Ahmed Imtiaz Humayun

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Research Interests

I'm interested in understanding the effect of data (real/synthetic) and objectives on foundation models, to enhance their robustness and interpretability. I use function geometry to analyze training dynamics, characterize models, and evaluate post-training behavior to improve the utility of neural networks and foundational generative models.

Education

Rice University, Houston, TX — Aug 2019 - Present
M.S. & Ph.D. in Electrical and Computer Engineering
Advisor: Prof. Richard Baraniuk
Thesis: A Fundamental Understanding of Deep Network Function Geometry

Bangladesh University of Engineering and Technology (BUET) — Sep 2017
Bachelor, Electrical and Electronic Engineering

Industry Experience

Google Research, *Student Researcher Intern* — Aug 2023 - Present

- *Local geometric characterization of T2I foundation models for attribution, guided generation, OOD/memorization detection and evaluation.* Work with Deepak Ramachandran, Junfeng He, Katherine Heller, Cristina Vasconcelos, Mohammad Havaei, and Negar Rostamzadeh.
- *Quantifying the utility of fine-tuning datasets using the pre-trained geometry of T2I models.* With Bryant Gipson, Andrew Smart, Atoosa Kasirzadeh, M. Havaei, N. Rostamzadeh.
- *Sparse pre-training of LLMs without loss of per FLOP performance.* Work with Karolina Dzugaite, Utku Evci and Amir Yazdanbaksh.
- *Using DNN geometry dynamics to explain plasticity loss during online learning.* With Pablo Samuel Castro.

Notable Papers — Full List: bit.ly/imtiaz_gscholar

Deep Networks Always Grok and Here is Why
AI Humayun, R Balestriero, R Baraniuk
TL;DR: Grokking happens due to a phase change in the function geometry during training, for even CNNs, ResNets, LLMs.
ICML 2024 [url]

SplineCam: Exact Visualization and Characterization of Deep Network Geometry and Decision Boundary
AI Humayun, R Balestriero, G Balakrishnan, R Baraniuk
TL;DR: Proposed a scalable framework for computing, visualizing and characterizing Neural Network geometry analytically.
CVPR 2023 (Highlight, Top 2.5%) [url]

Polarity Sampling: Quality and Diversity Control of Pre-Trained Generative Networks via Singular Values
AI Humayun, R Balestriero, R Baraniuk
TL;DR: We reverse engineer the learned weights of a pre-trained generative model, to obtain novel latent space sampling distributions that produce more diverse/higher quality images with SOTA FID.
CVPR 2022 (Oral Presentation) [url]

MaGNET: Uniform Sampling from Deep Generative Network Manifolds without Retraining
TL;DR: Plug-and-play method to uniformly sample the output manifold of pre-trained GANs/VAEs using network weights.
AI Humayun, R Balestriero, R Baraniuk
ICLR 2022 [url]

Learning Transferable Features for Implicit Neural Representations
K Vyas, **AI Humayun**, A Dashpute, R Baraniuk, A Veeraraghavan, G Balakrishnan
TL;DR: Novel shared encoder architecture to make the coarse geometry of functions learned by INRs transferrable.
NeurIPS 2024 [url]

Self-Consuming Generative Models Go MAD
S Alemohammad*, J Casco-rodriguez*, L Luzi, **AI Humayun**, H Babaei, D Lejune, A Siahkoohi, R Baraniuk
TL;DR: First evidence of image generative models trained on their own synthetic data undergoing model collapse.
ICLR 2024 [url]

Provable Instance Specific Robustness via Linear Constraints
AI Humayun*, J Casco-rodriguez*, Randall Balestriero, R Baraniuk
TL;DR: Obtain zero-shot robustness for a set of samples through weight perturbation via analytical constraints.
ICML 2023 Workshop on AdvML Frontiers [url]

What Secrets Do Your Manifolds Hold? Understanding the Local Geometry of Generative Models
AI Humayun, I Amara, C Vasconcelos, D Ramachandran, K Heller, G Farnadi, N Rostamzadeh, M Havaei
TL;DR: Local function geometry can distinguish aesthetics, diversity and memorization; can also be used to control generation.
ArXiv 2024 [url]

Self-Improving Diffusion Models using Synthetic Data
S Alemohammad, **AI Humayun**, S Agarwal, J Collomosse, R Baraniuk
TL;DR: Achieve SOTA generation for diffusion models using only their synthetic data; also mitigates model collapse.
Arxiv 2024 [url]

Selected Softwares

SplineCAM, A PyTorch toolbox for exact computation and visualization of a deep network's input space partition geometry and decision boundary. [github link]

LDM Geometry, A JAX library for computing local geometric descriptors from Stable Diffusion/Imagen scale foundational T2I models, to characterize datasets, prompts or latent vectors. [google internal]

Research Experience

Rice University, Houston, TX — May 2020 - Present
Graduate Researcher — Advisor: Prof. Richard Baraniuk

- Developing theoretically derived techniques for understanding and improving deep neural networks.
- Publications in NeurIPS 24, ICML 24, ICLR 24, CVPR 23 Highlight, CVPR 22 Oral, ICLR 22, ICASSP 22
- *News:* Communications of the ACM, New York Times, The Telegraph, New Scientist, Futurism, WIRED.

Bengali.AI, Dhaka, BD — Dec 2017 - Present
Co-founder and Chief

- Bengali.AI is a non-profit open-source research initiative that I have founded, to accelerate Bengali Vision-NLP research. We crowdsource datasets and open-source them through online competitions.
- Awarded Grants: 50K USD Kaggle Research Grant for ASR Competition, BRACU-Bangladesh Research Grant for ASR, Kaggle Research Grant for OCR
- Datasets: 2000 Hour out-of-distribution ASR dataset crowd-sourced from 24K+ Bengali speakers from India and Bangladesh (INTERSPEECH 23), Document Analysis dataset with 700K polygon annotation (ICDAR 23), Grapheme Recognition Dataset (ICDAR 21).
- Kaggle Competitions: ASR '23, OCR '23, GEC '23, ASR '22, OCR '20.
- News: Technology.org, The Business Standard, The Daily Star, Prothom Alo, The Front Page.

Bangladesh University of Engineering and Technology, Dhaka, BD — Sept 2017 - July 2019
Research Engineer, Digital Health Lab

- Developed novel Linear Phase and Zero Phase CNNs with wide applications in time-series deep learning and biosignal domain adaptation. Jointly with Human Machine Intelligence Group at Bosch Research.
- Publications: JBHI 20, US Patent 19, INTERSPEECH 18, EMBC 18, BHI {18,19}.

Honors & Awards

- **Kaggle Research Grant**, for Out-of-distribution ASR Comp. 2023.
- **D2K Fellowship**, Rice University Fall 2022.
- **Kaggle Community Host Award**, for Bengali.AI Speech Recognition Comp. 2022.
- **Loewenstern Fellowship**, Rice University, 2019-21.
- **Kaggle Research Grant** for Bengali.AI OCR Comp. 2019-20
- **D2K Project Showcase Winner**, Rice University 2019
- **Rice University Graduate Fellowship**, 2019-2020.
- **ISCA Student Travel Grant** for INTERSPEECH 2018
- **IEEE Signal Processing Cup 2017** Honorable Mention for Real-Time Beat Tracker
- **Young Innovator of the Year**, Falling Walls Lab 2016, Berlin.

Invited Talks

- **Deep Networks Always Grok and Here is Why**, Google Research, Host: Alex Paul
- **Dynamics of Deep Neural Network Linear Regions**, Google Deepmind, Host: Hugo Larochelle
- **Self-consuming Generative Models and Open Sourcing**, Eye on AI Podcast, Host: Craig Smith
- **Exact Visualization of Deep Network Geometry**, ONR MURI Monthly, Host: Pratik Patel
- **Exact Visualization of Deep Network Geometry**, Cohere for AI, Host: Nahida Sultana
- **Polarity Sampling: Controllable Generation For Free**, FAIR, Host: Pascal Vincent
- **Controlling Generative Models via Spline Theory**, FAIR, Host: Ari Morcos

Featured News

- **ACM Comm.**, Sept 2024, Training Neural Networks to Grok. [url]
- **New York Times**, Aug 2024, When A.I.'s Output Is a Threat to A.I. Itself. [url]
- **The Telegraph**, April 2024, AIs 'Mad Cow' Disease Problem. [url]
- **Yahoo News**, April 2024, AIs 'Mad Cow' Disease Problem. [url]
- **New Scientist**, July 2023, Self-consuming generative models go MAD. [url]
- **Futurism**, July 2023, AI loses its mind after training on AI generated data. [url]
- **Tom's Hardware**, July 2023, Generative AI goes MAD, [url]
- **The Front Page**, Jan 2023, Democratizing Bengali Language Technology '71 years after '52. [url]
- **The Business Standard**, Dec 2022, Bengali.AI: Democratizing AI Research in Bengali [url]
- **The Daily Star**, Nov 2022, Meet the Bengali.AI [url]
- **Somoy TV**, Nov 2022, on Bengali.AI 2000 hrs Speech Rec. Dataset [url]
- **NVIDIA Dev Blog** on Bengali.AI, Dec 2020, Grandmaster Series by Bojan Tunguz [url]
- **Technology.org**, Dec 2019, Bengali.AI Grapheme Recognition Challenge [url]
- **IEEE SP Magazine**, July 2017, Embedded Systems Feel the Beat, IEEE Signal Proc. Cup [url]
- **BBC Media Action**, Jan 2017, Project AudoVisor- wearable blind-aid [url]
- **The Asian Age**, Oct 2016, Falling Walls Lab award winner [url]

Skills

Python, Pytorch, Pytorch-JIT, Tensorflow, JAX, Graph-tool, C/C++, Matlab, Mitsuba, Blender, QT, Manim

Community Service

- **Reviewer**, NeurIPS 24, ICLR 24, ECCV 24, CVPR {24,23}, ICCV 23.
- "What Is the Future of Signal Processing?", **IEEE Signal Processing Magazine**, Nov 2017 [url]
- **Founding Moderator**, Bengali.AI Community of 11k+ AI/ML enthusiasts from Bangladesh [url]

Patents

Method and System for Detecting Abnormal Heart Sounds
S Ghaffarzadegan, Z Feng, **AI Humayun**, T Hasan
Assignee Bosch GmbH in US, Germany and China, 2019 [url]
For novel contributions on Linear Phase CNNs and their application as learnable filter banks.

Other Papers

Rethinking Sparse Scaling Through the Lens of Average Parameter Count
T Jin, **AI Humayun**, U Evci, S Subramanian, A Yazdanbakhsh, D Alistarh, GK Dziugaite
Pre-print 2024

ScaLES: Scalable Latent Exploration Score for Pre-Trained Generative Networks
O Ronen, **AI Humayun**, R Balestriero, R Baraniuk, Bin Yu
ArXiv 2024 [url]

On The Local Geometry of Deep Generative Manifolds
AI Humayun, I Amara, C Schumann, N Rostamzadeh, M Havaei
ICML 2024 GRaM [url]

Deep Networks Always Grok and Here is Why
AI Humayun, R Balestriero, R Baraniuk
ICML 2024 HiLD [url]

Grokking and the Geometry of Circuit Formation
AI Humayun, R Balestriero, R Baraniuk
ICML 2024 W. Mechanistic Interpretability [url]

What Secrets Do Your Manifolds Hold?
AI Humayun, M Havaei, N Rostamzadeh
CVPR 2024 ReGenAI [url]

OOD-Speech: A Large Bengali Speech Recognition Dataset for Out-of-Distribution Benchmarking
FR Rakib, SS Dip, S Alam, N Tasnim, MIH Shihab, +7 authors, AS Sushmit†, **AI Humayun**†
INTERSPEECH, 2023 [url]

BaDLAD: A Large Multi-Domain Bengali Document Layout Analysis Dataset
MIH Shihab, MR Hassan, M Rahman, SM Hossen, +11 authors, AS Sushmit†, **AI Humayun**†
ICDAR, 2023 [url]

No More than 6ft Apart: Robust K-means via Radius Upper Bounds
AI Humayun, R Balestriero, A Kyrillidis, R Baraniuk
ICASSP 2022 [url]

Exact Visualization of Deep Neural Network Geometry and Decision Boundary
AI Humayun, R Balestriero, R Baraniuk
NeurIPS 2022 Workshop on Symmetry and Geometry in Neural Representations [url]

Bengali Common Voice Speech Dataset for Automatic Speech Recognition
S Alam, A Sushmit, Z Abdullah, S Nakkhatra, +3 authors, T Reasat, **AI Humayun**
ArXiv, 2022 [url]

A Large Multi-Target Dataset of Common Bengali Handwritten Graphemes
S Alam, T Reasat, AS Sushmit, SM Siddique, F Rahman, M Hasan, **AI Humayun**
ICDAR 2021 [url]

Compressed Representations of Variable-Length Sequences Using Recurrent Neural Tangent Kernels
S Alemohammad, H Babaei, R Balastriero, MY Cheung, **AI Humayun**, D Lejeune, L Luzi, R Baraniuk
ICASSP, 2021 [url]

Towards Domain Invariant Heart Sound Abnormality Detection using Learnable Filterbanks
AI Humayun, S Ghaffarzadegan, Z Feng and T Hasan
IEEE Journal of BHI, 2020 [url]

An Ensemble of Transfer, Semi-supervised and Supervised Methods for Pathological Heart Sound Classification
AI Humayun, MT Khan, S Ghaffarzadegan, Z Feng and T Hasan
INTERSPEECH 2018 [url]

Learning Front-end Filter-bank Parameters using Convolutional Neural Networks
AI Humayun, S Ghaffarzadegan, Z Feng and T Hasan
IEEE EMBC 2018 [url]

Detection of Junctional Ectopic Tachycardia by Central Venous Pressure
X Tan, Y Dai, **AI Humayun**, H Chen, G Allen, P Jain
AI in Medicine Conference, 2021 [url]

A Novel Algorithm for Early Detection of Junctional Ectopic Tachycardia in Patients With Congenital Heart Disease
H Babaei, S Barua, R Patel, Y Dai, **AI Humayun**, M Paciuc, M Stauffer, V Gagne, C Rusin, P Jain
Pediatric Critical Care Medicine, 2020 [url]

X-Ray Image Compression Using Convolutional Recurrent Neural Networks
AS Shahriyar, S Zaman, **AI Humayun**, T Hasan and MIH Bhuiyan
IEEE Conf. of Biomedical Health Informatics, 2019 [url]

NumtaDB - Assembled Bengali Handwritten Digits
S Alam, T Reasat, RM Doha, **AI Humayun**
ArXiv 2018 [url]

Predictive Real-time Beat Tracking from Music for Embedded Application
IA Hussaini, **AI Humayun**, SI Foysal, S Alam, R Hyder, SS Chowdhury and MA Haque
IEEE Multimedia Information Processing and Retrieval (MIPR), 2018 [url]