論文 / 著書情報
Article / Book Information

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Title(English)	Distributed Design of Controllers in Dynamical Network Systems
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論 文 要 旨

THESIS SUMMARY

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要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

This thesis provides a line of work on distributed design of structured controllers for large-scale dynamical network systems. Although most existing distributed controller design methods are built on the premise that the controllers are designed and integrated in a centralized manner, actual network systems are managed by multiple operators in many cases and each subcontroller is independently designed by its own operator based only on the model of the corresponding subsystem. In this thesis, novel distributed design methods for decentralized controllers and distributed controllers are proposed. In Chapter 2, we consider distributed design problem of decentralized controllers for a large-scale network system that is stably operated. There are multiple operators with the aim of suppressing effects of disturbance injected into the network system by implementing subcontrollers. Each operator can attach a subcontroller to the corresponding subsystem but the subcontroller design is performed based only on the subsystem model without the other subsystems and the network, called environment. The difficulty here is that existing controller design methods cannot deal with the unknown environment and even stability of the resulting system cannot be guaranteed. We propose a local controller design method based on retrofit control to surmount the difficulty. In the proposed framework, the targeted network system is treated as an interconnected system composed of the subsystem of interest and an environment whose model is unknown for the designer. Retrofit controllers are defined as controllers that guarantee internal stability for any possible environment as long as the original network system is internally stable. We first show that all retrofit controllers can be characterized in an algebraic manner in the frequency domain. Considering a tractable class of retrofit controllers that can be explicitly parameterized we reveal that all output-rectifying retrofit controllers have the structure that composes a locally stabilizing controller and a rectifier under the assumption that the interconnection signal from the environment is available in the controller. Then we propose a systematic design method for retrofit control It is also shown that a dual structure can be observed inside all input-rectifying retrofit controllers when control input can be injected into the interconnection signal to the environment. We generalize the result in Chapter 3 by removing the assumption, the interconnection signal is available for feedback control, made in Chapter 2. We focus on the situation where only the state of the subsystem of interest can be fed back into the controller and show that all state-feedback output-rectifying retrofit controllers have a structure similar to the previous one in this case as well. In Chapter 4, we consider the power system stabilizer design problem for frequency control in power grids with renewable energy resources. The frequencies of every synchronous generator in a large power grid is necessarily kept to be around the nominal value; otherwise these lose synchronism and a fatal fault, e.g., blackouts, occurs. We first give a mathematical model of EAST30, which is a benchmark model of the power grid in the eastern half of Japan, that composed of synchronous machines, loads, PV generators in addition to buses that form the network. We show that the power grid can be regarded as an interconnected system treated in Chapter 2 and 3 and apply the proposed approach for the power system stabilizer design problem. A numerical simulation is shown to demonstrate the effectiveness of the proposed approach. In Chapter 5, we consider the problem of integration of supervising controller design and decentralized local controller design for network systems. We generalize the above approach to glocal (global/local) control, where spatially distributed decentralized controllers and a central broadcasting controller cooperatively manage the entire network system. The concept of glocal control has been already introduced in the existing work but a systematic design of glocal controllers has not been fully established yet. A novel glocal control method based on hierarchical representation, whose notion is newly introduced in this work, is proposed. Given the definition of hierarchical representation, we derive a necessary and sufficient condition for existence of hierarchical representation for a network system. Based on the hierarchical representation, we propose a linear function observer that preserves the hierarchical structure and distributed design of global and local controllers is achieved with the observer. The design procedure of controllers is independently performed and it indicates that the controllers can be designed in a distributed manner. It is shown that both of local and global behaviors are simultaneously suppressed thanks to the existence of the global controller. A numerical example with EAST30 is shown to illustrate the effectiveness of the proposed glocal control method. Finally, Chapter 6 draws conclusion and future research direction.

備考 ： 論文要旨は、和文 2000 字と英文 300 語を 1 部ずつ提出するか、もしくは英文 800 語を 1 部提出してください。
Note : Thesis Summary should be submitted in either a copy of 2000 Japanese Characters and 300 Words (English) or 1copy of 800 Words (English).