論文 / 著書情報
Article / Book Information

題目(和文)	分散型無線センサを用いたネットワーク制御システムに関する研究
Title(English)	Design of Networked Control System using Distributed Wireless Sensors
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（博士課程）
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論 文 要 旨

THESIS SUMMARY

専攻： Department of	電気電子工学 専攻	申請学位（専攻分野）： Academic Degree Requested	博士 Doctor of （ 工学 ）
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要旨（英文 800 語程度）
Thesis Summary (approx.800 English Words)

Networked control systems have attracted a great attention in recent decades, and have been applicated in a wide range of areas. In a networked control system, the sensors, actuators and controllers are working in a separate manner in a network. By replacing the complex and burdensome wiring systems with wireless networks, the control system can achieve such benefits as flexibility, extended range, security and easier implementation.

However, it also creates new problems and challenges to adopt wireless networks in the control loops, especially in large scale systems. Due to the large number of devices, sub-systems and the inter-communications between components, the control and feedback signals will greatly suffer the potential time delays, which decrease the control system' s performance and even could destabilize the system. And the state estimation of the control target based on the data from the spatially distributed sensors, whose detection performance is always limited by the energy and communication constraints, over wireless networks is also an important but challenging task for stable control. Moreover, the dynamics of targets and the interactions between targets and distributed sensors are important for estimation and control, but they are always difficult to accurately modeled, because the scale and structure of networked control systems are always large and complicated. By addressing the three challenges above, this thesis focuses on effective control through networked control systems, and aims to provide a design of networked control system using distributed wireless sensors, and to applicate it in building energy consumption control.

The traditional centralized control strategy highly limits the system' s stability and cannot handle large-scale systems due to the large time delays. To overcome such problem, the design and development of distributed networked control strategy is necessary. The thesis begins by designing a hierarchical distributed networked control system for large-scale power control system to realize demand and response during peak hours. Plenty of sub-controllers are distributed in the proposed networked control system in charge of managing the power balance in the local clusters. The sub-controllers are subject to local power consumption limits assigned from its upper layer. These form a local centralized control loops, whose scale can be maintained to be small enough to guarantee the local stable control. And a distributed control algorithm is also proposed, in which sub-controllers at higher layers determine appropriate local power consumption limits, which contributes to realizing the global objective of power reduction during peak hours. The numerical simulations with realistic parameters show that the proposed control network is scalable regardless of the size of the power system. Furthermore, a building-scale test-bed for power control system is implemented to confirm the effectiveness of the proposed scheme contributing to daily life power saving instead of high-cost planned blackouts.

And the collection and fusion of data from spatially distributed sensors and the estimation based on them are important for stable networked control. To further increase efficiency of building energy usage in virtue of networked control systems, an LED light control system, which is based on user localization by using multiple distributed wireless battery-less binary human detection sensors, is also designed and implemented. To increase the accuracy of estimation of user location through the wireless network, a multiple-distributed-sensors-based user localization algorithm is proposed. And in the system, sensors can be flexibly located, e.g., as close to user as possible, by using a battery-less wireless sensor network, in which all sensors are activated by wireless power transmission and can be placed freely in the space with high energy stability. The lighting control is designed to reduce office lighting energy consumption

without losing user satisfaction of illuminance requirement. And a verification experiment is conducted by measuring the practical illuminance and power consumption, and the performance agrees with design expectations. It shows that based on the estimation of user location, this LED lighting control system reduces the energy consumption significantly by 57% compared to batch control scheme without any loss of user's illuminance requirement.

Proper models of system, such as sensing process and target dynamics, are also key factors for accurate state estimation and stable networked control. A recurrent neural network is designed to accurately represent how the target process and sensing processes evolve and interact with each other. It extracts the models from training data instead of theoretical and experiential assumptions. The performance analysis shows that both the performance of location estimation and lighting control gain a further increase in performance, compared to that using experiential models.