M. Maruf

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Research Interests

• Knowledge-Guided Machine Learning • Vision-Language Models • Generative AI • Graph Neural Networks • AI for Science • Explainable AI • Semantic Segmentation Models • Self-Supervised Learning

Education

Virginia Tech — **September 2024 (Expected)**
PhD, Computer Science — Blacksburg, USA
Thesis: Knowledge-guided Machine Learning for Prediction and Segmentation Problems Involving Images.
Advisor: Dr. Anuj Karpatne

Virginia Tech — **Dec 2022**
Master of Science, Computer Science, GPA: 4.0/4.0 — Blacksburg, USA

Bangladesh University of Engineering and Technology (BUET) — **March 2016**
Bachelor of Science and Engineering, Computer Science, GPA: 3.82/4.0 — Dhaka, Bangladesh

Research Experience

Amazon.com — **Bellevue, WA**
Applied Scientist Intern, *Advisor: Dr. Badrinath Srinivas* — May 2022 – Aug 2022
- Developed a real-time delivery image ranking algorithm to help Amazon drivers improve package delivery. The algorithm utilizes object-detection models along with statistical methods that yield 70% improvement over prior baselines.

Qualcomm Inc — **Santa Clara, CA**
Machine Learning Engineer Intern, *Advisor: Dr. Will Morrison* — June 2021 – Aug 2021
- Collaborated with the GNSS Location team on GPS-based position estimation problem. This project involves improving the performance of state-of-the-art Graph Neural Network (GNN) models on satellite-based position estimations.

Virginia Tech — **Blacksburg, VA**
Graduate Research Assistant, *Advisor: Dr. Anuj Karpatne* — May 2019 – Present
- Enhanced the performance of large **vision language models (VLMs)** for discovering biological traits through **prompting, in-context learning, and instruction tuning** that leverages the scientific knowledge. Additionally, designed a multitask benchmark VQA dataset for scientific tasks on organismal images. See publication **P1, P2, W1**. *(Publications at AAAI 2024)*
- Developed a hierarchical prototype network to **discover evolutionary traits** directly from images as **prototypes**. Additionally, collaborated on accelerating trait discovery using **conditional diffusion models with phylogenetic knowledge** in the form of hierarchical embeddings. See publication **P3, C1, W2**. *(Publications at ECCV 2024)*
- Structured a thorough comparative analysis of **Weakly Supervised Semantic Segmentation** approaches, highlighting the superiority of saliency maps over class activation maps (CAMs) through novel evaluation metrics and introducing stochastic aggregation via random cropping to enhance saliency effectiveness. See publication **P4**.
- Developed Distance-aware Negative Sampling (DNS) for enhanced graph representation learning, optimizing cohesion and separation by considering node-pair distances, improving structural similarity in **Unsupervised Graph Representation Learning (GRL) project**. See publication **C4, W8**. *(Publications at SDM 2021, PIML 2020)*
- Innovated PID-GAN architecture merging physics insights into GAN training for robust uncertainty quantification and effective use of unlabeled data, advancing the **Physics Informed Discriminator (PID) Framework**. See publication **C3, W4, W7**. *(Publications at KDD 2021, NeurIPS 2020, AAAI 2021)*
- Implemented a **single-stage structured pruning** algorithm DAM that can enforce L_0 sparsity. It achieves state-of-the-art performance not only on structured pruning for image classification tasks but also on dimensionality reduction and graph representation learning tasks. See publication **C2**. *(Publications at NeurIPS 2021)*

Publications

Preprints/Under Submission

[P1] **M. Maruf**, A. Daw, K. Mehrab, A. Karpatne et al., "*VLM4Bio: A Benchmark Dataset to Evaluate Pretrained Vision-Language Models for Trait Discovery from Biological Images*", under submission at **NeurIPS 2024**. **[PDF]**

[P2] K. Mehrab*, **M. Maruf***, A. Daw*, A. Karpatne et al., "*Fish-Vista: A Multi-Purpose Dataset for Understanding & Identification of Traits from Images*", under submission at **NeurIPS 2024** (* - equal contribution). **[PDF]**

[P3] H. Manogaran, **M. Maruf**, A. Daw, A. Karpatne et al., "*What Do You See in Common? Learning Hierarchical Prototypes over Tree-of-Life to Discover Evolutionary Traits* ", under submission at **NeurIPS 2024**. **[PDF]**

[P4] **M. Maruf**, A. Daw, J. Bu, and A. Karpatne, "*Beyond Discriminative Regions: Saliency maps as Alternatives to CAMs for Weakly Supervised Semantic Segmentation* ", in ArXiv:2308.11052. **[PDF]**

Conference Proceedings

[C1] M. Khurana, A. Daw, **M. Maruf**, A. Karpatne et al., "*Hierarchical Conditioning of Diffusion Models Using Tree-of-Life for Studying Species Evolution* ", in **ECCV 2024**. **[PDF]**

[C2] J. Bu*, A. Daw*, **M. Maruf***, and A. Karpatne, "*Learning Compact Representations of Neural Networks using DiscriminAtive Masking (DAM)* ", in **NeurIPS 2021** (* - equal contribution). **[PDF]**

[C3] A. Daw*, **M. Maruf***, and A. Karpatne, "*PID-GAN: A GAN Framework based on a Physics-informed Discriminator for Uncertainty Quantification with Physics* ", in **KDD 2021** (* - equal contribution). **[PDF]**

[C4] **M. Maruf** and A. Karpatne "*Maximizing Cohesion and Separation in Graph Representation Learning: A Distance-aware Negative Sampling Approach* ", in **SDM 2021**. **[PDF]**

Journal Articles

[J1] M. Balk, J. Bradley, **M. Maruf**, A. Karpatne et al., "*A FAIR and Modular Image-based Workflow for Knowledge Discovery in the Emerging Field of Imageomics* ", in **Methods in Ecology and Evolution 2024**. **[PDF]**

[J2] Y. Bakis, Y. Altintas, **M. Maruf**, A. Karpatne et al., "*Extracting Landmark and Trait Information from Segmented Digital Specimen Images Generated by Artificial Neural Networks*", in **Biodiversity Information Science and Standards 2022**.

[J3] **M. Maruf** and S. Shatabda, "*iRSpot-SF: Prediction of Recombination Hotspots by Incorporating Sequence-based Features into Pseudo Components*", in **Genomics 2019**. **[PDF]**

Workshop Proceedings

[W1] **M. Maruf**, A. Daw, and A. Karpatne, "*Are Pre-trained Vision Language Models (VLMs) Decent Zero-shot Predictors in Scientific Contexts?*", in Imageomics Workshop **AAAI 2024**.

[W2] M. Khurana, A. Daw, **M. Maruf**, and A. Karpatne, "*Conditioning Diffusion Models Using the Knowledge of Phylogeny for Understanding Species Evolution*", in Imageomics Workshop **AAAI 2024**.

[W3] K. Mehrab, A. Daw, **M. Maruf**, and A. Karpatne, "Phylo-GNN: Phylogeny-guided Graph Neural Network Approach for Fine-Grained Image Trait Identification", in Imageomics Workshop **AAAI 2024**.

[W4] A. Daw*, **M. Maruf***, and A. Karpatne, "PID-GAN: A gan framework based on a physics-informed discriminator for uncertainty quantification with physics", in SGAI **AAAI 2021** (* - equal contribution).

[W5] **M. Maruf**, M. Elhamod, P. Mandke, and A. Karpatne, "Biology-guided Neural Network for Fish Trait Discovery", in Integrative and Comparative Biology 2021.

[W6] M. Elhamod, **M. Maruf**, P. Mandke, and A. Karpatne, "Biology-guided Neural Network for Species Classification", in Integrative and Comparative Biology 2021.

[W7] A. Daw, **M. Maruf**, and A. Karpatne, "Physics-Informed Discriminator (PID) for Conditional Generative Adversarial Networks", in ML4PS **NeurIPS 2020**.

[W8] **M. Maruf** and A. Karpatne, "Informing Neural Networks for Drug Effect Prediction Using Biological Knowledge of Protein-Protein Interactions", in **PIML 2020**.

Academic Services, Honors & Awards

Reviewer: NeurIPS (2024), Dataset and Benchmark track NeurIPS (2024), ML4PS NeurIPS(2021-present), SGAI-AAAI (2021, 2022), PKDD (2023), KDD (2021, 2022).
PC Member: SGAI-AAAI (2021, 2022).
Session Chair: Spatiotemporal Data at SDM 2021.
Fellowship: Kafura Graduate Fellowship, Virginia Tech, 2023.
Award: SDM Doctoral Student Travel Award (2020), Dean's List Award (BUET 2011-16).

Technical Skills

Python, C++, Java, PyTorch, Tensorflow, SageMaker, S2, S3, EC2, Deepspeed, LoRA.

References

Dr. Anuj Karpatne, Associate Professor, Department of Computer Science, Virginia Tech.
More references will be provided upon request.