

Muhammad Haseeb

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RESEARCH INTERESTS

Mechanistic Interpretability: Analyzing internal circuit evolution for domain generalization and to understand representational collapse in Federated Learning.

Domain Generalization: Adapting Models to distribution shifts through pruning to identify sparse subnetworks that preserve domain-invariant representations.

Efficient ML: Compression methods (pruning, quantization) to save compute and memory without loss in performance.

EDUCATION

Lahore University of Management Sciences (LUMS)

Sep 2022 – May 2026

B.S. Computer Science

Relevant Coursework: Machine Learning, Deep Learning, Computer Vision, AI on Edge Devices, Advanced Topics in ML, LLM Systems, Linear Algebra, Probability.

PUBLICATIONS

– BaCP: Backbone Contrastive Pruning for Preserving Representations in Extremely Sparse Neural Networks.

Mohammad Haroon Khawaja, **Muhammad Haseeb**, Mohammad Fatim Shoaib, Muhammad Tahir. Submitted to *AAAI 2025*.

RESEARCH EXPERIENCE

Research Assistant

Jan 2025 – Present

Centre for Urban Informatics, Technology and Policy (CITY), LUMS

Advisors: Dr. Muhammad Tahir, Dr. Zubair Khalid

– Backbone Contrastive Pruning (BaCP):

- Contributed to a generalized pruning framework to merge standard pruning criteria with contrastive learning to prevent representational collapse.
- Designed a **multi-objective loss function** that aligns sparse embeddings with pretrained, fine-tuned, and historical snapshot references to maintain feature consistency.
- Maintained accuracy comparable to dense baselines at up to **99% sparsity**, outperforming standard unstructured pruning approaches across ViTs/CNNs/Language Models.

– Mechanistic Analysis of Federated Learning:

- Applied Mechanistic Interpretability to diagnose FedAvg failures on Non-IID data, re-framing the statistical concept of weight divergence as Circuit Collapse—degradation of functional sub-networks in a model.
- Identified distinct failure modes through circuit tracking: Structural Drift, where valid topological pathways shift location, and Destructive Interference, where disjoint “specialist” circuits from different clients overwrite each other during aggregation.
- Demonstrated that while local circuits remain functional, the global aggregation of conflicting internal mechanisms creates induced polysemy, preventing the convergence of a coherent global model.

– Domain Generalization & Interpretability:

- Working on reliable AI by constructing models from understood, generalizable building blocks (circuits) rather than treating them as black boxes.
- Decomposing deep neural networks into constituent circuits to investigate whether domain shift failures arise from core pathways relying on shortcuts or from noise in non-essential pathways disrupting performance.
- Exploring the use of cross-domain data as a diagnostic probe to reveal generalizable, core circuits within a standard pre-trained model.
- Previously, developed a framework using visual queries in ViTs trained via group relative query optimization

to improve domain generalization, achieving a **3% accuracy gain** on the PACS dataset compared to empirical risk minimization.

– **Quantization of Diffusion Models:**

- Proposed **Log-SNR Conditioned Temporal Dynamic Quantization** to handle non-stationary activations, achieving a **55% reduction in LPIPS** on PixArt- α by conditioning predictor networks on physical signal dynamics rather than raw timesteps.
- Implemented Hessian-based optimization (GPTQ and QroNos) for **4-bit weight compression**, utilizing second-order curvature information to mitigate quantization errors.

Research Intern

May 2025 – Aug 2025

University of Illinois Urbana-Champaign (UIUC)

- Investigated LLM-based heuristics for automated `#ifdef` guard insertion in C codebases.
- Explored the use of large language models for software debloating and code dependency analysis.
- Contributed to the development of a VS Code extension supporting a C-to-Rust translation pipeline.

Research Assistant

Jan 2025 – Aug 2025

Computer Vision & Graphics Lab, LUMS

– **KL Aware Quantization (KLAWQ):**

- Proposed an augmented GPTQ framework that integrates knowledge distillation and second-order curvature information to optimize a combined MSE+KL+CE objective, achieving a **30% reduction in perplexity** over standard baselines.

– **Single-Image Camera Calibration (SOFI-UGCL):**

- Developed a hybrid method combining a Multi-Scale Deformable Transformer with geometric post-processing to recover full camera projection matrices (intrinsic and extrinsic) from single images.

INDUSTRY EXPERIENCE

OSS Engineer

Dec 2025 – Present

DatacurveAI (YC S24)

- Designing and implementing complex coding challenges for AI model training by resolving issues and engineering new features across various open-source machine learning repositories.

Machine Learning Engineer

Jul 2025 – Oct 2025

Innova Tech

- Automated data annotation pipelines and refined training architectures to achieve a **4% accuracy gain**, while implementing ONNX and TensorRT quantization to reduce memory footprint by **40%** on edge devices.

TEACHING EXPERIENCE

Teaching Assistant

Sep 2025 – Dec 2025

CS436: Computer Vision, LUMS

- Designed and supervised assignment on transfer learning and multithreaded C++ object detection pipeline, and mentored 40 student groups in building a virtual tour application using Structure from Motion.

SKILLS & OPEN-SOURCE

Technical Skills: Python, C, C++, Rust, SQL, TypeScript; PyTorch, Transformers, ONNX, TensorRT, diffusers, adapters.

Open-Source Contributions:

- **pytorch-image-models:** Added F1, precision, and recall metrics to evaluation and training pipelines for both single-GPU and distributed setups.
- **adapters:** Implemented PEFT support for Group Query Attention models, fixing tensor mismatch issues.