Functional Additive Models

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Abstract

In commonly used functional regression models, the regression of a scalar or functional response on the functional predictor is assumed to be linear. This means the response is a linear function of the functional principal component scores of the predictor process. We relax the linearity assumption and propose to replace it by an additive structure. This leads to a more widely applicable and much more flexible framework for functional regression models. The proposed functional additive regression models are suitable for both scalar and functional responses. The regularization needed for effective estimation of the regression parameter function is implemented through a projection on the eigenbasis of the covariance operator of the functional components in the model. The utilization of functional principal components in an additive rather than linear way leads to substantial broadening of the scope of functional regression models and emerges as a natural approach, as the uncorrelatedness of the functional principal components is shown to lead to a straightforward implementation of the functional additive model, just based on a sequence of one-dimensional smoothing steps and without need for backfitting. This facilitates the theoretical analysis, and we establish asymptotic consistency of the estimates of the components of the functional additive model. The empirical performance of the proposed modeling framework and estimation methods is illustrated through simulation studies and in applications to gene expression time course data.

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