Research on Fuzzy I-PD Optimal Preview Control

Wang Dong*, and Kazuo Aida**

* Faculty of Engineering, Niigata University, 8050 Igarashi 2-nocho Niigata, 950-2181, Japan
(Tel : 81-25-262-7019; Fax : 81-25-262-7019 ; E-mail:wd71@tm.eng.niigata-u.ac.jp)
**Faculty of Engineering, Niigata University, 8050 Igarashi 2-nocho Niigata, 950-2181, Japan
(Tel : 81-25-262-7018; Fax : 81-25-262-7018 ; E-mail:aida@eng.niigata-u.ac.jp)

Abstract

The Fuzzy Preview Control (FPC) design methodology using I-PD Preview Control (IPC) and Optimal Preview Control (OPC)[6] are discussed in this paper. First we show a new fuzzy controller with single input single output, and build a relationship between it and the I-PD Control proposed by Kitamari, as well as Optimal Control with some specific equations. We also give the stability analysis with Lyapunov theorem. On this way, we can design a Fuzzy I-PD Controller (FIC) very easier and more effective. Then, preview control element design methodology of FCP was given according to IPC and OPC. Third, to make the system more rapidly and more little overshooting, two factors are given to adjust the controller's properties. At last, the performance of FPC is revealed via computer simulation using a nonlinear plant.

1. Introduction

Fuzzy logic controller (FLC) have emerged as one of the most active areas in the application of fuzzy set theory since Mamdani's application to automatic control area. It may be true that some control engineers, who would try to adopt the fuzzy set theory to system control, focus on how to design the rule base according to experts knowledge, and the scaling factors which transfer the real number to fuzzy number.

Although these applications of fuzzy control to industrial process have often produced results superior to classical controller, the design procedure appears to be limited by the elucidation of heuristic rules for control because the experts knowledge not always exits. Moreover, the design of scaling factors is just based on the experience and could not always to get an optimal response.

Therefore, we want to build a design method of scaling factors with some mathematic equation. We give a S-FLC that has simple relation between the input and output. We try to build the relationship between the I-PD control and Fuzzy control. Using the parameter of I-PD control and structure, FIC is proposed. Moreover, based on IPC and OPC, we can design a preview control element for FIC, which can let the system have more rapid response and less overshoot. The simulation illuminates the method proposed in this paper is effective.

2. Fuzzy Controller for SISO

In this section, a Single-Input-Single-Output Fuzzy Controller (S-FLC) will be discussed.

Notice the rule base of fuzzy control, for example to two-dimensional FLC, we can see diagonal line is ZERO. That is mean, if e and $\dot{e}$ have the same fuzzy number and opposite sign, the fuzzy output's fuzzy number is ZERO. And also, as in Fig.1, some parallel lines of diagonal divide the rule base plant into some fuzzy number areas. Fig.2 show that, if the distance from a point to diagonal line is known, we can decide the FLC's output fuzzy number. And the distance was given by (1).

$$DS = \frac{\dot{e} + \lambda_0 e}{\sqrt{1 + \lambda_0^2}} \qquad (1)$$

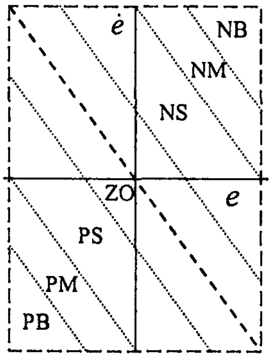

Fig. 1The rule base of FLC.

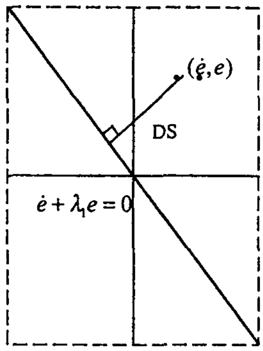

Fig. 2 Distance of SISO-FLC.

For a more general case, FLC with n-dimensional, the distance will be give by (2). Let $E^T = \{e^{(n-1)}, e^{(n-2)}, \cdots \dot{e}, e\}$ and $\lambda = \{1, \lambda_{n-1} \cdots \lambda_2, \lambda_1\}$

$$DS = \frac{\lambda E}{\sqrt{1 + \lambda_{n-1}^2 + \cdots + \lambda_1^2}} \qquad (2)$$

Therefore, according to distance from a point to diagonal line the output fuzzy number can be decided easily. And we can transfer n-dimensional fuzzy controller for single input one. The output of controller is shown in

$$u_f = -k_{ds} * DS \qquad (3)$$

On the other way, the control surface of single input fuzzy controller is near straight line, so we let the design and analysis of it more simply.

3. I-PD Preview Control

In this section, the IPC will be introduced briefly and give some formulae to explain how to design an IPC.

I-PD control, which was proposed by Kitamori[1], enables to design control systems of various types in the situation that the dynamic characteristics of the controlled process are not known perfectly. The structure of I-PD control is shown in Fig.3, whereas, not include the feedforward element. To a sampled control systems, if the transfer function of plant in

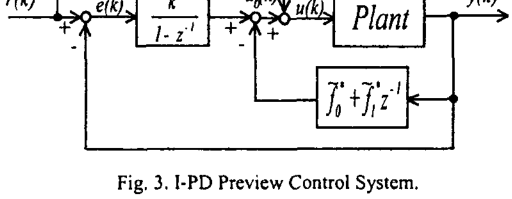

Fig. 3. I-PD Preview Control System.