Md Abdur **Rahaman**

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Education

Ph.D. Computational Science and Engineering | Expected Fall 2024 | Advisor: Dr. Vince Calhoun

Georgia Institute of Technology, GA, USA

M.Sc. Computer Science, July 2019

University of New Mexico, NM, USA

Research Interests

Machine Learning, Multi-modal Fusion, Reinforcement Learning, RLHF, Computer Vision, Health AI, Bi-clustering, Data Mining, NLP

Experience

Georgia Institute of Technology *Atlanta, GA*

Graduate Research Associate *Jun 2019 - present*

I design computational (AI/ML/statistical) models to extract knowledge from extensive datasets - imaging, text, health Informatics, time series, networks, etc. I've worked on AI challenges for learning voluminous, sparse, and high-dimensional data. I deployed AI solutions (RLHF-powered multi-modal, LLM + machine-log) to automate clinical service and customer experience. I have hands-on experience in model surveillance, retraining, fine-tuning, and debugging in real-world settings.

Selected Projects

Bi-clusformer: a Transformer based end-to-end biclustering framework.
- Leveraged transformer's self-attention across feature and sample dimensions to generate coherent submatrices
- A novel edge embedding enriched with graph semantics. Can capture submodules (biomarkers) of a dynamic graph.
- A cluster-guided attention for learning edge (token) inspired by ViT with computational complexity *O(kn)*

mBAM: deep multi-modal fusion with neuromorphic design
- A multi-modal latent space fusion using spatial and modality-wise attention inspired by the 'Bottleneck Attention Module'.
- Introduced a feedback loop from multi-modal neurons to unimodal. Fuse images, electronic health records, and genomics.
- Clinically deployed a large-scale distributed AI framework for initial mental disorder screening with an accuracy of 93%

Statelet: a summarization framework for time series data
- Discovers a set of 'k' most dominant and explanatory motifs from an extensive collection of time series.
- Novel implementation of Earth Mover Distance (EMD) for motifs comparison and Kernel Density Estimator (KDE) for smoothing their frequency subspace.
- Devised a probabilistic framework for selecting the summary shapes with maximum prevalence and diversity.

SpaDE: Semantic locality preserved clustering & segmentation
- Joint optimization of sample-feature distributions using an Auto-encoder architecture for instance-feature co-clustering
- Differentiable heuristic for sparsity & semantic locality to enhance 2D segmentation.
- RLHF fine-tuning with a reward model on neurologists subgrouping preference vs. clustering results from the base model.

Generative modeling with Concept activation vector (CAV) interpretability
- A latent diffusion model for 3D brain image generation & disease prediction.
- Introspect the trained model by finding active concepts - orthogonal vectors towards learned features.
- Calculate CAV (inclination) towards neuro-vision concepts: brain's region of interest (ROI), activation, and connectivity.

A robust graph neural network (GNN) for modeling Biological Networks
- Model biological networks by instantiating their components as nodes and interaction/causal inferences as the edges.
- Multi-headed self-attention to learn node embedding and an orthonormal readout for graph-level representation.
- Improve performance on downstream tasks (e.g., segmentation, classification) with insights into the underlying system.

IBRNN: Information-theoretic introspection for AI Interpretability
- Explore the theoretical upper/lower bound of information compression in RNN layers.
- CBOW for word2vec embedding of the text corpus and bi-LSTM for the downstream task.

NOKIA BELL LABS *Murray Hill, NJ*

Data Science Research Intern *Sep 2021 - Dec 2021*

Project Title: Routing failure tickets to the corresponding service team
- Built a machine-logs summarizer to compress log files with billions of lines.
- Instantiated a multi-modal LLM-log model to route IT tickets from customer error reports and machine logs.
- The deployed model achieved $\sim$ 9.7 % improvement over human performance.

University of New Mexico *Albuquerque, NM*

Research Assistant *June 2017 - Apr 2019*

- I've worked on data mining models for multivariate time series - motif detection and a summarization framework.
- Designed exhaustive-search-based solutions for biclustering and tri-clustering algorithms.

Department of Computer Science, University of New Mexico *Albuquerque, NM*

Teaching Assistant *Aug 2016 - May 2017*

A guest instructor for Linear algebra, Declarative Programming, and Computer Algorithms courses for CS undergrad students. I hold TA Office hours to help students with their assignments, grading, and tutorials on Haskell, Scheme, and GNU Emacs.

International Islamic University of Chittagong (IIUC) *Bangladesh*

Lecturer, Department of Electrical and Electronics Engineering *May 2013 - June 2016*

- Instructor for courses - C, C++ Programming Language, Data structures and Algorithms
- I worked as an Academic Advisor of a sophomore section (25 students) and mentored them for academic success.
- Undergraduate thesis advisor in Spring/Fall 2014, 2015, Spring 2016

Skills

Programming	Python, CUDA, C/C++, Scala, JAVA, C#, JavaScript, Jquery
Cloud Technologies & DB	AWS, Google Cloud, Flask, Hadoop, Spark, GCP, Hive, MySQL, BigQuery, MongoDB, PostgreSQL
Libraries	PyTorch, TensorFlow, OpenCV, Ray, Stanford CoreNLP, Pandas, NLTK, Scikit-Learn, PySpark, Hugging Face
Tools	MATLAB, R, MLOps, FMOps, XGBoost, Docker, DeepSpeed, Slurm, SPM, Git, Heroku

Selected Publications

- Md Abdur Rahaman, Zening Fu, Armin Iraji and V. D. Calhoun, 2024, "A Deep Biclustering Framework for Brain Network Analysis". In ***CVPR*** *2024 Workshop on Domain adaptation, Explainability, Fairness in AI for Medical Image Analysis.*
- Rahaman, Md Abdur, Yash Garg, Armin Iraj, Zening Fu, Jiayu Chen, and Vince Calhoun. 2022. "Two-Dimensional Attentive Fusion for Multi-Modal Learning of Neuroimaging and Genomics Data." In 2022 *IEEE 32nd International Workshop on Machine Learning for Signal Processing* ***(MLSP)***.
- Baker, Bradley Thomas, Noah Lewis, Debratta Saha, Md Abdur Rahaman, Sergey Plis, and Vince Calhoun. "Information Bottleneck for Multi-Task LSTMs." In ***NeurIPS*** *2022 Workshop on Information-Theoretic Principles in Cognitive Systems.*
- Dolci, G., Rahaman, M. A., Galazzo, I. B., Cruciani, F., Abrol, A., Chen, J., ... & Calhoun, V. D. (2023, June). "Deep Generative Transfer Learning Predicts Conversion To Alzheimer's Disease From Neuroimaging Genomics Data". In 2023 *IEEE International Conference on Acoustics, Speech, and Signal Processing Workshops* ***(ICASSPW)***
- M. A. Rahaman, E. Damaraju, D. K. Saha, V. D. Calhoun and S. M. Plis, "Statelets: A Novel Multi-Dimensional State-Shape Representation Of Brain Functional Connectivity Dynamics". 2021 *IEEE 18th International Symposium on Biomedical Imaging* ***(ISBI)***.
- Md Abdur Rahaman, Zening Fu, Armin Iraji and V. D. Calhoun, 2024, "SpaDE: a deep semantic locality preserving biclustering framework". 2024. *International Conference of the IEEE Engineering in Medicine & Biology Society* ***(EMBC)***.
- Rahaman, Md Abdur, Jessica A Turner, Cota Navin Gupta, Srinivas Rachakonda, Jiayu Chen, Jingyu Liu, Theo GM Van Erp, Steven Potkin, Judith Ford, and Daniel Mathalon. 2019. " N-BiC: a model order agnostic biclustering algorithm for imaging and behavioral data". *IEEE Transactions on Biomedical Engineering* ***(TBME)***.
- Rahaman, Md Abdur, Jiayu Chen, Zening Fu, Noah Lewis, Armin Iraji, Theo GM van Erp, and Vince D Calhoun. 2023. "Deep multimodal predictome for studying mental disorders". ***Human Brain Mapping***.
- Du, Yuhui, Zening Fu, Jing Sui, Shuang Gao, Ying Xing, Dongdong Lin, Mustafa Salman, Anees Abrol, Md Abdur Rahaman, and Jiayu Chen. 2020. "NeuroMark: An automated and adaptive ICA based pipeline to identify reproducible fMRI markers of brain disorders". ***NeuroImage***.

Leadership & Awards

2024	**Next Generation Scholar Award**, IEEE Engineering in Medicine & Biology Society
2024	**Career Development Award**, Georgia Institute of Technology
2024	**Conference Travel Fund**, Conference on Computer Vision and Pattern Recognition (CVPR)
2018	**Program organizing secretary**, UNM Computer Science Student Conference
2017	**Graduate Education**, Bangladesh-Sweden Travel Trust Fund for Higher Education
2008-2013	**Dean's List Merit Scholarship**, Chittagong University of Engineering and Technology
2005-2007	**Educational Board Scholarship**, The Government of Bangladesh for Academic Excellence