PRINCETON UNIVERSITY
OPERATIONS RESEARCH & FINANCIAL ENGINEERING SEMINAR

Population Modeling and Bayesian Estimation for the Deconvolution of Blood Alcohol Concentration from Transdermal Alcohol Biosensor Data

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Abstract

We develop statistical methods to estimate blood alcohol concentration (BAC) from transdermal alcohol concentration (TAC) measurements supplied by a transdermal alcohol sensor (TAS). This eliminates the need for clinical test data for each patient to calibrate the underlying mathematical models to each subject and each device. We parametrically estimate the distribution for transport parameters in a transdermal ethanol model based on population analysis and simulated data using the Global Two-Stage Method (GTS). We implement the GTS method using generated and clinical data obtained from 17 healthy volunteers with approximately the same body mass index. Next, we develop a Bayesian approach to estimate BAC for new patients from the population using TAS data generated by a full body alcohol model. The BAC signal is approximated by piecewise-constant (zero-order spline) functions. Prior distributions are assumed for skin model parameters (based on population analysis) and BAC spline coefficients. The new patient's TAS data is used to estimate BAC via maximization of a posterior distribution for skin parameters and input coefficients. This yields a maximum a-posteriori (MAP) estimate. With basic assumptions on the BAC spline coefficients and the TAS noise model, we obtain direct samples from the posterior distribution. This allows us to construct 95% confidence intervals (CI) for BAC.

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