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Medha Sawhney

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RESEARCH FOCUS

My research broadly focuses on generative AI for scientific discovery, spanning diffusion models & neural operators for physics-informed PDE solving, forward & inverse problems and vision-language models for symbolic regression and scientific reasoning.

EDUCATION

Virginia Tech, Blacksburg, Virginia, USA **GPA: 4.00 / 4.00** *May 2023 – May 2027*
PhD in Computer Science. Advisor: *Dr. Anuj Karpatne*

Virginia Tech, Blacksburg, Virginia, USA **GPA: 4.00 / 4.00** *Aug 2021 - May 2023*
MS Thesis in Computer Science. Advisor: *Dr. Anuj Karpatne*

Manipal Institute of Technology, MAHE, Manipal, India **GPA: 8.34 / 10.00** *Aug 2016 - Aug 2020*
Bachelor's in technology, Major -Electronics and Communication Engineering, Minor -Data Science

RESEARCH EXPERIENCE

Graduate Research Assistant, Knowledge Guided Machine Learning Lab *Aug 2021– Present*

- Developing diffusion models for solving Partial Differential Equations integrating physics-guided machine learning and neural operators, enabling faster inference sampling and high-fidelity super resolution in highly sparse, noisy settings
- Designed a unified, invertible framework, via latent space translations to jointly solve forward and inverse problems in seismic imaging, achieving robust generalization to real-world out-of-distribution datasets for full waveform inversion.
- Foundation Model for aquatic ecosystems to, (a) learn effective representations of process variables (b) represent ecosystem entities, (c) predict in 2D across temporal & depth axes and (d) handle variable frequency signals from highly sparse observations
- Introduced a novel training-free open-world scene graph generation method, leveraging pretrained VLMs for zero-shot object and relation prediction, reframing predicate classification as multiple-choice QA and enabling open-ended relation generation
- Reasoning evaluation of VLMs on VQA tasks for scientific images and fine-grained trait understanding and prediction
- Leveraged VLMs and LLMs for modular symbolic regression and scientific equation discovery from visual inputs like flowcharts of structured scientific processes.
- Constructed an algorithm to detect and track microscopic bacteria cells with a 95% precision by utilizing motion and temporal cues for an NSF funded cancer research project. Challenge: Hard to distinguish from background media
- Engineered an approach to predict force applied by a human cell on underlying fiber intersections using multi-object detection techniques in Computer Vision like RetinaNet

SELECTED PUBLICATIONS (* denotes equal contribution)

1. *A Unified Framework for Forward and Inverse Problems in Subsurface Imaging using Latent Space Translations* *ICLR 2025*
   Naveen Gupta*, **Medha Sawhney***, Arka Daw*, Youzuo Lin, and Anuj Karpatne
2. *Physics-guided Diffusion Neural Operators for Solving Forward and Inverse PDEs* *(Oral) CVPR CV4Science 2025*
   Medha Sawhney, Abhilash Neog, Mridul Khurana, Amartya Dutta, Arka Daw, Anuj Karpatne
3. *Open World Scene Graph Generation using Vision Language Models* *CVPR CVinWild 2025*
   Amartya Dutta, K.S. Mehrab*, **Medha Sawhney***, ..., Ismini Lourentzou, Arka Daw, Anuj Karpatne
4. *Scientific Foundation Models for Aquatic Ecosystems* *ICML FMSD 2025*
   Abhilash Neog, **Medha Sawhney**, K.S. Mehrab, Sepideh Fatemi Khorasgani, ..., Anuj Karpatne
5. *Scientific Equation Discovery using Modular Symbolic Regression via Vision-Lang Guidance* *(Oral) CVPR CV4Science 2025*
   Sepideh Fatemi, Abhilash Neog, Emma Marchisin, Amartya Dutta, **Medha Sawhney**, Paul C Hanson, Anuj Karpatne
6. *VLM4Bio: A Benchmark Dataset to Evaluate Pretrained VLMs for Trait Discovery from Biological Images* *NeurIPS 2024*
   Maruf, M, Arka Daw, K.S. Mehrab, Harish B. Manogaran, Abhilash Neog, **Medha Sawhney**, ..., Anuj Karpatne
7. *MEMTrack: A Deep Learning-Based Approach to Microrobot Tracking in Dense and Low-Contrast Environments* *AISY 2024*
   Medha Sawhney*, Bhas Karmarkar*, Eric J. Leaman, Arka Daw, Anuj Karpatne, and Bahareh Behkam
8. *Detecting and Tracking Hard-to-Detect Bacteria in Dense Porous Backgrounds* *(Oral) CVPR CV4Animals 2023*
   Medha Sawhney*, Bhas Karmarkar*, Arka Daw, Anuj Karpatne, and Bahareh Behkam
9. *An Efficient Approach to Detect Driver Distraction during Mobile Phone Usage* *(Oral) IJET 2018*
   Medha Sawhney, Vasundhara Acharya, and Krishna Prakasha
10. *Deep Learning Enabled Label-free Cell Force Computation in Deformable Fibrous Environments* *bioRxiv 2022*
    Abinash Padhi*, Arka Daw*, **Medha Sawhney**, Maahi M. Talukder, ..., Anuj Karpatne and Amrinder Nain

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WORK EXPERIENCE

Deep Learning Automation Intern, NVIDIA *May 2024 – Aug 2024*

- Crafted a multitask learning model capable of dynamically training on multiple heterogeneous datasets with varying class counts and image-resolutions, achieving over 90% accuracy across all datasets despite significant imbalances. Challenges: Dataset imbalances (custom batch sampler and dataloader and splitting functions for train set to maintain proportions), high-res image training (patching and padding), multi-GPU efficiency (pipeline parallelism), gradient mixing.
- Designed and validated models for detecting video corruption across diverse defect types. Enhanced accuracy by 15% in an existing video corruption detection model for GPU validation, reducing false positives by 60% and false negatives by 50%, leading to significant reliability improvements.

Machine Learning Engineering Intern, Twitter *Jun 2022 – Aug 2022*

- End to end development and deployment of a broadly applicable ML model using XGBoost within the account health space
- Boosted Key performance indicators by 74%. Challenges: Data imbalance, feature sparsity, enormous data, data distribution drift

Machine Learning Engineer Hewlett-Packard R&D *Jan 2020 – June 2021*

- Engineered a self-resolution tool for PC issues, with a 3x BLEU score, employing AWD-LSTM and Natural Language Processing.
- Designed and implemented a dynamic troubleshooting tool for printer issues based on Recurrent Neural Networks
- Applied optimization strategies to build hardware-efficient and reliable ML models, including a) identifying performance bottlenecks using CUDA Kernel Profiling with NVIDIA Nsight Systems & Compute and b) examining ML models for bias

Automatic Driver Assistant Systems Team Intern, The Hi-Tech Robotic Systems *May 2018 – Jul 2018*

- Developed a Computer Vision based Distraction Detection module using Deep Learning algorithms such as CNNs
- Cross-compiled a drowsiness detection product on ARM and constructed a unit testing framework for it, using Google test, in C++

Graduate Research Assistant, Informatics Lab, Virginia Tech *Aug 2021 – Dec 2021*

- Developed a Computer Vision solution to detect plant wilting. Improved performance accuracy by 10% with traditional methods like Support Vector Machines and feature engineering. Challenges: class imbalance, small dataset, images of varying resolutions

Research Intern, IIIT Hyderabad *May 2019 – Jul 2019*

- Designed and deployed an object recognition tool on NVIDIA Jetson TX2 board, funded by Defence Organisation (DRDO), India
- Successfully identified landmarks in aerial imagery also from viewpoints different than trained on, using YOLO and Deep Learning

SELECTED PROJECTS

Convergence analysis of PINN for solving inverse PDEs Code | PDF *Aug 2023 – Dec 2023*

- Performed adaptive weighing of physics-based and data-driven loss terms in Physics-informed Neural Networks
- Achieved 50% average error reduction in PDE (Partial Differential Eq.) parameter estimation of Burgers & Allen-Cahn eq.

Knowledge-guided Protein-Protein Interaction *Aug 2023 – Dec 2023*

- Integrated structure-aware equivariant GNNs with sequence-based models, achieving a +15% AUROC improvement over baseline

Investigating Pre-Trained Large Models for Program Translation *Jan 2022 – May 2022*

- Evaluated multilingual code translation using snippet-to-program transfer to validate identifier-aware learning for generalization.

AWARDS / HONORS/ TALKS

- Lighting talk at CV4Science, CVPR'25 - "Physics-guided Diffusion Neural Operators for Solving Forward & Inverse PDEs."
- Lightning talk at Imageomics, AAAI'24 - "Motion Enhanced Tracker: Tracking in Dense & Low-Contrast Environments."
- Scholarship to attend Grace Hopper Celebration Conference by AnitaB.org and Virginia Tech, 2022
- Best Paper Presentation for "An Efficient Approach to Detect Driver Distraction during Mobile Phone Usage", ICECNS-GOA 2018
- 2nd place for building a conversational agent to raise awareness of STDs, OK Google: Let's Build Hackathon, WTM Manipal, 2018
- 2nd position in Advanced Robotics Challenge by World Robot Olympiad Association (WRO) for Tetris solving bot, 2017

VOLUNTEER EXPERIENCE

- Conference & Journal Reviewer for KDD'22, ICLR'25, SDM 2025, for IJCV'23
- Workshop Reviewer: Imageomics AAAI'24, CV4Animals CVPR'24 and CVPR'25, ICLR'25 DeLTa and VerifAI
- Organizing Committee: First Imageomics Workshop at AAAI'24
- Guided a team of 30+ members as Coding Head, RoboManipal, official robotics student project team at MIT, Manipal 2018-2019
- Mentored 150+ students under the GirlScript Manipal Winter Programme on C++, Java, & Object Detection using OpenCV,2018

TECHNICAL SKILLS

Programming Languages: Python, Java, C++, MATLAB Frameworks: PyTorch, TensorFlow, Keras JupyterLab, Git