

Abstract

A class of stabilizing PD and PID controllers for linear system is obtained based on the results of generalized Hermite Biehler Theorem. This characterization is exploited to select an optimal PD and PID controller gains from the region of stabilizing controllers in order to have an optimum value of performance index by adopting a genetic algorithm based optimization technique. For a multi-input multi-output (MIMO) system, a set of stabilizing PD and PID controllers was obtained for each subsystem using PD and PID stabilization theorems. In order to study the stability of the designed PD and PID controllers for the interconnected MIMO systems, an LMI based optimization problem is adopted. On the other hand, for a class of nonlinear system a set of stabilizing PD and PID controllers is designed for each linear part of the nonlinear subsystems based on PD and PID stabilization theorems. If the nonlinearities satisfy certain quadratic constraints, the stability analysis of nonlinear systems with the designed set of PD and PID controllers is determined by an LMI based approach. Simulation results are shown to illustrate the design procedure for linear and nonlinear systems.

We have also indicated the possibility of obtaining a set of stabilizing PID controllers for single-input single-output (SISO) linear systems based on Lyapunov stability approach. Subsequently a set of PID controllers was designed for a class of SISO nonlinear system by taking into account the effect of nonlinear terms in the dynamic model using four different techniques. The set of stabilizing controllers obtained for the linear part of the nonlinear system stabilizes the system which is proved by an LMI approach. Simulation results are given for a single-link robot manipulator in order to illustrate all the four methods.

We have presented two different methods to design a set of decentralized controllers for MIMO nonlinear systems. The first method is based on Kharitonov's theorem and boundary stability condition where the Kharitonov theorem for interval plant is exploited to synthesize a stabilizing decentralized PID controller to meet the design specifications in terms of gain and phase margins for a linear system with nonlinear terms taken as perturbations. Then, stability analysis for the nonlinear system with the decentralized linear controllers is investigated based on an LMI approach. Our second method of designing stabilizing controllers is an extension of the adaptive control technique described in [49], based on Lyapunov interval matrix approach. The effectiveness of the proposed two methods is illustrated through simulation results for two-link robot manipulator by solving trajectory tracking control problem.

A variable structure sliding mode controller is designed for trajectory tracking of nonlinear systems. A discrete linear sliding-mode and terminal sliding mode control laws based on reaching law approach is designed for a MIMO nonlinear system after feedback linearization for output tracking. Simulation results are given for single-link and two-link robot manipulator which efficiently tracks a constant as well as a time-varying desired

position with the designed sliding mode controllers. We have also investigated the possibilities of designing a sliding surface and an equivalent control law based on LMI technique and subsequently stability analysis of nonlinear system is studied. Simulation results are given for single-link as well as two-link robot manipulators for controlling desired position of robot link using the designed controllers.

The trajectory tracking problem of a two-link manipulator is studied based on parametric formulation of the robot model. The robust control law of Spong [173] is studied and the additional control law proposed by Spong is replaced by a simple fuzzy controller. Furthermore, an equivalent adaptive fuzzy logic controller is introduced in order to compensate the parametric uncertainty in the payload and also to design a reliable control law for trajectory tracking problem of robot manipulator. Stability study is done for adaptive fuzzy control scheme based on Lyapunov approach. Simulation results are given with the proposed two controllers and are compared with Spong's controller.