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Fuzzy-based NCTF Controller for PTP Positioning: Fuzzy Membership and Rule Based Modifications

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ABSTRACT

Fuzzy-based Nominal characteristic trajectory following (NCTF) controller had been proposed as a practical controller for point-to-point (PTP) positioning system. In the Fuzzy-based NCTF controller, fuzzy compensator is introduced to increase the ease of design process. However, the Fuzzy-based NCTF controller is only effective for a small displacement. The Fuzzy-based NCTF controller fails to follow perfectly its nominal characteristic trajectory (NCT). As a result the response speed of the Fuzzy-based NCTF control system is not as fast as expected by the NCT. In order to overcome this problem, in this paper, membership functions of the fuzzy compensator are modified so as the motion of the plant controlled by the Fuzzy-based NCTF controller reach and then follow the NCT quickly even if the displacement is large. Simulation result using dynamic model of linear positioning system shows that the proposed modification of fuzzy compensator is effective for PTP positioning system and outperforms the original fuzzy compensators.

1. INTRODUCTION

Motion control systems play important roles in industrial equipment such as machine tools, semiconductor manufacturing and robot systems. As part of motion control systems, point-to-point (PTP) positioning system is used to move an object from one point to another point. Its performance generally require good controller to satisfy such requirements as high accuracy, fast response and robustness. In addition, realization of simple controller structure and ease of design are very important in practical application.

However, advanced controllers tend to be complicated and require deep knowledge concerning with controller theory and design. Moreover, exact modeling and parameter identifications are generally troublesome and time consuming tasks. In order to overcome these problems, nominal characteristic trajectory following (NCTF) controller has been proposed as a practical controller for point-to-point (PTP) positioning systems [1]. The proposed NCTF controller consists of nominal trajectory following (NCT) and a compensator. It has been shown that NCTF controller system has a good positioning performance and robustness [2, 3]. It is also effective to compensate effect of the friction which is the main source of positioning inaccuracy [3].

Originally, the NCTF controller uses PI compensator as one of the element in the controller. However, trial and error process in determining PI parameters can be troublesome and time consuming tasks. To overcome those problems, fuzzy compensator has been proposed and used to replace the PI compensator [4]. The fuzzy compensator design is easy to build since most of compensator parameters, membership function and gain, are defined according to the NCT parameters. It also has been shown through simulation study that the fuzzy-based NCTF control system has a good positioning performance and robustness [5].

However, the NCTF controller with fuzzy compensator is only effective for small reference input. For large reference input, fuzzy compensator failed to force the object reaching and following NCT perfectly. To overcome this problem dual mode approach has been proposed [6]. In this approach, switching rule was added to change from full power to fuzzy mode when the object motion reached deceleration range. The problem are additional structure is required while leaves fuzzy compensator performance limited. In this paper, to force an object reaches maximum velocity of NCT, is achieved