SAMUEL LEVENTHAL

CONTACT INFORMATION

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ABOUT

I am a Ph.D. candidate studying computer science at the University of Utah within the Scientific Computing and Imaging Institute under Valerio Pascucci. My focus is the application and derivation of machine learning and topological computing algorithms both independently and in novel combinations.

EDUCATION

current University of Utah

Ph.D. Computer Science (current) GPA; 3.692

School of Computing & Scientific Computing and Imaging Institute (SCI)

2009-13 University of Utah

B.Sc. Physics; Minor: Philosophy GPA; 3.213

Department of Physics and Astronomy & College of Humanities

2009-13 University of Utah

B.Sc. Mathematics; Minor: Comp. Sci. GPA; 3.213

Department of Mathematics & School of Computing

RESEARCH EXPERIENCE

2022 Modeling Hierarchical Topological Structure in Scientific Images with Graph Neural Networks

Samuel Leventhal, Attila Gyulassy, Valerio Pascucci, and Mark Heimann

Topological analysis reveals meaningful structure in data from a variety of domains. Tasks such as image segmentation can be effectively performed on the network structure of an image's topological complex using graph neural networks (GNNs). We propose two methods for using GNNs to learn from the hierarchical information captured by complexes at multiple levels of topological persistence: one modifies the training procedure of an existing GNN, while one extends the message passing across all levels of the complex. Experiments on real-world data from three different domains shows the performance benefits to GNNs from using a hierarchical topological structure.

2022 Exploring Classification of Topological Priors with Machine Learning for Feature Extraction

Samuel Leventhal, Attila Gyulassy, Mark Heimann, and Valerio Pascucci

In this paper, we describe an approach to creating learnable topological elements, explore the application of ML techniques to classification tasks in a number of areas, and demonstrate this approach as a viable alternative to pixel-level classification, with similar accuracy, improved execution time and requiring marginal training data. In this manuscript, we also introduce a tool allowing users to easily label topological priors of the Morse-Smale Complex to use for training downstream learning models in an active learning setting.

2021 GETO GNN: Topologically and Geometrically Constructed and Aware Graph Neural Networks

mentor: Mark Heimann, Jayaraman J. Thiagarajan, Lawrence Livermore National Labs

We propose a new approach that allows a user to efficiently select and label small subsets of geometric priors computed from the Morse-Smale complex of an image, represent it as a dual or line graph data structure with features, and use neighborhood aggregating graph neural networks (GNNs) to inductively extend the labeling to unclassified portions of the image via the learned graph embedding representation. We show that only sparse annotations are required to fully label the graph, no matter the specific task a user has. We then present GETO-GNN, a novel GNN architecture that uses the domains topology to guide the graph-based representation learning.

2018 High Dimensional Space Filling and Sampling Design with Improved Spectral Sampling and Applications Monte-Carlo Integration.

mentor: Jayaraman J. Thiagarajan, Lawrence Livermore National Labs

During this internship at Lawrence Livermore National Labs I aided in the design and implementation of a scalable spectral sampling design which exploits spectral and spatial properties for optimized sampling and selection providing a state of the art theoretical framework for space filling experimentation, high dimensional data analysis and statistical methods such as Monte-Carlo integration

2016 Topological Distortion as a Quality Measure for Dimension Reduction.

mentor: Bei Wang

Bei Wang and I address the problem of reducing high dimensional data with minimized information loss by identifying first degree homological features in high dimensional data on which we perform principle component analysis. We are then able to project large scale data along the sub-planes in manner which preserves the topological structure of the higher dimensional data. Using topological measures such as bottleneck and p-Wasserstein distances we can then identify optimal planes for projection which minimize distortion.

2013 A Deterministic Sketch of Geometric Extents.

mentor: Jeff Phillips

A publication meant for submission in December 2012 centered around constructing an algorithm able to determine the width along any direction of a geometrically plotted data set. This is accomplished by partitioning and refining an imposed data structure. The data structure takes the form of a square lattice defined by a modular relation dependent on length. The length is then continually reduced given some minimum resolution parameter.

2010-12 Search for Quantum like Structuring in Keplerian Systems.

mentor: Stephan LeBohec

Stephan and I first worked on deriving the postulates of quantum mechanics using Scale relativity- a theory which extends the principle of relativity with scale dependence and assumes space-time to be non-differentiable and continuous. The result leads to quantum geodesics in infinite number, fractal, and infinitesimally irreversible. The Schrödinger equation becomes scale dependent and similar to Brownian motion in a fluid. We therefore identify quantum like structuring within systems formed from chaotic behavior such as celestial systems. Proofs and explanations: http://samleventhal.wordpress.com Probabilistic and spectral graph analysis:https://github.com/sam-lev/SpectralGraphSetSimilarityAnalysisForQuantumStructuringInKeplerianSystems

PUBLICATIONS

2022 S. Leventhal, A. Gyulassy, M. Heimann, and V. Pascucci, Exploring Classification of Topological Priors with Machine Learning for Feature Extraction, To appear in: Transactions on Visualization and Computer Graphics, Accepted with Minor Revisions, 2022.

2022 Modeling hierarchical topological structure in scientific images with graph neural networks. S. Leventhal, A. Gyulassy, V. Pascucci, and M. Heimann. "Modeling hierarchical topological structure in scientific images with graph neural networks." In NeurIPS 2022 Workshop: New Frontiers in Graph Learning, 2022.

2020 Improving Augmented Human Intelligence to Distinguish Burkitt Lymphoma From Diffuse Large B-Cell Lymphoma Cases
American Journal of Clinical Pathology 153.6 (2020): 743-759.

Jeffrey Mohlman, Samuel Leventhal, Valerio Pascucci, PhD, Mohamed Salama, MD

Robust Deep Convolutional Neural Network for diagnosing Burkitt and Diffuse Large B-Cell Lymphoma from images of tissue samples. See description above in research experience for more details.

2019 PAVE: An In Situ Framework for Scientific Visualization and Machine Learning Coupling

5th International Workshop on Data Analysis and Reduction for Big Scientific Data (DRBSD-5) in Conjunction with Super Computing 2019 (SC19). Can be found with the above link or through the SC19 webpage.

Leventhal, S., Kim, M., Pugmire, D.

Machine learning (ML) has emerged as a tool for understanding data at scale. However, this new methodology comes at a cost because even more HPC resources are required to generate ML algorithms. In addition to the compute resources required to develop ML algorithms, ML does not sidestep one of the biggest challenges on leading-edge HPC systems: the increasing gap between compute performance and I/O bandwidth. This has led to a strong push towards *in situ* designs by processing data as it is generated and developing strategies to mitigate the I/O bottleneck. Unfortunately, there are no *in situ* frameworks dedicated to coupling scientific visualization and ML at scale to develop ML algorithms for scientific visualization.

To address the ML and *in situ* visualization gap, we introduce PAVE. PAVE is an *in situ* framework which addresses the data management needs between visualisation and machine learning tasks. We demonstrate our framework with a case study that accelerates physically-based light rendering, path-tracing, through the use of a conditional Generative Adversarial neural Network (cGAN). PAVE couples the training over path-traced images resulting in a generative model able to produce scene renderings with accurate light transport and global illumination of a quality comparable to offline approaches in a more efficient manner.

2019 High-throughput feature extraction for measuring attributes of deforming open-cell foams.

IEEE transactions on visualization and computer graphics. Petruzza, S., Gyulassy, A., Leventhal, S., Baglino, J. J., Czabaj, M., Spear, A. D., Pascucci, V.

Abstract: Metallic open-cell foams are promising structural materials with applications towards multifunctional systems such as biomedical implants, energy absorbers in impact, noise mitigation, and batteries, to name a few. There is a high demand for means to understand and correlate the design space of material performance metrics to the material structure in terms of attributes such as density, ligament and node properties, void sizes and alignments. Currently, X-ray Computed Tomography (CT) scans of these materials are segmented either manually or with skeletonization approaches that may not accurately model the variety of shapes present in nodes and ligaments, especially irregularities that arise from manufacturing, image artifacts, or deterioration due to compression. In this paper, we present a new workflow for analysis of open-cell foams that combines a new density measurement to identify nodal structures, and topological approaches to identify ligament structures between them. Additionally, we provide automated measurement of foam properties. We demonstrate stable extraction of features and time-tracking in an image sequence of a foam being compressed. Our approach allows researchers to study larger and more complex foams than could only previously be segmented manually, and enables the high-throughput analysis needed to predict future foam performance.

2018 Application of a Convolutional Neural Network to Distinguish Burkitt Lymphoma From Diffuse Large B-Cell Lymphoma

American Journal of Clinical Pathology, Volume 150, Issue suppl_1, 21 Sept, 2018, Pages S119

J. Mohlman, S. Leventhal, A. Venkat, A. Gyulassy, V. Pascucci, M. Salama.

For description see above research experience.

2013 A Search For Quantum Like Structuring in Keplerian Systems
University of Utah Undergraduate Research Abstracts Journal, Vol. 13, Book 1.
Leventhal, Samuel

For description see above research experience.

2011 Entropy Is Not Our Anomie
the Sponge, Volume 2, Issue 1.
Leventhal, Samuel.

An investigation into existentialism as a humanism - "We come into this world with nothing, as nothing, making purpose our project".

CURRENT PROJECTS

Topologically Oriented and Informed Machine Learning

A semi-supervised approach to machine learning learning for classification and segmentation through topologically informed features using the Morse-Smale complex as well as segmentation through graph learning over the Morse-Smale complex with traditional learning techniques and Graph Neural Networks.

Topological Segmentation and Visualization

Using merge trees and Morse-Smale complex segmentation in collaboration with two material engineering labs we construct topological representations of material from layered images to afford metrics and statistics of interest with materials such as ceramics and metallic foam.

High Performance Computing with Neural Networks with Optimized Data Formatting for Improved I/O Behavior

To address the high I/O requirements of machine learning (ML) attributing to a prevalent bottleneck for successful and efficient ML applications and their training, this project aims to improve the potential for ML in HPC environments using the newly developed data format IDX2, a compressed file format for scientific data represented as 2D or 3D regular grids of data samples which supports adaptive, coarse-scale data retrieval in both resolution and precision.

OTHER ACHIEVEMENTS

Award *2011* Scholar Athlete. Awarded by the collegiate water polo association.

Assistantship Fall and Spring 2012 U.R.O.P. Assistantship. University funding for research project "A Search for Quantum Like Structuring in Keplerian Systems"

Presentation *2019* Super Computing Conference 2019, 5th International Workshop on Data Analysis and Reduction for Big Scientific Data (DRBSD-5)

Presentation *2013* Presentation at the Utah Conference for Undergraduate Research on Quantum like Structuring in Keplerian Systems

Presentation *2012* Presentation at the Undergraduate Research Opportunities Program Conference on Quantum like Structuring in Keplerian Systems