DEPARTMENT OF MATHEMATICAL SCIENCES

Colloquium

Smoothness Preserving Nonlinear Dimensionality Reduction Using Splines

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ABSTRACT:
Existing Nonlinear Dimensionality Reduction (NDR) methods are adept at revealing the hidden low-dimensional manifolds underlying Nonlinear High-Dimensional (NHD) data. However, the smoothness of the manifolds revealed by classic NDR techniques in the presence of noise is not guaranteed. In fact, the embedding generated using such noisy measurements may distort the geometry of the manifold and thereby produce an unfaithful embedding. Herein, we propose two NDR techniques that generate smooth manifolds utilizing spline based approaches. In the first method, we generate a graph structure for given NHD data using a neighborhood search algorithm and then produce piecewise linear shortest paths that are interpreted as geodesics. Then, we fit points in each geodesic by a smoothing spline to emphasize the smoothness. In the second method, we construct a two-dimensional principal manifold directly in the high-dimensional space using cubic smoothing splines and define the embedding coordinates in terms of an intrinsic coordinate system with respect to a virtual origin. The robustness of these approaches for noisy and sparse datasets is demonstrated by the implementation of the methods on synthetic and real-world datasets.

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