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