

Hrusikesha Pradhan

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Research Summary

I have designed non-parametric function learning algorithms that prioritize resource efficiency while achieving enhanced learning accuracy, underpinned by solid theoretical convergence assurances. These novel learning algorithms incorporate a range of subset selection strategies, strategically addressing the memory complexity expansion intrinsic to kernel learning algorithms. This pivotal adaptation ensures scalability of the algorithms for extensive-scale learning scenarios. The development of these learning techniques draws inspiration from diverse fields including kernel learning, Gaussian Process, random Fourier features, stochastic optimization, distributed optimization, and submodular optimization.

Education

Indian Institute of Technology, Kanpur July'23
PhD, Electrical Engineering GPA: 8.8/10
Thesis Supervisor: Dr. Ketan Rajawat

Indian Institute of Technology, Kanpur June'14
M.Tech., Electrical Engineering GPA: 8.5/10
Thesis Supervisor: Dr. Adrish Banerjee

Institute of Technical Education & Research, Bhubaneswar May'11
B.Tech., Electronics and Telecommunication Engineering GPA: 8.7/10

Research Internship

Computational and Information Sciences Directorate at (CISD), U.S. Army Research Laboratory, Adelphi, MD, U.S.A. Oct.'18 - Dec.'18
Mentor: **Dr. Alec Koppel**

Topic: **Scalable Online Gaussian Process Regression**

- Developed the first compression sub-routine for online Gaussian processes that preserves convergence to the population posterior, i.e., asymptotic posterior consistency, while ameliorating their intractable complexity growth with the sample size
- Convergence to the true distribution with unbounded memory complexity, and to the neighbourhood of stationarity with finite memory complexity

Work Experience

Research Associate (Remote), SPiN Lab, Indian Institute of Technology (IIT) Kanpur, Aug.'23 - ongoing

- Communication efficient distributed learning algorithm for Non-convex stochastic composite optimization framework
- Data Summarization for online-learned predictive models using bilevel optimization

Research Engineer, Centre for Development of Telematics (C-DOT), Telecom Technology Centre of Government of India, Ministry of Telecommunication Aug.'14 - Aug.'16

- Developed firmware of Intelligent Platform Management Interface (IPMI) for power sequencing and management, fault and interrupt management, temperature and voltage monitoring of connected modules in various cards

- Optimized FPGA design of the IPMI for Carrier cards, Advanced Mezzanine cards (AMCs) and Intelligent Rear Transition Modules (IRTMs) used in C-DOT Multi Terabit Routers, the new FPGA designs led to space reduction of 12%

Publications

Preprints and Ongoing Work

- “Non-convex Distributed Composite Optimization” (in preparation)
- “Client Selection using Submodular Theory for Federated Learning” (in preparation)
- **H. Pradhan**, K. Rajawat, “An optimal Variance Reduction algorithm for Nonconvex optimization under Non-parametric learning settings” (to be submitted to *IEEE Transactions on Signal Processing*).

Peer Reviewed: Journals

- **H. Pradhan**, K. Rajawat, A. Koppel, “Near-optimal Kernel approximation using Submodular Set Cover Theory” (submitted to *IEEE Transactions on Signal Processing*).
- A. Koppel, **H. Pradhan**, and K. Rajawat, “Consistent Online Gaussian Process Regression without the Sample Complexity Bottleneck,” *Statistics and Computing*, Springer 31, 76 (2021). (Date of publication: 24 September 2021)
- **H. Pradhan**, A. S. Bedi, A. Koppel, and K. Rajawat, “Adaptive Kernel Learning in Heterogeneous Networks,” *IEEE Transactions on Signal and Information Processing over Networks*, vol. 7, pp. 423-437, 2021. (Date of publication: 14 June 2021)
- **H. Pradhan**, R. Budhiraja, and K. Rajawat, “Robust Transceiver Design for AF Asymmetric Two-Way MIMO Relaying,” *IEEE Transactions on Signal Processing*, vol. 68, no. 1, pp. 5488-5503, 2020. (Date of Publication: 18 September 2020)
- **H. Pradhan**, S. S. Kalamkar and A. Banerjee, “Sensing-Throughput Trade-off in Cognitive Radio With Random Arrivals and Departures of Multiple Primary Users”, *IEEE Communication Letters*, vol. 19, no. 3, pp. 415-418, 2015. (Date of Publication: 19 January 2015) [Ranked 27th, 20th, and 21st in the most popular downloads in IEEE Communications Letters for March 2015, April 2015, and May 2015, respectively.]

Peer Reviewed: Conferences

- **H. Pradhan**, K. Rajawat, “A Variance Reduced Nonconvex Stochastic Optimization framework for Online Kernel Learning,” *Asilomar Conf. on Signals, Systems, and Computers*, Pacific Grove, CA, USA, Nov. 2022. (Date of Publication: 07 March 2023)(Talk: Virtual mode)
- **H. Pradhan**, A. Koppel, K. Rajawat, “On Submodular Set Cover Problems for Near-Optimal Online Kernel Basis Selection,” *ICASSP*, Singapore, May 2022. (Date of Publication: 27 April 2022) (Talk: Virtual mode)
- **H. Pradhan**, A. S. Bedi, A. Koppel, K. Rajawat, “Conservative Multi-agent Online Kernel Learning in Heterogeneous Networks,” in *Proc. of the Asilomar Conf. on Signals, Systems, and Computers*, Pacific Grove, CA, USA, Nov. 2020. (Date of Publication: 03 June 2021) (Talk: Virtual mode)
- **H. Pradhan**, A. S. Bedi, A. Koppel, K. Rajawat, “Exact Nonparametric Decentralized Online Optimization,” in *Proc. of the IEEE GlobalSIP*, Anaheim, CA, USA, Nov. 2018. (Date of Publication: 21 February 2019) (Talk: Physical Mode)
- A. S. Bedi, **H. Pradhan**, and K. Rajawat, “Decentralized Asynchronous Stochastic Gradient Descent: Convergence Rate Analysis,” in *Proc. of the Intl. Conf. on Signal Processing and Communications (SPCOM)*, Bangalore, India. June 2018. (Date of Publication: 30 May 2019) (Talk: Physical Mode)

- Academic Honors and Awards**
- TCS PhD fellowship for doctoral studies (Fully funded for Research, Salary and Travel) Jul.'18 - Dec.'23
 - Summer Journeyman Fellowship, US Army Research Laboratory, Adelphi, Maryland Oct.'18 - Dec.'18
 - MHRD fellowship for doctoral studies Jul.'16 - Jun.'18
 - MHRD fellowship for graduate studies Jul.'12 - Jun.'14

- Technical Skills**
- Programming Languages: MATLAB, Python, C, C++
 - Firmware and FPGA Tool: Microsemi Soft Console, Libero IDE

Research Projects undertaken during PhD

Near Optimal Basis Selection in Non-Parametric Function Learning

(In collaboration with Dr. Alec Koppel, now at JP Morgan Chase & Co) Jan.'21 - Dec.'22

- Designed large scale kernel approximation algorithms using Submodular Set Cover theory for kernel regression and Fourier features
- Proposed a data-dependent approach for Fourier feature selection
- Constructive point selection algorithms establish near optimal sample complexity guarantees that is only logarithmically far from the optimal one
- Numerically Validated on real data sets: Taiwan real estate valuation, Mackey-Glass time series, Abalone, Parkinson's telemonitoring, Seoul bike sharing, Boston Housing

Variance Reduced Nonconvex Stochastic Optimization Algorithms for Online Kernel Learning

Jun.'21 - Feb.'23

- Proposed the first variance-reduced stochastic gradient algorithm for kernel learning
- Established convergence in terms of number of iterations and memory complexity
- Proposed a compression algorithm to handle the memory complexity growth, thereby making it applicable to large-scale data sets

Distributed Online Kernel Learning under Heterogeneous Network Settings

(In collaboration with Dr. Alec Koppel, U.S. Army Labs, Adelphi) May'18 - Apr.'20

- Solved the non-linear proximity constrained multi-agent optimization problem using a functional variant of stochastic primal dual method
- Established a non-asymptotic bound on the memory complexity, denoting the finiteness of the online kernel learning algorithm, and achieved zero constraint violation, optimality gap in terms of iterations and model complexity parameter
- Proposed algorithm estimated ocean climatological fields such as temperature and salinity fields across Gulf of Mexico

Robust Transceiver Design of AF Asymmetric Two-Way MIMO Relaying Using First Order Perturbation Analysis

(In collaboration with Dr. Rohit Budhiraja, IIT Kanpur) Aug.'16 - Aug.'20

- Designed robust transceiver using first-order perturbation of singular value decomposition by modelling the channel uncertainties using stochastic approach
- Designed a relay precoder to cancel the back propagating interference for receive only user in asymmetric two-way relaying
- Verified the efficiency of design using the power allocation problem by geometric programming approach with objective functions of maximizing minimum per-stream SINR and minimizing total network transmit power

Joint Relay Precoder and Equalizer Optimization for Two-Way MIMO Relaying Systems using MSE Criterion

(In collaboration with Dr. Rohit Budhiraja, IIT Kanpur)

Aug.'16 - Aug.'18

- Non-convex optimization problem is solved with objective function of minimizing sum of mean square errors at both the destination nodes with a constraint on total network transmit power at all the nodes
- Solved using alternating minimization technique and quadratically constrained quadratic problem using semi-definite programming

M.Tech. Dissertation

Sensing Throughput Trade-off in Cognitive Radio with Random Arrival And Departure Of Multiple Primary Users

Jun.'13 - Jun.'14

Thesis Supervisor: Dr.Adrish Banerjee

- Investigated & validated the effects of multiple primary user traffic parameters on sensing-throughput trade-off
- Achieved a more practical network utilization by probabilistic modelling of random arrival and departure of multiple primary users during secondary user frame

Relevant Coursework

Optimization for Big Data, Introduction to Machine learning[†], Probabilistic machine learning[†], Deep Learning[†], Convex Optimization in SP/COMM, Optimization Techniques, Statistical Signal Processing, Information & Coding Theory, Introduction to Signal Analysis, Representation and Analysis of Random Signals, MIMO Wireless communication, Wireless Communication, Advanced Comm. Systems, [[†]- audited coursework]

Invited Talks

- “Online learning via optimally compressed Non-parametric Learning Framework” at Google Research Week, Jan. 2023
- “Optimally compressed Non-parametric Learning under streaming settings” at Early Research Career forum, ANTS 2021, Dec. 2021 (virtual)
- “Online learning via optimally compressed Non-parametric Learning: Kernel Regression and Gaussian Processes” at PhD Forum ACML (virtual) on Nov., 2021
- “Sequential Learning using Non-parametric Learning Settings” at TCS Research Cafe (virtual) on 2nd August, 2021
- “Non-parametric Online function learning using Gaussian Processes” at Mathematics and Statistics Department, IIT Kanpur, Nov. 2019

Certifications

- Neural Networks and Deep Learning (Certificate URL: <https://www.coursera.org/account/accomplishments/certificate/XA5BD2HW7W3L>)
- Unsupervised learning, Recommenders, Reinforcement Learning (Certificate URL: <https://www.coursera.org/account/accomplishments/certificate/NCWNSMCEPDE4>)
- Advanced Learning Algorithms (Certificate URL: <https://www.coursera.org/account/accomplishments/certificate/MZ6BKHEUFWNL>)
- Supervised Machine Learning: Regression and Classification (Certificate URL: <https://www.coursera.org/account/accomplishments/certificate/U4JKX2LP8HZ3>)
- Sequence Models (RNN, Natural Language Processing)-Ongoing

Professional Services

- Formed the first IEEE Signal Processing Society student branch chapter at IIT Kanpur
- Founding chair of IEEE Signal Processing Society student branch chapter at IITK
- Organized a semester long IEEE Signal Processing Society Seminar Series on Optimization and Learning
- Reviewer for IEEE Transactions on Signal Processing, Journal of Selected Topics in Signal Processing, IEEE Transactions on Wireless Communications, IEEE Transactions on Vehicular Technology, IEEE Communication Letters, and IEEE Signal Processing Letters
- Reviewer for AISTATS 2023, ICASSP (2019), SPCOMM (2016, 2018, 2020), NCC (2021, 2019)

References

- Dr. Ketan Rajawat, Associate Professor, Department of Electrical Engg., IIT Kanpur, India, Email: ketan@iitk.ac.in (Ph.D. Thesis Supervisor)
- Dr. Alec Koppel, Artificial Intelligence Research Lead, JP Morgan Chase and Co., USA, Email: aekoppel314@gmail.com (Collaborator from US Army Lab 2018 - 2021)
- Dr. Rohit Budhiraja, Associate Professor, Department of Electrical Engg., IIT Kanpur, India, Email: rohitbr@iitk.ac.in (Collaborator from IIT Kanpur)
- Dr. Adrish Banerjee, Professor, Department of Electrical Engg., IIT Kanpur, India, Email: adrish@iitk.ac.in (Masters Thesis Supervisor)