HUMAN DEVELOPMENT AND FAMILY STUDIES

DISSERTATION DEFENSE FOR

Lu Ou

ESTIMATION OF MIXED-EFFECTS CONTINUOUS-TIME MODELS

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ABSTRACT

The increased popularity of intensive longitudinal studies presents some renewed opportunities, but also some unique data analytic challenges in studying change. For instance, many intensive longitudinal measurements may be collected at irregularly spaced time intervals, and involve complex, possibly nonlinear and heterogeneous (across individuals) patterns of change. Effective modeling of such change processes requires continuous-time models (i.e., differential equation models) that may be nonlinear in form and include mixed effects in key dynamic parameters of interest. To fit such models, the continuous-discrete extended Kalman filter (CDEKF; Bar-Shalom, Li, & Kirubarajan, 2001; Chow et al., under review; Kulikov & Kulikova, 2014) approach has been proposed. However, its performance had only been evaluated in fitting ordinary differential equation (ODE) models with no process noise; its performance in handling stochastic differential equation (SDE) models with mixed effects was unclear. In the current project, I 1) evaluated the feasibility of using the CDEKF approach to fit nonlinear mixed-effects SDE models in which random effects are represented as latent variables, 2) mathematically derived the necessary condition under which the underlying approximate model for a mixed-effects SDE model in the CDEKF approach is identifiable; 3) extended a previously published linear mixed-effects continuous-time model of emotions to a nonlinear mixed-effects SDE model and fitted it to a set of irregularly-spaced intensive longitudinal data from the Affective Dynamics and Individual Differences (ADID; Emotions and Dynamic Systems Laboratory, 2010) study; and 4) performed a Monte Carlo simulation study to evaluate the strengths and limitations of the CDEKF approach in fitting the nonlinear mixed-effects continuous-time model proposed in 3). Results showed that the model proposed for studying positive and negative emotions provided a reasonable fit to the empirical data, and the CDEKF

approach was able to produce accurate and dependable parameter and standard error estimates in fitting mixed-effects SDE models. I also addressed how sample-size, process noise variance, and data spacing conditions could affect the performance of the CDEKF approach, and provided practical suggestions on its utility based on results from the simulation study. The CDEKF approach has been implemented in the R package, dynr (Ou, Hunter, & Chow, 2017).