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Matroids in TDA: Combinatorial Perspectives on Persistence, Stability, and Computation

Abstract

A basic notion in modern topological data analysis (TDA) is the idea of a persistent homology group. The elements of homological persistence have existed since at least the mid 1980s, emerging independently in the work of Robins in shape theory, of Edelsbrunner, Kirkpatrick, and Seidel in biogeometry, and of Patrizio and Ferri in size theory. Two principle challenges in modern TDA center on questions of modeling and computation: what do persistent homology groups have to say about empirical data, and how can they be computed? A recurring issue in the face of these challenges has been the body of algebraic machinery needed to make the idea of persistent homology precise; this apparatus, while standard in pure mathematics, poses a basic barrier to entry for newcomers to the field of TDA, and an impediment to formal interpretation of elementary topological statistics. In this talk we introduce a new approach to persistent homology which relies on no algebraic structure whatever, but rather some elementary combinatorial properties of linear independence. This simplified framework yields useful insights into the mathematical descriptors commonly associated to homological persistence - barcodes and generators - as well as computation. As an application, we will discuss a new algorithm to compute barcodes and generators, recently implemented in the Eirene library for computational persistence, and its advantages for large and high-dimensional data sets.