UNIVERSITÀ DEGLI STUDI DI BERGAMO

Dottorato di Ricerca in Ingegneria e Scienze Applicate

Scuola di Ingegneria, Dalmine (BG)

Active Vibration Control

Short Doctoral Course (24 h): 11-18 December 2017

Prof. Maryam GHANDCHI TEHRANI

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UNIVERSITY OF Southampton
Institute of Sound and Vibration Research

Abstract

In this doctoral course, an overview on active vibration control will be presented. Both feedback and feedforward strategies will be introduced.

In feedback control, receptance method will be introduced and implemented to assign the eigenvalues of the system. This problem is known as "pole placement". Experimental results will be shown on a T-plate, where the natural frequencies and damping ratios of the plate are modified as a result of feedback gains. Stability analysis using Nyquist criteria will be presented. The receptance method will also be extended to partial pole placement and robust control. Experimental results on an H-rig structure show how these techniques in active control work. An application of pole placement will be demonstrated on an Agusta-Westland W30 helicopter. Vibration suppression is achieved using both velocity and displacement feedback by assigning the poles of the helicopter to avoid blade passing frequency.

In feedforward control, Least Mean Square (LMS) algorithm will be considered. A secondary signal will be generated to cancel the vibrations from primary (disturbance) source. Examples such as active noise control of a duct and active vibration control of an aircraft wing will be provided.

Active control of periodic time-varying systems and nonlinear systems will be presented. Parametrically excited systems can exhibit unstable dynamics and the aim of active control is to stabilise such systems using both velocity and displacement feedback. A beam subject to an axial load is considered for the experimental work. It will be demonstrated that for certain excitation amplitude, the system becomes unstable. Active control is used to stabilise the system. Finally, active control is also developed for nonlinear systems. The problem is challenging as the response of such systems is amplitude dependent. Examples of nonlinear systems will be presented and some control strategies are developed, taking into account the nonlinearities both in the system and in the controller.

The course also includes four ***tutorials***. The first tutorial is to obtain FRFs from simulation and experiment. The second tutorial is to simulate a feedback control based on measured data using an inertial actuator. In the third tutorial, feedforward control using LMS algorithm will be practiced. In the fourth tutorial, active control in a duct will be considered.

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Day 1 – Mon. Dec. 11

09:00–10:00 Introduction to active control

10:15–11:15 Feedback control and stability analysis

11:30–12:30 Pole placement by the receptance method

14:00–15:00 Application of feedback control on helicopters

15:00–17:00 Laboratory 1: Construction of FRF from measurements, Computer Lab

Day 2 – Wed. Dec. 13

09:00–10:00 Digital control

10:15–11:15 Feedforward control in a duct, nonlinear control

11:30–12:30 Application of feedforward control on an aeroplane wing

14:00–17:00 Laboratory 2: Active noise control, LMS algorithm, Computer Lab

Day 3 – Fri. Dec. 15

09:00–10:00	Introduction to periodic time-varying systems	
10:15–11:15	Feedback control and stability analysis	
11:30–12:30	Experiment	
14:00–15:00	Application to a beam subject to an axial load	
15:00–17:00	Laboratory 3: Feedback control,	Computer Lab

Day 4 – Mon. Dec. 18

09:00–10:00	Introduction to nonlinear systems	
10:15–11:15	Structural nonlinearity	
11:30–12:30	Control nonlinearity	
14:00–15:00	Feedforward control of a nonlinear wing	
15:00–17:00	Laboratory 4: Feedforward control,	Computer Lab