SAMUEL LEVENTHAL

CONTACT INFORMATION

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ABOUT

Ph.D. computer scientist (University of Utah, Scientific Computing and Imaging Institute) working at the intersection of geometric and topological deep learning, graph neural networks, scientific machine learning, scientific visualization, and high-performance computing. My research builds structure-respecting machine learning, in which geometric and topological structure (Hodge decomposition, discrete Morse theory, persistence filtration, copresheaf transports, and neural operators on simplicial and cellular complexes) is imposed as an architectural inductive bias rather than recovered after training, so that models learn along the structure of a problem and remain interpretable by construction. The same machinery carries across domains: PDE surrogates and operator learning that generalize across mesh resolutions and topological refinements; physics- and geometry-informed modeling of scientific and engineering data; topology-aware graph neural networks for segmentation and classification on large scientific volumes and meshes; topological methods for scientific visualization (Morse–Smale complexes, persistence, Reeb graphs) of real-world data or high-dimensional data or representation embeddings. I also build and ship ML systems on real HPC with multi-GPU distributed training and in-situ extraction of data from running computation.

EDUCATION

Ph.D. Computer Science

2024 University of Utah

School of Computing & Scientific Computing and Imaging Institute. *Dissertation:* Leveraging Topology to Advance Machine Learning Models and Methods. *Advisor:* Valerio Pascucci. *Committee:* V. Pascucci (Chair), C. R. Johnson, D. Pugmire (ORNL), B. Wang Phillips, A. Bhaskara.

B.Sc. Physics
Minor: Philosophy

2013 University of Utah

Department of Physics and Astronomy & College of Humanities.

B.Sc. Mathematics
Minor: Comp. Sci.

2013 University of Utah

Department of Mathematics & School of Computing.

RESEARCH EXPERIENCE

Postdoctoral Researcher

2025– University of San Francisco

Supervisor: Mustafa Hajij. Topological neural operators and structure-respecting ML. Designed copresheaf- and cochain-level operator-learning architectures grounded in Hodge theory (decomposing signals into exact, coexact, and harmonic components), so that representational structure is fixed by the architecture rather than recovered post hoc; built PDE surrogates that generalize across mesh resolutions and topological refinements. Investigating these constructions as a route to interpretability by construction.

Graduate Research Assistant

2017–24 University of Utah, SCI Institute

Mentor: Valerio Pascucci. Topology-aware graph learning for scientific images (Morse–Smale complexes, hierarchical GNN training) for segmentation and classification on 3D volumes and large unstructured meshes. Co-designed PAVE, an in-situ pipeline that extracts and processes data from running HPC simulations and couples generative models with path tracing without round-tripping through disk. Ongoing LLNL and ORNL collaboration on geometry- and topology-driven ML and HPC deployment.

AI Research Engineer

2023–24 University of Utah / ARPA-H
High-resolution tissue scanning with ML and HPC. Set imaging requirements, model milestones, and task breakdowns for a multi-institution team; built discrete-Morse-based topological and graph pipelines for large 3D datasets integrated with high-throughput imaging and HPC inference.

AI Research Engineer

2022 Lawrence Livermore National Laboratory
Mentors: Mark Heimann, Jayaraman J. Thiagarajan. GETO-GNN: topologically and geometrically aware graph neural networks for node and edge classification; homophily- and heterophily-aware filtrations and hierarchical training schemes that use the domain's topology to guide representation learning.

ML & Sci-Vis Research Engineer

2019 Oak Ridge National Laboratory
Mentors: Mark Kim, David Pugmire. Co-developed PAVE, an in-situ framework coupling scientific visualization with ML in HPC; conditional GANs on path-traced images to accelerate physically based rendering on large GPU resources, with memory-to-memory transport between the running simulation and training.

Research Scientist

2018 Lawrence Livermore National Laboratory
Mentor: J. J. Thiagarajan. Spectral sampling frameworks for surrogate modeling and high-dimensional experimental design.

AI & Sci-Vis Research Engineer

2022–24 WiFIRE Lab, UC San Diego
BurnPro3D: geometry- and physics-informed wildfire modeling. ML components integrating terrain, fuels, and simulation outputs, with explainability and active-learning workflows.

SELECTED SYSTEMS & PROJECTS

PAVE (U of U & ORNL): in-situ ML and scientific-visualization framework on HPC; extracts and processes data from running simulations over a memory-to-memory transport, with no disk round-trip.

Topological segmentation tools: hierarchical, multi-scale, Morse–Smale-based segmentation and feature extraction and tracking for scientific, medical, and materials data.

Interactive labeling & active-learning tool: GUI for labeling topological priors and iteratively retraining geometric ML models on image-derived graphs.

TECHNICAL SKILLS

ML/DL: PyTorch, PyTorch Geometric, DGL, TensorFlow. **HPC & Systems:** CUDA, MPI, OpenMP, SLURM; multi-GPU distributed training; in-situ pipelines; GPU clusters (ORNL, LLNL). **Languages:** Python, C++. **Topology & Geometry:** Hodge decomposition, discrete Morse theory, Morse–Smale complexes, persistence filtrations, copresheaf and sheaf methods, TTK, VTK/VTK-m, ParaView. **Methods:** topological and geometric deep learning, graph neural networks, neural operators and PDE/operator surrogates, scientific machine learning, scientific visualization, interpretable and structure-respecting ML, generative models.

PUBLICATIONS

Peer-Reviewed Publications

2026 L. Bastian, **S. Leventhal**, M. Hajij, T. Birdal. *Topological Neural Operators*. NeurIPS, 2026 (under review). arXiv:2606.09806.

2023 **S. Leventhal**, A. Gyulassy, M. Heimann, V. Pascucci. *Exploring Classification of Topological Priors with Machine Learning for Feature Extraction*. IEEE Transactions on Visualization and Computer Graphics (TVCG).

2023 **S. Leventhal**, A. Gyulassy, V. Pascucci, M. Heimann. *Modeling Hierarchical Topological Structure in Scientific Images with Graph Neural Networks*. IEEE International Conference on Image Processing (ICIP).

2020 J. S. Mohlman, **S. Leventhal**, T. Hansen, J. Kohan, V. Pascucci, M. E. Salama. *Improving Augmented Human Intelligence to Distinguish Burkitt Lymphoma from Diffuse Large B-Cell Lymphoma Cases*. American Journal of Clinical Pathology.

2019 S. Petruzza, A. Gyulassy, **S. Leventhal**, J. J. Baglino, M. Czabaj, A. D. Spear, V. Pascucci. *High-Throughput Feature Extraction for Measuring Attributes of Deforming Open-Cell Foams*. IEEE TVCG.

2018 J. Mohlman, **S. Leventhal**, A. Venkat, A. Gyulassy, V. Pascucci, M. E. Salama. *Application of a Convolutional Neural Network to Distinguish Burkitt Lymphoma from Diffuse Large B-Cell Lymphoma*. American Journal of Clinical Pathology.

Workshop Papers

2022 **S. Leventhal**, A. Gyulassy, V. Pascucci, M. Heimann. *Modeling Hierarchical Topological Structure in Scientific Images with GNNs*. NeurIPS Workshop: New Frontiers in Graph Learning.

2019 **S. Leventhal**, M. Kim, D. Pugmire. *PAVE: An In-Situ Framework for Scientific Visualization and Machine Learning Coupling*. IEEE/ACM DRBSD-5, at SC19.

In Preparation / Under Review

2026 **S. Leventhal**, L. Bastian, T. Birdal, M. Hajij. *Topological Neural Operators* (extended journal version, in preparation).

2026 **S. Leventhal**, A. Gyulassy, M. Heimann, V. Pascucci. *Homophily-based Filtration Learning for Graph Neural Networks* (in preparation).

Earlier / Undergraduate Research

2013 **S. Leventhal**, S. LeBohec. *A Search for Quantum-Like Structuring in Keplerian Systems*. University of Utah Undergraduate Research Abstracts Journal.

INVITED TALKS & PRESENTATIONS

2023 IEEE ICIP — Graph Signal Processing and ML for Interpretable and Robust Image Processing II.

2019 SC19 — DRBSD-5 Workshop.