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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 ）

Control of complex dynamical systems is an important and active research area. Dynamical models of various complex real life systems from biology, physics, finance, and engineering fields incorporate randomly varying parameters. These parameters often describe the state of external environment in which the system under consideration operates, and hence they may not be directly measurable or may not be observed as frequently as the state of the system itself. Therefore, when a control problem for a complex dynamical system with stochastic parameters is explored, one needs to take into account the fact that system parameters may not be available for control purposes at all time instants.

In this thesis we address feedback control problem for linear stochastic parameter-varying systems, under the assumption that the controller has access only to sampled information of parameters.

We first develop sampled-parameter feedback control frameworks for linear systems with a stochastic parameter that takes values from a finite set. Each value of the parameter represents a mode of the dynamical system. The overall system in this case is called a "switched system", since the operation mode of the dynamics switches when the parameter changes its value. Switched stochastic systems accurately characterize complex processes that are subject to dynamical changes due to sudden environmental variations. We investigate continuous-time switched systems with a randomly varying mode signal. This mode signal is assumed to be observed (sampled) periodically. In this case, information about the operation mode of the switched system is available for control purposes only at periodic mode observation instants. We propose a feedback control law that achieves stabilization of the system states by using only periodically observed (sampled) mode information. We then direct our attention to a more complex feedback control problem for the case where the sampled mode information is subject to time delay before it becomes available for control purposes. This time delay may emanate from communication delays between the mode sampling mechanism and the controller or computational delays in mode detection. We propose stabilizing control laws that depend only on delayed and sampled version of the mode signal.

In addition to continous-time switched stochastic systems, we also explore the feedback control problem for discrete-time switched stochastic systems. We consider the case where the mode of the switched system is periodically observed. We develop a stabilizing feedback control framework that incorporates sampled-mode-dependent and time-varying feedback gains, which allow stabilization despite the uncertainty of the operation mode between consecutive mode observation instants. We utilize the periodicity induced in the system dynamics due to periodic mode observations, and employ discrete-time Floquet theory to obtain necessary and sufficient conditions for the stabilization of the system states. Furthermore, we address the case where mode information obtained through periodic observations is imprecise. Imprecise mode information characterizes the situation where some of the modes are indistinguishable by the mode detector. Specifically, in this situation, the modes of the switched system are divided into a number of groups, and the controller periodically receives information of the group that contains the active operation mode. For this case, we develop a feedback control law that guarantees stabilization by using only the group information rather than a precise information of the active mode.

Next, we address feedback control problem for continuous-time and discrete-time switched stochastic systems for the case where the mode of the switched system is observed at random time instants. For the continuous-time case, we develop a stabilizing control law under the assumption that the lengths of intervals between mode sampling instants are exponentially distributed independent random variables. For this particular case, we observe that the closed-loop system under our proposed sampled-mode control law can be modeled as a switched linear stochastic system with a mode signal that is defined to be a bivariate stochastic process composed of the actual mode signal and its sampled version. On the other hand, for the discrete-time case we do not assume a particular structure for the distribution of the lengths of intervals between the time instants at which mode is sampled. We observe that this characterization encapsulates periodic mode observations as a special case. Our investigation for the discrete-time case is predicated on the analysis of a sequence-valued process that encapsulates the stochastic nature of the evolution of active operation mode between mode observation instants.

Parameters of certain dynamical system models from engineering field evolve in multidimensional spaces composed of a continuum of points. Hence, dynamical systems with such kind of parameters can not be characterized as switched systems. In the last part of this thesis, we explore sampled-parameter feedback control of discrete-time dynamical systems with stochastic parameters that are defined on multidimensional spaces. Furthermore, we investigate a special class of linear parameter-varying systems where the system matrix depends affinely on the entries of the stochastic parameter vector. For this class of parameter-varying systems, we show that stabilization can be achieved by using a control law with a feedback gain that is an affine function of the entries of the sampled parameter vector.

All sampled-parameter feedback control frameworks that we develop in this thesis have guaranteed stabilization properties. Specifically, we obtain conditions under which our proposed control laws guarantee that the system states converge to the zero solution for all possible trajectories of the parameters.