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Stochastic optimal control of structures. (English)

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Classical stochastic control theory is based on stochastic systems represented by stochastic differential equations. However, the dynamic state equation of many technical problems under stochastic uncertainty, such as the control of mechanical structures under stochastic loads, active control of structures under stochastic load, etc., has to be modelled by a system of ordinary differential equations

$$\dot{z}(t) = g(t, \theta(\omega), z(t), u(t)), \quad t \geq t_0.$$

with a random parameter vector $\theta = \theta(\omega)$ involving external load, material, manufacturing parameters, etc. Further stochastic parameters arising in the corresponding control problem are, e.g., the initial, terminal state z_0, z_f, parameters of the cost function along the trajectory of the terminal costs. In order to take into account stochastic parameter variations, appropriate deterministic substitute control problems have to be introduced, as described, e.g., in stochastic optimization. According to the selected cost functions, objective criterion involving expected costs, probabilities, risk terms, etc., occur. Using then approximation techniques for dealing with expectations, probabilities, optimal open-loop, feedback and open-loop feedback controls can be determined by applying optimization techniques from deterministic control theory.
In the first two chapters of the present book, several technical foundations are given, such as random vibration of mechanical structures, random seismic problems, reliability of structures. Moreover, the traditional approach to stochastic control is described. The main topic of the volume, hence, the consideration of control problems with state equations of type (1) is started in the third chapter. The proposed solution technique is described in case of active structural feedback control problems with a second order linear differential equation involving a random external load term: for a given realization θ of the random load parameter $\theta(\omega)$, first the feedback control law $u(t)$ is optimized by using a quadratic objective function. The remaining parameters of the gain matrix, such as weight parameters of the primal objective function, are then determined by minimizing a secondary expected-value goal function taking into account the stochastic parameter variations. Numerical applications to controlled single- and multiple-story buildings follow. Then, several generalizations of the considered control procedures are discussed, such as active-passive-hybrid control of structures, control of hysteretic structures, and control of nonlinear systems by using functional expansions of nonlinear terms. Technical applications of the presented control concepts are given to the control of wind-resistant structures with viscous dampers, and seismic structures with magneto-rheological (MR) dampers. Finally, some experimental studies are provided.
The book, containing many numerical examples and technical applications as well as many references, can be recommended especially to readers interested in optimal control of mechanical structures under stochastic uncertainty.

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