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A Higher-Dimensional Homologically Persistent Skeleton

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A data set is often given as a point cloud, i.e. a non-empty finite metric space. An important problem is to detect the topological shape of data
– for example, to approximate a point cloud by a low-dimensional non- linear subspace such as a graph or a simplicial complex. Classical clustering methods and principal component analysis work very well when data points split into well-separated groups or lie near linear subspaces. Methods from topological data analysis detect more complicated patterns such as holes and voids that persist for a long time in a 1-parameter family of shapes associated to a point cloud. These features were recently visualized in the form of a 1-dimensional homologically persistent skeleton, which optimally extends a minimal spanning tree of a point cloud to a graph with cycles. We generalize this skeleton to higher dimensions and prove its optimality among all complexes that preserve topological features of data at any scale.