Nonparametric Bayesian multivariate meta-regression with functional meta-predictor: an application in environmental epidemiology.

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Abstract

Meta-analysis has been a useful statistical tool to combine evidences from multiple studies in many fields of applications. Two-stage approach is popular for conducting a meta-analysis because of its computational convenience and flexibility; the first stage models the study-specific association between exposure and response controlling for potential confounders, and the second stage combines the association parameters estimated from the first stage accounting for uncertainty. The second stage often incorporates meta-predictors that may explain the between-study variation in the association, and is called meta-regression. The existing meta-regression model associates univariate or multivariate association parameters with multiple meta-predictors in a normal linear regression framework, and therefore, is limited when the normality or linearity assumptions do not hold. Moreover, it does not account for functional meta-predictors which frequently arise in many applications. Motivated by an environmental epidemiology study, this research proposes a flexible meta-regression model where parametric assumptions are relaxed and functional meta-predictors are incorporated. The proposed model adapts a nonparametric Bayesian regression to the second stage meta-regression. Specifically, the association parameters and the functional meta-predictors are jointly modeled using a Dirichlet process mixture of Gaussians, from which a flexible regression formulation is derived. For the functional meta-predictors, we obtain a lower-dimensional representation using basis for splines, and the basis coefficients are included as meta-predictors in the joint modeling. The proposed model was validated and compared with existing methods through a simulation study, and was applied to the motivating environmental epidemiology study.