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1 Introduction

Systems considered in science are becoming more and more complex and of an interconnected nature. Fields where interconnected systems, from now on called networks, are studied include but are not limited to engineering, biology and finance. In these fields modeling the network will generate additional understanding of the underlying system, in engineering in particular the model can be used for control design. We focus on black-box modeling since first principles modeling becomes increasingly complex in networks. A network identification framework was introduced in [1] which allows for consistent identification of modules in the network. In the framework it is assumed that the topology of the network is known, while in practice this assumption might not hold. We work on extending the network identification framework by making less restrictive assumptions. For example in this work we focus on topology detection.

2 Network identification

Consider the network given by the equation

\[
w(t) = G_0(q)w(t) + R_0(q)r(t) + H_0(q)e(t)
\]

with \(w(t)\) a vector of \(L\) internal variables, \(G_0(q)\) an \(L \times L\) transfer matrix with 0 diagonal, \(r(t)\) a vector of \(K\) external variables, \(e(t)\) a vector of \(L\) independent stochastic variables and \(R_0(q)\) and \(H_0(q)\) transfer matrices of appropriate dimension. A network model structure \(\mathcal{M}(\theta)\) is used to define a network predictor as

\[
e(t, \theta) := H^{-1}(q, \theta)\{(I-G(q, \theta))^{-1} - R(q, \theta)\}.
\]

We do not make assumptions on the structure, hence model \(G(q, \theta)\) is fully parametrized with zero diagonal, but also \(R(q, \theta)\) and \(H(q, \theta)\) are fully parametrized. Consistent estimates of the dynamics are obtained under similar conditions as in [1] when some elements of the network model structure are restricted. The network model structure \(\mathcal{M}(\theta)\) is flexible enough to have a model set that contains infinite models that can represent the network equally well, which can be classified as an identifiability problem. Identifiability was addressed in [3] and we continue in a similar reasoning. Restricting the model flexibility using a-priori knowledge is a way to reduce the amount of models in the model set that fit the network. Conditions under which the model structure has been restricted enough and is therefore identifiable are such that each node either has an independent input or the interconnections coming from that node are not parametrized [2]. A special case is the assumption that all noises are independent \((H(q, \theta)\) diagonal), which leads to a diagonal noise model \(H(q, \theta)\) and ensures identifiability.

3 Topology detection

The estimated network models are consistent, however due to variance all the transfer functions will be parametrized as non-zero and as a result no topology detection has been performed then. We would like to see transfer functions be identified as 0 in some measure when there is no interconnection. Parameters or transfer functions are dragged to 0 by adding L1 or mixed L1-L2 regularization to the identification criterion. The regularized estimate is still consistent, and it is sparse such that the topology has been detected.

4 Conclusions

We relaxed assumptions in network identification by allowing noises to be correlated and investigated the consequences for identifiability. Relaxing the assumptions even further could be done by letting the noises be represented by less than \(L\) independent noise sources, which leads to interesting mixed stochastic/deterministic problems. Other interesting questions include the tuning of the regularization and making an analysis of the variance.

References

