Dutch Institute of Systems and Control

Course: System Identification
Fall 2020

Assignment number 5 (concerning Lectures 7 and 8)

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Problem 1

Consider the first order system

$$y(t) = G_0(q)u(t) + H_0(q)e(t)$$

with

$$G_0(q) = \frac{b_0 q^{-1}}{1 + a_0 q^{-1}} \qquad H_0(q) = \frac{1}{1 + a_0 q^{-1}}$$

with a_0, b_0 given real-valued coefficients, and $\{e(t)\}$ a white noise process of zero mean and variance σ_e^2.
The input signal satisfies

$$u(t) = r(t) - cy(t)$$

with $c \in \mathbb{R}$ and $\{r(t)\}$ a quasi-stationary signal that is uncorrelated with $\{e(t)\}$.
Consider the situation that we want to identify this system with the direct identification method, using measurements of $\{u(t), y(t)\}$.

- What are the minimum excitation conditions on $\{r(t)\}$ in order to be able to arrive at a consistent estimate of $(G_0(q), H_0(q))$?
- Re-design the controller in such a way that it remains to have to property of having a finite impulse response (FIR), but additionally provides an experimental situation in which the direct method can yield a consistent estimate of the system (G_0, H_0) even when $\{r(t)\} = 0$, so on the basis of excitation of the loop through $\{e(t)\}$.

Problem 2

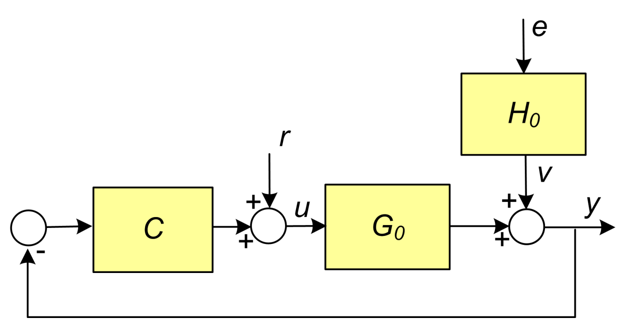

Figure 1: Closed-loop system

One the variants of the indirect methods for closed-loop identification, is a method where in the first step of the algorithm a model is estimated that describes the transfer from external excitation signal r to output y. To this end a predictor model is utilized where the output of the system is predicted on the basis of past (and present) values of the external excitation signal r.

Show that by utilizing a noise model, and by parametrizing the predictor filters in terms of the parameters of the (open-loop) system (G_0, H_0), while utilizing knowledge of the controller C, the first step of this indirect method can actually be made equivalent to a direct method for closed-loop identification of (G_0, H_0).

Problem 3 (You may choose between Problems 3 and 4)

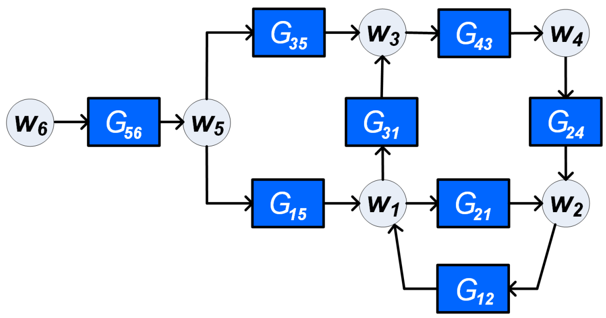

Figure 2: Dynamic network

Consider the dynamic network depicted in Figure 2.

a. Determine the smallest number of external excitation signals that one would need to apply to the network for satisfying the conditions for generic network identifiability of the full network, based on all measured node signals.

b. Specify the nodes to which the excitation signals would need to be applied for satisfying the conditions under a.

Problem 4 (You may choose between Problems 3 and 4)

Consider the dynamic network depicted in Figure 3 where disturbance signals v_2 and v_3 are assumed to be correlated. The objective is to identify the green module G_{21}^0.

a. How would you identify G_{21}^0 when using an indirect identification method, with the objective to obtain a consistent estimate? Specify the chosen predictor model (inputs and outputs) and the steps to take.

b. How would you identify G_{21}^0 when using the direct method, with the objective to obtain a consistent estimate? Specify the predictor model (inputs and outputs).

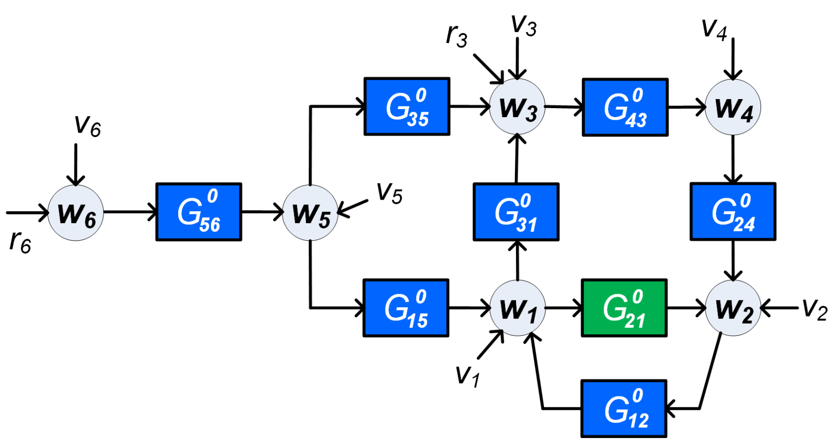

Figure 3: Dynamic network