Nancy Nayak

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Google Scholar | Research Gate | Github | LinkedIn | Website

RESEARCH INTERESTS

Machine learning based scheduling • Energy efficient Machine Learning methods • Compression techniques for Deep Neural Networks • Deep reinforcement learning • Online learning • Binary Neural Networks and their application in Wireless Communication • Adversarial robustness • Optimizers for Binary Neural Networks • Reconfigurable Intelligent Surfaces for Smart city • Vision Transformers • Time-series data analysis • Generative Adversarial Networks

CURRENT AFFILIATION

IMPERIAL COLLEGE LONDON
Postdoctoral Research Associate in Intelligent Communications

Duration: 2024 - Present
Focus: Machine Learning Techniques for Resource allocation in Wireless Networks
PI :   Dr. Kin Leung

EDUCATION AND RESEARCH EXPERIENCE

INDIAN INSTITUTE OF TECHNOLOGY MADRAS
Integrated MS and Ph.D. in Communications and Signal Processing

CGPA: 8.51 / 10 (2017 - 2024)
Thesis topic: Energy-efficient Machine Learning Methods for Green Communication Systems
Supervisor: Dr. Sheetal Kalyani

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR
Bachelor of Technology in Electronics and Communication Engineering

CGPA: 9.26 / 10 (2011 - 2015)

PUBLICATIONS

PEER-REVIEWED

1. **Nayak, Nancy** , Sheetal Kalyani, and Himal A. Suraweera. "A DRL Approach for RIS-Assisted Full-Duplex UL and DL Transmission: Beamforming, Phase Shift and Power Optimization." IEEE Transactions on Wireless Communications (2024).

2. **Nayak, Nancy** and Sheetal Kalyani. "Rotate the ReLU to Sparsify Deep Networks Implicitly." Transactions on Machine Learning Research.

3. **Nayak, Nancy** , Vishnu Raj, and Sheetal Kalyani. "Deep reinforcement learning based blind mmwave MIMO beam alignment." IEEE Transactions on Wireless Communications 21, no. 10 (2022): 8772-8785.

4. **Nayak, Nancy** , Vishnu Raj, and Sheetal Kalyani. "Leveraging online learning for CSS in frugal IoT network." IEEE Transactions on Cognitive Communications and Networking 6, no. 4 (2020): 1350-1364.

5. Vikas, Devannagari, **Nancy Nayak** , and Sheetal Kalyani. "Realizing neural decoder at the edge with ensembled bnn." IEEE Communications Letters 25, no. 10 (2021): 3315-3319.

6. **Nayak, Nancy** , Vishnu Raj, and Sheetal Kalyani. "A comprehensive study on binary optimizer and its applicability." ReScience C 6, no. 2 (2020).

7. Shankar, Nitin Priyadarshini, Deepsayan Sadhukhan, **Nancy Nayak** , Thulasi Tholeti, and Sheetal Kalyani. "Binarized ResNet: Enabling Robust Automatic Modulation Classification at the Resource-Constrained Edge." IEEE Transactions on Cognitive Communications and Networking (2024).

8. Suresh, Janani, **Nancy Nayak** , and Sheetal Kalyani. "First line of defense: A robust first layer mitigates adversarial attacks." arXiv preprint arXiv:2408.11680 (2024). Accepted at AAAI 2025 Main Technical Track.

UNDER-REVIEW

1. Kumar, Ashok S., **Nancy Nayak** , Sheetal Kalyani, and Himal A. Suraweera. "Energy Efficient Fair STAR-RIS for Mobile Users." arXiv preprint arXiv:2407.06868 (2024). Submitted to IEEE Transactions on Green Communications and Networking

PRE-PRINTS

1. Raj, Vishnu, **Nancy Nayak** , and Sheetal Kalyani. "Understanding learning dynamics of binary neural networks via information bottleneck." arXiv preprint arXiv:2006.07522 (2020).

2. Sharma, Akshay, **Nancy Nayak** , and Sheetal Kalyani. "BayesAoA: A Bayesian method for Computation Efficient Angle of Arrival Estimation." arXiv preprint arXiv:2110.07992 (2021).

3. **Nayak, Nancy** , Thulasi Tholeti, Muralikrishnan Srinivasan, and Sheetal Kalyani. "Green detnet: Computation and memory efficient detnet using smart compression and training." arXiv preprint arXiv:2003.09446 (2020).

OTHER RESEARCH EXPERIENCES

PROJECT OFFICER | Collaboration between IIT Madras and Ministry of Electronics and Information Technology (MEITY) (July 2022 to January 2024)

Topic:	Reduced signaling in Reconfigurable Intelligent Surfaces (RIS)
Collaborator:	Dr. Sheetal Kalyani and Dr. Himal A. Suraweera

UNDERGRADUATE PROJECT | NIT Durgapur, India (2015)

Topic:	Area optimization of two-stage CMOS comparator with Particle Swarm Optimization and verified with Cadence
Supervisor:	Dr. Rajib Kar

RESEARCH INTERN | CERN, Geneva, Switzerland (2014)

Topic:	Designed LabVIEW application to remotely control oscilloscope to collect, save, and analyze data
Supervisor:	Dr. Anne Dabrowski

RESEARCH INTERN | Variable Energy Cyclotron Centre, Kolkata, India (2013)

Topic:	Analyzed lumped and distributed circuit using MATLAB and designed high-frequency cavity coupled band pass filter using CST Microwave Studio
Supervisor:	Dr. Hemendra Kumar Pandey

TEACHING EXPERIENCE

TEACHING ASSISTANT | Imperial College London, UK (2025)
- Reinforcement Learning for Communication Systems

TEACHING ASSISTANT | IIT Madras, India (2018-2022)
- Machine Learning • Estimation Theory • Digital Modulation and Coding • Linear Algebra • Signal and System

CO-MENTORING

Topic:	First line of defense: A robust first layer mitigates adversarial attacks
Student:	Janani Suresh (M.S.)
Topic:	Energy Efficient Fair STAR-RIS for Mobile Users
Student:	Ashok S. Kumar (Ph.D.)
Topic:	Neural decoder at the edge with ensembled BNN
Student:	Vikas Devannagari (M.Tech.)
Topic:	A Bayesian method for Computation Efficient Angle of Arrival Estimation
Student:	Akshay Sharma (M.S.)
Topic:	Enabling Robust Automatic Modulation Classification at the resource-constrained Edge with Binarized ResNet
Students:	Deepsayan Sadhukhan (M.S.), Nitin Priyadarshini Shankar (Ph.D.)

PROFESSIONAL EXPERIENCE

ASSISTANT MANAGER, NETWORKS TEAM | Idea Cellular Ltd., Hyderabad, India (2015 - 2017)

Roles: Network planning for 2G and 3G, optimizing network performance to enhance KPIs, including call blocking, call drop rates, and uplink/downlink qualities.

SKILLS

Programming: Python • Matlab • C • LaTeX • Git

Proficiency in: Pytorch • Tensorflow • Docker • JAX • Flax • Keras • Cluster computing • Numpy • Scipy • Matplotlib

PROFESSIONAL SERVICES

Reviewer: IEEE Transactions on Signal Processing • IEEE Transactions on Wireless Communications • IEEE Transactions on Communications • Plos One • Sadhana • IEEE International Conference on Communications

ACHIEVEMENTS

Selected from the batch of 2015 to get prestigious **Summer Internship 2014 at CERN, Geneva, Switzerland**.

Recipient of **CSS Scholarship 2011** , MHRD, GOI.

Selected for Senior Talent Search Examination by **JBNSTS** .

REFERENCES

Dr. Kin Leung   Professor, Imperial College London, UK   `kin.leung@imperial.ac.uk`

Dr. Sheetal Kalyani   Professor, Indian Institute of Technology Madras, India   `skalyani@ee.iitm.ac.in`

Dr. Himal A. Suraweera   Senior Lecturer, University of Peradeniya, Sri Lanka   `himal.suraweera@gmail.com`

ANNEXURE

ONGOING RESEARCH PROJECTS:
- Topic: Learning beam patterns to serve multiple non-stationary users using mmWave MIMO communication systems
- Topic: Learning to schedule users smartly using Deep Reinforcement Learning
- (Co-mentoring, IIT Madras) Topic: Energy efficient Smart City using Reconfigurable Intelligent Surface

COMPLETED RESEARCH PROJECTS

1. Deep Reinforcement Learning based Blind beam alignment for millimeter wave communication
   - Studied scenarios with multiple base stations and mobile users (UEs), utilizing only Radio Frequency fingerprints for UE
   - Achieved a data rate up to **four times** higher than traditional methods, with **no computational overhead**, compared to time-overhead and hardware constraints in brute-force and location-aided blind beam alignments, respectively

2. Online Collaborative Spectrum Sensing (CSS) for energy-efficient IoT
   - Efficiently combined individual sensing based on past performances
   - Achieved **both fewer collisions and mis-detections** compared to other CSS techniques
   - Selectively enabled the sensing of the devices that **extended the field life** of the devices

3. Rotated ReLU activation for intrinsic sparsity of Neural Networks
   - Proposed to rotate the activations (e.g. ReLU and GeLU) that provide **sparsification intrinsically** to deep networks
   - Achieved a saving of 49.1% in memory and 36.81% in the computation without any loss in accuracy in ResNet-164.

4. Native Adversarial Robustness by redesigning the first layer of the Neural Networks
   - Showed that a simple, well-designed first layer in a neural network can naturally work as an adversarial noise filter (ANF), improving its robustness
   - We have showed improved decision margins in the model's decision regions, smoother loss surfaces for better optimization, higher modified peak signal-to-noise ratio (mPSNR) values at the ANF output, enhanced attenuation of high-frequency components, superior denoising performance in Gaussian noise compared to baseline architectures.

5. Application of Binary Neural Networks in Wireless Communication eg. Turbo Auto Encoder and Automatic Modulation Classification
   - Proposed extreme compression techniques like binarization and ternarization for Neural Decoders such as TurboAE
   - Ensemble TurboAEs give a **saving of** 16 **and** 64 **times** in memory and computation respectively with a **performance the same** as real-valued TurboAE
   - Proposed a Rotated Binarized ResNet and two Ensembled versions (i) Multilevel-classification (MC) and (ii) Bagging for **robust** Automatic Modulation Classification for **resource-constrained** edge network
   - MC with RBLResNets provided 4.75 times lower memory and 1214 times lower computation than InvoResNet
   - RBLResNet-MC achieved an adversarial accuracy of 87.25% over a wide range of SNRs better than all existing SOA

6. Information-theoretic perspective of Binary Neural Networks
   - Understanding learning dynamics of BNNs via information theory
   - Numerical experiments reveal simultaneous empirical risk minimization and representation compression phases in BNNs

7. Compression techniques for deep neural networks for MIMO detection
   - Proposed **Incremental Training** for compressing deep networks based unfolded MIMO detection algorithm to select the optimal depth while training using sparse group LASSO
   - Achieved 98.9% reduction in memory requirement and 81.63% reduction in FLOPs without compromising on BER

8. Other works
   - Proposed a Bayesian method for **Computation Efficient** Angle of Arrival Estimation where the channel noise and receiver antenna configuration change over time • Not sensitive to angle initialization • Demonstrated faster convergence
   - Studied **the optimal number of layers** for unfolding deep learning algorithms like a MIMO detection algorithm DetNet using discounted Hedge • Measured the **relative importance** of these networks

IITM-MEITY COLLABORATION

Project topic: Reduced signaling in Reconfigurable Intelligent Surfaces (RIS)
- Solves for the Beamforming, Phase Shift, and Power optimization in a RIS-aided full-duplex system as a step toward Beyond 5G communication
- The proposed two-stage Deep Reinforcement Learning (DRL) solution, capable of predicting **quantized and grouped** RIS phases, is **independent of channel state information and residual self-interference**, resulting in reduced signaling.