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Abstract

In spite of the current state of control theory, a fundamental issue in control remains open: which model is appropriate for control design? Mathematical models of complex systems are not always reliable, while adaptive and robust control methods have not completely overcome the danger of modelling errors. Furthermore, the design of an accurate model from first principles or from system identification, is often a time consuming and not a straightforward task. In this work [1], another approach to design controllers for a system is discussed. The control action that realizes system regulation or tracking control is derived without the use of any model or preliminary information about the system, but is merely based on input-output data observed from the system. This way, the step of modelling or system identification is not required anymore. Such a control strategy is known as data-based control.

Standard model-based discrete-time finite horizon optimal control is obtained using a state-space description of the system. A linear quadratic cost function is optimized resulting in two difference Riccati equations, with which the optimal state feedback and state observer gains can be computed. Since a linear quadratic cost function is used together with Gaussian process and measurement noises, the combination of the optimal control and the state observation is known as Linear Quadratic Gaussian (LQG) control.

Reference [2] presents an algorithm that omits the need for a state-space model of the system, when computing the solution to the discrete-time finite horizon LQG problem. The computation makes use of closed-form solutions to the difference Riccati equations instead of the normally used recursive solutions. This way, the solution no longer requires an explicit system model, but is based on a finite number of Markov parameters of the system that equal the values of the impulse response at discrete sample times. These parameters can be estimated on-line from almost any set of input/output data of the system using ARMarkov representations [3].

The combination of on-line Markov parameter estimation and data-based LQG control can be used to construct a moving horizon controller. A system can then be regulated using only the input and output data, without requiring any model of the system or any parametric representation of the controller. Based on the measured input/output data, the controller can adapt its action to the actual dynamics. Consequently, the data-based controller can also be used to control systems with changing dynamics. Apart from state regulation, the data-based controller can be used for tracking control tasks.

The effectiveness of data-based LQG control is evaluated in simulations and in experiments. Simulations show that, in case of time-invariant plants, a model-based and data-based LQG controller give identical results while in case of time-varying plants, the data-based controller is able to adapt itself to the changing dynamics. Although not yet delivering a high tracking performance, experimental results obtained on a direct-drive robot of spatial kinematics look promising. At this moment, a high computational burden is the most important factor which limits the performance. Reduction of the computational costs, so performance improvement can be obtained with a longer horizon length is under investigation.

References

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