

# 論文の要旨

題 目 DESIGN OF DATA-ORIENTED CONTROLLERS

(データ指向型制御系の設計)

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In the industrial world, further efforts for improving productivity, saving of energy and power saving are required due to escalation of global competition. In order to accomplish these purposes, highly-functional control systems are required. Controller design schemes are broadly divided into two methods. One is a model-based controller design. Another is a data-oriented controller design. The model-based design schemes require an accurate mathematical system model to design a high-performance controller. In order to make an accurate system model, input signals with wide-range frequency component and/or many experiments for system identification are required. However, these conditions are undesirable from the view point of the safety of the system and time costs. On the other hand, data-oriented controller design schemes typified by the Virtual Reference Feedback Tuning (VRFT) method and the Fictitious Reference Iterative Feedback Tuning (FRIT) method can determine control parameters directly by using only a set of closed-loop data without any system models. Data-oriented controller design schemes are effective when details about system characteristics cannot be understood and/or system identification parameters cannot be easily obtained. Actually, recent industrial systems have complex architectures and these characteristics vary from hour to hour. Therefore, it is difficult to obtain an accurate mathematical model. It is expected that a data-oriented controller design will be an important method for the industrial world in the future. In this thesis, three data-oriented controller design schemes which are especially-important from the practical point of view are considered. The first is a 'direct controller design' where a controlled object can be described as a linear system. The second is an 'intelligent controller design' where a controlled object has nonlinearity. The third is a 'performance-driven controller design' where system properties vary from hour to hour. This works consider these schemes as three pillars of the data-oriented controller design, and sets out to establish these design methods. The thesis is composed of following five chapters.

In Chapter 1, the research background and the necessity of data-oriented controller designs is explained. The outline of this thesis is also given in this chapter.

In Chapter 2, a direct PID controller design method based on the Generalized Minimum Variance Control (GMVC) is discussed. According to the proposed method, a PID controller can be designed without system identification by converting control parameters that are obtained by the implicit GMVC method to PID gains approximately. Moreover, an operator can adjust control performances (stability and tracking property)

by tuning only one user-specified parameter  $\lambda$ . Furthermore, it is demonstrated that the proposed method is easily extended to MIMO systems by expanding a system description to  $p \times p$  expression. The performance of the proposed PID controller is verified by simulation results. Experimental results are also provided for a temperature control system and a level plus temperature control system.

In Chapter 3, an intelligent controller design method for nonlinear systems by using the Cerebellar Model Articulation Controller (CMAC) is discussed. Intelligent CMAC-based PID controller (CMAC-PID controller) which has a CMAC-PID tuner is first composed, and the CMAC-PID tuner is learned its weight tables by using closed-loop data in an offline manner by introducing a fictitious reference signal in the FRIT method. According to the proposed method, the problem of online learning for implementing an intelligent controller is resolved. Furthermore, in this chapter, it is also been considered that the learned CMAC-PID tuner is converted to a GMDH-PID tuner using the Group Method of Data Handling (GMDH) network. According to the scheme, required memory for mounting the algorithm on a computer is drastically reduced. Therefore, the nonlinear PID tuner can be implemented on a general-purpose microcomputer, which enables the range of application of the intelligent PID controller is extend. The effectiveness of the proposed method is validated by a simulation and an experimental result by using a magnetic levitation device.

In Chapter 4, a performance-driven controller that unifies control performance assessment and controller redesign is proposed. According to the method, the controller including only one user-specified parameter  $\delta$  is first designed. Moreover, control performance is evaluated without any system models by turning its attention to a ratio between variances of control errors and differential control input. By reflecting the result of the assessment to the user-specified parameter  $\delta$ , desired control performance can be maintained. Therefore, control performance assessment and controller redesign is unified by only one user-specified parameter, as a result, the performance-driven controller design scheme becomes more clearly. The proposed performance-driven scheme is called one-parameter tuning. The effectiveness of the proposed method is verified by a simulation result and an experimental result by using a weigh feeder.

Chapter 5 sums up this research, and mentions some of the outstanding issues. Finally future direction of a data-oriented controller is also discussed.