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Bayesian Generalized ANOVA Modeling for Functional Data Using INLA

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Functional analysis of variance (ANOVA) modeling has been proved particularly useful to investigate the dynamic changes of functional data according to certain categorical factors and their interactions. However, the current existing methods often encounter difficulties when the functional data are high-dimensional, non-Gaussian, and/or exhibit certain shape characteristics that vary with spatial locations. In this paper, we propose a unified generalized functional ANOVA modeling approach under Bayesian framework. The models are constructed based on a class of highly flexible Gaussian Markov random fields (GMRFs) taken on the effect functions as priors. This allows us to consider various types of functional effects, such as (discrete or continuous) temporal effects and (point-level or areal) spatial effects. The posterior distributions are obtained by an efficient computational tool based on integrated nested Laplace approximations (INLA) (Rue et al., 2009). We also employ the excursion method introduced by Bolin & Lindgren (2015) to build simultaneous credible intervals of functional effects and test their significance from a Bayesian point of view. A simulation study and multiple real data examples are presented to demonstrate the merits of our method.