

DEEPAK N. SUBRAMANI

deepakns@iisc.ac.in | (O): +91-80-2293 2058; (M) +91-8139883769 | cds.iisc.ac.in/faculty/deepakns
Address: Dept. of Computational and Data Sciences, Room No. 321, Indian Institute of Science,
Bengaluru 560012

EXPERIENCE

Indian Institute of Science, Bangalore, India	
Assistant Professor Department of Computational and Data Sciences	31 Dec. 2018 – Present
• Leader of QUEST (Quantifying Uncertainty in Engineering, Science and Technology) Lab	
Massachusetts Institute of Technology, Cambridge MA, USA	
Postdoctoral Research Associate Advisor: Prof. Pierre F.J. Lermusiaux	Dec. 2017 – Nov. 2018
• Developed a data-driven AI and IoT tool for efficient and sustainable fishing. • Further developed our PDE-based optimal ship routing system in dynamic and uncertain ocean currents and waves.	
Graduate Research Assistant Advisor: Prof. Pierre F.J. Lermusiaux	Sept. 2012 – Nov. 2017
• Optimal path planning in strong, dynamic and uncertain environments <ul style="list-style-type: none">○ Developed governing planning S-PDEs and efficient numerical schemes for energy-, stochastic time-, and risk-optimal path planning of autonomous vehicles.○ Completed multiple sea experiments for real-time validation of our path planning system with REMUS 600 AUVs in Buzzard's Bay.	
• Uncertainty quantification and probabilistic regional ocean predictions <ul style="list-style-type: none">○ Developed theory, schemes and implemented dynamically orthogonal ocean primitive equations for quantifying and predicting uncertainties in regional oceans.○ First full-fledged ocean modeling system with probabilistic prediction capability.	
• The above uncertainty quantification theory and schemes is accurate and computationally faster (3-4 orders of magnitude) compared to earlier approximate methods.	

SKILLS

Uncertainty Quantification; Numerical Ocean Modeling; Nonlinear Data Assimilation; Nonlinear Optimization; AI/ML for Geosciences.

IN-HOUSE HPC SOFTWARE

Stochastic Path Planner for Marine and Aerial Vehicles: In-house scalable CPU and GPU software for optimal path planning of autonomous marine and aerial vehicles in stochastic dynamic environments.

Probabilistic Regional Ocean Forecasting System: In-house stochastic dynamically orthogonal ocean primitive equation solver for predicting 4-D (3-D in space and 1-D in time) probabilities of dynamic ocean states.

EDUCATION

Massachusetts Institute of Technology, Cambridge, MA

Ph.D. in Mechanical Engineering and Computation Nov. 2017

Thesis: Probabilistic Regional Ocean Predictions: Stochastic Fields and Optimal Path Planning

Major: Computational Science and Engineering

Minors: Stochastic Systems; Ocean Sciences; Technology and Public Policy;

Development in Resource Constrained Economies (set of three courses in each)

M.S. in Computation for Design and Optimization 2014

Thesis: Energy Optimal Path-Planning using Dynamically Orthogonal Level-Set Optimization GPA: 4.8/5

Indian Institute of Technology Madras, Chennai, India

M.Tech and B.Tech in Mechanical Engineering 2012

Masters specialization: Energy Technology

GPA: 9.11/10

Minor: Operations Research

Thesis: Profile Match-up Algorithms for Geophysical Retrievals and Their Application for Data Assimilation

AWARDS

Arcot Ramachandran Young Investigator Award 2019 – 2021

Division of Interdisciplinary Research, IISc Bengaluru

Postdoctoral and Graduate Fellowship 2015 – 2018

MIT-Tata Center

SNAME Graduate Travel Award in Ocean Engineering Dec. 2017

Department of Mechanical Engineering, MIT, Cambridge, MA

Wunsch Foundation Silent Hoist & Crane Award for Outstanding Research May 2017

Department of Mechanical Engineering, MIT, Cambridge, MA

First Place in Graduate Science May 2017

De Florez Design Competition, MIT, Cambridge, MA

Best Demonstration/Prototype Award Sept. 2016

Mechanical Engineering Research Exhibition 2016, MIT, Cambridge, MA

Esteemed Presenter Award for Best Computational Research Sept. 2015

Mechanical Engineering Research Exhibition 2015, MIT, Cambridge, MA

Best Poster Award Mar. 2015

Center for Computational Engineering Symposium, MIT, Cambridge, MA

Runner-up Poster Award Nov. 2014

DyDESS 2014 Conference, Cambridge, MA

Institute Merit Prize (Highest GPA in Energy Technology) 2012

Indian Institute of Technology Madras, India

GE Foundation Award 2009-2011

GE Foundation Scholar-Leaders Program (Global)

National Talent Search (NTS) Scholar, India 2005

PHD/MTECH SUPERVISION

1. **Graduated**
 - a. **MPI and CUDA-based Implementation of High-order Narrow-band Level-set Schemes for Time-optimal Ship Routing** (Chennam Revanth Sri Sesha Sai, 2020 M.Tech)
 - b. **Deep Learning of Synoptic Ocean Features from Concurrent Satellite Images** (Raghav Sharma, 2020 M.Tech)
 - c. **Digital Twins for Satellite Systems** (Ramkiran Balivada, 2021 M.Tech)
2. **Expected to Graduate in 2021**
 - a. **Deep Learning for Satellite Oceanography** (Devyani Lambhate, 2021, M.Tech (Research))
 - b. **Polynomial Chaos-Gaussian Mixture Model Filtering: Theory, Schemes and Applications** (Srikanth Avasarala, 2021, M.Tech (Research))
3. **On going Ph.D. Students**
 - a. **AI for Social Good: Applications of ML in Human-Wildlife Conflict** (PhD, P. Anjali, Joined 2020)
 - b. **Machine Learning, Combinatorial Optimization and Environmental Applications** (PhD, Sumanth Boya, Joined 2020)
 - c. **Ocean Modeling and Data Assimilation** (PhD, P. Abhishek, Joined 2019)
 - d. **Bayesian Deep Learning for Environmental Sensing** (PhD, Chinmay Khasanis, Joined 2019)
 - e. **Optimal Path Planning of Autonomous Underwater Vehicles** (PhD, Rohit Chowdhury, Joined 2018)
 - f. **Time Series Modeling and Data Assimilation** (PhD, Akanksha Rajak, Joined 2018)

SPONSORED RESEARCH

DECOVID: Data-assimilation and Error Correction Of Viral Infectious Diseases Models – 5.5 Lakhs

Department of Science and Technology, SERB MATRICS Covid Special Call May 2020 – April 2021 [PI]

Arcot Ramachandran Young Investigator Award – 6 Lakhs

Indian Institute of Science, Bengaluru. Oct 2019 - Oct 2021 [PI]

Data Assimilation for Ship Routing – 5.56 Lakhs

Maersk Digital Center, Bangalore, India. Jan 2019 - Jul 2020 [PI]

INSPIRE Faculty Fellowship – 35 Lakhs

Department of Science and Technology, Govt. of India. Jan 2019-Jan 2024 [PI]

SPADE: Stochastic Parmoon for Analysis, Design and Estimation – 98.4 Lakhs

Ministry of Human Resource Development STARS program. Mar 2020 – Mar 2023 [Co-PI; 50% Role]

Hardware Aware Algorithms in Scientific Computing – 1.6 Crores

UGC-Indo German Partnership 2021-2025 [co-PI; 25% Role]

MANDALA (MPI+X Accelerated Numerics on hybrID Architecture with acceLerAtors): An Exascale Computing Project – 44.14 Lakhs

Department of Science and Technology, Govt. of India. 2021-2024 [co-PI; Minor Role]

PROFESSIONAL ACTIVITY

- Expert Panel Member for Data Science at VIT-AP Recruitment
- Expert panel member on mathematical modeling of infectious disease spread – podcasts, news discussion, conferences.
- More than 20 Invited lectures delivered at universities, colleges, and industry labs.

- Participant at the NASA JPL-Caltech Climate Summer School 2017
- Received the Kaufman Teaching Certificate in June 2015.
- Reviewer for Robotics and Autonomous Systems, International Journal of Control, Automation and Systems, IEEE Journal of Cybernetics, IEEE International Conference on Robotics and Automation, Journal of Computational and Nonlinear Dynamics, Dynamic Data-Driven Environmental System Sciences Conference, International Journal of Thermal Sciences, The Sea, Current Science, Sadhana, Remote Sensing of the Environment, IEEE TGRS.
- Department and Institute Service: Admission Committee (Chair Research 2019, Course 2020, Online 2021), Safety Champion (2019-Present), Faculty Recruitment Committee (2019-2020), M.Tech Curriculum Review Committee Chair (2021), GATE/KCPY Institute Representative, PMRF Interview Committee, IMI Interview Committee, MTech and Research Examiner, Comprehensive Exam Senate Nominee, External Doctoral Examiner (ICTS)

PUBLICATIONS

Google Scholar Profile: <https://scholar.google.com/citations?user=d-V0TTwAAAAJ&hl=en>

As on 14 Jul, 2021 – Number of Citations: 413, h-index: 12, i10-index: 13

Papers in Peer-Reviewed International Journals

1. R. Gadi, P. N. Vinayachandran, D. N. Subramani (2021*). *Data-Driven Feature Modeling of Southwest Monsoon Current*. **Ocean Modelling**. [Sub Judice. Submitted Apr 2021]
2. S. Avasarala and D. N. Subramani (2021*). *A non-Gaussian Bayesian Filter for Sequential Data Assimilation with non-intrusive Polynomial Chaos Expansion*. **International Journal for Numerical Methods in Engineering** [Sub Judice. Submitted Apr 2021]
3. R. Chowdhury and D. N. Subramani (2021*). *Optimal Path Planning of Autonomous Marine Vehicles in Stochastic Dynamic Ocean Flows using a GPU-Accelerated Algorithm*. **IEEE Journal of Oceanic Engineering** [Sub Judice. Submitted Apr 2021]
4. D. Lambhate, R. Sharma, J. Clark, A. Gangopadhyay and D. Subramani (2021). *W-Net: A Deep Network for Simultaneous Identification of Gulf Stream and Rings from Concurrent Satellite Images of Sea Surface Temperature and Height*. **IEEE Transactions on Geoscience and Remote Sensing**. In Print. Accepted on 06 July 2021. DOI: 10.1109/TGRS.2021.3096202
5. S. Ganesan and D. N. Subramani (2020). *Spatio-temporal predictive modeling framework for infectious disease spread*. **Nature Scientific Reports**. 11, 6741 (2021). DOI: 10.1038/s41598-021-86084-7 [A novel population balance PDE for predicting the spatio temporal spread of infectious diseases with a focus on Covid-19 in India]
6. G. Mannarini, D. N. Subramani, P. F. J. Lermusiaux and N. Pinaridi (2019). *Graph-Search and Differential Equations for Time-Optimal Vessel Route Planning in Dynamic Ocean Waves* in **IEEE Transactions on Intelligent Transportation Systems**. DOI: 10.1109/TITS.2019.2935614. [Impact Factor – 5.744. Citations – 3. IEEE TITS is a top journal for research on intelligent transportation systems.]
[This collaborative work with groups in Italy, USA and India (me from IISc) show the first direct comparison of our data-driven PDE-based methodologies for routing marine traffic and graph search methods, clearly showing the former’s advantage.]

7. Subramani, D.N. and P.F.J. Lermusiaux (2019). *Risk Optimal Path Planning in Stochastic Dynamic Environments*. **Computer Methods in Applied Mechanics and Engineering**. Volume 353, 15 August 2019, Pages 391-415.
[Impact Factor - 5.02. Citations – 2. CMAME is a top journal in the field of data-driven computational methods for engineering applications.]
[Combined decision theory and data-driven stochastic planning methods for learning paths for autonomous agents that minimize risk of being sub-optimal in uncertain dynamic environments]
8. Subramani, D.N., Q.J. Wei and P.F.J. Lermusiaux (2018). *Stochastic Time Optimal Path Planning in Uncertain, Strong, and Dynamic Flows*. **Computer Methods in Applied Mechanics and Engineering**. 333, pp 218-237. doi: 10.1016/j.cma.2018.01.004
[Impact Factor - 5.02. Citations - 10. CMAME is a top journal in the field of data-driven computational methods for engineering applications.]
[Developed data-driven time-optimal planning algorithm for robot motion in uncertain dynamic environments.]
9. Lermusiaux, P.F.J., D.N. Subramani, J. Lin, C.S. Kulkarni, A. Gupta, A. Dutt, T. Lolla, P.J. Haley Jr., W.H. Ali, C. Mirabito, and S. Jana (2017). *A Future for Intelligent Autonomous Ocean Observing Systems*. **The Sea Vol. 17: The Science of Ocean Prediction**, Special Issue of J. Marine Res., 75, 765–813.
[Impact Factor - NA. Citations - 20. The Sea is a prestigious and classic monograph with invited review papers recently revived. Co-authors are members of group led by Prof. Lermusiaux at MIT.]
[My contribution is a review of data-driven optimal planning methods for intelligent marine robots and a description of real-time demonstration with REMUS 600 AUVs]
10. Subramani, D. N., P. J. Haley, Jr., and P. F. J. Lermusiaux (2017). Energy-optimal path planning in the coastal ocean, **Journal of Geophysical Research: Oceans**, 122, 3981–4003, doi:10.1002/ 2016JC012231
[Impact Factor – 2.71. Citations - 18. JGR: Oceans is a flagship journal by the American Geophysical Union for research related to applications in oceanography.]
[Demonstrated realistic simulations of data-driven energy-optimal planning of autonomous gliders.]
11. Sun, W., P. Tsiotras, T. Lolla, D.N. Subramani, and P.F.J. Lermusiaux (2017). *Multiple-Pursuit/One-Evader Pursuit Evasion Game in in Dynamical Flow Fields*. **Journal of Guidance, Control, and Dynamics**. doi: 10.2514/1.G002125.
[Impact Factor – 2.061. Citations - 22. JGCD is a flagship journal by the AIAA for research related to control theory in aerospace applications. Co-authors are experts in pursuit evasion games with application to autonomous vehicles.]
[My contribution is towards developing the idea of using level-set equations for devising a stopping criterion for pursuit evasion games in dynamical flow fields.]
12. Lermusiaux, P.F.J., P.J. Haley Jr., S. Jana, A. Gupta, C.S. Kulkarni, C. Mirabito, W.H. Ali, D.N. Subramani, A. Dutt, J. Lin, A. Y. Shcherbina, C. M. Lee, A. Gangopadhyay (2017). *Optimal Planning and Sampling Predictions for Autonomous and Lagrangian Platforms and Sensors in the Northern Arabian Sea* **Oceanography** 30(2), 172-185.
[Impact Factor – 3.883. Citations - 12. Oceanography is a popular journal by The Oceanography Society that published invited review articles. Co-authors are members of group led by Prof. Lermusiaux at MIT.]
[My contribution is towards providing data-driven reachability front predictions for gliders deployed in a real-time sea exercise in the Northern Arabian Sea.]
13. Subramani, D.N. and P.F.J. Lermusiaux (2016). *Energy Optimal Path Planning by Stochastic Dynamically Orthogonal Level-Set Optimization*. **Ocean Modelling**, 100, pp 57-77.

[Impact Factor - 3.503. Citations - 55. OM is the most respected venue for data-driven computational modelling in the ocean domain.]

[First ever stochastic optimization technique for exact data-driven energy-optimal path planning of marine robots.]

14. Subramani, D., Chandrasekar, R., Ramanujam, K.S. and C. Balaji (2014). *A new ensemble-based data assimilation algorithm to improve track prediction of tropical cyclones*. **Natural Hazards**, 71, pp 659-682.

[Impact Factor – 2.319. Citations - 6. Natural Hazards is a popular venue for data-driven predictions of environmental hazards.]

[Developed a Bayesian inference algorithm for data-driven prediction of tropical cyclones.]

15. S. Ramanujam, C. Radhakrishnan, D. Subramani and C. Balaji (2012). *On the Effect of Non-Raining Parameters in Retrieval of Surface Rain Rate Using TRMM PR and TMI Measurements*. **IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing**, 5(3), pp. 735-743.

[Impact Factor – 3.392. Citations - 8. IEEE JSTARS is within the top 10 journals for remote sensing and computational methods in earth sciences. First author was a research scholar at IIT Madras.]

[My contribution was in developing a Bayesian retrieval algorithm from a precipitation radar. Co-authors had developed a retrieval algorithm from Microwave Imager that needed information from radar data for correct inference, which I completed.]

Selected Papers in Peer-Reviewed International Conferences

1. Chowdhury, R. and D. N. Subramani (2020). Physics-Driven Machine Learning for Time-Optimal Path Planning in Stochastic Dynamic Flows. In: Darema F., Blasch E., Ravela S., Aved A. (eds) *Dynamic Data Driven Application Systems. DDDAS 2020. Lecture Notes in Computer Science*, vol 12312. Springer, Cham. https://doi.org/10.1007/978-3-030-61725-7_34
[DDDAS is the topmost conference in the field of data driven application systems conducted at MIT. Work completed with my Ph.D. student Rohit Chowdhury.]
[Developed a novel reinforcement learning algorithm that learns from a distribution of pre-planned time-optimal paths, and updates policy onboard by data assimilation.]
2. Lambhate, D. and D. N. Subramani (2020). *Super Resolution of Sea Surface Temperature Satellite Images*. In: IEEE/MTS Oceans '20 Gulfcoast. Oct 2020.
3. Subramani, D.N., T. Lolla, P.J. Haley and P.F.J Lermusiaux (2015). *A stochastic optimization method for energy-based path planning*. In: Ravela, S., Sandu, A. (Eds.), Vol. 8964 *Lecture Notes in Computer Science*, Springer, pp. 347-358.
[Citations – 17. The papers presented at the Dynamic Data Driven Environmental System Science Conference 2014 was published in LNCS.]
[Introduced the use of stochastic optimization for data-driven energy-optimal planning in dynamic environments.]
4. Subramani, D. N., P. F. J. Lermusiaux, P.J. Haley, Jr., C. Mirabito, S. Jana, C. S. Kulkarni, A. Girard, D. Wickman, J. Edwards, J. Smith (2017). *Time-Optimal Path Planning: Real-Time Sea Exercises*. In: *Oceans '17 MTS/IEEE Aberdeen*, 19-22 June 2017, DOI: 10.1109/OCEANSE.2017.8084776.
[Citations – 10. Popular conference for any application related to oceans.]
[First demonstration of real-time applicability of data-driven time-optimal planning with REMUS 600 AUVs in real-time.]
5. Mirabito, C., D.N. Subramani, T. Lolla, P.J. Haley, Jr., A. Jain, P.F.J. Lermusiaux, C. Li, D.K.P. Yue, Y. Liu, F.S. Hover, N. Pulsone, J. Edwards, K.E. Railey, and G. Shaw, (2017). *Autonomy for Surface Ship Interception*. In: *Oceans '17 MTS/IEEE Aberdeen*, 19-22 June 2017, DOI: 10.1109/OCEANSE.2017.8084817.

[Citations – 3. Co-authors are experts in acoustics for naval applications.]

[Results and software of data-driven time-optimal planning of autonomous agents used to demonstrate a ship interception application.]

6. Sun, W., P. Tsiotras, T. Lolla, D. N. Subramani, and P. F. J. Lermusiaux, (2017). *Pursuit-Evasion Games in Dynamic Flow Fields via Reachability Set Analysis*. 2017 American Control Conference. Seattle, WA, 2017, pp. 4595-4600. doi: 10.23919/ACC.2017.7963664
[Citations – 8. ACC is a flagship international conference on science and engineering of control systems. Co-authors are experts in pursuit evasion games with application to autonomous vehicles.]
[My contribution is towards developing the idea of using level-set equations for devising a stopping criterion for pursuit evasion games in dynamical flow fields.]
7. Edwards, J., J. Smith, A. Girard, D. Wickman, P.F.J. Lermusiaux, D.N. Subramani, P.J. Haley, Jr., C. Mirabito, C.S. Kulkarni, and, S. Jana, (2017). *Data-driven Learning and Modeling of AUV Operational Characteristics for Optimal Path Planning*. In: Oceans '17 MTS/IEEE Aberdeen, 19-22 June 2017, DOI: 10.1109/OCEANSE.2017.8084779
[Citations – 6. Popular conference for any application related to oceans. Co-authors own and operated the AUV.]
[Developed data-driven models for predicting AUV speed from data collected by co-authors who operated the AUV.]
8. Ferris, D.L., D.N. Subramani, C.S. Kulkarni, P.F.J. Lermusiaux (2018). *Time-Optimal Multi-Waypoint Mission Planning in Dynamic Environments*. In: MTS/IEEE Oceans '18 Charleston, pp 1-8. doi: 10.1109/OCEANS.2018.8604683
[Citations – 1. Popular conference for any application related to oceans. First author was a Master's student under Prof. Lermusiaux, who worked with my help for his thesis while I was a post-doc.]
[Demonstrated a solution to the optimal tours to be taken by AUVs to visit multiple targets in a dynamic environment. The setup resembles a dynamic traveling salesman problem.]
9. Dutt, A., D.N. Subramani, C.S. Kulkarni, P.F.J. Lermusiaux (2018). *Clustering of Massive Ensemble of Vehicle Trajectories in Strong, Dynamic and Uncertain Ocean Flows*. In: MTS/IEEE Oceans '18 Charleston, pp 1-8. doi: 10.1109/OCEANS.2018.8604683
[Citations – 1. Popular conference for any application related to oceans. First author was a Master's student under Prof. Lermusiaux, who worked with my help while I was a post-doc.]
[First demonstration of unsupervised clustering algorithms on massive ensembles of optimal paths taken by AUVs, with a goal to learn optimal paths from data.]

Patents Applied

1. Subramani, D.N., C.S. Kulkarni, P.J. Haley Jr., Lermusiaux P.F.J (2018). Optimal Ship Routing in Strong, Dynamic, and Uncertain Ocean Currents and Waves. US Provisional Application No.: 62/689,011. Filing Date: June 22, 2018.