Qiang Liu, Jia-chen Ma, 2016. Subspace-based identification of discrete time-delay system. *Frontiers of Information Technology & Electronic Engineering*, **17**(6):566-575. http://dx.doi.org/10.1631/FITEE.1500358

Subspace-based identification of discrete time-delay system

Key words: Identification problems, Time-delay systems, Subspace identification method, Alternate convex search, Least squares

Corresponding author: Qiang Liu E-mail: lqianghit@163.com ORCID: http://orcid.org/0000-0003-2464-8007

Motivation

- Time delays often appear in various engineering systems, such as chemical processes, mechanical systems, transmission lines, and economic systems.
- Subspace identification methods have undergone tremendous development in the last 20 years in both theory and practice.
- In this study, we investigate the identification problems for discrete stochastic time-delay systems with a single delay in the state vector.

Main idea

- To handle the time-delay property, the state augmentation technique is be used to transform the time-delay system into an equivalent linear timeinvariant (LTI) system.
- Subspace methods can be used to provide an initial consistent estimate for the augmented system model.

Method

- To recover the time-delay system matrices from the estimated augmented model, an alternate convex search (ACS) algorithm is presented.
- The time-delay system matrices under the same state-space basis can be recovered from the Kalman state sequences and input-output data by solving two least squares problems.

Major results

Bode plot of the estimated augmented system



Fig. 1 Bode plot of the estimated augmented system

Major results (Cont'd)

Pole locations of the estimated augmented system



Fig. 2 Pole locations of the estimated augmented system

Major results (Cont'd)

Eigenvalue locations of the estimated A



Fig. 3 Eigenvalue locations of the estimated A

Major results (Cont'd)

• Eigenvalue locations of the estimated A_d



Fig. 4 Eigenvalue locations of the estimated A_d

Conclusions

- Identification problems of linear stochastic time-delay systems in discrete time have been investigated in this paper.
- The N4SID algorithm was used to provide an initial consistent estimate for the augmented system matrices.
- An ACS algorithm was also presented for recovering the time-delay system matrices from the estimated augmented matrices, and the local convergence of this algorithm has been proved.
- Finally, the time-delay system matrices up to a similarity transformation were derived by solving two least squares problems based on the reconstructed Kalman state sequences and inputoutput data. A numerical example was provided to show the effectiveness of the developed method.