Approximate dynamic programming (ADP) scheme is employed to overcome the curse of dimensionality of the classical dynamic programming and to obtain near optimal controllers. Neural dynamic programming (NDP) provides approximate solutions to dynamic programming where neural networks (NN) are used for function approximation. In recent years, adaptive critic architecture using NDP is being applied to design controllers for a class of affine nonlinear systems. Many of these designs are shown on a linear system and/or on nonlinear systems under ideal circumstances when approximation errors and disturbances are assumed to be zero and by using an offline NN training phase. To overcome these limitations for real-time control, adaptive critic NN based controllers for affine nonlinear systems in continuous time are being addressed by solving Hamilton-Jacobi-Bellman formulation. However, adaptive critic NN controllers are not reported for strict and nonstrict feedback nonlinear system in continuous and discrete-time so that Lyapunov stability can be established rigorously for non ideal situations. For instance, for engine emission control application, the engine dynamics can be expressed only as a nonlinear system in nonstrict feedback form and existing controllers cannot be easily extended to such nonlinear systems.

Thus, the overall goal of this study is to provide the next generation adaptive critic NN controllers with adaptation, optimization, and learning for the control of complex nonlinear systems, has guaranteed performance, and is supported by a rigorous and repeatable design and mathematical framework. Therefore the objectives are:

1. Develop a robust adaptive critic NN control scheme for a class of strict feedback and non strict feedback nonlinear systems in discrete-time even when the system dynamics are not known accurately. Demonstrate the Lyapunov stability in the presence of approximation errors, actuator constraints, delays and disturbances.

2. Develop a robust adaptive critic NN-based output feedback control scheme, with an observer to estimate certain unmeasured states, for a class of strict feedback and non strict feedback nonlinear systems both in continuous and discrete-time even when the system dynamics are not known before hand. Demonstrate Lyapunov stability.

3. Compare a robust adaptive NN control scheme using both tracking error-based unsupervised learning and reinforcement learning in real-time. This is critical to show the superior capability of adaptive critic NN controllers over other NN controller designs.
Web link for this project: http://web.mst.edu/~sarangap/

Publications:


