Abstract

Most of the dynamical systems around us are inherently nonlinear. Systems which are characterized by interacting of continuous nonlinear dynamics along with discrete dynamics known as Nonlinear Hybrid Dynamical Systems (NHDS). These systems are capable of exhibiting simultaneously continuous dynamics, discrete dynamics, jump phenomena, switching characteristics. Classical way to control a nonlinear plant by selecting few operating points which cover the required span of the system and a linear model is obtained. The controller is designed for each model and activates one of these controllers when the process is operating in the neighborhood of the corresponding operating point.

The aim of our work is to design event wise multiple linearized model based controller with appropriate stability analysis of the NHDS. To this aim, the NHDS is approximated as PieceWise Affine autoRegressive eXogeneous (PWARX) models. Firstly, an algorithm to estimate the number of discrete events presents in the NHDS is proposed. Built upon this result, a weighted least squares based PWARX model identification technique is proposed. The equivalence between PWARX model and event wise linearized model is provided. The event wise linearized models are used for the formulation of the optimal control laws, which are then patched together through switching to become a control law for the NHDS. The Hamilton-Jacobi-Bellman (HJB) equation is formulated using a suitable quadratic term in the objective function. By the use of the direct method of Lyapunov stability, the control law is shown to be optimal with respect to objective functional and stabilized the event wise linearized models. The proposed modeling and control algorithm have been applied on the different NHDS. Necessary simulation and experimental results are presented to demonstrate the performance and validation of the proposed algorithm.

Robust control law is formulated for the NHDS under matched and unmatched model uncertainties. The HJB equation based optimal control problem is formulated using a suitable non-quadratic term in the objective function for robust control design of event wise linearized model. The families of bounded control laws are designed to enforce stability using Lyapunov theorem for the individual events with the knowledge of the maximum bound of uncertainty. By use of the direct method of Lyapunov stability, the bounded control law is shown to be optimal with respect to the objective function of the system

under uncertainty. The switching between the stability regions according to the discrete events such a way that it guarantees stability of the closed-loop NHDS using Lyapunov functions. The proposed robust constrained control algorithm has been applied on the different NHDS. Necessary theoretical, simulation and hardware results are presented to demonstrate the performance and validation of the proposed robust control algorithm.