

# 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

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. Karpadne 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. Karpadne, “Learning Compact Representations of Neural Networks using Discriminative Masking (DAM) ”, in **NeurIPS 2021** (\* - equal contribution). [\[PDF\]](#)
- [C3] 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). [\[PDF\]](#)
- [C4] **M. Maruf** and A. Karpadne “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. 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.