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Subspace-based identification of discrete time-delay system

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

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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.

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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 time-invariant (LTI) system.
- Subspace methods can be used to provide an initial consistent estimate for the augmented system model.

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Method

1. To recover the time-delay system matrices from the estimated augmented model, an alternate convex search (ACS) algorithm is presented .
2. 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.

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Major results

- Bode plot of the estimated augmented system

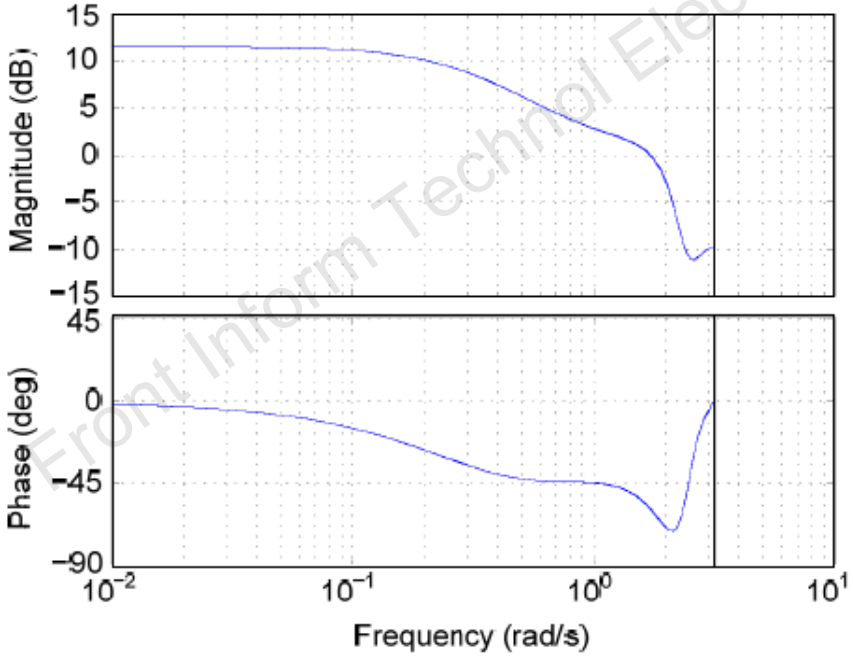


Fig. 1 Bode plot of the estimated augmented system

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Major results (Cont'd)

- Pole locations of the estimated augmented system

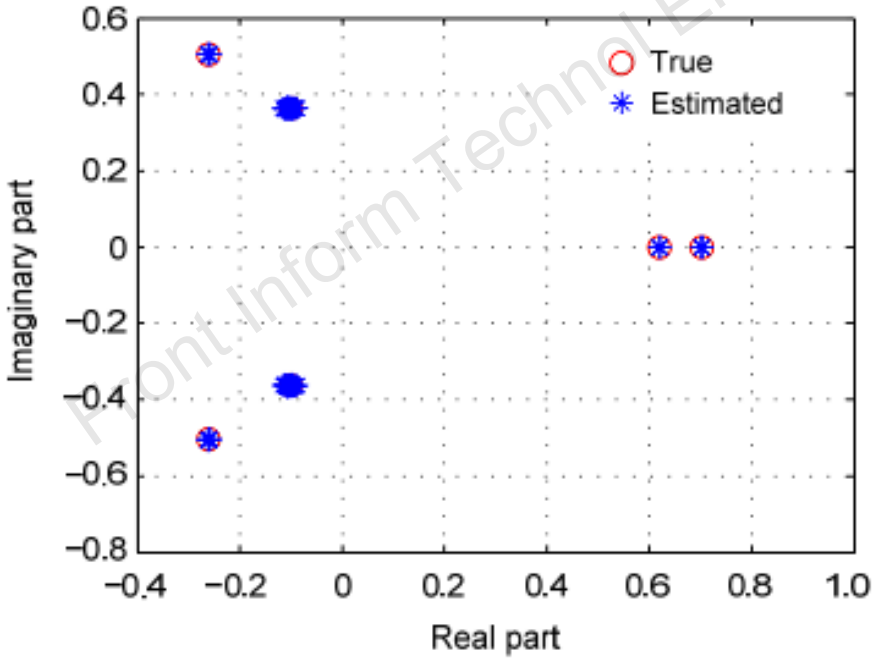


Fig. 2 Pole locations of the estimated augmented system

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Major results (Cont'd)

- Eigenvalue locations of the estimated ***A***

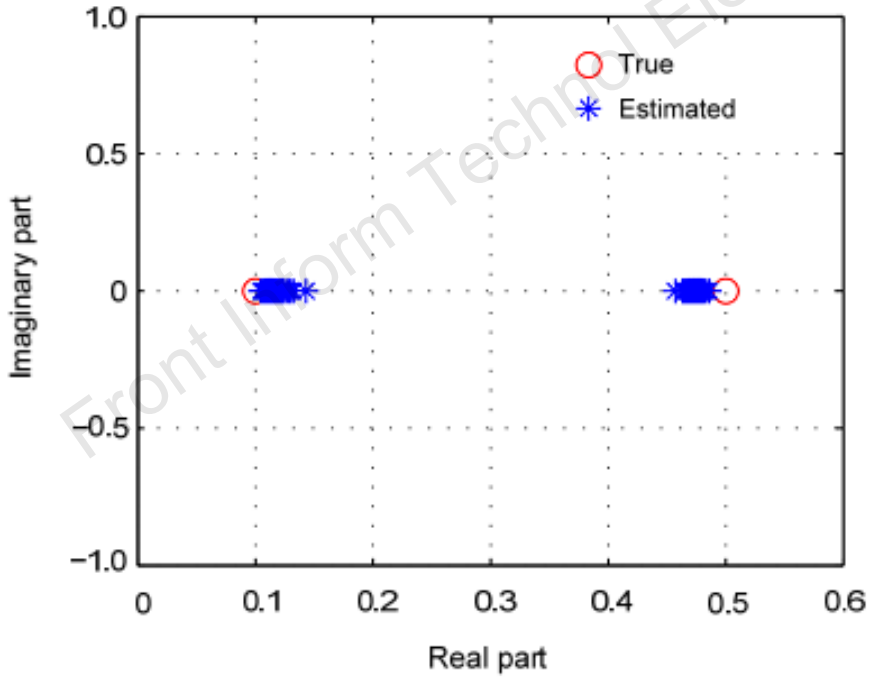


Fig. 3 Eigenvalue locations of the estimated *A*

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Major results (Cont'd)

- Eigenvalue locations of the estimated $\boldsymbol{A}_{\mathrm{d}}$

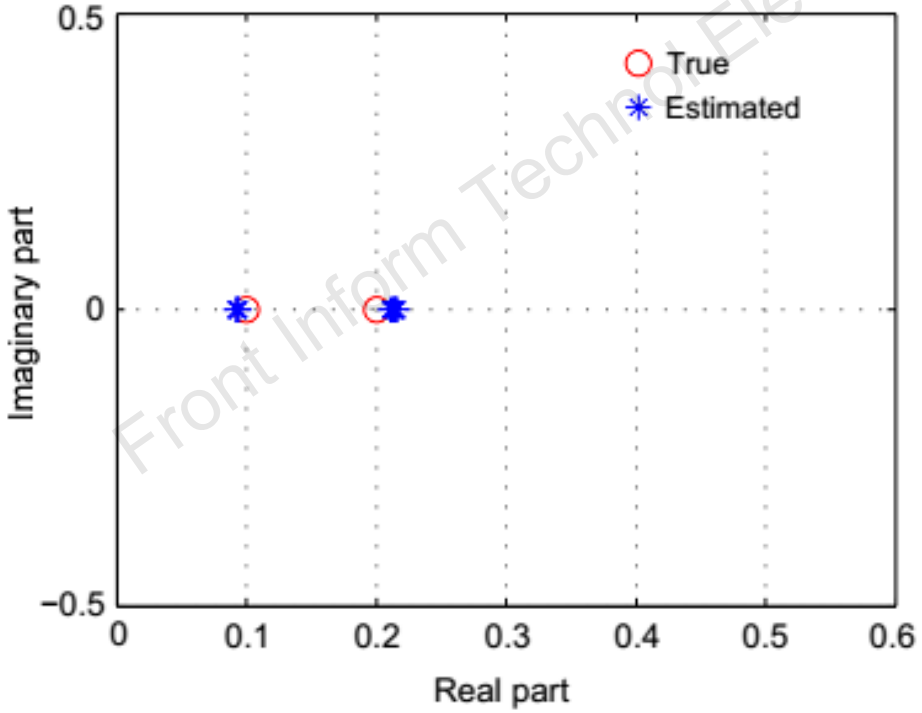


Fig. 4 Eigenvalue locations of the estimated A_{d}

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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 input-output data. A numerical example was provided to show the effectiveness of the developed method.

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