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Analysis of Binary Longitudinal Data with Time-Varying Effects

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Abstract

This paper considers the analysis of longitudinal data where a binary response variable is observed repeatedly for each subject over time. In analyzing such data, regression coefficients are commonly assumed constant over time, which may not properly account for the time-varying effects of some subject characteristics on a sequence of binary outcomes. This paper proposes a Bayesian method for the analysis of binary longitudinal data with time-varying regression coefficients and random effects to account for nonlinear subject-specific effects over time as well as between-subject variation. The proposed method facilitates posterior computation via the method of partial collapse and accommodates spatially inhomogeneous smoothness of nonparametric functions without overfitting via a basis search technique. The proposed method is illustrated with a simulated study and the binary longitudinal data from the German socioeconomic panel study.

Keywords: Longitudinal data, Probit mixed model, Nonparametric regression, Partial collapse, Repeated measures

1. Introduction

A binary response variable is often measured repeatedly for each subject over time, along with each subject's time-dependent personal characteristics. In analyzing such binary longitudinal data, a model needs to account for nonlinear subject-specific effects on a sequence of binary responses and between-subject variability present in longitudinal data. Mixed models with random effects are thus generally adopted because they provide effective modeling of the longitudinal nature of data (Laird and Ware, 1982).

Among some link functions that provide binary transformation, the probit link is often preferred because it avoids the unrealistic assumption of independence of irrelevant alternatives of logistic models (Imai and van Dyk, 2005). Probit mixed models are, in this sense, widely used to analyze binary longitudinal data and, until recently, have been studied in various statistical settings (Varin and Czado, 2010; Kyung et al., 2010; Soyer and Sung, 2013).

A significant extension to probit mixed models can be developed by allowing the effect of predictors on a sequence of binary responses to vary with time. That is, the regression coefficients of the probit mixed models are not assumed constant but rather change with a time-dependent effect modifier, e.g., time itself. Regression models that have coefficients varying with other effect modifiers are referred to as varying-coefficient models (Hastie and Tibshirani, 1993), which are widely used to capture the time-varying effect of predictors on a response variable in a longitudinal study (Hoover et al., 1998; Wu et al., 1998; Huang et al., 2002).

Most references on varying-coefficient models focus on the estimation of the unknown functions of varying regression coefficients. In particular, the tuning of surface roughness parameters (e.g., bandwidths for kernel

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