Engineering Nonlinear Dynamics: Identification, Modeling and Solution Techniques (ASEN 6519, Spring 2009)

Class Room: ECAE 1B73

Class Meets: TTh 3:30PM-4:45PM

Website:
http://www.colorado.edu/engineering/CAS/courses.d/ASEN6519.d/ASEN6519_2009.html

Course Description
We will be devoting to fundamentals of nonlinear dynamics, model equation derivation, classical methods for solving nonlinear oscillations, and modern nonlinearity identification techniques that are employed in solids mechanics, fluid dynamics, meteorology, even macro-economic forecasting. During the first half of the course, a series of formal lectures will be given. This will be followed by common and individualized reading assignments, and by student presentations that summarize each topical areas. Term project(s) will then cap the course.

Instructor:
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References
Nonlinearity in Structural Dynamics by K. Worden and G. R. Tomlinson
(Institute of Physics Publishing, 2001);
Chaotic and Fractal Dynamics by F. Moon (John Wiley & Sons, Inc., 1992);
Nonlinear Oscillations by A. H. Nayfeh and D. T. Mook (John Wiley & Sons, Inc., 1979);
Independent Component Analysis by A. Hyvarinen, J. Karhunen and E. Oja
(John Wiley & Sons, Inc., 2001);
Hilbert-Huang Transform and Its Applications ed. By N. E. Hunag and S. S. P. Shen
(World Scientific Publishing Co., 2005)

Grading
Your grade in this course will be assessed by homework, exams, and class discussions with the following weights:
Homework 30%
One mid-term exams: 30%
Term Project: 30%
Class participation: 10%

Course Outline
Nonlinearities in Engineering Dynamical Systems (1 lect)
Sources of Nonlinearities, Nonlinearity Detection and Classification

Duffing and allied nonlinear model equations and their solution methods (2 lect)
Numerical Solution Techniques
Phase Plot, Poincare Mapping
Periodicity, Chaos, and Attractors
Essentials of Linear Algebra and Probability for Nonlinear Dynamics (3 lect)
  Linear Independence, Linear Transformation
  Singular Value Decomposition and Related Techniques
  Probability Tutorial
  Gaussian and Non-Gaussian Distributions
  Means, Variance, Kurtosis, etc.

Nonlinearity Detection Techniques (2 lect)
  Homogeneity test
  Nyquist plots
  Coherence function
  Hilbert Transform
  Cross correlation test

Classical Nonlinearity Modeling Techniques (6 lect)
  Describing functions
  Nonlinear normal mode
  Floquet theory
  Perturbation (averaging, Poincare, multiple scaling, etc.)
  Restoring force surface and Force-state mapping
  Iwan method and Bouc-Wen model

Nonlinearity Modeling Techniques (14 lect)
  Principal component analysis (PCA or POD)
  Independent component analysis (ICA)
  Hilbert-Huang transform (HHT)
  Time-frequency method (e.g., Wavelets)
  Volterra-Wiener series
  Neuro-fuzzy model and Genetic algorithms
  Chaos and random noise methods
  NIFO (nonlinear identification through feedback of the output)

Applications (1 lect)
  To be chosen according to class preference

Term Project Due Date: Wednesday, May 6th