# "Structural Health Monitoring is a Problem in Statistical Pattern Recognition... Because the Assessment of Damage Always Entails a Comparison."

*Structural Health Monitoring Using Statistical Pattern Recognition* will introduce engineers to the most recently developed techniques for detection and location of damage in structures from changes in their measured dynamic properties. In addition to the historical motivation and development of the methods, the course will cover the theory, application, and computerized implementation of this technology. Many **real-world** examples and results will be presented from the fields of aerospace, civil, and mechanical engineering. The application of techniques involving **statistical pattern recognition** will be emphasized.

## Course Goals

Upon completion of this course, attendees will be able to:

- Describe structural health monitoring as a problem in statistical pattern recognition
- Describe and classify the primary methods of structural health monitoring, with their associated advantages and disadvantages
- Describe the historical and current real-world applications of damage identification in the aerospace, civil, and mechanical engineering fields
- Discuss the primary practical implementation issues, including relevance of baseline measurements, importance of measurement statistics, and aspects of comparative studies between methods
- Explain recent developments in sensing technology relevant to SHM

To ensure top-quality content, the instructors reserve the right to alter the course schedule.

## Course Outline

### Introduction
- Motivation for Structural Health Monitoring (SHM)
- Statistical pattern recognition (SPR) paradigm
- Sensing issues for SHM
- Fundamental axioms of SHM

### Historical Overview
- Discipline specific applications (aerospace, civil, rotating machinery, offshore oil platforms)
- Damage detection methods review (modal parameters, model updating techniques)
- Impact of other technologies on SHM

### Operational Evaluation
- Define system specific damage
- Evaluate environmental/operational conditions

### Active SHM Sensing Technologies
- Lamb wave propagation/Impedance method
- Time reversal acoustics
- Sensor self-diagnostics
- Active-sensing hardware development
- Hardware/software integration

### Emerging SHM Sensing Technologies
- Sensing system design issues
- Fiber optic sensing
- Active versus passive sensing
- Embedded Computing
- Energy Harvesting

### Feature extraction
- Feature selection criteria
- Limitations of commonly used features
- Time series analysis & state-space representation
- Frequency domain analysis
- Features based on nonlinear analysis

### Introduction to Statistical Inference
- Supervised/unsupervised learning
- Group classification
- Regression modeling

### Basic Statistical Tools
- Statistical moments
- Probability distributions and density estimation
- Fisher's discriminant
- Principal component analysis

### Unsupervised Learning Methods
- Hypothesis testing
- Statistical probability ratio test
- Statistical process control
- Outlier analysis

### Supervised Learning Methods
- Neural networks
- Support vector machines
- Clustering
- Regression analysis

### Data Normalization
- Influence of environmental/operational variability
- Test modification
- Modeling of environmental effects
- Auto-associative neural networks

### Examples/Applications
- I-40 bridge
- Bridge concrete column
- Three story shear building model
- Light rail system
- Fast patrol boat

This course is designed for those who seek a thorough understanding of the analytical techniques for Structural Health Monitoring as well as an appreciation for the theoretical and practical issues.

**The instructors will assume a basic knowledge of structural mechanics, dynamics, and mathematics, such as that obtained in a bachelor's level aerospace, civil, or mechanical engineering program.**

# About the Instructors

**Dr. Charles "Chuck" Farrar**
Dr. Farrar is currently the director of the Engineering Institute at Los Alamos National Laboratory, which focuses on developing SHM and model validation technology.

**Prof. Hoon Sohn**
Prof. Sohn is currently Associate Professor in Civil and Environmental Engineering at the Korea Advanced Institute of Science and Technology (KAIST), where his research focuses on active sensing, guided-wave propagation, and time-reversal acoustics applied to SHM.

**Dr. Gyuhae Park**
Dr. Park is currently a Technical Staff Member assigned to the Engineering Institute at Los Alamos National Laboratory where he develops active-sensing approaches for damage detection.

**Prof. Michael Todd**
Prof. Todd is currently Associate Professor of Structural Engineering and lead for Engineering Institute activities at UC—San Diego. Mike was awarded the SHM "Person of the Year" award at the 2005 International Workshop on SHM.

**Prof. Jerome Lynch**
Prof. Lynch is currently Assistant Professor of Civil Engineering at the University of Michigan. His research focuses on the development of wireless sensor nodes for SHM applications.

**Prof. Douglas Adams**
Prof. Adams is currently Associate Professor of Mechanical Engineering at Purdue University. His research covers a broad range of technology development in the area of SHM for aerospace and vehicular applications.

# Location, Lodging & Transportation Information

Attendees are responsible for their own transportation and lodging. See conference web site for lodging information. Detailed course location information will be sent to registrants by September 1.

**Download Sample Course Notes at www.la-dynamics.com**

# Registration Form

**Structural Health Monitoring**
Download a larger form at www.la-dynamics.com

Direct questions to farrar@la-dynamics.com

**Fax to:**
(814) 284-8772

**or**

**Mail to:**
PO Box 1193
Los Alamos NM 87544

Please circle one:

| | |
|---|---|
| Full Registration Fee: | US $1695 |
| Early Registration* | US $1495 |
| Full-time Student Registration Fee | US $795 |

(Class size limited to 30 participants.)

## Course Fees Include:

Course notes (hardcopy & CD-ROM), refreshments, certificate of completion, meeting facilities, and individual consultation with instructors.

| |
|---|
| Name: |
| E-mail Address: |
| Company: |
| Mailing Address: |
| |
| City/State/ZIP: |
| Phone Number: |
| FAX Number: |
| Payment by (circle): VISA MC Check |

**To pay by credit card, please place a secure online payment on our web site, www.la-dynamics.com**

**Make Checks Payable to:**
Los Alamos Dynamics, LLC (US Dollars only)

* To qualify for early registration discount, form must be received by FAX or postmarked by August 10, 2007

# Los Alamos Dynamics

**Structural Dynamics Consultants**
www.la-dynamics.com

# Structural Health Monitoring Using Statistical Pattern Recognition

**to be held at**

## Palo Alto, California
## September 8-10, 2007

**A 3-Day Short Course for Aerospace, Civil and Mechanical Engineers**

**in conjunction with the**

**6th International Workshop on Structural Health Monitoring**
**September 11-13, 2007**
**Palo Alto, California**
structure.stanford.edu/workshop

Los Alamos Dynamics is an independent company not affiliated with Los Alamos National Laboratory