

Manifold Dimension Estimation: An Empirical Study

Bi, Zelong and Pierre Lafaye de Micheaux

School of Mathematics & Statistics, University of New South Wales

September 22, 2025

Abstract

The manifold hypothesis suggests that high-dimensional data often lie on or near a low-dimensional manifold. Estimating the dimension of this manifold is essential for leveraging its structure, yet existing work on dimension estimation is fragmented and lacks systematic evaluation. This article provides a comprehensive survey for both researchers and practitioners. We review often-overlooked theoretical foundations and present eight representative estimators. Through controlled experiments, we analyze how individual factors—such as noise, curvature, and sample size—affect performance. We also compare the estimators on diverse synthetic and real-world datasets, introducing a principled approach to dataset-specific hyperparameter tuning. Our results offer practical guidance and suggest that, for a problem of this generality, simpler methods often perform better.

Keywords: manifold hypothesis, intrinsic dimension, nonlinear dimension reduction