PREDICTIVE FUNCTIONAL CONTROL AND ITS APPLICATION TO MISSILE CONTROL SYSTEM

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Abstract

The Predictive Functional Control (PFC) Technology is introduced, and the robustness and tracking performance for PFC control system are studied. The simulation results of PFC in missile control system show that the PFC control law has the following properties: simple calculation, strong robustness, disturbance attenuation and high control precision.

1 Introduction

Predictive Functional Control (PFC) is developed by the requirement for the fast process control. It is a new predictive method based on the predictive control theory. This control method has the following properties: simple calculation, strong robustness, disturbance attenuation and high control precision. This control method has been widely used in robit, chemical engineering process control. Specially, this method is being widely used in the fast motional aim tracking system, such as radar, missile, fish torpedo and artillery.

In this paper, the analysis of robustness and tracking performance for PFC control system are studied. The proposed method is used in the missile control system. The simulation results of PFC in missile control system show that the PFC control law does better than other control method.

2 PFC Method

Consider the following discrete system,

$$\begin{cases} X_m(n) = A_m X_m(n-1) + B_m U(n-1) \\ Y_m(n) = C_m X_m(n) \end{cases} \tag{1}$$

Let $u(n+i) = \sum_{j=1}^{N} \mu_j \cdot f_j(i)$. It is the linear combination of base-functions, which is chosen according to the process characteristic and the tracking purpose. Usually, it is chosen as the following functions: step, grade and parabola. μ_j is the optimizing weighted coefficient.

We have the PFC as follows

$$u(n) = k_0 \cdot (c_0(n) - y_p(n)) + \sum_{j=1}^{Nc} k_j \cdot c_j(n) + V_x \cdot X_m(n) \tag{2}$$

$$k_0 = v \cdot \begin{bmatrix} 1-\alpha^{h_1} \\ \vdots \\ 1-\alpha^{h_s} \end{bmatrix}, \quad v_x = -v \cdot \begin{bmatrix} C_m\left[A_m^{h_1} - I\right] \\ \vdots \\ C_m\left[A_m^{h_s} - I\right] \end{bmatrix},$$

$$k_c(j) = v \cdot \begin{bmatrix} h_1^{\,j} \\ \vdots \\ h_s^{\,j} \end{bmatrix},$$

where

$v = [f_1(0) \ \cdots \ f_N(0)] \cdot M$, $M = (B \cdot B^T)^{-1} \cdot B$;

$$B = \begin{bmatrix} y_{B1}(h_1) & \cdots & y_{B1}(h_s) \\ \vdots & \cdots & \vdots \\ y_{BN}(h_1) & \cdots & y_{BN}(h_s) \end{bmatrix};$$

$y_{Bj}(i) = C_m A_m^{i-1} G_m f_j(0) + \cdots\cdots + C_m G_m f_j(i-1)$;

We can find that the proposed predictive control method is very simple. Compared with the traditional predictive control method, its calculation is lower and the control speed is faster. It is very suit for the real control system of the fast control system.

3 PFC' s application to the missile control system

Consider the following missile control system

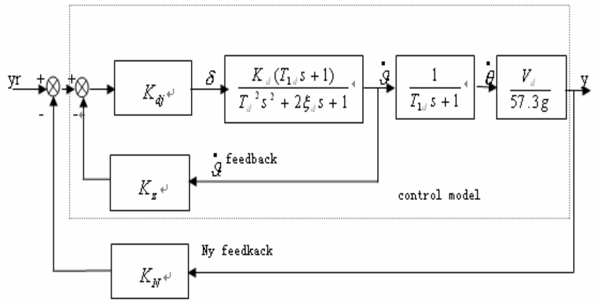

Fig 1 The missile control system

In a special trajectory, the corresponding parameters are shown in table 1.

Table 1(where, $K_z = 0.0476$, $g = 9.8$)

$T(s)$	K_{dj}	K_d	T_{1d}	T_d	ξ_d	V_d
6	12.320	0.5030	1.00	0.0844	0.1260	547.67
14	12.200	0.4150	1.16	0.0906	0.1077	600.67
22	12.104	0.3118	1.45	0.1014	0.0868	682.29
30	12.160	0.2102	2.15	0.1294	0.0672	804.08
38	12.784	0.1239	3.95	0.1890	0.0471	978.81
45	13.120	0.0695	7.57	0.2900	0.0333	1163.3

We use a PFC to take place K_N in fig 1. The simulation results shown in fig 2 are much better than that in fig 3.

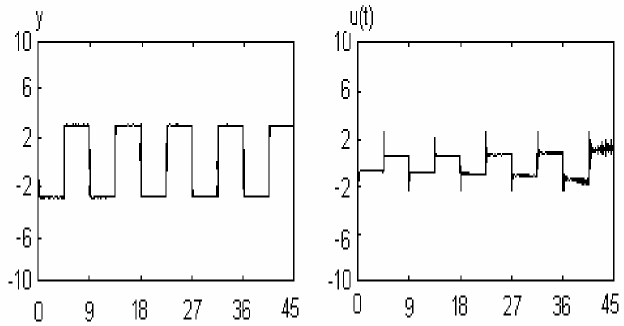

Fig 2 PFC' s simulation results

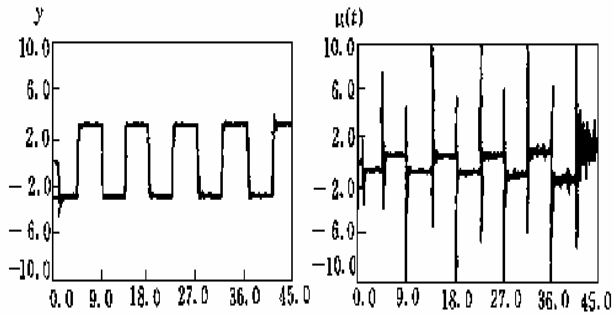

Fig 3 The adaptive predictive control method's simulation results

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