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| 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 | Deep learning-based computational physics • Numerical methods for conservation laws • Uncertainty quantification • Bayesian inference. | |
| EMPLOYMENT HISTORY | <p>Postdoctoral Research Associate October 2018 - 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"> 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. <i>Journal of Computational Physics</i>, 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. <i>Computational Geosciences</i>, 2021. 13. Controlling oscillations in spectral methods by local artificial viscosity governed by neural networks. L. Schwander, D. Ray, J.S. Hesthaven. <i>Journal of Computational Physics</i>, 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

3. Probabilistic Image Imputation in Contrast-Enhanced CT. (*submitted, 2021*)
R. Raad, D. Patel, C.-C. Hsu, V. Kothapalli, D. Ray, B. Varghese, D. Hwang, I. Gill, V. Duddalwar, A. A. Oberai.
2. Solution of Physics-based Bayesian Inverse Problems with Deep Generative Priors. (*submitted, 2021*)
D. Patel, D. Ray, A. A. Oberai.
1. On the approximation of rough functions with deep neural networks. (*submitted, 2019*)
T. De Ryck, S. Mishra, D. Ray.

TEACHING EXPERIENCE

Instructor/co-instructor:

- 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:

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| 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:

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| Moritz Reinders | ETH | 2019 |
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Undergraduate project co-supervision:

- 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

- Served as external expert for the oral exam of a Master's project at EPFL (July 2021).
- Session chair and organizer for the minisymposium *Advances in data-enhanced predictive modeling in simulation science* 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 *Science Forum* at Hindu College (2008-10).
- Founding member of the model UN society *Caucus* at Hindu College (2009-10).

TALKS AND POSTERS

- 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