Mixed Linear System Estimation and Identification

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We consider a mixed linear system model, with both continuous and discrete inputs and outputs, described by a coefficient matrix and a set of noise variances. When the discrete inputs and outputs are absent, the model reduces to the usual noise-corrupted linear system. With discrete inputs only, the model has been used in fault estimation, and with discrete outputs only, the system reduces to a probit model. We consider two fundamental problems: Estimating the model input, given the model parameters and the model output; and identifying the model parameters, given a training set of input-output pairs. The estimation problem leads to a mixed Boolean-convex optimization problem, which can be solved exactly when the number of discrete variables is small enough. In other cases the estimation problem can be solved approximately, by solving a convex relaxation, rounding, and possibly, carrying out a local optimization step. The identification problem is convex and so can be exactly solved. Adding ℓ_1 regularization to the identification problem allows us to trade off model fit and model parsimony. We illustrate the identification and estimation methods with a numerical example.