Spline Smoothing of 3D Geometric Data

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Abstract:
Over the past two decades, we have seen an increased demand for 3D visualization and simulation software in medicine, architectural design, engineering, and many other areas, which have boosted the investigation of geometric data analysis and raised the demand for further advancement in statistical analytic approaches. In this work, we propose a class of spline smoothers appropriates for approximating geometric data over 3D complex domains, which can be represented in terms of a linear combination of spline basis functions with some smoothness constraints. We start with introducing the tetrahedral partitions, Barycentric coordinates, Bernstein basis polynomials, and trivariate spline on tetrahedra. Then, we propose a penalized spline smoothing method for identifying the underlying signal in a complex 3D domain from potential noisy observations. Simulation studies are conducted to compare the proposed method with traditional smoothing methods on 3D complex domains.

Keywords:
Nonparametric smoothing; 3D geometric data; Penalized splines; Trivariate splines; Tetrahedra partitions