# Structural Health Monitoring Using Statistical Pattern Recognition

# Damage-Sensitive Features II

# The Structural Health Monitoring Process

1. Background
2. Operational evaluation
3. Data acquisition & networking
4. **Feature selection & extraction**
5. Probabilistic decision making

- **Data Cleansing**
- **Data Normalization**
- **Data Fusion**
- **Information Condensation**

**Material in this module is covered in Chapter 8 of the Course Reference Book**

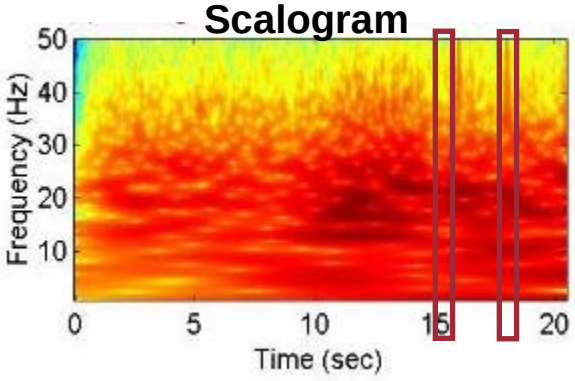
# Outline

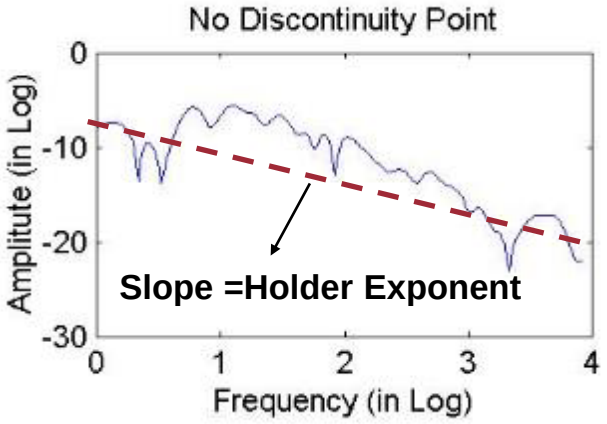
- Features based nonlinear system modeling and identification
  - Waveform comparisons: Nonlinear detection
    - Coherence function
    - Harmonic distortion
    - Linearity and reciprocity checks
    - Information theory/statistical tests
    - Time-frequency analysis
  - Nonlinear modeling
    - Residual errors from linear models
    - Nonlinear time series model
  - Chaotic interrogation methods
  - Automated feature selection

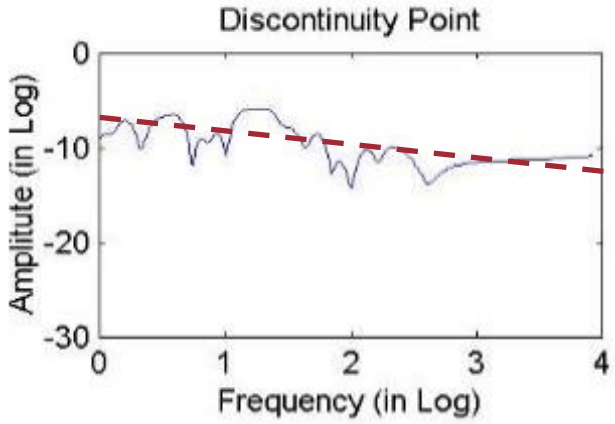
# Holder Exponent

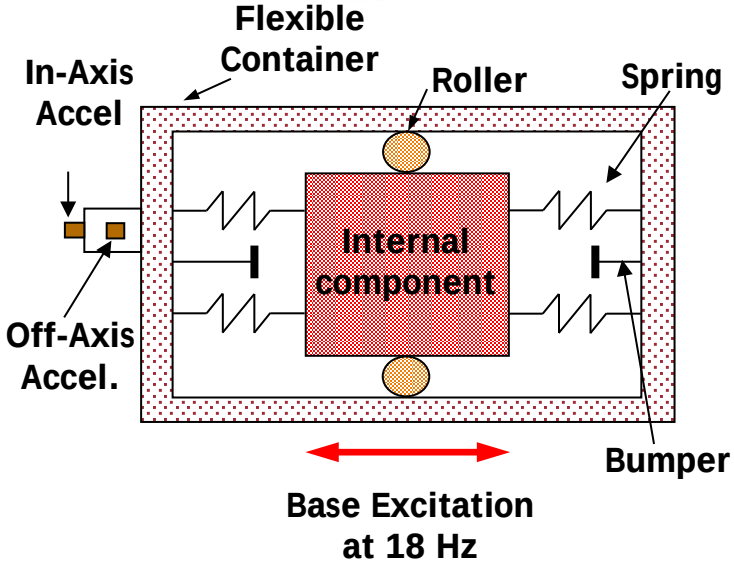
- The Holder exponent estimates the discontinuity (or regularity) of a signal.
- The measure of singularity provided by the Holder exponent can be used to detect discontinuities in a signal.
- The Holder exponent quantifies to what order a function is differentiable.
- The more continuous the signal, the closer the value is one and a Holder exponent of 0 indicates the presence of a singularity (discontinuity).
- Using a Wavelet Analysis, the signal discontinuity can be located in time.

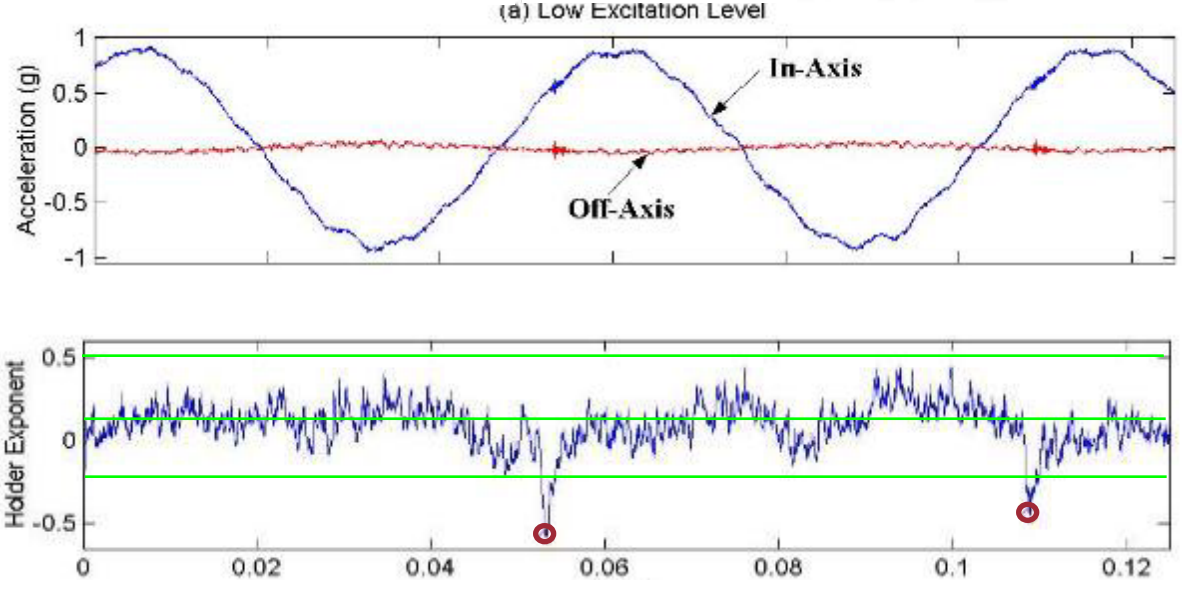
# Feature Extraction Using Holder Exponent Analysis



# Challenges for Feature Selection and Extraction

- Developing an analytical approach to feature selection.
  - Feature selection is still based almost exclusively on engineering judgment
- Quantifying the features sensitivity to damage
- Quantifying how the feature's change with damage level.
- Understanding how the feature will change with changing environmental and operational conditions
  - One of the biggest barriers to in situ deployment of SHM systems!
- There are many more features defined in the literature than the ones presented in last two lectures

# References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- Nonlinear Time series models
  - L. Bornn, C. R. Farrar, G. Park and K. Farinholt, (2009) "Structural Health Monitoring with Autoregressive Support Vector Machines," ASME J. of Vibration and Acoustics 131(2) 0121004.
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