

Neelanjana Pal, Ph.D.

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SUMMARY

AI Researcher with a Ph.D. in Electrical & Computer Engineering and 6+ years of combined research and industry experience. Specialized in agentic AI systems, **multimodal reasoning**, and RAG, with deep expertise in **uncertainty quantification**, **graph neural networks** and **scalable AI architectures**, with a strong foundation in machine learning, deep learning, and autonomous decision-making. Proven track record translating advanced theory into research-grade prototypes and enterprise-ready systems spanning agent-based workflows, LLM-powered pipelines, semantic retrieval, time-series modeling, robustness, and explainability. Prior industry experience at MathWorks includes adversarial training, neural operators, scalable CV/ML pipelines, and verification-informed AI systems. Published at CAV, FMICS, FMAS, and ICMLA; experienced cross-functional collaborator across research, product, and engineering teams.

TECHNICAL SKILLS

Agentic Frameworks: Copilot Studio, Claude Agents, LangGraph, mem0, Multi-Agent Coordination, RAG, OpenAI APIs, Hugging Face

ML / AI: Multimodal Reasoning, Uncertainty Quantification, Graph Neural Networks, Causal Inference & Attribution, Formal Verification, Adversarial ML, Fourier Neural Operators, XGBoost, LightGBM, Time-Series, Computer Vision, Semantic Segmentation, Explainability (SHAP, Grad-CAM)

Libraries & Tools: PyTorch, TensorFlow, Keras, scikit-learn, NumPy, Pandas, ONNX, Elasticsearch, Postgres, Docker, Git

Languages & Platforms: Python, MATLAB, C#, Go · AWS, Azure ML, GCP, Linux

SELECTED PUBLICATIONS

- Robustness verification of DNNs using star-based reachability analysis with variable-length time series input — *FMICS 2023*
- Formal verification of LSTM-based audio classifiers: A star-based approach — *FMAS 2023*
- Robustness verification of semantic segmentation neural networks using relaxed reachability — *CAV 2021*
- Verification of piecewise deep neural networks: a star set approach with zonotope prefilter — *Formal Aspects of Computing 2021*
- DeepECO: Applying deep learning for occupancy detection from energy consumption data — *ICMLA 2019*

WORK EXPERIENCE

Princeton IT Services, Inc. · *AI Researcher*

Jan 2026 – Present

- Designing a multi-agent architecture for mid-size enterprise workflows, including document routing, cross-department search, and approval chain automation, integrating MS Copilot and Claude-based agents into a unified orchestration layer.
- Leading a team of 2 on Claude-based agentic systems for enterprise clients; conducting applied research on **autonomous reasoning, planning, and multi-agent coordination** with evaluation metrics covering agent performance, robustness, and scalability.
- Architecting **RAG pipelines and SLM architectures** for scalable, real-world enterprise applications; developing experimental prototypes validated through iterative design reviews and milestone evaluations with senior technical leadership.
- Designing **data posture and telemetry infrastructure** for agent observability, covering pipeline monitoring, behavioral tracing, and governance across multi-agent workflows.

Independent AI/ML Research & Prototyping · *AI/ML Researcher (Collaborative)*

Oct 2025 – Present

- Designing a hybrid **multimodal** retrieval architecture combining embedding-based semantic vector search with **causal** user-behavior signals (browsing patterns, implicit feedback, interaction histories) for vibe-based product discovery.
- Improving cluster coherence (silhouette scores) by building **LLM-powered** product clustering pipelines integrating Elasticsearch full-text retrieval with **graph-structured** product relationships for semantic grouping of inventory.
- Reducing cold-start errors in personalized recommendation by leveraging **causal** interaction histories as ranking features within a hybrid tag + embedding retrieval system.

MathWorks · *Senior ML Engineer / Senior Software Engineer*

Jan 2024 – Sep 2025

- Improved Copilot subsystem retrieval precision while reducing LLM token usage by implementing a **graph neural network**-inspired heat kernel diffusion approach (KG2RAG) on Simulink dependency graphs.
- Improved SLA adherence and reduced workload imbalance across four engineering teams by framing support-case distribution as a **causal** time-series problem; applied **SHAP causal attribution** to identify latent demand drivers in XGBoost/LightGBM models integrated into an optimization framework for engineer allocation.
- Improved robustness under adversarial conditions across **multimodal** domains (CV + time-series) by designing adversarial training pipelines (FGSM, BIM, PGD) and embedding **uncertainty quantification** checks into production ML workflows.
- Developed Fourier Neural Operator (FNO) architectures for time-series forecasting under distribution shifts.

- Deployed an internal OpenAI Chat Completions mock API cutting token spend while accelerating cross-team prototyping.
- Built a consumer product safety classifier parsing ingredient lists, training custom embeddings from scratch, and applying **causal interpretability** (SHAP token attribution) to surface features driving carcinogenicity predictions.
- Built CV pipelines for ecological monitoring (Faster R-CNN, YOLO, U-Net, DeepLab) with explainability (Grad-CAM, feature attribution) validated against robustness checks across augmented datasets.

veriVITAL Lab, Vanderbilt University · *Graduate Research Assistant*

Aug 2019 – Dec 2023

- Advanced **uncertainty quantification** for safety-critical AI by developing star-set reachability analysis for DNNs, providing provable robustness bounds with 20–1400× faster runtimes than state-of-the-art tools; published at CAV, FMICS, FMAS.
- Extended **formal verification** to **multimodal** neural architectures (semantic segmentation, LSTMs, U-Net, autoencoders), spanning research using relaxed reachability and zonotope pre-filtering, scaling robustness verification beyond standard classifiers.
- Applied SHAP-based **causal feature attribution** in DeepECO to identify energy-signature drivers of occupancy from smart-meter time-series, demonstrating causal inference in safety-relevant non-intrusive detection.
- Led VNNComp 2020–2023 benchmarking; collaborated with Collins Aerospace and MathWorks to translate formal verification methods into scalable engineering tooling on AWS HPC using modular Docker codebases.

MathWorks · *Intern, Deep Learning Verification & Validation*

May – Sep 2022

- Shipped formal verification features in MATLAB R2022b, enabling engineers to apply **uncertainty quantification** and robustness checks to production AI models; collaborated with ETH Zurich, Vanderbilt University, and Collins Aerospace.

Rockwell Automation (Shanghai, China & India) · *Project Engineer*

May 2015 – June 2017

- Delivered automation solutions from design to commissioning for global clients (Hindustan Unilever, Colgate Palmolive, MARS); ensuring reliable large-scale system integration across manufacturing plants.
- Selected as 1 of 5 engineers nationally (India) and 1 of 14 globally (the only female in the cohort), for a 3-month international training in Shanghai; collaborated on a capstone project guided by industry experts and presented the technical outcomes in a cross-cultural setting to global leadership.

ADDITIONAL EXPERIENCE

Vanderbilt University · *Teaching Assistant*

2017 – 2019

- Mentored 60+ undergraduate and graduate students across Programming, Digital Logic, Circuits, and AI Verification courses; guided hands-on robustness analysis of neural networks using the NNV tool, and served as Head TA for two years.

Vanderbilt University · *Mentorship*

2020 – 2021

- Supervised interns and undergraduate researchers in ML verification and GANs, providing hands-on guidance on experimental design and implementation; measurably expanded the number, variety, and quality of NNV evaluation case studies available to the lab.

MathWorks · *Mentor & Leadership*

2024 – 2025

- Scaled ML knowledge across US and UK offices by creating and delivering technical training on Machine Learning, Deep Learning, and Image Processing for Support Engineers. Mentored MathWorks interns and Georgia Tech undergraduates through MathWorks' mentorship program, guiding projects spanning ML pipelines and applied deep learning.

EDUCATION

Ph.D., Electrical & Computer Engineering · Vanderbilt University

2023

M.S., Electrical & Computer Engineering · Vanderbilt University

2020

B.E.E., Electrical Engineering · Jadavpur University, Kolkata

2015

AWARDS & SERVICE

Awards: Research Assistance Fellowship (ISIS, Vanderbilt, 2019–2023) · Graduate School Travel Award (2023) · Summit on Foundations of Data Science Travel Grant, San Francisco (2019) · Summer School on Formal Techniques Student Grant (2021, 2022)

Reviewer: Women in Machine Learning 2024 · Science of Computer Programming 2024 · CVPR, ICCV, AAAI, CAV, EMSOFT, ICCPS, HSCC (2020–2023)

Workshops: Grace Hopper Celebration (TA, 2024) · International Women in Engineering Day (Presenter, 2024) · MATLAB Expo 2024

Community: Global Shapers Alumni Nashville (Curator & Vice-Curator, 2020–2023) · Climate Reality Leader, Al Gore's Climate Reality Project (2022)