Direct Model Reference Adaptive Control for Linear Fractional System of Commensurate Order with Time Delay using Smith Predictor

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ABSTRACT

In this research work, a model reference adaptive control design is introduced in order to deal with a class of fractional order systems of commensurate order with time delay. By using a Smith predictor (SP) design, slightly different from the conventional SP based on a fractional order inner model. The strategy for adjusting the controller parameters is the MIT rule. Two simulation examples are provided to show the efficiency of the proposed control configuration for this class of fractional-order systems.

Keywords: Delayed fractional-order system, Direct model reference adaptive control, Fractional Smith Predictor

1 Introduction

In the last decades, the number of research works dealing with the stability analysis of fractional order time-delay systems took an exponential trend [1]. The problem of parameter and gains adjustment in control has found many solutions in literature, many of them do not require any model of the process to control. Generally, the only needed information is the time response of the system. One can cite among these rules the method of Ziegler and Nichols, Cohen and Coon, and the Kappa-Tau rules. The most popular technique is the Ziegler-Nichols method that is widely used by engineers in industry. One modern technique that is taking a good place in the designers' documents is based on the relay auto-tuning [2], [3]. In this work, a fractional order adaptive control scheme based on MRAC configuration and associated with a fractional order Smith Predictor is designed in order to control a class of fractional order commensurate systems with time delays.

2 Model reference adaptive control based on MIT rule

Let us take an example of a first order system [4],

$$\frac{dy_p}{dt} + a_p y_p = b_p u \quad (1)$$

$$\frac{dy_m}{dt} + a_m y_m = b_m r \quad (2)$$

where r is the reference input signal of the reference model, y_m is its output, and a_m and b_m are known constants.

$$u(t) = \emptyset_1 r - \emptyset_2 y_p(t) \quad (3)$$

and the MIT rule is applied in order to update the control gains.

$$\emptyset_1 = -\gamma \left(\frac{1}{s+a_m}\right) r\, e \quad (4)$$

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$$\emptyset_2 = \gamma \left(\frac{1}{s+a_m}\right) y_p \, e \tag{5}$$

3 Simulation Results

We consider the following fractional system of commensurate order, which incorporates a time delay, together with its corresponding proposed model reference, respectively:

$$T(s) = \frac{25}{s^{2.61}+6s^{1.74}+30s^{0.87}+25} e^{-0.5s}, \ M(s) = \frac{1}{10s^2+10s+1} e^{-0.5s} \tag{6}$$

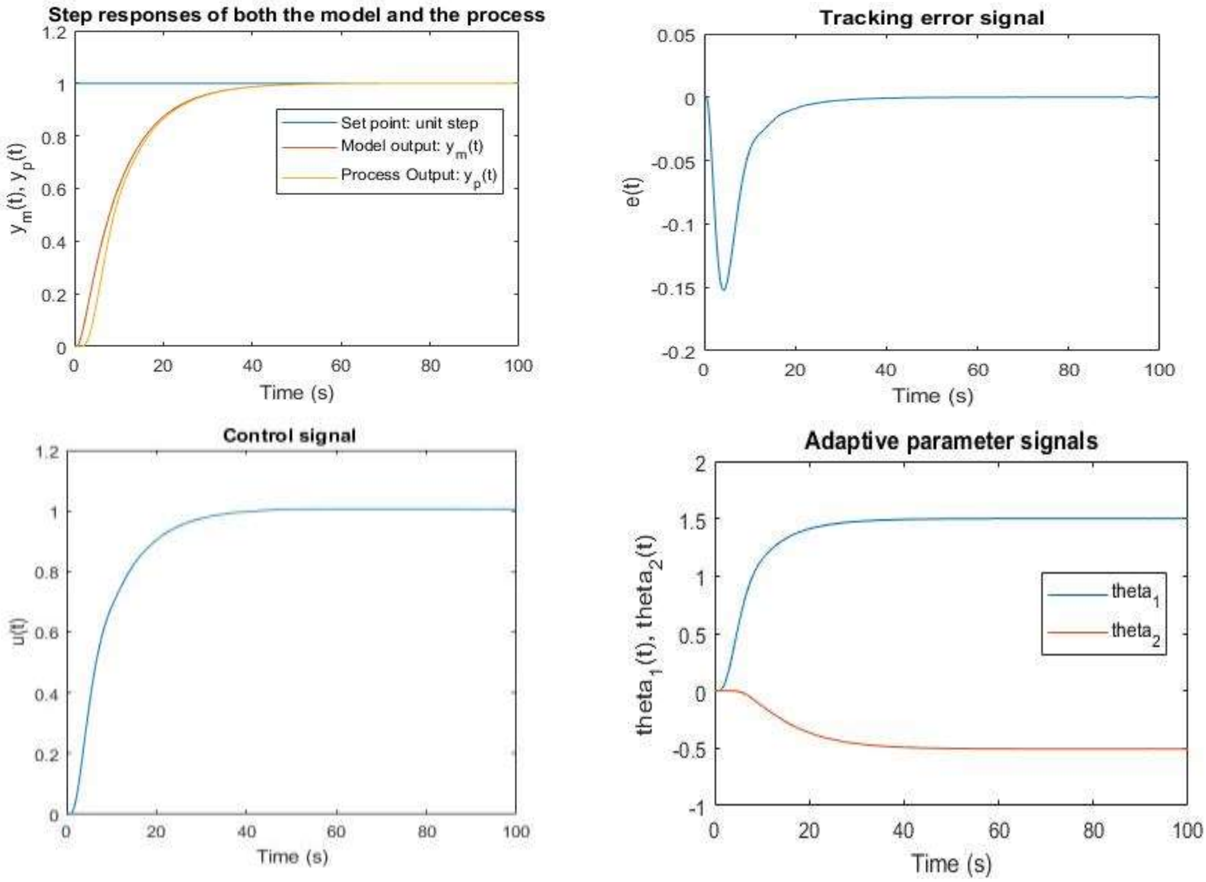

Figure 1: *Simulation results for the proposed control design*

Simulation results for the plant $T(s)$ are depicted in Figure 1. These results show that the tracking error tends to zero, indicating that the model follows the underlying process.

4 Conclusion

In this study, a fractional order SP-based MRAC control design is proposed for dead-time compensation of a class of fractional systems of commensurate orders and time delay. The structure of the FSP, is similar to the conventional one, the difference lies in the inner model of the deadtime compensator. Using a conventional MRAC design to control the system, the adaptation law is obtained based on the MIT rule.

5 Competing Interests

The authors declared that no conflict of interest exists in this work (or declare a conflict of interest here)

How to Cite

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