Modeling Amplitude and Phase Variation of Multivariate Random Processes in Geodesic Spaces

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ABSTRACT

For real-valued functional data, it is well known that failing to distinguish between amplitude variation and phase variation can distort subsequent statistical analysis, and extensive work has been devoted to developing time-warping methods to address this issue. However, much less is known about how to characterize and handle these two sources of variability when they co-exist in random processes taking values in general metric spaces, which lack inherent linear structure, particularly in the multivariate setting. In this paper, we formalize the concepts of amplitude and phase variation for multivariate random processes in geodesic spaces and propose a latent deformation model for jointly analyzing both types of variation. We establish the asymptotic convergence rates for the model estimators and demonstrate the versatility of the proposed method through simulation studies on positive semi definite (PSD) matrix-valued data and network-valued data, as well as a real-world application to annual sex-specific age-at-death distributions across countries, providing new insights into global longevity dynamics.

Keywords: distributional data; functional data; metric spaces; networks; PSD matrices; time warping

Transfer Learning for Functional Linear Regression

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ABSTRACT

We explore functional linear regression under posterior drift with transfer learning. Specifically, we investigate when and how auxiliary data can be leveraged to improve the estimation accuracy of the slope function in the target model when posterior drift occurs. We employ the approximated least square method together with a lasso penalty to construct an estimator that transfers beneficial knowledge from source data. Theoretical analysis indicates that our method avoids negative transfer under posterior drift, even when the contrast between slope functions is quite large. Specifically, the estimator is shown to perform at least as well as the classical estimator using only target data, and it enhances the learning of the target model when the source and target models are sufficiently similar. Furthermore, to address scenarios where covariate distributions may change, we propose an adaptive algorithm using aggregation techniques. This algorithm is robust against non-informative source samples and effectively prevents negative transfer. Simulation and real data examples are provided to demonstrate the effectiveness of the proposed algorithm.

Keywords: Transfer learning; functional data analysis; data fusion.

Inference for Dispersion and Curvature of Random Objects

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ABSTRACT

A basic statistical task is to quantify statistical dispersion or spread. When one deals with random objects located in general metric spaces a challenge is the absence of vector space structure. A CLT for the joint distribution of Fréchet variance and metric variance, two measures of dispersion in geodesic spaces, reveals that the Alexandrov curvature of the geodesic space determines the relationship between these two dispersion measures, which generally do not coincide. This relation can be harnessed to infer the underlying curvature of the data, which results from properties of both the space and the probability measure that generates the random objects. The resulting test for curvature is supported by theory and aids in determining the intrinsic curvature of the (sub)space where the objects reside. Its finite sample properties are demonstrated for various data types and applications. This talk is based on joint work with Wookyeong Song, UC Davis.

Keywords: Metric Statistics; Fréchet Variance; Metric Variance; Intrinsic Curvature