

論文の要旨

題目 A Study on Designing Schemes of Data-driven PID Controllers Based on Augmented Output
(拡張出力に基づくデータ駆動型PID制御系の設計に関する研究)

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Recently, global warming is an international issue. One of the reasons of the global warming is greenhouse gas, and almost of the greenhouse gas is emitted by industries. In industries, there are decent amount of control loops, and the control performances of the control loops strongly affect productivity and the amount of greenhouse gas. Therefore, high functional control algorithms are demanded.

A lot of sophisticated control algorithms have been proposed. However, only a few of them are employed in industrial world. The reasons are as follows:

- (i) Control algorithms are complicated.
- (ii) It is required to change conventional controllers drastically.
- (iii) Large computational cost is required.

At first, PID controllers have been widely applied as conventional controllers. Especially in process systems, over 90% of control loops employ PID controllers. A PID controller is composed of proportional, integral and derivative elements. Then, it is easy to understand physical meanings of the elements, and operators can tune PID controllers by trial and errors. These are the reasons why PID controllers are common. In contrast, the physical meanings of control parameters of complicated algorithms have high complexity, and parameter tuning is difficult on the spot. Next, if controllers are drastically changed, it is difficult to deal with problems quickly in an emergency. At last, the computational cost is an implementation problem. Generally, conventional implemental devices do not have high calculation capacity. Then, the devices must be changed to apply complicated algorithms, and many costs are required. In this research, some high-performance control systems that do not have the problems mentioned above are considered. Features of the control systems are as follows.

- (i) The PID parameters are tuned.
- (ii) PID controllers are extended.
- (iii) Recursive least squares with small computational cost is employed.

Therefore, control methods with lower difficulty of implementation are considered. This dissertation is composed of the following five chapters.

In chapter 1, an overview of a PID controller, tuning methods of the controller, and high functional PID controllers are mentioned as the research background. At first, a structure, general view, and extensions of a PID controller is mentioned. Next, two PID tuning schemes called model-

based tuning and data-driven tuning are explained. At third, some aims of high functional PID controllers are mentioned. At last, the research object and the structure of the dissertation are explained.

In chapter 2, a novel data-driven approach in designing PID controllers for single-input and single-output systems are explained. The augmented output from the PID control law is defined, and details of the tuning method is described. This tuning method can calculate a suitable set of PID parameters from one set of closed-loop input-output data. At the last of the chapter, the effectiveness of the proposed method is evaluated by simulation and experimental examples.

In chapter 3, a design method of the data-driven self-tuning PID controllers for single-input and single-output systems are explained. The method described in the chapter 2 employs off-line optimization, and it is not effective for time-variant processes. In this chapter, the method that is effective for time-variant system is proposed. This method uses the recursive least squares for minimization. The effectiveness of the proposed method is evaluated by simulation and experimental examples.

In chapter 4, a design method of a data-driven multi-loop self-tuning PID controller is described. At chapter 2 and 3, controller tuning method for single-input and single-output systems are proposed. However, many actual systems have multi-inputs and multi-outputs. In this chapter, a design method of the multi-loop controller is explained. In the multi-loop control, a compensator that removes the influence of the mutual interference is employed. PID controllers and a compensator can be designed independently. Therefore, it is easy to employ in industries. The effectiveness of the proposed method is evaluated by simulation and experimental examples.

Finally, these researches are concluded, and social significance and future works are summarized in chapter 5.