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★**Model abstraction in dynamical systems: application to mobile robot control.**

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This book explores model abstraction of dynamic systems in order to design controllers. First, control design using abstraction is developed, and then propagation of uncertainty in abstracted systems is analyzed.

To reduce the complexity of system analysis and control, simplified models that capture the behaviour of interest in the original system can be obtained. These simplified models, called abstractions, can be analyzed more easily than the complex model. First, this book investigates the conditions under which controllers can be designed in abstracted systems and then transferred to the original dynamical system, taking advantage of design using the simpler model. The hierarchies of consistent abstractions can significantly reduce the complexity in determining the reachability properties of nonlinear systems. Such consistent hierarchies of reachability-preserving nonlinear abstractions are considered in this book for a robotic car.

These abstractions can be analyzed with respect to some behavior of interest, but they can also be used to transfer control design for the complex model to the simplified model. Working towards control design, the authors show that there are certain classes of trajectories that exist in the rolling risk system that cannot be achieved by the robotic car. In order to account for these cases, the new concepts of traceability and ε-traceability are introduced. This book also studies the relationship between the evolutions of uncertain initial conditions in abstracted control systems. It is shown that a control system abstraction can capture the time evolution of the uncertainty in the original system by an appropriate choice of control input. Abstracted control systems with stochastic initial conditions show the same behavior as systems with deterministic initial conditions. A conservation law is applied to the probability density function (pdf) requiring that the area under it be unity. Application of the conservation law results in a partial differential equation known as the Liouville equation, for which a closed form solution is known. The solution provides the time evolution of the initial pdf which can be followed by the abstracted system.

This book provides a comprehensive survey of the theory behind abstraction and applies the results to general nonlinear dynamical systems. In particular, the following topics are presented: an overview of the history and current research in mobile robotic control design, a mathematical outline that provides the tools used in this research area, the development of the robotic car model and both controllers used in the new control design, a survey of abstraction and an extension of these ideas to new system relationship characterizations called traceability and ε-traceability, a framework for designing controllers based on abstraction, an open-loop control design with

simulation results, and an investigation of system abstraction with uncertain initial conditions.

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