Hiren Madhu

Research interests: *Geometric Deep Learning, AI for Genomics, Non-Euclidean Geometry*

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Education

Yale University 2024-2029
PhD, Computer Science — GPA: 4.0 / 4.0 ***Co-advisors:*** *Smita Krishnaswamy, Rex Ying*

Indian Institute of Science, Bangalore 2021-2023
MTech, Artificial Intelligence — GPA: 8.1 / 10 ***Advisor:*** *Sundeep Chepuri*

LDRP-ITR, Gandhinagar 2017-2021
BE, Computer Engineering — GPA: 8.4 / 10 ***Co-advisors:*** *Sandip Modha, Thomas Mandl*

Research Experience

Indian Institute of Science, Bangalore June 2023 – June 2024
Pre-doc Research Fellow (Advised by Prof. Sundeep Chepuri) *Bangalore, IN*

- Developed weakly-supervised representation learning techniques for topological structures.
- Designed an augmentation method and contrastive loss for simplicial complexes, achieving higher performance and robustness compared to supervised baselines (NeurIPS 2023).
- Proposed a parameter-free scattering framework for unsupervised feature extraction on simplicial complexes, improving benchmark performance and efficiency (ICML 2024).

Indian Institute of Management, Ahmedabad Feb 2021 – Jun 2021
Research Student (Advised by Prof. Hyokjin Kwak) *Ahmedabad, IN*

- Conducted in-depth bottom-up analysis of Amul Hits by scraping and evaluating user interactions across major social media platforms (Twitter, Facebook, LinkedIn, Instagram).
- Developed a custom web-scraping agent and data analysis tool.

Selected Publications

Preprints and Conference Proceedings (* equal contribution)

- *HiPoNet: A Topology-Preserving Multi-View Neural Network For High Dimensional Point Cloud and Single-Cell Data*. S. Viswanath*, **H. Madhu***, et al. **NeurIPS 2025**. [NeurIPS] [Arxiv]
- *HELM: Hyperbolic Large Language Models via Mixture-of-Curvature Experts*. N. He*, R. Anand*, **H. Madhu**, A. Maatouk, S. Krishnaswamy, L. Tassiulas, M. Yang, R. Ying. **NeurIPS 2025**. [NeurIPS] [Arxiv]
- *HEIST: A Graph Foundation Model for Spatial Transcriptomics and Proteomics Data*. **H. Madhu**, et al. **Arxiv 2025**. [Arxiv]
- *Hyperbolic Deep Learning for Foundation Models: A Survey*. N. He, **H. Madhu**, et al. **KDD 2025 Tutorial**. [ACM]
- *Unsupervised Parameter-free Simplicial Representation Learning with Scattering Transforms*. **H. Madhu***, S. Gurugubelli*, SP Chepuri. **ICML 2024**. [ICML]
- *TopoSRL: Topology Preserving Self-Supervised Simplicial Representation Learning*. **H. Madhu**, SP Chepuri. **NeurIPS 2024**. [NeurIPS]
- *Detecting offensive speech in conversational code-mixed dialogue on social media: A contextual dataset and benchmark experiments*. **H. Madhu**, et al. **Expert Systems with Applications**. [Elsevier]

Projects

HypRAG | *Huggingface, LLMs, Pre-training* | Graph-and-Geometric-Learning/hyperbolic_rag Apr 2025 – Now

- Developing a retrieval-augmented generation (RAG) framework that leverages **hyperbolic embeddings** to model hierarchical knowledge more effectively than Euclidean methods.
- Built key components including a **Lorentzian Transformer**, a **Hyperbolic Vector Database (HVD)**, and efficient hyperbolic nearest-neighbor search for scalable retrieval.
- Benchmarking against BEIR, MS MARCO, and reasoning-intensive RAG tasks to demonstrate improved **accuracy, efficiency, and hierarchical reasoning** in LLMs.

Technical Skills

ML Frameworks: Torch, PyTorch, PyTorch Geometric, Gudhi, TensorFlow, Keras, Huggingface,
Languages: Python, JavaScript