Seminário

Data: 17 de março de 2014
Horário: 16:30h
Local: sala de aula – Hangar I
(prédios da Eng. Aeronaútica – Campus 2)

Reduced-order modeling and analysis of flapping flight

Muhammad R. Hajj
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Aerospace vehicles, like many other multi-disciplinary engineered systems, are usually subjected to varying loading conditions and must survive harsh operating conditions in a wide range of environments and over extended periods. Required capabilities of future vehicles and risks associated with their operation are expected to take on new levels that can only be enabled by breaching traditional barriers in the design and technology space. One example is the flapping-wing micro-air-vehicle. From the aerodynamic point of view, the flapping motion generates a nonlinear unsteady flow. This flow is characterized by the leading edge vortex; a non-conventional contributor to the aerodynamic loads. From a dynamics perspective, the vehicle's motions constitute a nonlinear, non-autonomous dynamical system; specifically a time-periodic system. Additionally, the stringent weight and size constraints invoke the need for a design with minimal actuation, which results in an under-actuated nonlinear time-periodic system. These issues may be generic to other applications. In this presentation, we will discuss approaches developed to tackle such issues. In particular, we will present an analytical unsteady aerodynamic model that accounts for arbitrarily non-conventional lift mechanisms, such as the leading edge vortex. We will show the need to perform higher-order averaging for appropriate assessment of the dynamics of flapping flight. Finally, we propose a design methodology for the actuation mechanism that makes use of the saturation phenomenon to provide the required kinematics for both of hovering and forward flight using only one actuator. Throughout the presentation, we point out the benefits of using analytical formulations to represent the unsteady aerodynamics, perform kinematic optimization, and assess flight dynamics and control mechanisms.

Mais informações:
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Apoio: FAPESP

Universidade de São Paulo
Escola de Engenharia de São Carlos
Programa de Pós-Graduação em Engenharia Mecânica

Short Course

Higher-Order Spectral Analysis:

Background and Applications in the fields of Fluid Mechanics, Structural Dynamics and Structural Health Monitoring

Developed and Presented by

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Data: 14 e 17 de Março de 2014
Horário: 9:00h – 12:00h
Sala de Seminários da Pós-Graduação – Eng. Mecânica

Introduction

One of the most applied procedures for data analysis is the estimation of the power spectrum which yields the energy distribution amongst frequency components. Yet, there is much more information in stochastic and deterministic signals than is obtained from the power spectrum. This information can be obtained from the **higher-order spectral moments.** Because they preserve phase information, these moments can be used to identify nonlinearly interacting frequency components in a signal and quantify the extent of this interaction. This aspect inspires the idea of proposing them as tools for the analysis, interpretation, and modeling of random time series data as measured or numerically generated from linear and nonlinear systems.

The objective of this course is to show how additional information obtained from higher-order spectral analysis can be used to characterize and/or model physical phenomena. The course is split into two parts: Background and Applications. In the background, the basic theory of higher-order spectra is presented and their use for the detection and quantification of nonlinearities is illustrated. In the second part, applications of higher-order spectra in the fields of fluid mechanics, fluid structure/ interactions, structural dynamics, and structural health monitoring are presented. The applications part is designed to show the similarities in terms of exploitation of nonlinear aspects, nonlinear system identification and development of reduced-order models that exist in the application of higher-order spectral analysis across many disciplines. Additionally, they are intended to enable the students to build a perspective on how to apply higher-order spectra to their own areas.

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Short Course

Day 1, 14/Mar/2014:

1. The Fourier Transform
   - The Continuous Fourier Transform
   - Complex Fourier Series
   - The Sampling Theorem
   - Aliasing
   - The Discrete Fourier Transform
   - The Fast Fourier Transform
2. The Auto and Cross-Power Spectra
   - Stationarity
   - Definition of the Power Spectrum
   - Computation of Power Spectra
   - Estimation Considerations
   - Applications: Wavenumber /Frequency Spectrum
3. The Bispectrum
   - Bicorrelation Functions
   - Definition of the Auto- and Cross-Bispectra
   - Computation of the Auto- and Cross-Bispectra
   - Estimation Considerations
   - Applications
4. The Trispectrum
   - Tricorrelation Functions
   - Definition of the Auto- and Cross-Trispectra
   - Computation of the Auto- and Cross-Trispectra
   - Estimation Considerations
   - Applications

Day 2, 17/Mar/2014:

5. Nonlinear System Identification
   - Phase Relation of Coupled Frequency Components
   - Analytical Modeling
   - Design of Experiments
6. Examples and Applications
   - Modeling Lift and Drag on Oscillating Cylinders
   - Modeling Ship Motions
   - Modeling Structural Vibrations – Damping and Nonlinear Characterization
   - Modeling Nonlinear Aeroelastic Phenomena
   - Material Fatigue Prognosis – Exploitation of Nonlinearities
7. The Wavelet Transform
   - Wavelet-based Higher-order Spectral Moments
   - Applications

Dr. Muhammad R. Hajj is a Professor of Engineering Science and Mechanics in the Department of Engineering science and Mechanics at Virginia Tech. He received a Bachelor of Engineering with distinction from the American University of Beirut in 1983 and a M. Sc. and Ph. D. degrees from the University of Texas at Austin in 1985 and 1990. Over the past twenty years, his research has centered on developing analysis techniques to interpret experiments. More specifically, he has been applying higher-order spectral moments and wavelets to analyze nonlinear, nonstationary and transient phenomena in different research areas. The objectives of his research have been the prediction of extreme responses, the control of nonlinear behavior, or the identification and modeling of nonlinear phenomena. His research in different fields has enabled him to put together a coherent idea of special features of contemporary nonlinear problems.

LABORATÓRIO DE AEROELASTICIDADE

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