FEEDBACK CONTROL SYSTEMS (9 credits)

http://didattica.uniroma2.it/programma/index/insegnamento/160392-Feedback-Control-Systems

Instructor:

Verrelli Cristiano Maria, Electronic Engineering Department, Tor Vergata University

Course Format:

4 Hours Lecture, 2 Hours Exercitation

Period:

Spring Trimester

Language:

English

Recommended Previous Knowledge:

Linear Algebra, Mathematical Analysis.

Contents:

The theory of differential equations is successfully used to gain profound insight into the fundamental mathematical control design techniques for linear and nonlinear dynamical systems. Tutor-guided individual projects (including computer simulations and lab experiments) invite an intensive participation.

Learning Outcomes:

Learning the basic elements of feedback control theory. In particular:

- Linear systems

The matrix exponential; the variation of constants formula. Computation of the matrix exponential via eigenvalues and eigenvectors and via residual matrices. Necessary and sufficient conditions for exponential stability: Routh-Hurwitz criterion. Invariant subspaces. Impulse responses, step responses and steady state responses to sinusoidal inputs. Transient behaviors. Modal analysis: mode excitation by initial conditions and by impulsive inputs; modal observability from output measurements; modes which are both excitable and observable. Popov conditions for modal excitability and observability. Autoregressive moving average (ARMA) models and transfer functions.

Kalman reachability conditions, gramian reachability matrices and the computation of input signals to drive the system between two given states. Kalman observability conditions, gramian observability matrices and the computation of initial conditions given input and output signals. Equivalence between Kalman and Popov conditions. Kalman decomposition for non reachable and non observable systems.

Eigenvalues assignment by state feedback for reachable systems. Design of asymptotic observers and Kalman filters for state estimation of observable systems. Design of dynamic compensators to stabilize any reachable and observable system. Design of regulators to reject disturbances generated by linear exosystems.

Introduction to adaptive control. Introduction to tracking control. Minimum phase systems and proportional Integral Derivative (PID) control.

Bode plots. Static gain, system gain and high frequency gain. Zero-pole cancellation. Nyquist plot and Nyquist criterion. Root locus analysis. Stability margins. Frequency domain design. Realization theory.

- Introduction to nonlinear systems

Nonlinear models and nonlinear phenomena. Fundamental properties. Lyapunov stability. Linear systems and linearization. Center manifold theorem. Stabilization by linearization. Control mechanisms, bifurcation phenomena, complexities and subtleties in biology and physiological processes.

- Tutor-guided individual projects (including computer simulations) are involved and may concern one of the following topics.

•Population dynamics

- L. Edelstein-Keshet, Mathematical models in biology, Siam, 2005.

- J. D. Murray, Mathematical biology I, Springer, 2003.

- D. S. Jones, M. J. Plank, B. D. Sleeman, Differential equations and mathematical biology, CRC press, 2010.

•Mathematics of heart physiology and control

- D. S. Jones, M. J. Plank, B. D. Sleeman, Differential equations and mathematical biology, CRC press, 2010.

- J. Keener, J. Sneyd, Mathematical physiology, Springer, 2004.

- M. C. K. Khoo, Physiological control systems, IEEE press, 2000.

•Mathematics for glucose regulation control

- J. Keener, J. Sneyd, Mathematical physiology, Springer, 2004.

- M. C. K. Khoo, Physiological control systems, IEEE press, 2000.

Reading Resources:

C.M.Verrelli. La matematica elementare del feedback, III Edizione. Esculapio, 2015.

Michael E. Taylor. Introduction to Differential Equations. American Mathematical Society, 2011.

M.W. Hirsch, S. Smale, R.L. Devaney. Differential equations, dynamical systems & an introduction to chaos. Elsevier, Academic Press, 2004.

Richard C. Dorf, Robert H. Bishop. Modern Control Systems. Prentice Hall, 2011.

K.J.Astrom, R. Murray. Feedback systems. An introduction for scientists and engineers. Princeton University Press, 2008.

Performance Record:

Written and Oral

Workload:

90 hours total

Contact:

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