

A Simple PI-Extension Controller

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Abstract: A simple extension controller, using the type of Proportional Integral (PI), is proposed. On the basis of the concept of extension set. A novel method for determining the amount of control will be discussed. The universe of discourse regarding to the defined extension dependent function can be firstly partitioned and labeled in some regions. We then show that the resulting control is the linear combination of the grade of extension dependent function and the labeled number. Essentially, the expert knowledge and the experience of a skill operator can be embedded in extension controller design. Broadly speaking, the design of extension controller is easily than that of fuzzy controller. Finally, the proposed simple extension controller is used to control a linear process, and its effectiveness and ability is verified.

Key words: extension set; extension controller; PI controller

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0 Introduction

It is well known that most control techniques implemented in industrial processes are Proportional-Integral-Derivative (PID) controllers for its simple structure and a not bad performance in various applications^[1~2]. However, it usually needs to tune the parameters mutually by a skilled operator. In particular, in order to improve its performance the fuzzy set is incorporated to dynamically change the parameters^[3~6]. Since the fuzzy controller was proposed, it becomes a powerful design technique in physical applications^[7~10]. The great advantages of the fuzzy controller are that (1) the human knowledge and experiences can be integrated in the fuzzy controller design for some specific applications and (2) good robustness and adaptation. Generally speaking, the mentioned controllers above are not easy to implement; especially, when we do not have enough expert knowledge about a process. Therefore, a time-consuming process is required in designing such controller. In this paper, an effective extension controller will be developed, which may be a good solution to overcome the previous mentioned disadvantages.

Extension engineering method initial proposed by Prof. Cai^[11]. It has been successfully used in various applications^[12~16]. Although the control concepts have been widely discussed, the development tendency of extension control is far ill so far. This is because that the transformation strategy in extension engineering is not given clearly. As we mentioned in another paper, there are two main disadvantages in control field if we employ the extension set to implement a control task^[17]. First, although the concept of ex

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tension set is alluringly, a well structure of extension controller is wanting so far. Second, the valuation set in the dependent function of extension set is bounded in $(-\infty, 1]$, thus there arise a serious problem, that is, what kind of strategy should be utilized to design the extension controller based on the defined extension sets. In his paper, a very simple Proportional-Integral (PI) extension controller will be introduced.

The remaining of this paper is organized as follows. In Section 2, the structure of a simple PI type extension controller is firstly presented; the designing of extension controller that motivated from the grade of dependent function and the labeled number is then derived. In Section 3, a simulation example for a linear system is used to illustrate the performance of the proposed controller. Finally, the conclusions are given in Section 4.

1 A simple PF extension controller

In this section, the structure of PF extension controller is first introduced, and then the operation of controller is given. The block diagram of the extension controller is shown in Fig. 1.

The error and the change in error of the system are respectively defined by

$$e(k) = r - y(k), \quad (1)$$

$$ce(k) = \frac{e(k) - e(k-1)}{T}, \quad (2)$$

where r is the reference input, y is the system output, and T is the sampling time interval. The

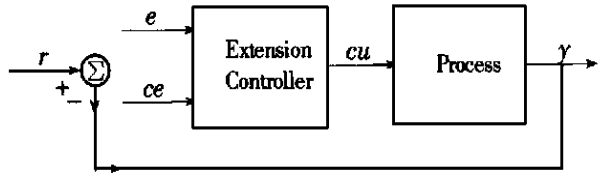


Fig.1. Block diagram of proposed extension controller

control input of the extension controller is adopted by the following PF type.

$$u(k) = u(k-1) + cu(k). \quad (3)$$

The change in control input, $cu(k)$, is resulted from the extension controller. To begin with, suppose that the extension dependent functions for the error and change in error are shown in Fig. 2 and Fig. 3, respectively. It can be seen from Fig. 2 and Fig. 3 the universe of discourse are, respectively, bounded in $[-e_{\max}, e_{\max}]$ and $[-ce_{\max}, ce_{\max}]$. Furthermore, we divide the extension region into $2n+1$ subinterval. For example, there are overall n subinterval from the label 1 to n in the positive error. The extension controller is constructed as

$$cu(k) = -iK_i(e) - jK_j(\alpha), \quad (4)$$

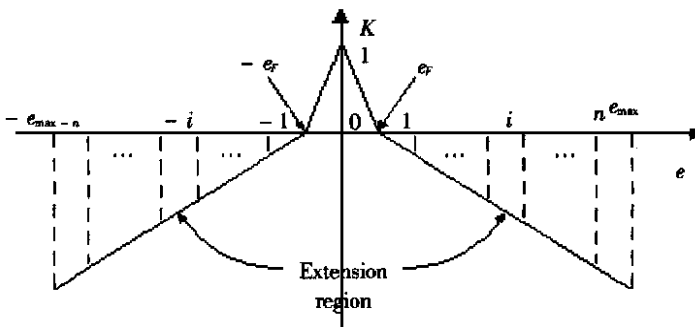


Fig. 2 Extension dependent function of error e

where the i and j are respectively the labeled number for the error and the change in error; $K_i(e)$ and $K_j(\Delta e)$ are the values of extension dependent function of error and change in error with respect to the labeled number i and j . For simplicity, we allow the extension dependent function have the same slope in each subinterval. In addition, the labeled number is given as a successive integer number. From the structure of extension controller we have constructed, intuitively, the system performance may be affected by (a) labeled number, (b) dependent functions, and (c) universe of discourse. Compared with the fuzzy controller, the proposed extension controller is easily than that of fuzzy controller from the viewpoint of the structure of controller, dependent functions and the inference algorithm.

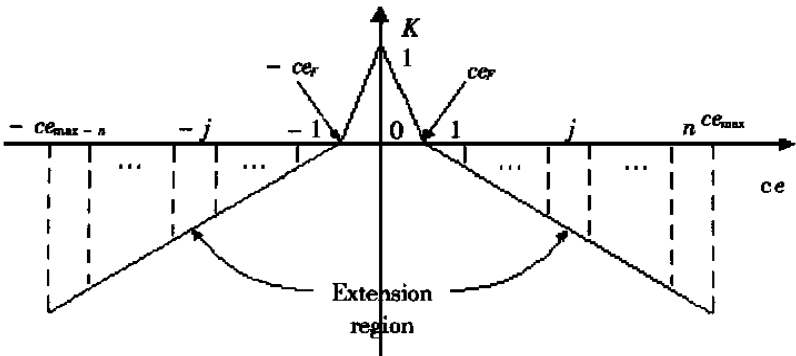


Fig. 3 Extension dependent function of change in error Δe

2 Simulation results

In this section, to exhibit the performance of the proposed extension controller, a simulation example is employed. The transfer function is given as

$$G(s)=\frac{1}{s^2+3s+2}.$$

The step output response for this process with the proposed extension controller is shown in Fig. 4. Simulation conditions are given as:

$i \in \{0, 1, 2, 3, 4, 5\}, j \in \{0, 1, 2, 3, 4, 5\}, T=5\text{ms}, [-e_{\max}, e_{\max}] = [-1.5, 1.5], [-ce_{\max}, ce_{\max}] = [-1.5, 1.5]$

3 Conclusions

In this paper, a simple PI- extension controller is studied. The structure of the proposed controller is easily implemented. The determination of the extension dependent functions is easy to understand based on the concept of extension set. We show that the change in control signal that results from the extension controller can be realized directly. Simulation results show the effectiveness of the proposed control scheme of the extension controller. Further research will focus on the adaptation and robustness analysis of such extension control systems.

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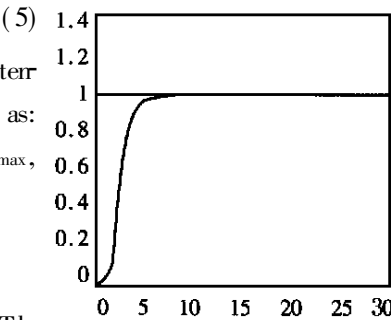


Fig. 4 Step response

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一种简单的比例积分可拓控制器

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摘要: 运用比例积分型提出了一种简单可拓控制器. 以可拓集合为基础, 研究了一种确定控制量的新方法. 该方法首先在某些区域内对涉及可拓函数的论域进行划分并作标记. 所得的控制结果是分级可拓函数及其标数的线性组合. 从本质上看, 专家知识和熟练技术人员的经验可嵌入可拓控制器设计之中. 可以说, 可拓控制器的设计比模糊控制器的设计要容易得多. 最后, 把所提出的可拓控制器用于一个线性过程控制, 并验证了控制的效果和性能.

关键词: 可拓集合; 可拓控制器; PI 控制器

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