INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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Thesis Title: Control of Uncertain Nonlinear Systems using Event-Triggered Adaptive Dynamic Programming

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SHORT ABSTRACT

This thesis presents novel tracking control strategies by utilizing the event-triggered adaptive dynamic programming (ADP) approach for diverse nonlinear systems, addressing matched uncertainties, unmatched uncertainties, control constraints, and state constraints. The first part focuses on event-triggered guaranteed cost tracking control of nonlinear matched uncertain systems. The original problem is transformed into an optimal control problem of the nominal augmented system. A critic neural network (NN) within the framework of ADP is employed to solve the Hamilton-Jacobi-bellman (HJB) equation associated with the optimal control problem. The event-based guaranteed cost is derived, and its relation with the time-based one is discussed. Furthermore, it is proved that the controller can make the tracking error uniformly ultimately bounded (UUB). In the second part, the robust tracking control problem for systems with unmatched uncertainties is investigated using an event-based ADP approach. First, an augmented system is constructed based on the nonlinear system and the reference trajectory. Then, by forming an auxiliary system and introducing a discounted cost function, the event-based robust tracking control problem is transformed into the event-based optimal control problem of the auxiliary system. A modified critic weight update law is developed that avoids the need for an initial admissible control. Meanwhile, it is demonstrated that the obtained event-based controller can guarantee the tracking error's uniform ultimate boundedness. The third part introduces an event-triggered robust guaranteed cost tracking controller for nonlinear systems with control constraints and unmatched uncertainty. Detailed Lyapunov analysis guarantees the ultimate boundedness of the closed-loop event-triggered system. The derivation of event-based guaranteed cost and its relation with the time-based counterpart is presented. The exclusion of the infamous Zeno behavior is guaranteed. The uniform ultimate boundedness of the critic weight estimation error is established. The fourth part addresses safety-critical control of partially unknown nonlinear uncertain systems with input and state constraints. The unknown part of the system dynamics is approximated using a neural network-based identifier. A novel safe HJB equation is formulated by incorporating a control barrier function (CBF) and a nonquadratic term into the cost function to penalize violations of safety regulations. Solving the new safe HJB equation involves employing a critic neural network to approximate the solution. The proposed methods are validated through simulation studies on nonlinear systems, including a robotic arm and other benchmark nonlinear models.