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Fuzzy control with limited control opportunities and response delay—a production-inventory control scenario

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Abstract

This paper examines the utility of fuzzy control over crisp in situations where the control opportunities are limited and the system response to control actions is delayed. Such situations are often encountered in production systems where limited resources restrict the control opportunities and the operation time delays the response. The performance of a real-time production-inventory control system is studied with fuzzy control strategy and compared with a corresponding crisp control and no-control strategy. The system consists of a production shop having a number of identical processing machines which produce two products. The output goes into two bins whose inventory is required to be controlled at desired level by varying the number of machines allocated to the products. Real-time inventory variation, output, average inventory and machine usage, number of setups and stock-outs are used as performance measures. The simulation results of the system with various configurations show that the capability of fuzzy control is seriously inhibited by limited opportunities and response delay although fuzzy has distinct advantage over crisp. As control opportunities increase fuzzy control becomes increasingly efficient with diminishing effect of response delay.

Keywords: Fuzzy control; Production-inventory control; Crisp control; Control opportunities; Response delay

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1. Introduction

Fuzzy logic has been successfully used for designing and building industrial systems with two main purposes—rapid control and low cost, although the quality of control is not necessarily better than the corresponding crisp control. This can be seen in [1], where the capabilities of fuzzy controllers for complex systems are presented including an example of a controller for an inverted pendulum. In most applications of fuzzy control the opportunities for control in terms of manipulations of control parameters are quite large along with almost immediate setting of parameters at levels desired by the control system.

However, there exists a class of problems where either the scope for parameter manipulation is limited or there is a delay in setting of parameters to new values or both. Such situations are found in control of production systems due to its fixed capacity (limited resources) and a delay in resetting the machines and getting responses on signal parameters. It is interesting to investigate the usefulness of fuzzy controller in comparison to the simple crisp controller in such situations. We choose real-time control of a discrete production-inventory system to investigate this effect.

Fuzzy logic has been used by other researchers in production systems for various kinds of problems. Chan et al. [2] have shown the benefit of using fuzzy approach to operation and routing selection over other conventional rules like WINQ (work in queue) and SNQ (shortest number of jobs in queue). Details of the use of fuzzy logic in production planning, scheduling, process and quality monitoring, group technology etc. can be found in [3,4]. Other studies using fuzzy logic in production management in general can be seen in [5–7].

Studies closer to our study are Sudiarso and Labib [8] who use maintenance data to determine optimal batch size for production control. Grabot et al. [9] convert various objectives to a fuzzy based multi-objective optimization problem for a decision support system for production activity control. Tsourveloudis et al. [10] develop fuzzy systems for work-in-process inventory control of unreliable machines in three different modules—a transfer line module, an assembly module, and a disassembly module. They attempt to control WIP by varying machines' processing rates. They demonstrate the performance of the control system through continuous flow simulator and took averages of the simulation runs, which may not show a typical response of a discrete production system in real-time. Moreover, they show comparisons of their system with full capacity production and, in one case, with hedging point control. The paper does not show a comparison with a crisp control strategy with similar reasoning as fuzzy.

Another paper of interest is by Samanta and Al-Araimi [11] who use fuzzy logic for inventory control with varying demands by varying monthly production quota. They compare three strategies, fuzzy PID (proportional-integral-derivative) with resetting, fuzzy PID without resetting, and PID without fuzzy. Their last case may be thought of as crisp control. Their results show only slight advantage of using fuzzy approach. Since they used monthly setting of production levels, the study does not bring out the behavior of the system in real-time control.