Nonparametric Density Estimation on Manifolds with Applications to Shape Analysis

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Abstract

Statistical analysis on landmark-based shape spaces has diverse applications in morphometrics, medical diagnostics, machine vision and other areas. These shape spaces are non-Euclidean quotient manifolds. To conduct nonparametric inferences, one may define notions of center and spread on the manifold and work with their estimates. However, it is useful to consider full likelihood-based methods which allow nonparametric estimation of the probability density. This presentation describes a broad class of mixture models constructed using suitable kernels on a general metric space and then on the planar shape space in particular. Following a Bayesian approach with a nonparametric prior on the mixing distribution, conditions are obtained under which the density estimate is consistent. Gibbs sampling methods are developed for posterior computation, and the methods are applied to problems in density estimation and classification with shape-based predictors. Simulation studies show improved estimation performance relative to existing approaches.

Key Words: Riemannian Manifold; Planar Shape Space; Mixture Density Model; Nonparametric Bayes; Posterior consistency; Mixture Discriminant Analysis.