

Emadeldeen Hamdan

Efficient deep learning through signal processing: transform-domain operators, multiplication-reduced networks, hardware-aware deployment

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RESEARCH SUMMARY

Ph.D. candidate in Electrical and Computer Engineering at the University of Illinois Chicago (Expected Dissertation Defense: January 2027) building neural networks that are efficient *by construction*. I replace expensive learned operations with fast signal-processing transforms (Walsh–Hadamard, DCT, wavelets), producing multiplication-reduced convolutions, decorrelated attention for Vision Transformers, and transform-fused state-space (Mamba) models, and carry them through to real-time and FPGA deployment. I validate these methods on demanding applications: prostate MRI, neural-oscillation tracking, and wildfire remote sensing. 10+ papers, including IJCAI and IEEE TBME. Seeking Research Scientist roles in efficient / on-device ML.

EDUCATION

University of Illinois Chicago

Ph.D., Electrical and Computer Engineering

Chicago, IL

Jan. 2023 – May 2027 (expected)

- Thesis: *Orthogonal Transform-Based Deep Learning for Efficient and Scalable Imaging Applications*.

University of Illinois Chicago

B.S., Electrical and Computer Engineering, Magna Cum Laude; Dean's List 2021, 2022

Chicago, IL

Sep. 2020 – May 2022

RESEARCH EXPERIENCE

Graduate Research Assistant, Electrical and Computer Engineering

Jan. 2023 – Present

University of Illinois Chicago

Chicago, IL

- Designed a Hadamard-transform-assisted convolutional operator that cuts multiplications by up to 50% with no loss in accuracy on CIFAR100 and Tiny-ImageNet (top-1 56.1% vs. 55.3% baseline) (In review ICASSP 2027).
- Co-developed DCT-based decorrelated attention for Vision Transformers, reducing params/FLOPs to 25.45M/4.18G while improving accuracy on ImageNet1K (IJCAI 2026).
- Built a lightweight dual-branch complex-valued network for real-time phase estimation of neural oscillations and implemented it on FPGA with 283 μ s latency and 12 degrees improvement over ecHT in phase estimation (IEEE TBME 2025).
- Created an open-source multimodal wildfire benchmark (visible, IR, multispectral; 7 classes, 30K+ images in each major class) with over 20k downloads in Kaggle and Walsh–Hadamard models for peatland fire detection with $6.6 \times$ fewer FLOPs than prior methods and improved cross-domain generalization. (ICIP 2026 & SIVP Journal 2026)

Research Assistant, Machine and Hybrid Intelligence Lab

May 2025 – Present

Northwestern University

Chicago, IL

- Developing a Hadamard-fused Mamba-UNet for zonal-aware prostate cancer segmentation and detection; Dice of 0.95 (TZ) and 0.85 (PZ) on PI-CAI, +2 and +5 points over the strongest prior baseline, at 33M parameters with an average speed of 4 seconds per patient. (In review SPIE Medical Imaging 2027)
- Working on accelerated MRI reconstruction and the role of non-IID weight initialization in reconstruction ambiguity (In review CVPR 2027).

PUBLICATIONS

Published and Accepted

- [1] Pan, **E. Hamdan**, et al. “Discrete Cosine Transform-Based Decorrelated Attention for Vision Transformers.” *International Joint Conference on Artificial Intelligence (IJCAI)*, 2026.
- [2] **E. Hamdan**, et al. “Toward Generalizable Deep Learning-Based Peatland Fire Detection via Walsh–Hadamard Transform and Domain Adaptation.” *Signal, Image and Video Processing (SIVP)*, Springer, 2026.
- [3] **E. Hamdan**, et al. “Hybrid Multi-Dimensional MRI Prostate Cancer Detection via Hadamard-Based Bias Correction and Residual Networks.” *IEEE Engineering in Medicine and Biology Conference (EMBC)*, 2026.
- [4] **E. Hamdan**, et al. “Large-Scale Open-Source Image and Video Dataset for Robust Wildfire Detection and Classification.” *IEEE ICIP Workshop on HydroImaging*, 2026.
- [5] **E. Hamdan**, et al. “Real-Time Instantaneous Phase Estimation Using a Deep Dual-Branch Complex Neural Network.” *IEEE Transactions on Biomedical Engineering (TBME)*, 2025.
- [6] **E. Hamdan**, et al. “Diffusion Model-Based Assisted Attacks on PUF-Secured Telematics and Medical Devices.” *IEEE MTT-S International Microwave Biomedical Conference (IMBioC)*, 2025.

- [7] Ren, Sun, De Silva, Pan, Nie, **E. Hamdan**, et al. “Reconfigurable Electromagnetically Unclonable Functions Based on Graphene RF Modulators.” *ACS Nano*, 2025.
- [8] Hong, **E. Hamdan**, et al. “Wildfire Detection via Transfer Learning: A Survey.” *Signal, Image and Video Processing (SIViP)*, Springer, 2024.
- Under Review
- [9] **E. Hamdan**, et al. “Rethinking Multiplication in Neural Networks with Hadamard Transform-Assisted Operators.” *Under review, ICASSP 2027*.
- [10] **E. Hamdan**, et al. “Zonal-Aware Prostate Cancer Detection and Classification via Hadamard-Fused Mamba-UNet.” *Under review, SPIE Medical Imaging 2027*.
- [11] **E. Hamdan**, et al. “Beyond IID Initialization: Understanding Ambiguity and Reconstruction in Deep Neural Networks.” *Under review, CVPR 2027*.

AWARDS AND HONORS

- **NASA Beyond the Algorithm Challenge**, Top 9 Finalist (2025): transform-based layers (Hadamard, Haar) for quantum and in-memory computing.
- **NASA MSI Incubator Wildfire Climate Tech Challenge**, Runner-Up (2024): vision system for early wildfire detection.
- **NSF I-Corps (POSE)**, Entrepreneurial Lead (2024): customer discovery for hardware-aware ML (hls4ml).

TECHNICAL SKILLS

- **Efficient ML**: transform-domain layers (WHT, DCT, wavelets), multiplication-free operators, low-complexity architecture design, quantization, pruning, knowledge distillation.
- **Hardware & Deployment**: GPU (CUDA), CPU, FPGA (hls4ml), real-time inference.
- **Models**: CNNs, Vision Transformers, State-Space Models (Mamba), U-Nets, diffusion models (DDPM), complex-valued networks
- **Languages & Frameworks**: Python, PyTorch, TensorFlow, C, MATLAB, Linux, Git

SERVICE, TEACHING, AND INDUSTRY

- **Assistant Editor**, *Signal, Image and Video Processing* (Springer), Jul. 2025 – present.
- **Teaching Assistant**, UIC (2023 – present): Digital Signal Processing, Neural Networks, Image Analysis & Computer Vision, Pattern Recognition (on-campus and online M.Eng. sections).
- **Secretary**, IEEE Communications Society UIC Student Chapter (2025 – present).
- **Electrical Engineer**, L3DFX LLC, Bolingbrook, IL (May 2022 – Jan. 2023): signal-processing circuits and microcontroller-based embedded control systems.