Title:
Applications of Adaptive Critic Design

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Abstract:
Many difficult real-life control design problems can be formulated in the framework of nonlinear optimal control theory. Dynamic programming formulation offers the most comprehensive solution approach to nonlinear optimal control in a state feedback form, which is desirable because of its beneficial properties like online applicability (because of a closed-form solution), robustness with respect to noise and modeling uncertainties. However, solving the associated Hamilton-Jacobi-Bellman (HJB) equation demands a very large (rather infeasible) amount of computations and storage space dedicated for this purpose (popularly known as "curse-of-dimensionality" issue). An innovative idea is to get around this numerical complexity by using an "Approximate Dynamic Programming (ADP)" formulation, the solution of which is obtained through a dual neural network approach called Adaptive Critic (AC) design. The AC method determines an optimal control law for a system by successively adapting two neural networks, an action network (which dispenses the control signals) and a critic network (which 'learns' the desired performance index for some function associated with the performance index). This adaptive critic optimal control synthesis approach has many desirable features, viz. having a feedback form of the control, ability for on-line implementation, no need for approximating the nonlinear system dynamics with linearization or quasi-linearization etc. A recent improvement of this idea is "Single Network Adaptive Critics (SNAC)", which is applicable to a wide class of nonlinear problems. It leads to simplicity in the AC neural network architecture, which results in a substantial reduction of computational load for training the networks, while retaining all the beneficial properties of the AC architecture. The adaptive critic design has been successfully demonstrated in a large number of challenging application problems, including power systems control and optimization, MEMS actuator design and biomedical control. In recent times, the philosophy of AC and SNAC designs have also been extended to make it applicable to 'distributed parameter systems' (DPS), which cover a vast number of applications like temperature control, chemical reactor control, ecology management etc. The objective of this tutorial is to provide the audience a brief exposure to the philosophy of adaptive critic design, especially to give them a good exposure to a wide variety of applications. Application problems to be presented in this tutorial will include various topics as mentioned above, which will be derived largely from the vast research experience of the speakers in this field.