

# 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

PhD, Computer Science

*Thesis: Knowledge-guided Machine Learning for Prediction and Segmentation Problems Involving Images.*

Advisor: Dr. Anuj Karpatne

November 2024 (Expected)

Blacksburg, USA

### Virginia Tech

Master of Science, Computer Science, GPA: 4.0/4.0

Dec 2022

Blacksburg, USA

### Bangladesh University of Engineering and Technology (BUET)

Bachelor of Science and Engineering, Computer Science, GPA: 3.82/4.0

March 2016

Dhaka, Bangladesh

## Research Experience

### Amazon.com

Applied Scientist Intern, Advisor: Dr. Badrinath Srinivas

Bellevue, WA

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

Machine Learning Engineer Intern, Advisor: Dr. Will Morrison

Santa Clara, CA

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

Graduate Research Assistant, Advisor: Dr. Anuj Karpatne

Blacksburg, VA

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 **C1, P1, W1**. (*Publications at NeurIPS 2024, 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 **C2, C3, W2**. (*Publications at NeurIPS 2024, 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 **P2**.
- 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 **C6, 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 **C5, 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 **C4**. (*Publications at NeurIPS 2021*)

## Publications

### Conference Proceedings

- [C1] **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*”, accepted in **NeurIPS 2024**. [\[PDF\]](#)
- [C2] 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*”, accepted in **NeurIPS 2024**. [\[PDF\]](#)
- [C3] 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**. [\[PDF\]](#)

- [C4] J. Bu\*, A. Daw\*, **M. Maruf\***, and A. Karpadne, “*Learning Compact Representations of Neural Networks using Discriminative Masking (DAM)*”, in **NeurIPS 2021** (\* - equal contribution). [\[PDF\]](#)
- [C5] A. Daw\*, **M. Maruf\***, and A. Karpadne, “*PID-GAN: A GAN Framework based on a Physics-informed Discriminator for Uncertainty Quantification with Physics*”, in **KDD 2021** (\* - equal contribution). [\[PDF\]](#)
- [C6] **M. Maruf** and A. Karpadne “*Maximizing Cohesion and Separation in Graph Representation Learning: A Distance-aware Negative Sampling Approach*”, in **SDM 2021**. [\[PDF\]](#)

#### Preprints/Under Submission

- [P1] K. Mehrab\*, **M. Maruf\***, A. Daw\*, A. Karpadne et al., “*Fish-Vista: A Multi-Purpose Dataset for Understanding & Identification of Traits from Images*”, under submission at **NeurIPS 2024** (\* - equal contribution). [\[PDF\]](#)
- [P2] **M. Maruf**, A. Daw, J. Bu, and A. Karpadne, “*Beyond Discriminative Regions: Saliency maps as Alternatives to CAMs for Weakly Supervised Semantic Segmentation*”, in ArXiv:2308.11052. [\[PDF\]](#)

#### Journal Articles

- [J1] M. Balk, J. Bradley, **M. Maruf**, A. Karpadne 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. Karpadne 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. Karpadne, “*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. Karpadne, “*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. Karpadne, “*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. Karpadne, “*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. Karpadne, “*Biology-guided Neural Network for Fish Trait Discovery*”, in Integrative and Comparative Biology 2021.
- [W6] M. Elhamod, **M. Maruf**, P. Mandke, and A. Karpadne, “*Biology-guided Neural Network for Species Classification*”, in Integrative and Comparative Biology 2021.
- [W7] A. Daw, **M. Maruf**, and A. Karpadne, “*Physics-Informed Discriminator (PID) for Conditional Generative Adversarial Networks*”, in ML4PS **NeurIPS 2020**.
- [W8] **M. Maruf** and A. Karpadne, “*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 Karpadne**, Associate Professor, Department of Computer Science, Virginia Tech.

More references will be provided upon request.