

STRUCTURAL HEALTH MONITORING USING STATISTICAL PATTERN RECOGNITION

Palo Alto, CA, September 7 - 9, 2019

Time	Day 1 September 7 th	Time	Day 2 September 8 th
8:30-9:00	Registration & Introductions		
9:00-9:55	1. Introduction (Farrar) <ul style="list-style-type: none"> - Course overview - Definition of Damage and SHM - Motivation for SHM, (NDE vs SHM) - Statistical pattern recognition paradigm - Historical overview: aerospace /civil/mechanical application 	8:30-9:25	8. SHM Sensing Technologies I (Todd) <ul style="list-style-type: none"> - Excitation methods - Conventional force/pressure sensing - Conventional strain sensing - Conventional acceleration sensing - Acoustic emission sensing - Fiber optic sensing
9:55-10:20	2. Operational Evaluation (Farrar) <ul style="list-style-type: none"> - Economic/Life-safety justification for SHM - Defining the damage to be detected - Constraints on the SHM process - Case Study 	9:25-10:20	9. SHM Sensing Technologies II (Flynn) <ul style="list-style-type: none"> - Piezoelectric materials - Commercial transducers/actuators - Custom transducers/actuators - Design consideration - Instrumentation techniques
10:20-10:40	Coffee Break	10:20-10:40	Coffee Break
10:40-11:45	3. Review of NDE Methods (Todd) <ul style="list-style-type: none"> - Ultrasound - Thermography - Eddy Current - Radiography - Limitations 	10:40-11:45	10. SHM Sensing Technologies III (Todd) <ul style="list-style-type: none"> - Laser-based non-contact measurements - Video-based non-contact measurements - Robotic devices used for SHM sensing - Specialty sensors developed for SHM (comparative vacuum monitoring, pressurized aircraft tubing, HERT, Underwater system) - Emerging sensing and data visualization hardware
11:45-12:45	4. Sensing & Data Acquisition (Todd) <ul style="list-style-type: none"> - Sensor and sensor system overview - Sensor performance metrics - Signal conditioning issues - Telemetry and power - Embedded systems - Sensor network paradigms 	11:45-12:45	11. Introduction to SHM Features (Farrar) <ul style="list-style-type: none"> - Define "features" in the context of SHM - Features in the context of detection theory - Sufficient statistic - Feature types - Examples (frequencies, mode shapes)
12:45-13:45	Lunch	12:45-13:20	Lunch
13:45-14:45	5. Signal Processing (Flynn) <ul style="list-style-type: none"> - Conditioning signals - Analyzing Signals - Time, Frequency & Time-frequency Methods - Correlation methods - Input-output methods 	13:45-14:45	12. Ultrasonic Methods (Flynn) <ul style="list-style-type: none"> - Acoustic emissions - Impedance method - Sensor self-diagnostics - Guides waves - Nonlinear acoustics - Integration with other SHM technologies
14:45-15:40	6. Basic Statistics (Farrar) <ul style="list-style-type: none"> - Statistical moments/distributions - Density estimation - Confidence limits - Central limit theorem - Principal component analysis 	14:45-15:40	13. Advanced Features (Todd) <ul style="list-style-type: none"> - Nonlinear response concepts - Waveform comparisons (nonlinear) - Nonlinear time series modeling - Residual errors - Chaotic interrogation methods
15:40-16:00	Coffee Break	15:40-16:00	Coffee Break
16:00-17:00	7. SHMTools Demonstration: Signal Analysis (Flynn) <ul style="list-style-type: none"> - Using SHMTools & mFUSE - Function & process assembly - Data import - Statistical analysis - Signal processing 	16:00-17:00	14. SHMTools Demonstration (Flynn) <ul style="list-style-type: none"> - Feature extraction with time series models - Rotating machinery example - Guided wave example

Time	Day 3 September 9 th
8:30-9:25	15. Damage Detection: Unsupervised Learning Methods (Farrar) <ul style="list-style-type: none"> - Motivation for statistical decision analysis - Define supervised and unsupervised learning methods in the context of SHM - Cluster analysis - Outlier (Novelty) detection - Statistical process control
9:25-10:20	16. Damage Detection/Classification: Supervised Learning Methods (Todd) <ul style="list-style-type: none"> - Group classification & regression - Neural networks - Radial basis function - Support vector machines - Automated feature selection
10:20-10:40	Coffee Break
10:40-11:45	17. Data Normalization (Farrar) <ul style="list-style-type: none"> - Environmental/operational effects on SHM - Parametric modeling environmental effects - Look-up table technique - Machine learning techniques - SHM system design for normalization
11:45-12:45	18. SHM System Design: Detection and Location (Todd) <ul style="list-style-type: none"> - Bayesian risk framework - Classical detection theory - Detector design - Detection/location examples
12:45-13:45	Lunch
13:45-14:45	19. Value of Information in SHM (Thöns) <ul style="list-style-type: none"> - Scenario definition for value of information analyses - Structural system and structural health information modelling - Example for value of information analysis
14:45-15:40	20. SHMTools Demonstration Detection & Classification (Flynn) <ul style="list-style-type: none"> - Outlier detection - Data normalization - Supervised learning example
15:40-16:00	Break
16:00-17:00	21. Fundamental Axioms & Closing Remarks (Farrar) <ul style="list-style-type: none"> - Recap the statistical pattern recognition paradigm - Fundamental axioms of SHM - Other sources of information - Course survey