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Dimension Estimates for Multivariate Geoscientific Measurements

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Geoscientific data sets often consist of simultaneous records of different parameters. For example, in geology, a number of biological, chemical, physical and sedimentological parameters is obtained along sedimentary sequences in order to analyze signatures of climate change and attribute them to particular climatic variables. In meteorology and hydrology, different parameters are used to characterize the variations of the local weather and forecast its future evolution. Moreover, in these cases, the spatial distribution of data is often of particular interest.

In our presentation, we address the question of how to quantify the relative content of information about variations of the underlying system recorded in particular data sets. For this purpose, we develop a theoretical framework to characterize multivariate data in terms of the complexity of interrelationships between the respective component time series. Applying standard linear principal component analysis to a data set, we study the decay of remaining variances with an increasing number of considered eigenmodes and define a novel dimension estimate basing on an exponential decay model.

The performance of our measure is compared to that of the recently introduced KLD dimension by applying both approaches to different model systems. We propose a bootstrap test to approximate confidence intervals for the computed dimension densities. Possible generalizations of our approach with respect to other methods of statistical decomposition include applications to univariate time series by considering an appropriate embedding.