathematics and Statistics, UNC Charlotte.
- Discontinuous Galerkin discretization of phase-field models for pore-scale flows (24th June, 2021)
SIAM-GS 2021, Milan, Italy.
- A data-driven approach to predict artificial viscosity in high-order solvers (14th May, 2021)
Department of Mathematics, University of Würzburg, Germany.
- A Deep Learning Framework for p-adaptation (5th March, 2021)
SIAM-CSE 2021, Fort Worth, Texas.
- Poster: Bayesian Inference in Physics-Driven Problems with Adversarial Priors (11th Dec, 2020)
NeurIPS 2020 Workshop on Deep Learning and Inverse Problems.
- Data-driven enhancements of numerical methods. (2nd March, 2020)
Colloquium Talk, Department of Mathematical Sciences, Michigan Technological University.
- Deep learning enhancements of numerical methods (12th Feb, 2020)
Colloquium Talk, Department of Mathematics, University of Florida.
- Deep learning enhancements of numerical methods (9th Sep, 2019)
CAAM Colloquium, Rice University, Houston, Texas.
- Using deep learning to overcome algorithmic bottlenecks (18th June, 2019)
Invited speaker at NumHyp 2019, Malaga.
- Detecting discontinuities using deep learning (12th April, 2019)
Deep Learning Meetup, Zürich, Switzerland.
- Controlling oscillations in high-order accurate methods through artificial neural networks (28th Feb, 2019)
SIAM-CSE 2019, Spokane, Washington.
- A fully-discrete kinetic energy preserving and entropy conservative scheme for compressible flows (27th Feb, 2019)
SIAM-CSE 2019, Spokane, Washington.
- Controlling spurious oscillations in high-order methods through deep neural networks (9th Jan, 2019)
TIFR-CAM Colloquium, Bangalore, India.
- Controlling spurious oscillations in high-order methods through deep neural networks (15th Nov, 2018)
High-Fidelity Industrial LES/DNS symposium, Brussels, Belgium.
- An artificial neural network as a troubled-cell indicator (10th July, 2018)
SIAM Annual Meeting 2018, Portland, Oregon.
- Using neural nets to detect discontinuities (19th June, 2018)
MATHICSE Retreat, St. Croix, Switzerland.
- An artificial neural network for detecting discontinuities (11th March, 2018)
7th International Conference on High Performance Scientific Computing, Hanoi, Vietnam.
- An artificial neural network for detecting discontinuities (3rd Jan, 2018)
TIFR-CAM Colloquium, Bangalore, India.
- A high-resolution energy preserving method for the rotating shallow water equation (27th Sep, 2017)
European Conference on Numerical Mathematics and Advanced Applications, Voss, Norway.

- A third order entropy stable scheme for the compressible Euler equations (4th Aug, 2016)
XVI International Conference on Hyperbolic Problems (HYP2016), Aachen, Germany.
- A sign preserving WENO reconstruction (23rd Nov, 2015)
Department of Mathematics, University of Würzburg, Germany.
- A sign preserving WENO reconstruction (14th Aug, 2015)
International Conference on Industrial and Applied Mathematics, Beijing, China.
- A sign preserving WENO reconstruction (11th June, 2015)
Department of Applied Mathematics, University of Washington, Seattle, Washington.
- Entropy stable schemes for compressible flows on unstructured meshes (20th Dec, 2014)
Conference on Computational PDEs, Finite Element Meet, TIFR-CAM, Bangalore, India.
- Entropy stable schemes for compressible flows on unstructured meshes (9th Nov, 2014)
The 5th International Conference on Scientific Computing and Partial Differential Equations, HKBU, Hong Kong.
- Poster: Entropy stable schemes for compressible flows on unstructured meshes (9th Sep, 2014)
Analysis and Numerical Approximation of PDEs, ETH Zürich, Switzerland.

REVIEW FOR JOURNALS

Journal of Computational Physics • SIAM Journal on Numerical Analysis • SIAM Journal on Scientific Computing • Communications in Computational Physics • Journal of Scientific Computing • Proceedings of the Royal Society A • Computers & Fluids • SN Partial Differential Equations and Applications • Combustion Theory and Modelling • Boundary Value Problems • Communications in Nonlinear Science and Numerical Simulation • Applied Numerical Mathematics • Numerical Algorithms • BIT Numerical Mathematics • Indian Journal of Pure and Applied Mathematics.

WORKSHOPS & VISITS

- Academic Industry Modelling Week, University of Zürich (9th-13th November, 2015)
- Workshop on the Analysis and Numerical Approximation of PDEs, ETH Zürich (8th - 10th September, 2014)
- CIME-CIRM Workshop on Mathematical Models and Methods for Living Systems, Levico Terme, Italy (1st - 5th September, 2014)
- Workshop on Optimization with PDE constraints, TIFR-CAM (25th November - 6th December, 2013)
- Compact course on Discontinuous Galerkin method for time-dependent convection-dominant PDEs, by Prof. Chi-Wang Shu, TIFR-CAM (4th - 5th July, 2013)
- IFCAM Summer School on Numerics and Control of PDEs, IISc, Bangalore (22nd July - 2nd August, 2013)
- CIMPA Summer Research School on Current Trends in Computational Methods for PDEs, IISc, Bangalore (24th June - 19th July, 2013)
- Workshop on Theoretical and Computational Aspects of Nonlinear Waves, NPDE-TCA, IIT-Bombay (27th - 31st May, 2013)
- Advanced Workshop on Non-Standard Finite Element Methods, NPDE-TCA, IIT Bombay (11th - 15th February, 2013)
- Data Assimilation Research Program, TIFR-CAM (4th - 23rd July, 2011)
- Visiting Students' Research Programme, TIFR Mumbai (15th June - 10th July, 2009)

COMPUTING
SKILLS

Languages:	Python, C++, Fortran
Programming Software:	MATLAB
Visualisation Software:	Paraview, Gnuplot, VisIt, Paraview, Gmsh
Machine-Learning Software:	TensorFlow, PyTorch

Last updated on September 15, 2022.