Two models for shapes

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We present two approaches to model shapes: one based on integral geometry and one based on diffeomorphisms.

Using ideas from integral geometry we introduce two summary statistics the persistent homology transform (PHT) and Euler characteristic transform to model shapes and surfaces. We illustrate how to use this statistic for geometric morphometrics and radio genomics. We also provide some theoretical properties for this statistic, such as when it is sufficient.

We develop a geometric framework that characterizes the synchronization problem — the problem of consistently registering or aligning a collection of objects. The theory we develop is based on fibre bundles and relates to diffeomorphisms. We also develop a twisted cohomology theory associated to this theory. Motivated by our geometric framework, we study the problem of learning group actions — partitioning a collection of objects based on the local synchronizability of pairwise correspondence relations. A dual interpretation is to learn finitely generated subgroups of an ambient transformation group from noisy observed group elements. A synchronization-based algorithm is also provided and applied to primate teeth to uncover dietary habits.