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# 1st Conference on Topology, Algebra, and Geometry in Data Science (TAG-DS 2025): Preface

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As AI-enabled systems are increasingly deployed across different sectors of the economy, the need for mathematics to both build more performant, reliable, and explainable systems and mathematics to better understand the systems that we already have has become a critical need. This was part of the motivation for the First Annual Topology, Algebra, and Geometry in Data Science (TAG-DS) Conference which occurred on December 1st and 2nd, 2025 at the University of California, San Diego. The goal of this event was to bring together researchers who are using mathematics (especially those areas of mathematics not traditionally associated with machine learning such as topology, algebra, and geometry) to advance the field of machine learning.

The event included participants from a range of technical backgrounds, from mathematicians to statisticians to computer scientists. This led to contrasting perspectives and lively exchanges across the four featured keynotes, the two panel discussions, and the 35 accepted works (of which 26 were selected for archival publication here). We were honored to have over 150 researchers attend.

The four keynote talks were organized thematically by the three mathematical domains (topology, algebra, and geometry) targeted by the conference. Richard Baraniuk presented a fascinating talk called ‘The Geometry of Deep Learning’ which described how a spline-based decomposition of deep neural networks can reveal surprising changes late in training. Symmetry remained a central theme among many of the speakers. Elisenda Grigsby’s talk ‘The Effect of Hidden Symmetries on Neural Network Optimization and Generalization’ discussed parameter symmetries in neural networks, including the role they play in the behavior of the network. Parameter symmetries were central to Haggai Maron’s summary of recent progress developing metamodels, machine learning models that learn on neural network weights. Finally, Robin Walters described the interplay between architectural priors and symmetries in data with a focus on the robotics setting.

The conference also featured four spotlight talks which represented what our reviewers assessed to be our most interesting and impactful submissions. This included Behrooz Tahmasebi’s presentation of the paper *Achieving Approximate Symmetry Is Exponentially Easier than Exact Symmetry*, Charles Kulick’s presentation of the paper *Investigating Zero-Shot Size Transfer of Graph Neural Differential Equations for Learning Graph Diffusion Dynamics*, Nicholas Karris’s presentation *Which Way from B to A: The role of embedding geometry in image interpolation for Stable Diffusion*, and Marco Campos’ presentation *Topological Preservation in Temporal Link Prediction*. Happily, all of these papers can be found within this volume.

In addition to the talks, the conference also featured a poster session, which afforded all accepted authors the opportunity to exhibit their work. The posters can be found on the conference website: <https://www.tagds.com/events/tag-ds-2025>. The conference included two panel discussions. The first, ‘Math Beyond Academia’, focused on the intersection of AI and math important to industry and government. This panel featured Katie Rainey (Naval Information Warfare Center Pacific), Cayley Rice (Leidos), Christian Shewmake (New Theory AI) and Haggai Maron (Technion and NVIDIA Research). The aim of the second panel was to explore the current landscape of math + AI research. For example, how does mathematics interact with scaling trends? And how is AI likely to change the way that mathematicians work? This panel featured Richard Baraniuk, Elisenda Grigsby, Javier Duarte, Dima Drusvyatskiy and Yusu Wang.

Finally, the conference included another iteration of the Topological Deep Learning Challenge. This year’s challenge aimed to address the data bottleneck in the field by systematically expanding the ecosystem of Topological Deep Learning (TDL). Powered by TopoBench, the challenge was organized into two primary missions: enriching the data landscape with diverse datasets, and advancing core data infrastructure. In particular, participants were invited to contribute to the open-source platform by implementing new dataset loaders, designing new benchmark tasks, or engineering robust, scalable data pipelines. The initiative successfully yielded 44 qualifying submissions.

The organizers would like to thank our amazing reviewers – without their efforts we would not have been able to accept such a large number of diverse technical papers: Erik Amezquita, Brian Bell, Gergely Berczi, Dhananjay Bhaskar, Nello Blaser, Georg Bökman, Ayon Borthakur, Semih Cantürk, Maghesree Chakraborty, Stephan Chalup, Tobias Cheung, Seunghyuk Cho, Timothy Doster, Thomas Gebhart, Marco Guerra, Sree Harsha Tanneru, Vineet Jain, Alvin Jin, Arjun Karuvally, Bill Kay, Gavin Kerrigan, Mingyu Kim, Jinwoo Kim, Henry Kvinge, Thien Le, Juyong Lee, Mary Letey,

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Please see the conference website <https://www.tagds.com/events/tag-ds-2025> for further information about this and other TAG conferences and watch <https://www.tagds.com> and <https://twitter.com/TAGinDS> for future TAG workshops.