

# 論文の要旨

題 目 Design of Data-Oriented PID Controllers Based on Minimizing Generalized Output Errors  
(一般化出力誤差の最小化に基づくデータ指向型 PID 制御器の設計)

氏 名 林 香 予 子

PID controllers have been widely employed in industrial processes. It is important to determine PID gains because PID gains influence the control performance. Lots of model-based PID control schemes have been considered up to now. According to their control schemes, PID gains are computed based on a system model which is constructed by using the operating data. However, desired control performance can not be often obtained by the poverty of the system model accuracy. Moreover, much time is spent in order to build the system model. To overcome these problems, data-oriented control design schemes which directly calculated PID gains using the operating data, have been considered aggressively. Moreover, the effectiveness of application to real processes has been verified. In this thesis, as one of data-oriented PID control schemes, a control design scheme is newly proposed, which is based on minimizing the generalized output errors. Here, the generalized output can be derived from a PID control law. According to the proposed control scheme, if operating data and control specification are given, the PID gains which give the desired control performance can be easily computed. In addition, the calculation algorithm has the intuitive and intelligible feature. The data-oriented PID controller design is first considered for single-input/single-output linear systems, and the effectiveness of the proposed control scheme is illustrated by some numerical simulation examples. Furthermore, the proposed scheme is employed for an injection molding process, and the usefulness of the proposed control scheme is verified. On the other hand, when practical application of the proposed scheme is discussed, expansion to multivariable systems and nonlinear systems must be considered. For multivariable system, the non-diagonal elements of the PID gain matrix should be optimized in order to remove the influence of the interaction. For nonlinear systems, the proposed scheme is designed based on a data-driven approach. The conventional data-driven approach needs some experiments in real process to construct an initial database. However, the proposed scheme can create database in offline manner. Thus, the computation burden can be drastically reduced.

In chapter 1, as the background, the problems in model-based control schemes as conventional PID gain adjustment method are explained, and the necessary of data-oriented control design schemes is discussed. The outline of this thesis is also given in this chapter.

In chapter 2, a key concept of the proposed scheme and how to determine the generalized output using PID control law are discussed. The generalized output is developed from a control law so that it is equivalent to a reference signal. PID gains are adjusted by using errors between the generalized output and output signal of an obtained operating data. Moreover, in order to e the effectiveness of the proposed scheme, some single-input and single-output linear systems as numerical example are simulated. As a result, the scheme can computed a set of suitable PID gains without system identification. After influence of given

operating data is discussed, it is found that the desired control performance can be obtained by using the control result like persistent oscillation. If time-delay systems are controlled by the proposed scheme, the time-delay can be estimated by the value of the generalized output errors. Furthermore, the usefulness for real system is evaluated by employing it to an injection molding process.

In chapter 3, design of a multivariable PID controller is discussed because lots of real processes are given as multivariable systems. The generalized output are defined as is the case with linear systems, and the optimized non-diagonal elements of the PID gain matrix can remove the influence of the interaction. The user-specified parameter of weight for each output in the fitness function can be set by operating condition.

In chapter 4, the extension to the nonlinear systems is discussed based on the data-driven approach. The approach illustrates the effectiveness for nonlinear systems. However, the conventional data-driven controller must construct database in an offline manner, and from a practical application perspective, it is at issue. On the other hand, the proposed scheme described in previous chapters calculates the fixed PID gains. The fixed PID gains are not always obtained good control performance. Therefore, by fusing the proposed scheme and the data-driven control scheme, the nonlinear PID control scheme can be designed based on constructed database in offline manner. According to the proposed scheme, the database contains information vectors including the generalized output errors. According to the proposed scheme, the database is prospectively composed by information vectors including the generalized output errors, and the set of information vectors are selected data similar to current system condition. PID gains which are computed using neighbor data, are employed in the nonlinear system. Moreover, the effectiveness of the proposed scheme is verified by numerical simulation examples.

Finally, a data-oriented PID controller design schemes which is based on minimization of the generalized output errors are summarized, and the related future works are mentioned in chapter 5. The idea of developing the generalized output is not limited to PID controllers. If a controller is designed based on the defined generalized output as equivalent to a reference signal, the controller can be satisfied the desired control performance. Thus, the controller which is automatically determined the structure and the feature (control parameters) , can be proposed based upon the idea. The controller is called "the universal controller" by authors.