

*Dilating Mission relevant Impact of autonomous data driven  
Topologically informed analytics & Fusion*

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**Abstract**

This decade's 'digital wild' is inundated with high rate, voluminous combinations of physics- and human-based data. The challenge is further exacerbated by rapidly accelerating autonomous architectures lacking accessible explainability, compromised/poisoned heterogeneous data, and managing denied/degraded/intermittent/low-bandwidth environments. These and other prohibitive symptoms continuously weaken user certainty and erode modeling confidence while concurrently increasing compute complexities and reducing edge processing compatibility, resulting in failed support of resilient (near) real-time decision speed. Addressing these challenges motivates rigorous scientific creativity through multi-disciplinary approaches, particularly leveraging the rich mathematical properties of a network's upstream data and their fused aggregates. Computational and algebraic topology implemented by topological data analysis (TDA), both classical (e.g., persistent homology and the Mapper algorithm) and emerging (e.g., topological machine/deep learning), provide access to these properties and a path to modality/model agnostic fusion within rugged data topographies. This talk exhibits one such ongoing success, Dr. Schrader's efficient and scalable TDA Machine Learning (TDAML) algorithm and examines several case studies recently developed from the TDAML including applications in surveillance, time-series forecasting, data assurance, and materials/systems inspection. TDAML is one of several emerging/promising techniques contributing to a growing body of evidence and testifying to the efficacy of topologically-informed data driven analytics/fusion. After a brief overview introducing TDA, an overarching dissection of the TDAML along with a survey of its initial object detection/classification studies and emerging implementation family are presented. The impact of TDAML technology on a much broader range of relevant objectives are interjected throughout the exposition amplifying the need for further research investment in TDA-inspired/informed data-driven autonomy. Finally, future directions are discussed for the TDAML leveraging arbitrary physics- and human-based data analytics/fusion towards reliable and deployable situational/state/systems/material/cyber awareness.

**Bio**

Dr. Paul T. Schrader is a Research Mathematician for the Air Force Research Laboratory's Information Directorate>Information Warfare Division>Information Exploitation Branch (AFRL/RIGC). A non-traditional student originally working for years in the wholesale distribution and welded fabrication industries, he received his BA (2011) and MS (2013) in mathematics from Cleveland State University where he began his studies in topological data analysis (TDA). In 2018 he obtained a PhD in mathematics from Bowling Green State University specializing in non-associative algebras and monoidal/tensor/modular categories. Prior to the AFRL/RI he was a tenure track Assistant Professor of Mathematics at Southern Arkansas University from 2018-2022. With multiple publications and patents pending in a variety of TDA, mathematics, math education, and AI/ML based subjects, his current research includes the applications of TDA and other novel mathematical approaches to modality agnostic data driven information fusion for collaborative/distributive autonomy in: target recognition and continuous custody, arbitrary tactical/strategic sensing grids, systems/materials/high-rate health monitoring and situational/state awareness, battle/natural disaster damage assessment, network/data assurance, human-machine interfacing, wearables, and general dynamic data-driven applications systems/phenomena.

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