論文の内容の要旨

Stabilization and Synchronization for Hierarchical Dynamical Networks
（階層化動的ネットワークの安定化と同期化）

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In this thesis, we propose several approaches for the stabilization and synchronization of hierarchical dynamical networks which are presented in the following three main parts.

The first part introduces our viewpoints and formulations of hierarchical dynamical networks. We first investigate multi-agent dynamical systems from the viewpoint of hierarchical dynamical networks where each agent is cast as a subsystem in the hierarchical network. For homogeneous hierarchical multi-agent networks, the subsystems are identical. On the other hand, for heterogeneous hierarchical networks, the interconnection structures in subsystems are different and the numbers of agents in subsystems are distinct. Next, we study the entrainment in nonlinear multi-agent networks, in particular oscillator networks described by Goodwin-type models. In this case, each agent is a nonlinear oscillator and the oscillator network is excited by a periodic exogenous signal.

The second part is devoted to propose a new and systematic method to design hierarchical feedback controllers for both homogeneous and heterogeneous linear

hierarchical dynamical networks such that the prescribed hierarchical structures of the networks are preserved. The key idea is to employ the LQR approach where the weighting matrices are selected with proper hierarchical structures. This gives us an LQR controller with a specific hierarchical structure. As a result, the closed-loop system has the desired hierarchical structure. When not all states of subsystems are measurable, we propose local observers to reduce the output feedback design to the state feedback case which is already resolved. In a further step, we elaborate more on the selection of weighting matrices so that the proposed LQR controller is able to selectively shift the undesirable poles of the subsystems without affecting to other poles.

The last part in the thesis presents a framework to analyze the entrainment in nonlinear oscillator networks forced by external periodic signals. Utilizing harmonic balance method, the conditions for entrainment are proposed. Next, the monotone properties of the entrainment are figured out. The network of 3rd-order Goodwin oscillators which has been used to describe circadian rhythms is employed in this research to illustrate the theoretical results. Interestingly, some obtained results agrees with the experiment observations. Thus, they would be helpful to get more insights and to further studying circadian oscillations. Moreover, the networks of higher-order Goodwin-type oscillators are considered where the obtained results for networks of 3rd-order Goodwin oscillators can be similarly achieved.