Modeling problems using Bayes' rule for finite impulse response models and Markov models

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Abstract

This thesis concentrates on the modeling problems using Bayes' rule for finite impulse response models and Markov models. First, the Bayesian system identification for positive systems is exploited. The truncated Gaussian prior is applied for identifying the positive systems. The hyperparameter estimation allows the application of the expectation-maximization (EM) algorithm. In addition, a numerical experiment for identifying positive systems using the proposed algorithm is provided. Secondly, we work on the input design problem for the general Bayesian identification. The input design problem is first formulated by considering deterministic inputs, which leads to a non-convex optimization problem. Restricting inputs to be periodic makes the problem convex but introduces conservativeness. The stochastic consideration facilitates the input design problem to be presented as a convex problem whose decision variables are a finite number of autocorrelation coefficients. Using the maximum entropy extension gives the complete input spectrum. Scaling up the designed stochastic process improves the probability of sampling a good input. The optimal input is selected to be the minimum energy one in the good inputs. Simulation results demonstrate the effectiveness of the proposed method. Lastly, we consider the reduced-order modeling problem for aggregated Markov models (AMMs) whose reachable space is constructed by Bayes' rule. The order of an AMM is an index of the complexity and is closely related to the reachable subspace of the model. When the reachable subspace is not the whole space, there exists a reduced-order quasi aggregated Markov model (quasi-AMM), which may not satisfy the nonnegative constraints, equivalent to the original AMM. Such an AMM will be called reachable-space reducible. The set of AMMs where the transition matrix and the observation matrix jointly have a structured non-zero pattern is called a structured AMM. We explore the classification of the structured AMM and work out the superset of the reachable space corresponding to each class. The reducibility for structured AMMs is analyzed based on the superset of the reachable space. Subsequently, we reveal a reduced-order realization of the structured AMM in each class. Examples are provided to support our results.