Regularized Pre-image Estimation for Kernel PCA De-noising - DTU Orbit (01/01/2019)

Regularized Pre-image Estimation for Kernel PCA De-noising: Input Space Regularization and Sparse Reconstruction

The main challenge in de-noising by kernel Principal Component Analysis (PCA) is the mapping of de-noised feature space points back into input space, also referred to as “the pre-image problem”. Since the feature space mapping is typically not bijective, pre-image estimation is inherently illposed. As a consequence the most widely used estimation schemes lack stability. A common way to stabilize such estimates is by augmenting the cost function by a suitable constraint on the solution values. For de-noising applications we here propose Tikhonov input space distance regularization as a stabilizer for pre-image estimation, or sparse reconstruction by Lasso regularization in cases where the main objective is to improve the visual simplicity. We perform extensive experiments on the USPS digit modeling problem to evaluate the stability of three widely used pre-image estimators. We show that the previous methods lack stability in the non-linear regime, however, by applying our proposed input space distance regularizer the estimates are stabilized with a limited sacrifice in terms of de-noising efficiency. Furthermore, we show how sparse reconstruction can lead to improved visual quality of the estimated pre-image.

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