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CONFIGURATION OF A ROBUST MODEL FOLLOWING SYSTEM WITH AN ADAPTIVE IDENTIFIER

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Abstract

The robust compensation controller, which has been proposed by one of the authors and is based on the fundamental principle of making the plant follow the reference model, consists of the reference model and the robust compensator. The reference model is constructed by using the nominal model of the plant and determines the input-output properties of the resultant system. The robust compensator is obtained as a solution of the mixed sensitivity problem in H infinity control theory. Therefore the resultant system is of low sensitivity and robust stability. In the case where uncertainty does not occur in the plant, the plant follows perfectly the reference model. Therefore, in the case where uncertainty occurs in the plant, we propose the system configuration which improves the following accuracy without replacing the robust compensator but by identifying the plant and reconstructing the reference model.

1. Introduction

In practical control system design methods, it is required that the appointed input-output transmission properties, low sensitivity and robust stability can be realized in the resultant control system. The robust model following system [**RMFS**] has been proposed as a design method satisfying these requirements [1]. The controller in the **RMFS**, called a robust compensation controller, which is based on the fundamental principle of making the plant follow the reference model, consists of the reference model and a robust compensator. The reference model is constructed by using the nominal model of the plant and determines the input-output properties of the **RMFS**. The robust compensator is obtained as a solution of the mixed sensitivity problem in H infinity control theory. This means that low sensitivity and robust stability are realized in the **RMFS**. Therefore, even if the plant has uncertainty, the input-output properties of the **RMFS** hardly change because of low sensitivity, namely the output of the plant can follow the output of the reference model with the arbitrary accuracy.

In this paper we consider to improve

the following accuracy without replacing the robust compensator in the case where uncertainty occurs in the plant. Noting that the nominal model of the plant is in the reference model, we attempt to reconstruct successively the nominal model of the plant by identifying the plant, and to modify synchronously the controller in the reference model to keep the appointed input-output properties of the reference model.

2. Robust model following system

It is assumed that the input-output pulse transfer function of the plant can be expressed as $G_0(z)\{1 + \Delta(z)\}$ where $\Delta(z)$ represents uncertainty. We consider the system shown in Fig.1 which is called a basic **RMFS**. In this system the sensitivity and complementary sensitivity functions are obtained as

$$S(z) = \frac{1}{1 + G_0(z)G_c(z)} \tag{1}$$

and

$$T(z) = \frac{G_0(z)G_c(z)}{1 + G_0(z)G_c(z)} \tag{2}$$

respectively. Therefore when we obtain the compensator $G_c(z)$ as a solution of the mixed sensitivity problem in H infinity control theory under the performance index

$$\left\| \begin{matrix} W_S(z) & S(z) \\ W_T(z) & T(z) \end{matrix} \right\|_\infty \tag{3}$$

where $W_s(z)$ and $W_T(z)$ are appropriate weighting functions, low sensitivity and robust stability are guaranteed in the basic **RMFS.** This means that, in spite of existence of uncertainty, we can regard the pulse transfer function from R(z) to Y(z) as $G_0(z)$ because of low sensitivity and stability can be held because of robust stability. The reference model which contains the nominal model of the plant is shown in Fig.2. The system shown in Fig.3 which is constructed by uniting the basic **RMFS** (Fig.1) and the reference model (Fig.2), called the **RMFS**, has the same input-output pulse transfer function as that of the reference model and is of low sensitivity and robust stability.

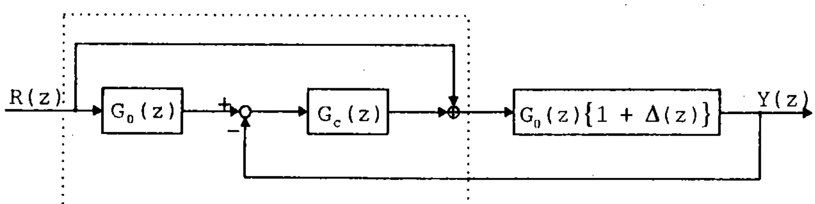


Fig.1 The basic robust model following system

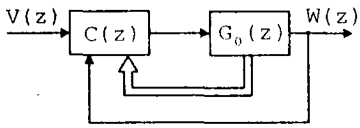


Fig.2 The reference model

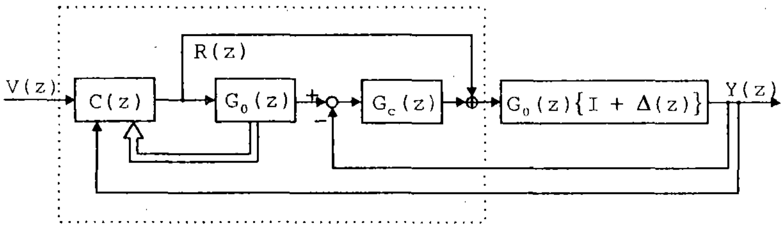


Fig.3 The robust model following system

3. Robust model following system with an adaptive identifier

We note that if $\Delta(z) = 0$, the output of the plant follows perfectly the output of the reference model in the **RMFS**. Therefore, when the parameters in the plant vary, we consider to reconstruct the reference model by using the estimated parameters.

We construct the system shown in Fig.4 from this consideration. The adaptive identifier can estimate the parameters from only the input and output signals of the plant. $G_0(z)$ in the reference model is reconstructed by using these estimated values. The controller parameter calculator calculates the parameter values in the controller C(z) to maintain the appointed input-output pulse transfer function in spite of the reconstructed $G_0(z)$.

Consequently we can expect that the output of the plant can follow the output of the reference model more accurately than in the case without the adaptive loop.

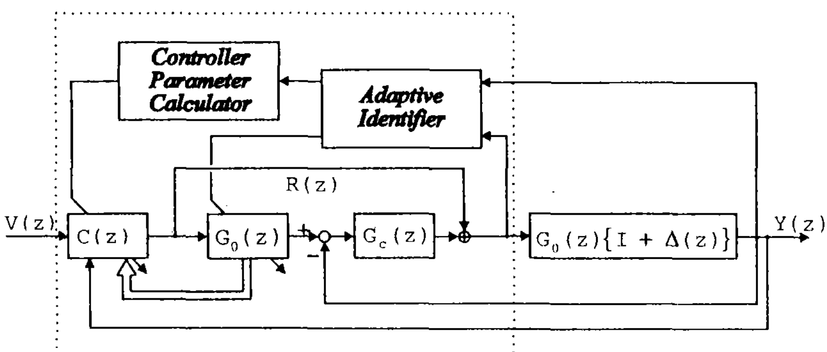


Fig.4 The robust model following system with the adaptive identifier

4. Simulation

We simulate the **RMFS** with the adaptive identifier in the case where the input-output pulse transfer function of the plant changes from Eq(4) to Eq(5) after 600 sampling steps. Eqs(4) and (5) are discretized such as Eqs(6) and (7) by using a sampler of which sampling period is 50msec and a zero-order hold device. Now the robust compensator $G_c(z)$ is rejected in order to make the effect of the adaptive identifier clear. The adaptive identifier works by the algorithm of weighted least squares [2].

$$G_0(s) = \frac{1}{s(s+4)} \tag{4}$$

$$G_0(s) = \frac{1}{s(s+2)} \tag{5}$$

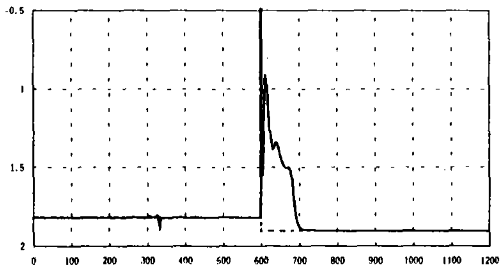
$$\begin{aligned} G_0(z) &= \frac{b_1 z + b_0}{z^2 + a_1 z + a_0} \\ &= \frac{0.00117067z + 0.00109519}{z^2 - 1.81873z + 0.818731} \end{aligned} \tag{6}$$

$$G_0(z) = \frac{0.00120935z + 0.00116971}{z^2 - 1.90484z + 0.904837} \tag{7}$$

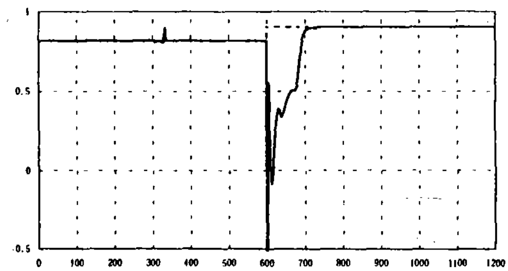
Fig.4 shows the estimated parameters in the plant. We find from Fig.4 that the parameters are almost estimated accurately in 100 sampling steps after the parameter variations occurred.

The simulation of the total system is shown in Fig.5. **A** and **B** in Fig.5 show the output responses of the **RMFS** with and without the adaptive identifier, respectively. And **C** shows the output response of the reference model.

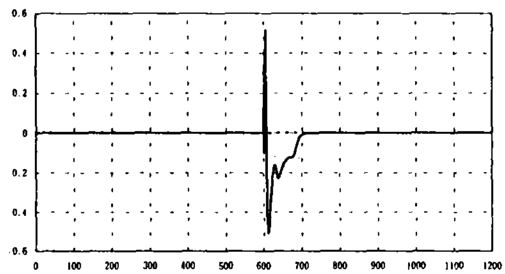
It follows from Fig.5 that the following accuracy of the **RMFS** is improved by using the adaptive identifier.



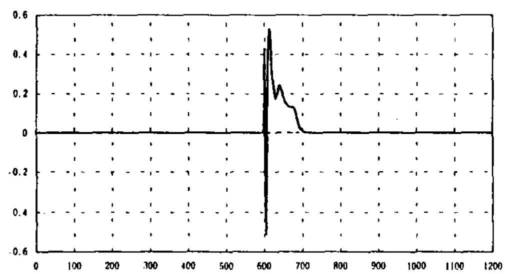
(a) : a_1



(b) : a_0



(c) : b_1



(d) : b_0

Fig.4 The estimated parameters

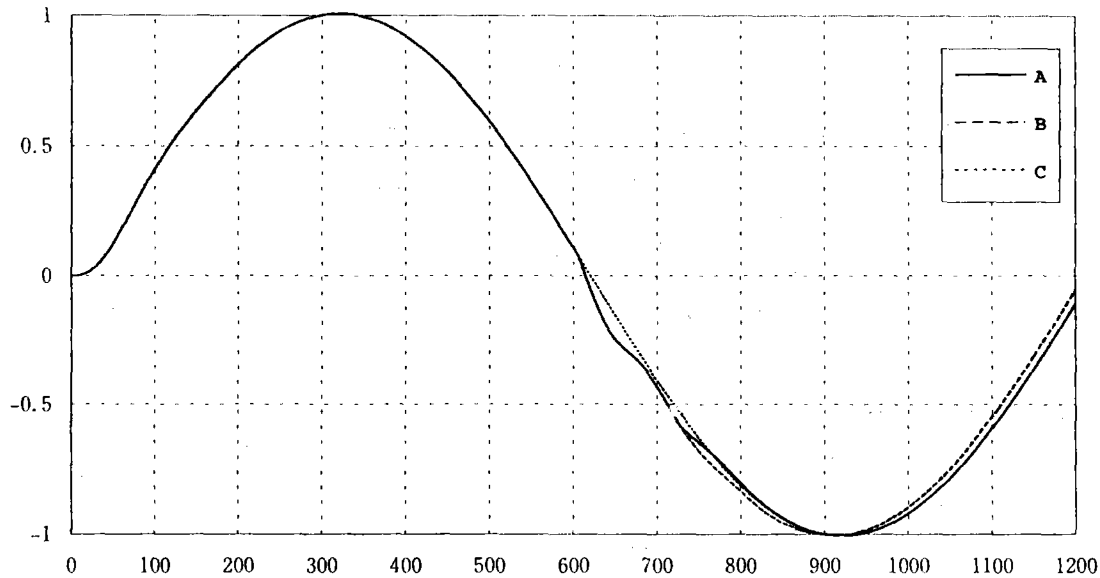


Fig.5 The output responses of the RMFS with and without the adaptive identifier and the reference model

5. Conclusion

We proposed the **RMFS** with the adaptive identifier, and showed by the simulation that the adaptive identifier is useful to improve the following accuracy of the **RMFS**.

6. References

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Construction of a Robust Compensation Controller,
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[2] Takayoshi Nakamizo:
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