Thesis Proposal

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Title of Study

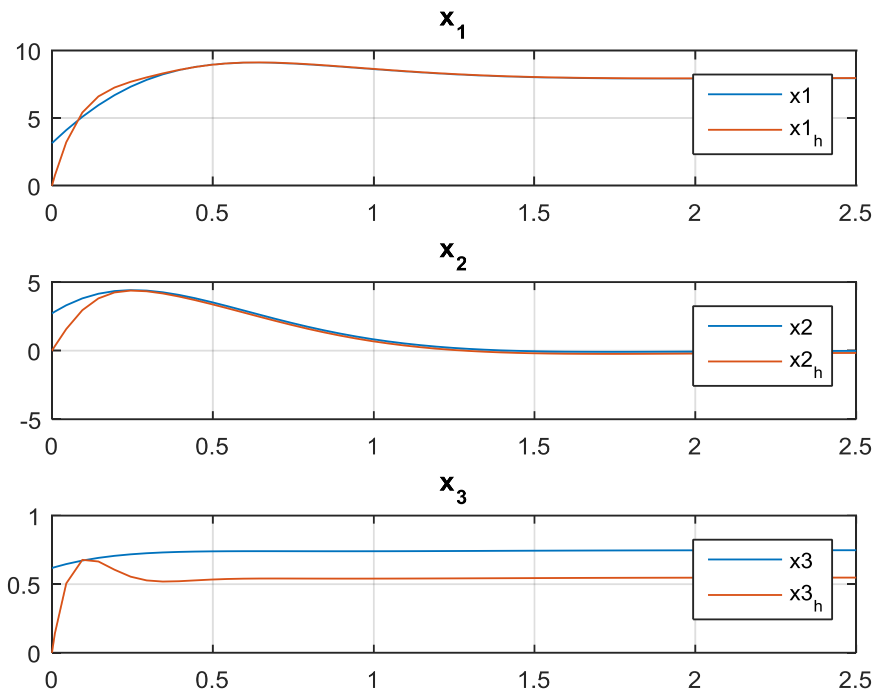
Proportional Integral Observer (PIO) Design for Linear Control Systems

Statement of the Problem

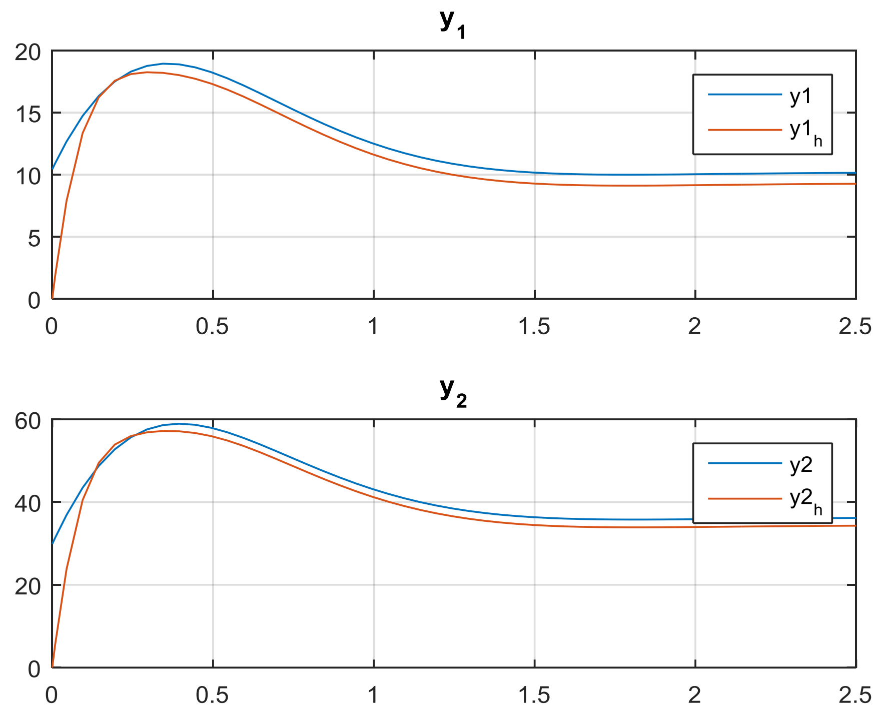
In state feedback control systems, all state variables need to be measured for control in order to make the system stable. However, as is pointed out in [1], state variables might not be available for the reason of inaccessible of some variables, or the limitation on the number of sensors. Therefore, observers are designed to estimate the unmeasured state variables for feedback purpose. Compared with Proportional Observer (PO) introduced by Luenberger [2, 3], Proportional Integral Observer (PIO) may offer advantages such as: reducing the effect of disturbances on control system performance, more accurate state-variables estimation and improved stability robustness [1, 4].

Significance of the Study

Proportional observer (PO) has the ability of estimating state variables in general cases. However, in case of disturbance existing in plant, the estimated variables and outputs will not match that of the actual ones. Fig.1 shows this estimation using proportional observer.



(a) State variables estimated by PO



(b) Outputs estimated by PO

Fig.1 Estimation error using proportional observer

To minimize error in output estimation, proportional integral observer (PIO) can be applied to the system.

In [1], a general idea of designing a PI observer has been derived, however, detailed design procedure for selecting observer gains is not provided in the book. In [4], a loop transfer recovery (LTR) method is provided to minimize the difference between estimated state variables and actual ones. The shortcoming of this method is that the observer poles cannot be chosen on demand, and the settling time of observer cannot be directly controlled.

In [5], an observer design method is introduced to minimize disturbance by noise on output measurement. However, this paper does not provide a design method with disturbance in plant. In [6-9], design methods of observer gain for both continuous-time and discrete-time cases are provided, however, system robustness is not checked in these papers. Besides, some other applications of PIO are raised by F. Bakhshande et. al. [10], and Z. Gao et. al. [11, 12].

In proportional observer design, 'place' command in MATLAB is a commonly used method of designing observer gains, and this method can be modified and apply to proportional integral observer gain design. Furthermore, in [13], an optimization approach to the pole placement is introduced to design feedback gain for regulators, with desired pole location and good system robustness, which can also be modified and applied to proportional observer gain design. One of the goals of this thesis is to extend the method described in [13] to the design of PI observers.

Methodology

In order to find a rational method of designing proportional integral observers, both theoretical and computational methods will be used.

For the first step, a state space model will be built and analyzed to describe the observer based control system. After analyzing the mathematical model of observer, stability and system response of the observer will be checked, and a rational design method of proportional and integral observer gains will be provided. In the end, computational software such as MATLAB and Simulink will be used to simulate the response of the system subject to a disturbance, and verify the design method provided by previous theoretical method.

Resources Required

Literature searching and viewing resource from library

MATLAB

Simulink

References

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