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ENG ME/SE/EC 501: Dynamic Systems Theory — State-space linear systems

Course Outline: (Fall 2011)

1. Mathematical preliminaries: linear algebra
   (i) Finite dimensional linear spaces
   (ii) Linear transformations and matrices
   (iii) Jordan normal form
2. State-space representation of linear control systems
3. Mathematical foundations of state-space representations
   (i) Existence and uniqueness results for linear ordinary differential equations
   (ii) Peano-Baker series and matrix exponentials
   (iii) Properties of the state-transition matrix
4. Points of contract with frequency-domain analysis
   (i) The resolvent; Newton's algorithm
   (ii) Stability analysis in the frequency domain
5. Controllability and observability
   (i) The controllability Grammian; the observability Grammian
   (ii) Algerbaic tests for controllability and observability
6. Shaping the dynamic response — Where do we put the closed-loop poles?
   (i) Analysis of second-order systems; dc-motor control example
   (ii) Design of regulators
7. Digital control theory
   (i) Modeling discrete-time and sampled-data systems
   (ii) Analysis of sampled data systems
8. Linear observers
9. Compensator design by separation of variables principle
10. Linear quadratic optimal control theoryl
    (i) The Pontryagin maximum principle
    (ii) Least squares theory and the matrix Riccati equation
11. Random processes
    (i) Wiener processes
    (ii) The Ito calculus and the theory of stochastic differential equations
    (iii) Recursive estimation
12. Nonlinear/geometric control theory
    (i) Introduction to the theory of differentiable manifolds
    (ii) Accessibility, controllability, and system Lie algebras

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Suggested Reading

Text: Bernard Friedland, Control System Design: An Introduction to State-Space Methods, McGraw-Hill, 1986. Reissued by Dover Books on Engineering, 528 pages, Dover Publications (March 24, 2005), ISBN-10: 0486442780, ISBN-13:978-0486442785. Order online from: http://www.amazon.com or http://store.doverpublications.com.

Other books:

Panos J. Antsaklis & Anthony N. Michel, Linear Systems, ISBN: 0-07-041433-5, Electrical and Computer Engineering Series, McGraw-Hill, 1997, 696pages.

Chi-Tsong Chen, Linear System Theory and Design, Oxford University Press, 3-rd Edition, ISBN 0-19511777-8, 1999, 334pages.

Karl Johan ˚Astr¨om and Richard M. Murray, Feedback Systems: An Introduction for Scientists and Engineers, Princeton University Press, ISBN-13: 978-0-691-13576-2, ISBN-10: 0-691-13576-2, 2008, 396 pages.

Joao P. Hespanha, *Linear Systems Theory*, Princeton University Press, ISBN: 978-0-691-14021-6, 2009, 278 pages.

Roger W. Brockett, *Finite Dimensional Linear Systems*, John Wiley and Sons, SBN 471 10585 6, 256 pages. (Out of print. See http://www.amazon.com/ or download from course web site (http://people.bu.edu/johnb/ME501.html.)

Grading

Grades will be given for homework assignments (one every week or so), class participation, and perhaps for a term project that will be assigned during the first few weeks of the class.

For up-to-date information about the class, visit: http://people.bu.edu/johnb/ME501.html.

For a downloadable PDF version of this syllabus, click http://people.bu.edu/johnb/ME501.pdf.