Use of a Collocated Sensor / Actuator for Dynamic Control and Structural Health Monitoring

PROJECT DESCRIPTION

A piezoelectric (PZT) material produces an electric charge when mechanically stressed, and conversely exhibits a mechanical strain when subject to an applied electric field. The use of PZT transducers has received considerable attention in recent years due to their versatility and adaptability in structural applications. When incorporated into a structure, these materials can provide a variety of solutions to dynamic problems such as vibration suppression and structural health monitoring.

This project will investigate a technique that combines the piezoelectric sensing and actuation functions into a single element, and use this element for both structural control and health monitoring. Such an element is referred to as a self-sensing collocated actuator, and has many engineering applications. Indeed, for vibration analysis and feedback control applications a collocated input/output response is generally desirable. It has been shown that, in the absence of sensor and actuator dynamics a structure controlled through self-sensing actuation will be unconditionally stable for all modes of the structure. Such a system would create an intelligent structure capable of controlling unwanted vibrations while being able to monitor and detect damage within the system.

In this project students will conduct analytical and experimental investigations to apply and evaluate the performance of self-sensing vibration control and diagnostics. An analytical model will be developed using the first principles of piezoelectric devices, electric circuits and Euler-Bernoulli beam theory. Positive position feedback (PPF) control will be used for vibration suppression since it provides an effective and straightforward control approach that can be implemented through the self-sensing actuator. This control approach will be coupled with LANL's time series analysis or impedance method to provide an effective tool for damage identification and diagnosis. Each stage of this project will first be investigated analytically and numerically, then, experiments will be performed on a cantilever beam (or other structural configuration) to verify the analytical prediction. Finally, issues of combining the health monitoring and control algorithms on the same hardware and software platforms will be addressed.

The ultimate goal of this project is to generate design guidelines of the self-sensing actuation, which will assist in the implementation of this technique in real-world, complex structures.

SCHEDULE

Weeks	Tasks
1	Orientation
2	Reading on the topics of piezoelectricity and papers listed below
3	Development of analytical model. Analytical investigations on unbalanced bridge circuits
4	Fabrication of the beam with PZT patch. Design and construction of the self-sensing circuit.
5	Vibration testing and control of the beam with self-sensing actuators

6-7	Damage detection based on the measured time and frequency data. Experimental investigation on the effects of the unbalanced bridge circuit
8	Combining hardware and software for simultaneous monitoring and control
9	Writing up of results and presentation

HELPFUL REFERENCES

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4. Fanson, J.L. and Caughey, T.K. 1990. "Positive Position Feedback Control for Large Space Structures, *AIAA Journal*, V.28 (4), 717-724.
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6. Park, G., Sohn, H., Farrar, C.R., Inman, D.J., 2003, "Overview of Piezoelectric Impedance-based Health Monitoring and Path Forward," *The Shock and Vibration Digest*, Vol. 35, No. 6, pp. 451-463.
7. Sirohi, J. and Chopra, I. 2000. "Fundamental Understanding of Piezoelectric Strain Sensors," *Journal of Intelligent Material Systems and Structures*, V.11, 246-257.
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