VAIBHAV CHOUDHARY

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SUMMARY

I am a Ph.D. student specializing in developing and theoretically characterizing model-based learning solutions for inverse problems in computational imaging and machine learning. Research interests focus on enhancing forward models and physics-based estimators across various imaging problems, including:

- Developing imaging models for particle beam microscopy, with a focus on material analysis, edge detection for segmentation, and sample topology determination, applied to semiconductor device characterization and metrology.
- Developing stereo-hyperspectral imaging for 3D scene characterization and absorption-based ranging.
- Developing physics-based probabilistic models to establish design metrics for chiplet architectures.
- Utilizing generative models, including diffusion models and coordinate-based neural networks, to solve inverse problems in imaging.

Seeking opportunities to apply expertise in computational imaging, physics-informed machine learning, computer vision, generative models, and inverse problems with a focus on metrology and material analysis.

EDUCATION

Boston University — **2021–Present**

Ph.D. in Electrical Engineering — *Boston, Massachusetts*

Advised by Dr. Vivek Goyal

Relevant Coursework: • Statistical Foundations of Learning Theory • Machine Learning • Stochastic Processes • Computational Imaging and Inverse Problems • Analysis

North Carolina State University — **2019–2021**

M.S. in Electrical Engineering — *Raleigh, North Carolina*

Advised by Dr. Dror Baron

Relevant Coursework: • Neural Networks • Computer Vision • Optimization Theory • Data Science • Informatiuon Theory • Linear Algebra

Netaji Subhas Institue of Technology, Delhi University — **2014–2018**

B.E. in Electronics and Communication Engineering — *Delhi, India*

AWARDS AND HONORS

- **Distinguished Electrical Engineering Fellowship**, Department of Electrical and Computer Engineering, Boston University, 2021.
- Third Prize, National Hackathon organized by India Smart Grid Forum and Tata Power, 2017
- First Prize, IEEE Hardware Hackathon, 2017

RESEARCH

1. **Physics-Informed Quantitative Microscopy** (*Manuscript in preparation*)
    - **Objective:** Develop new quantitative and physics-informed methods for secondary electron imaging in particle beam microscopy.
    - Designed a maximum-likelihood estimator using Poisson mixture modeling to jointly predict material properties and the incident beam width of the microscope.

- Created quantitative imaging models to predict edge locations and segment materials, identifying boundaries between different materials and analyzing performance gains using Fisher information analysis.

2. **Destructive Imaging in Particle Beam Microscopy**
    - **Objective:** Develop new imaging techniques to minimize surface damage and sample modification when imaging under a high dose, resulting in low-noise, high-fidelity images.
    - Developed a forward model to explain atom sputtering and surface damage, leading to reduced fidelity in the captured images.
    - Currently developing a diffusion model-based estimator to predict surface topology of undamaged samples using paired low- and high-dose images.
3. **Passive Stereo-Hyperspectral Imaging**
    - **Objective:** Design a new imaging model that integrates hyperspectral and stereo imaging techniques, improving predictions of temperature, material composition, depth, and texture for enhanced 3D scene characterization.
    - Currently developing an attention-based encoder-decoder model to process stereo-hyperspectral infrared data, leveraging the strengths of both imaging modalities and incorporating a physical loss function that accounts for optical properties like temperature, emissivity, depth, and light absorption.
4. **Active Interposer-based Multi-Chiplet Architectures** (in collaboration with MARS Lab, Washington State University, Pullman)(*under review*)
    - **Objective:** Develop an analytical model to establish key design metrics for chiplet architectures aimed at large-scale CNN inference tasks, evaluating the new design strategy on latency, energy consumption, and fabrication costs.
    - Developed a probabilistic model to characterize the thermal performance of chiplet systems and conducted the first-ever joint performance-thermal-accuracy trade-off analysis.
    - Demonstrated the effectiveness of the new design strategy, achieving an average 2.95× reduction in latency, 3.45× reduction in energy, and significantly lower fabrication costs and carbon footprint compared to state-of-the-art counterparts.

PROJECTS

Bit banging SPI, I2C on the Programmable Real-Time Unit on Beaglebone Black

- Funded under the *Google Summer of Code*
- Developed and implemented Master Controller Drivers for SPI and I2C, as well as firmware for bit-banging these protocols on the PRU, to provide additional serial interfaces to the BeagleBone Black without the need for costly hardware controllers or excessive CPU usage.

SpaceX Hyperloop pod design challenge

- Represented India in the competition finals as part of Hyperloop India, ranking among the top 35 teams globally.
- Designed and implemented the communications center and Controller Area Network (CAN) system to control the pod's movement.

Collection Style Transfer using Cycle-GANs

- Developed a CycleGAN-based style transfer algorithm in PyTorch, successfully achieving style transfer between different artists such as Monet, Van Gogh, and Ukiyo-e.
- Implemented Cycle Loss and Identity Loss with parameter fine-tuning, achieving better results than a pre-trained CycleGAN for summer-to-winter style transfer in just 50 training epochs.

ADMM Optimization based Lasso and Ridge Regression

- Implemented Lasso and Ridge Regression using the Alternate Direction Method of Multipliers (ADMM), achieving a convergence rate twice as fast as Scikit-learn on the diabetes dataset.

TEACHING

Graduate Teaching Assistant for Computer Networks **September 2024–Present**

Boston University *Boston, MA*

- Teaching, leading lab sessions, and grading for a course on computer networks.

Graduate Teaching Assistant for Machine Learning **September 2022–May 2023**

Boston University *Boston, MA*

- Teaching tutorial classes, leading discussion sessions, and grading exams for a graduate-level course of 40 students in machine learning.

Graduate Teaching Assistant for Data Science **August 2020–November 2020**

North Carolina State University *Raleigh, North Carolina*

- Delivery of course material, including setting tests, homework, and class projects for a graduate-level probability theory and data science course.

WORK EXPERIENCE

Machine Learning and Computer Vision intern **December 2018 – January 2018**

Singularity Automation *Bangalore, India*

- Running and optimizing the Tiny YOLO model for Intel Movidius and Raspberry PI.
- Track a person of interest in the frame using Tiny YOLO and intersection over union over all frames. This was further used to generate velocity vectors and analyze suspicious movements to raise an alarm.

Software and Networking Intern **June 2017 – August 2017**

Bharti Airtel *Gurugram, India*

- Planning, Installing, and programming routers for implementing the precision-time protocol in the Airtel Network.

MENTORSHIP AND OUTREACH

Assistant Instructor, Physical Computing

Google CS4HS

- Taught embedded systems design and physical computing using the BeagleBone Black to teachers and students from schools in and around Delhi as part of a Google outreach program aimed at improving computer science education at the secondary school level.

Mentor, Summer Internship Program

Texas Instruments

- Mentored 300 students in a summer internship program on microcontroller-based embedded system design as part of the Texas Instruments India University Program.

President, Nakshatra-Math and Astronomy Society

NSIT

- Served as the president of the math and astronomy society at my undergraduate institution, overseeing public outreach, fundraising, and conducting astronomy and math classes for high school students.

SKILLS

- **Programming Languages.** Python, MATLAB, C/C++
- **Tools/Packages.** PyTorch, Torch-Geometric, Scikit-Learn, Numpy, Git, LaTeX