EE 706: NONLINEAR SYSTEMS AND CONTROL (3-0-0 : 3)

Preamble

In many engineering applications, the plant turns out to be nonlinear, i.e., described by ordinary nonlinear differential equations. The huge ensemble of various types of nonlinearities makes determination of general control strategies for larger classes of nonlinear systems a challenging task. However, over the past few decades a significant development regarding analysis of nonlinear systems has been carried out and state-of-the-art methods for control of such systems have been devised. The aim of this course is twofold: first, to get a thorough mathematical basis for analyzing nonlinear dynamical systems. Secondly, to go through various methods for control of such systems, and to understand their working principles.

Course Contents

Introduction: state-space representation of dynamical systems, phase-portraits of second order systems, types of equilibrium points: stable/unstable node, stable/unstable focus, saddle; Existence and uniqueness of solutions: Lipschitz continuity, Picard's iteration method, proof of existence and uniqueness theorem, continuous dependence of solutions on initial conditions; Features of nonlinear dynamical systems: multiple disjoint equilibrium points, limit cycles, Bendixson criterion, Poincare-Bendixson criterion; Linearization: linearization around an equilibrium point, validity of linearization: hyperbolic equilibrium points, linearization around a solution; Stability analysis: Lyapunov stability of autonomous systems, Lyapunov theorem of stability, converse theorems of Lyapunov theorem, construction of Lyapunov functions: Krasovskii method and variable gradient method, LaSalle invariance principle, region of attraction, input/output stability of non-autonomous systems, L-stability; Control of nonlinear systems: describing functions method, passivity theorem, small gain theorem, Kalman-Yakubovich-Popov lemma, Aizermann conjecture, circle/Popov criteria, methods of integral quadratic constraints and quadratic differential forms for designing stabilizing linear controllers, multiplier techniques.

References:

1. H. K. Khalil, Nonlinear systems, Prentice Hall.
2. M. Vidyasagar, Nonlinear systems analysis, Society of Industrial and Applied Mathematics.
3. H. Marquez, Nonlinear Control Systems: Analysis and Design, Wiley.
4. Isidori, Nonlinear Control Systems, Springer.
5. F. Verhulst, Nonlinear Differential Equations and Dynamical Systems, Springer.