SYNTHESIS OF DISCRETE TIME FLIGHT CONTROL SYSTEM USING NONLINEAR MODEL MATCHING

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Key Words : Aircraft, Nonlinear Control, Model Matching

Abstract

Until now various model matching systems have been proposed for linear system, but very little has been done for nonlinear system. In this paper, a design method of discrete time flight control system using nonlinear model matching is proposed. This method is based on Hirschorn's algorithm and facilitates easy determination of the control law using the relationship, between the output and the input, which is obtained by the time shift of the output. Also as a result, this method is the extension of the linear model matching control system proposed by Wolovich, in which the control law is obtained by left-multiplying the output by the interactor matrix. At the end of paper, the proposed control system is applied to CCV flight control system of an aircraft and the feasibility of the proposed approach is shown by the numerical simulations.

1. Introduction

• •Recently control systems have been applied to many industrial machines and vehicles etc. used in various circumstances and users require the higher control performance[1]. Especially in the field of aircraft development, the critical control performance which makes a higher maneuver at high speed possible is required[1-3]. At the present time in U. S. A. or Europe Thrust Vector Control type airplanes have been developed. This type airplane can fly at a range of higher angle of attack.

Such a system becomes nonlinear[4], so the conventional linear model matching control system cannot be applied directly. However latest small-sized computers which have higher performance can be used to construct a flight control system which satisfies such a critical control requirement[1].

In this paper, we propose a design method of discrete time nonlinear model matching control system and attempt to apply it to a flight system of aircraft.

First, the longitudinal and lateral-directional equations of aircraft motion of CCV(Control Configured Vehicle)[1] are shown. Here this system becomes coupled nonlinear one, flaperon and vertical canard are added to the equations as new control surfaces.

Next, for some nonlinear system, the discrete time dynamic model matching control system based on Hirschorn's algorithm[5,6] extended with Silverman's structure algorithm[7] is proposed. This method facilitates easy determination of the control law using the relationship, between the output and the input, which is obtained by the time shift of the output. This method is the extension of the linear model matching control system proposed by Wolovich[8], in which the control law is obtained by left-multiplying the output by the interactor matrix.

At the end of paper, the proposed control system is applied to the flight system of a small sized high speed aircraft CCV and numerical simulations are shown to investigate the feasibility of the proposed approach. On the simulation, the satisfied result of the proposed nonlinear control system will be obtained.

2. Equation of Aircraft Motion (CCV mode)

Consider the longitudinal and lateral-directional maneuver of a small sized, high speed aircraft CCV as a controlled system. The coupled nonlinear equations of aircraft motion using flaperon vertical canard angle as the new control inputs may be described as follows:

$$x(k+1) = F(x)+B\,u_f(k) \qquad \cdots (1)$$

where

$$x(k)^T = [u(k)\ w(k)\bullet\ (k)\ q(k)\bullet\ (k)\bullet\ (k)\ p(k)\ r(k)\bullet\ (k)]$$

$$u_f(k) = [\bullet\ _e(k)\ \bullet\ _f(k)\ \bullet\ _a(k)\ \bullet\ _r(k)\ \bullet\ _{vc}(k)]$$

$$F(x) = [f_1(k), f_2(k), \bullet\ , f_9(k)]^T$$

$$f_1(k) = (1+\bullet X_u)u(k)+\bullet X_w w(k) -\bullet g \sin[\bullet (k)]$$

$$f_2(k) = \bullet Z_u u(k)+(1+\bullet Z_w)w(k)+\bullet U_0 q(k)$$

$$f_3(k) = \bullet (k)+\bullet q(k) \cos[\bullet (k)] -\bullet r(k) \sin[\bullet (k)]$$

$$f_4(k) = \bullet (M_u+M_{\dot{w}} Z_u)u(k) +\bullet (M_w+M_{\dot{w}} Z_w)w(k) + \{1+\bullet (M_q+U_0 M_{\dot{w}})\}q(k)$$

$$f_5(k) = (1+\bullet Y_\bullet{}^*)\bullet (k)+\bullet (g_0/U_0) \cos[\bullet (k)] \sin[\bullet (k)] -\bullet r(k)$$

$$f_6(k) = \bullet (k)+\bullet p(k)$$

$$f_7(k) = \bullet L_\bullet' \bullet (k)+(1+\bullet L_p')p(k)+\bullet L_r' r(k)$$

$$f_8(k) = \bullet N_\bullet' \bullet (k)+\bullet N_p' p(k)+(1+\bullet N_r')r(k)$$

$$f_9(k) = \bullet (k)+\bullet r(k)$$

$$B = [b_1^T, b_2^T, \bullet\ , b_9^T]^T$$

$$b_1 = [\bullet\ \bullet\ \bullet \Delta X_{\delta_e} \quad \Delta X_{\delta_f} \quad 0 \quad 0 \quad 0]$$

$$b_2 = [\quad \Delta Z_{\delta_e} \quad \Delta Z_{\delta_f} \quad 0 \quad 0 \quad 0]$$