Assessment of Robust Control on Damage Growth

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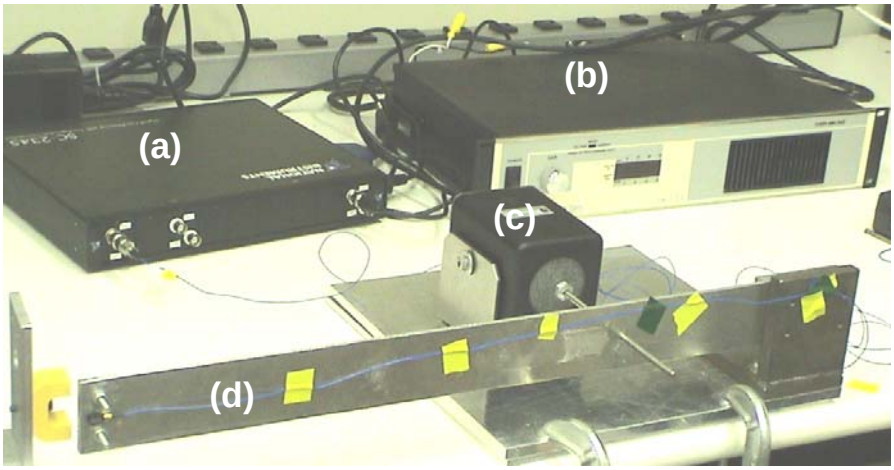
Abstract

It is common to use changes in the natural frequencies of a structure as indicators of damage to the structure. It is also common that the number of damage locations and levels will significantly exceed the number of natural frequencies that can be reliably measured. Consequently, a given set of observed natural frequencies will not correspond to a unique damage condition. In an effort to address this problem, this project will investigate the use of feedback control as a mechanism for obtaining additional natural frequencies. Specifically, this project will assess the degree to which the technique proposed in [1] is applicable to a real structure, with the ultimate goal of identifying the location and level of damage to a cantilever beam.

Project Description and Approach

This project will fundamentally focus on identifying the location and level of damage of as simple structural system. A cantilever beam will be used as the test structure and is shown in Figure 1.



(e)

a. National Instruments signal conditioner SC2345
b. Labworks PA-138 amplifier
c. Labworks ET-132-2 electromechanical shaker
d. Test Structure – 6061 Aluminum beam with steel plate at free end
e. Permanent, stationary U-magnet (NOT APPLICABLE FOR THIS PROJECT)

Figure 1. Experimental setup

The cantilever beam will be instrumented with one or more accelerometers to provide feedback. Actuation, both for control and excitation, will be provided by a small electro-

dynamic shaker. The controller will be developed in Matlab and Simulink, and implemented via Matlab's XPC target.

The general procedure for the project will be as outlined in [1]. Damage will be introduced in the form of added mass at some position along the beam. The first few natural frequencies of this damaged system will be measured. Various feedback controllers will then be implemented, and the natural frequencies of each of the closed loops will be measured. Then, through the aid of a finite element model of the beam, the sensitivities of the natural frequencies to the damage parameters will be estimated. This estimate will then be used to provide a damage parameter correction factor, in order to get the predicted natural frequencies to correspond to the observed natural frequencies. Provided this iterative procedure converges, an estimate of the damage location and level will be obtained.

Timeline

- Week 1: LANL training and orientation, introduction to vibration and control.
- Week 2: Hardware and XPC target orientation. Demonstration of the technique in [1] on a purely numerical example.
- Week 3: Develop ABAQUS models of beam and damage cases.
- Week 4: Develop and numerically verify feedback controllers.
- Week 5: Implement controllers.
- Week 6: Data analysis.
- Week 7: Repeat necessary tests, begin write-up.
- Week 8: Prepare presentation, complete write-up.

References

[1] "Structural Damage Detection Using Virtual Passive Controllers", *Journal of Guidance, Control, and Dynamics*, vol 25. no. 3., 2002, pp. 419-424

[2] "Shaker control in the presence of nonlinearities", 2003 LADSS Project, http://www.lanl.gov/projects/dss/Projects/2003/Matt%20Bement/220_kai.pdf;

[3] "Active Vibration Damping in the Presence of Uncertainties", 2002 LADSS Project, http://www.lanl.gov/projects/dss/Projects/2002/Matt/Bement_paper.pdf;

[4] Franklin; Powell; Emami-Naeini; *Feedback Control of Dynamic Systems, Third Edition;* Addison-Wesley; 1994 (general reference for control theory)

[5] Thomson; *Theory of Vibration with Applications, Fourth Edition;* Prentice-Hall; 1993 (see the section on vibration of continuous systems)