論　文　の　要　旨

題　目　Design of Smart Adaptive Control Systems
（スマート適応制御システムの設計）

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In process industries, control performance deterioration occurs owing to a change in the system characteristics or surrounding environment. Conventionally, self-tuning and performance control schemes have been utilized to enhance control performance. In the self-tuning control scheme, system parameters are recursively calculated via system identification, thus enabling acquirement of controller parameters based on the system parameters. However, considering calculation cost and reliability, it is an impractical scheme because it necessitates continuous re-tuning of controller parameters even when control performance requirements are satisfied. Alternatively, the performance-driven controller integrates control performance assessment and control system design, thus only allowing the tuning of control parameters via system identification when control performance has deteriorated. To summarize, in the above-mentioned schemes, control performance is influenced by the accuracy of system identification. Therefore, this thesis proposes a scheme in which controller parameters are calculated exclusive of system identification. In the proposed scheme, the controller parameters are re-tuned only when control performance deteriorates, as determined by the performance-driven control law; thus, controller parameter tuning is not required when control performance is excellent. Control performance is enhanced by adjusting one controller parameter (i.e., one-parameter tuning) prior to performance degradation to an unacceptable level; more specifically, a single parameter is adjusted when the control performance is determined to be good, not excellent. All control parameters are recalculated via closed-loop data when control performance degrades. Features of the proposed scheme are summarized as follows:

(1) The controller parameters are calculated directly via closed-loop data, exclusive of system identification.
(2) Control performance assessment and system design methods are integrated.
(3) Necessitation of either one-parameter tuning or controller redesign is determined according to the level of control performance deterioration.

In this thesis, the proposed scheme is referred to as follows: smart adaptive control scheme.

This thesis comprises five chapters as summarized below.

In Chapter 1, self-tuning and performance-driven control schemes are described as the background of this thesis. Additionally, the aforementioned three features of the smart adaptive control scheme are

explained.

In Chapter 2, a smart adaptive control scheme based on the generalized minimum variance control law (GMVC) is proposed. To begin, a scheme directly calculating controller parameters exclusive of system identification is provided in detail.

In addition, implementation of either one-parameter tuning or full controller redesign is regulated by the trade-off curve; this trade-off curve demonstrates the relationship between input and control error variance. Hence, methods used to derive the trade-off curve are described, and the algorithm employed to achieve the desired control performance using a GMVC-based smart adaptive control law is presented. The effectiveness of this scheme is verified via a numerical model developed to attain the desired control performance for a time-variant system.

In Chapter 3, a smart adaptive control scheme based on fictitious reference iterative tuning (FRIT) is described. The updated target control performance (control error and input variance) varies among controlled objects, thereby yielding difficulty in threshold determination between one-parameter tuning and controller redesign. Therefore, in Chapter 3, control performance assessment (MV-Index and GMV-Index) becomes the focus, and the controller parameters are calculated to enhance control performance assessment via FRIT. The effectiveness of this scheme is confirmed via a numerical example.

In Chapter 4, the application of each of the smart adaptive control schemes to the temperature control system, as described in Chapters 2 and 3, is discussed. In the temperature control system, the control output and input are the water temperature and open/close ratio of the hot water valve, respectively. Furthermore, system characteristics are altered by increasing/decreasing the flow rate of cold water. Finally, a control results comparison is performed between the two smart adaptive control schemes and the effectiveness of each of the proposed schemes is demonstrated.

Chapter 5 concludes this thesis and discusses several outstanding problems.