

# Md Abdur Rahaman

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## Education

### Georgia Institute of Technology, GA, USA

Ph.D. in Computational Science and Engineering | Expected August 2024

### University of New Mexico, NM, USA

M.S. in Computer Science, July 2019

## Research Interests

Machine Learning, Deep Learning, Computer Vision, Pattern Recognition, Big Data, Multi-modal Fusion, Multi-dimensional Clustering, Statistical Modeling, NLP, Signal Processing, Computational Neuroscience

## Experience

### Center for Translational Research in Neuroimaging and Data Science (TReNDS) at Georgia Tech

Atlanta, GA

GRADUATE RESEARCH ASSOCIATE

Jun. 2019 - present

- Developing computational frameworks for learning discriminative and semantically meaningful patterns from big data
- Implement robust AI for multi-dimensional clustering, pattern recognition, and multi-modal fusion
- Leveraging neurocomputational paradigms to enhance SOTA AI (Neuromorphic Computing).

### NOKIA BELL LABS

Murray Hill, NJ

DATA SCIENCE RESEARCH INTERN

Sep. 2021 - Dec. 2021

- Worked with log analytics group to develop a log summarizer to compress the machine logs (billions of lines).
- Applied BERT models for learning log representation to detect a system failure.
- A multi-modal framework for combining system logs and user's error descriptions to route the failure alert.

### Mind Research Network

Albuquerque, NM

GRADUATE RESEARCH ASSITANT

May. 2017 - Apr. 2019

- Developed an automated preprocessing pipeline for brain images (MRI).
- Designed exhaustive biclustering and tri-clustering algorithms by relaxing the specification of the model order ( $k$ ).

### University of New Mexico

Albuquerque, NM

GRADUATE TEACHING ASSITANT

Aug. 2016 - Apr. 2017

- Assisted with Linear algebra, Declarative Programming, Computer Algorithms courses designed for CS undergrad students.
- Roles: TA Office hour, Grading, Conducting tutorials on Haskell, Scheme, GNU Emacs

## Research 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 - biclusters.
- A transformer powered GNN for learning intricate submodules in graph-structured data.
- Computational complexity reduction [ $\mathcal{O}(kn)$ ] with cluster-guided self attention for ViT.

### 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'.
- Combines Neuroimages (fMRI, sMRI) and genomics data to classify mental disorder.
- Model's architecture and processing powered by neuromorphic computing

### SpaDE: Semantic locality preserving Auto-decoder for deep biclustering

- Auto encoder-based feature learning with a novel bi-clustering regularization – uncovering data point's true manifold.
- Formulated the regularization terms for semantic locality preservation (increases biological relevance) and sparsity.
- Designed a latent space meta-heuristic for two-dimensional cluster assignment of samples and features.

### 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 the frequency subspace is applied on the brain's functional connectivity (FC) time course.
- Developed a module for selecting the summary shapes with maximum prevalence and diversity.

### BrainGraph: a graph neural network (GNN) for modeling Brain Networks

- Generate a weighted brain graph  $G(V, E)$  using the regions of interest (ROI) as nodes (V) and the functional connection (correlation) between them as edges 'E'.
- Use self-attention to learn enhanced graph embedding through a novel readout.
- Provide insights into the coordination among the brain's functional hubs.

### N-BiC: greedy biclustering algorithm without specific model order (k)

- Constraint depth-first search (DFS) - based algorithm to semi-exhaustively explore all possible combinations of instances.
- Discover data intrinsic subgroups without specifying 'k'.

### mriCAV: Concept activation vector (CAV) for model interpretability

- Introspect the fully trained deep models by finding active concepts - orthogonal vectors towards learned features.
- Allows testing model's inclination towards pre-defined concepts.
- For a neuro-vision task, the concepts include the brain's region of interest (ROI), activation, networks, and connectivity patterns.

### IBRNN: Information-theoretic introspection for Recurrent Neural Networks

#### (RNNs)

- CBOW for word2vec embedding of the text corpus and bi-LSTM for the downstream task.
- Inspired by information Bottleneck theory, compute mutual information (MI) around labels, features, and layers and quantifies feature compression

## Skills

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<b>Programming</b>	Python, CUDA, C/C++, Scala, JAVA, C#, JavaScript, JQuery
<b>Cloud Technologies &amp; DB</b>	AWS, Google Cloud, Flask, Hadoop, Spark, MySQL, BigQuery, MongoDB
<b>Libraries</b>	PyTorch, TensorFlow, Keras, OpenCV, Stanford CoreNLP, Pandas, NLTK, Scikit-Learn, PySpark, Hugging Face
<b>Tools</b>	Docker, Slurm, Free Surfer, FSL, SPM, Git, MATLAB

## Selected Publications

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- **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.
- **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).
- **M. A. Rahaman**, J. Chen, Z. Fu, N. Lewis, A. Iraj and V. D. Calhoun, "Multi-modal deep learning of functional and structural neuroimaging and genomic data to predict mental illness," 2021 43rd Annual International Conference of the IEEE Engineering in Medicine & Biology Society (EMBC).
- Dolci, Giorgio, **Md Abdur Rahaman**, Jiayu Chen, Kuaikuai Duan, Zening Fu, Anees Abrol, Gloria Menegaz, and Vince D Calhoun. 2022. "A deep generative multimodal imaging genomics framework for Alzheimer's disease prediction." In 2022 IEEE 22nd International Conference on Bioinformatics and Bioengineering (BIBE).
- **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 novel biclustering algorithm for brain and behavioral features without specifying the model order". IEEE Transactions on Biomedical Engineering (TBME).
- 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)
- 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
- **Md Abdur Rahaman**, Zening Fu, Armin Iraj and V. D. Calhoun, 2024, "SpaDE: a deep semantic locality preserving biclustering framework", (under review)