NONLINEAR ADAPTIVE CONTROL

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PRE-REQUISITES : Linear Systems (State Space)

INTENDED AUDIENCE : Advanced Undergraduate and MTech/PhD students in their second year

INDUSTRY SUPPORT : Space Industry – ISRO, Control and Robotics industry – John Deere, ABB, MATLAB, GE Research, Mercedes Benz Research etc.

COURSE OUTLINE :

The course provides a comprehensive introduction to control design for nonlinear systems, specifically adaptive control which is a popular applied nonlinear control method for uncertain parametric systems. Adaptive control is one of the few nonlinear control methods to have found significant acceptance in the industry, especially defense and aeronautics. The course attendees will delve into nonlinear control design methods much more than anywhere else and by the end of the course are expected to be able to design nonlinear and adaptive controllers for a variety of systems. The examples used in the course will usually come from spacecraft attitude dynamics, robot manipulator dynamics and other aeromechanical systems.

ABOUT INSTRUCTOR :

Prof. Srikant Sukumar completed his PhD in Aerospace Engineering from The University of Texas at Austin with a specialisation in nonlinear adaptive control of space and aerial vehicles in 2011. He has since been a faculty at the Systems and Control Engineering Department at IIT Bombay where he is currently an Associate Professor. He has been a Max Planck Fellow. He serves as a member of the IEEE conference editorial board , the IEEE Technical Society for Space Vehicles and as an Associate Editor for the IEEE Transactions for Aerospace Engineering Systems. He actively mentors student teams in developing urban aerial vehicles, nano-satellites and autonomous vehicles. His research interests lie in adaptive nonlinear control, geometric control and observation, cooperative control and estimation over networks.

COURSE PLAN :

Week 1: Introduction to Adaptive Control; Common myths in control; Vector, Matrix and Signal Norms
Week 2: Barbalat’s Lemma and Illustration of use; Equilibrium definitions;

Week 3: Lyapunov Stability definitions – stability, uniformity, attractivity, asymptotic stability, exponential stability; Stability of Linear systems.
Week 4: Function classes; Definiteness, radial boundedness, decrescence; Lyapunov stability theorems
Week 5: La Salle’s Invariance; Persistence of Excitation; Uniform Complete Observability; Alternate Exponential stability theorems
Week 6: Certainty Equivalence Adaptive control – First and Second order systems; Detectability obstacle and Ortega construction
Week 7: Introduction to Backstepping in Adaptive Control; Backstepping for unmatched unknown
Week 8: Unknown Control Gain adaptation; Model Reference Adaptive Control (MRAC)
Week 9: integrator backstepping adaptation general case; Extended Matching – integrator backstepping adaptation
Week 10: Tuning Functions based integrator backstepping adaptation, Robustness in adaptive control – sigma modification; Parameter projection
Week 11: Initial excitation adaptive control – single and double integrator
Week 12: Deep Learning – Introduction and applications, Radial Basis function based Neural Network function approximation, Multilayer Neural Networks