PAPER

Design of Flexible PID-Plus Bang-Bang Controller with Neural Network Predictive Model

Sung Hoon JUNG†*, Kwang-Hyun CHO†, Tag Gon KIM†, *Nonmembers*, Kyu Ho PARK†, *Member*, *and* Jong-Tae LIM†, *Nonmember*

SUMMARY PID-type controllers have been well-known and widely used in many industries. Their regulation property of those was more improved through the addition of Bang-Bang-action. In spite of the potentials of these PID-plus Bang-Bang controllers, their regulation property is still limited by the fixed window limit value that determines the control action, i.e., PID or Bang-Bang. Thus, this paper presents an approach for improving the regulation property by dynamically changing the window limit value according to the plant dynamics with Neural Network predictive model. The improved regulation property is illustrated through simulation studies for position control of DC servo-motor system in the sense of classical figures of merit such as overshoot and rise time.

key words: *PID-plus Bang-Bang control, active window, neural network predictive model*

1. Introduction

Although there exist so many modern control algorithms, PID-type controllers are still used in the most practical application areas. It may be regarded as experimental evidence for their usefulness that the large number of PD and PID controllers are used routinely for process control applications.

To improve the performance of those PID-type controllers, several methods have been proposed. Especially, to overcome the difficulties due to the integral wind-up of the controllers with PI-action, the PI-plus Bang-Bang (BB)-action [1] has been proposed. In this proposed configuration, the controller employs the PI-action when the magnitude of the error between a reference value and a current value of plant output is smaller than a prescribed value—the window limit. Otherwise, the controller generates the maximum permissible control signal. The integral wind-up difficulties can be removed with this scheme, but the improvement of the regulation property is still limited by the fixed window limit value.

Nowadays, various self-tuning expert PID-type controllers are developed by using intelligent control methodologies [2]-[5]. This paper proposes one method for overcoming the limited regulation property by employing a flexible window limit value. This method is realized with the Neural Network (NN) predictive model.

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† The authors are with the Faculty of Electrical Engineering, KAIST, Taejon, 305-701, Korea.
The author is with the Faculty of Information and Computer Science, Hansung Univ., Seoul 136-792, Korea.
* To whom all correspondence should be addressed.

2. PD-Plus BB Control

To concentrate on the regulation property, i.e., transient error dynamics, we will consider only the PD-action in a PID-type controller.

PD-plus BB control algorithm is shown in Fig. 1.

The next step control action is determined according to the magnitude of the present error. That is, the controller employs the PD-action when the magnitude of the error between the reference signal (y_r) and the present output signal ($y(t)$) is smaller than the prescribed constant window limit value (w_l). Otherwise, the controller produces the maximum allowable control signal. It can be summarized as follows.

Existing PD-BB control scheme;

$$u(t+1)=\begin{cases}\text{PD} & : \text{if } |y_r-y(t)|<w_l \\ \pm u_m & : \text{if } |y_r-y(t)|\geqq w_l\end{cases}$$

3. Flexible PD-Plus BB Control

The need for introducing a flexible window can be illustrated with a step response of a SISO (Single-Input Single-Output) system which is shown in Fig. 2.

As the output reaches near the set point at t^* in Fig. 2, the next control action, PD control will be taken only according to the present error. Thus a large overshoot will occur at the next step. If some later state

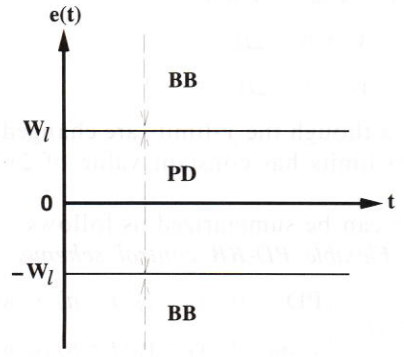

Fig. 1 PD-plus BB control. (w_l: window limit)